Technology and problem-based learning - The higher technical examination programme

How can we strengthen the disciplinary tradition in the subject of technology in the Danish HTX programme?

Møller Jeppesen, Mette

DOI (link to publication from Publisher):
10.54337/aau470870268

Publication date:
2021

Document Version
Publisher's PDF, also known as Version of record

TECHNOLOGY AND PROBLEM-BASED LEARNING – THE HIGHER TECHNICAL EXAMINATION PROGRAMME

HOW CAN WE STRENGTHEN THE DISCIPLINARY TRADITION IN THE SUBJECT OF TECHNOLOGY IN THE DANISH HTX PROGRAMME?

BY
METTE MØLLER JEPPESEN

DISSERTATION SUBMITTED 2021

AALBORG UNIVERSITY
DENMARK

TECHNOLOGY AND PROBLEM-BASED LEARNING – THE HIGHER TECHNICAL EXAMINATION PROGRAMME

HOW CAN WE STRENGTHEN THE DISCIPLINARY TRADITION IN THE SUBJECT OF TECHNOLOGY IN THE DANISH HTX PROGRAMME?

by

Mette Møller Jeppesen

AALBORG UNIVERSITY
DENMARK

Thesis submitted

Dissertation submitted:	November 2021
PhD supervisor:	Associate Professor. Lars Bo Henriksen Aalborg University
Assistant PhD supervisor:	Distinguished Professor. Jan van Tatenhove Aalborg University
PhD committee:	Associate Professor Lykke Brogaard Bertel (chairman) Aalborg University
	Docent Susanne Dau UCN
	Associate Professor Lena Gomaelius KTH/ECE
PhD Series:	Technical Faculty of IT and Design, Aalborg University
Department:	Department of Planning

ISSN (online): 2446-1628
ISBN (online): 978-87-7210-904-6

Published by:
Aalborg University Press
Kroghstræde 3
DK – 9220 Aalborg Ø
Phone: +45 99407140
aauf@forlag.aau.dk
forlag.aau.dk

Printed in Denmark by Rosendahls, 2022

CV

Mette Møller Jeppesen began as a PhD student at the Department of Planning, Faculty of IT and Design, Aalborg University, 1 November 2017. Mette Møller Jeppesen is a member of the research group Techno-Anthropology and Participation (TAPAR).

ENGLISH SUMMARY

HTX is a vocational high school education, which in its form is very unique to Denmark. The education has existed since 1982 and was established with an interest in having a high school education that provided access to the technical and scientific higher educations. It is a three-year education program based on technological-, scientific- and vocational education perspectives. Students on HTX are taught a combination of technological and scientific disciplines and general subjects. Over the course of the three years, they will develop their ability to engage in professional immersion and their understanding of theoretical knowledge as a tool for analysing real life. This is worked on HTX through a combination of theory and practice, which is tested in workshops and laboratories (Ministry of Children and Education, 2020). As described below by a teacher, the students through the education experience that:

> 'They themselves can put something into action, that they can create and produce something that they do not know the result of in advance, and in that sense, they live forward in an open world. It provides students with an emphasis on creativity and innovation, because they do not only reproduce, but create completely new knowledge through the insight they gain in the interaction between the subjects. HTX is not just a specific curriculum, but an education that has something to do with the real world. In this way, the students also become ready in a completely different way to navigate the knowledge society, which is the reality they will enter' (Pedersen, 2007: 57).

What the HTX education can do, and the general character of formation (Bildung) that the students can acquire through the education fits the existing discourse that society needs more young people to acquire STEM competencies, as young people with STEM competencies are in demand in both higher education and in companies. For that reason, it is important to get more young people to choose HTX but that is not the only reason why it is important. In addition, figures from the coordinated registration (KOT) (2017) also show that most of the young people with an HTX education choose their further studies in continuation of the profile subjects; Technology and Engineering leading to some form of STEM education which can also be seen in a top six of popular education choices for HTX students: 1) Graduate Engineer 2) Master of Science in Engineering 3) Medicine 4) Computer Scientist 5) Computer Science 6) Mechanical Engineer (Professions Bachelor). Last but not least, it is also the HTX students who after high school start studying a higher education the fastest (Danish Business Schools and - Colleges, 2017).

Therefore, it is also important to do research on HTX. In relation to the students, in relation to the teachers' practice and the subjects, as it can help us to understand how we can get even more young people to choose an HTX education.

This also underlines the relevance of the research conducted in connection with this thesis. A study of how it is possible to strengthen the disciplinary tradition in the

technology subject on HTX, because a stronger disciplinary tradition in the technology subject can contribute to more young people choosing a higher STEM education and thus achieve the STEM competencies that are so coveted in companies.

The study carried out in connection with this thesis is made up of a number of smaller studies. Initially, a study was conducted that substantiated the presence of the initiating problem expressed by the teachers. In this part of the study it was concluded that the technology teachers' collaboration around the technology subject on HTX is challenged, as the teachers agree to disagree when it comes to the understanding (conceptualisation) of problem-based learning (PBL) and related concepts, e.g. in connection with the students' project work. The individual teachers therefore find their own solutions to how they can work with PBL when teaching technology, which contributes to the degree of problem orientation varying from teacher to teacher. In addition, it also became clear that teachers will most likely never reach any kind of consensus or full agreement on how the concepts within PBL should be understood (conceptualized), but that they also do not find such an agreement necessary. On the basis of this, it was concluded that a solid disciplinary tradition within the technology subject has not yet been fully established and that on that basis there is potential for further development of the teaching in the technology subject on HTX.

Subsequently, a number of studies have been carried out that provided a deeper insight into the technology subject on HTX through the concepts; Technology, PBL, Bildung and Language.

Technology

The study of the concept of technology and the way it is conceptualized in the technology subject, on HTX, is carried out on the basis of the Technology Model[1]. In short, the study concludes that the Technology Model works according to its purpose stated in the Ministerial Order, but it is also argued that teachers should be aware of the model's shortcomings and discuss these with the students so that they gain a more dynamic and dialectical understanding of technology.

PBL

Furthermore, the role of technology teachers is also examined when they teach the technology subject on HTX and also how this role is expressed in a practice where the use of PBL is recognized as an important teaching pedagogy. Based on this, it is concluded that there is a need for management support for the teachers in their work with the technology subject so that they can best handle the very hybrid role they have in the subject. With recognition and a detailed knowledge of the teachers' hybrid role in the subject, it will be possible to identify some directions for future development of the technology subject.

[1] (Müller et al., 1984)

Bildung
The concept of a general character of formation - Bildung - is further investigated, including if the students on HTX can acquire Bildung during their studies. On the basis of this part of the study, it was concluded that it is actually possible for the students to acquire the Bildung and study competencies described in the Ministerial Order, through their study time on HTX.

Language games
In this study, work continues on the lack of consensus that was expressed in the first part of the study. The contribution made to the concepts in the technology subject consists of a merged language or merged conceptual device which was created with the technology teachers on HTX. The conceptual device that have been merged include the concepts used in the teaching of the technology subject, including concepts of problem-based learning (PBL) and product development. The merged language is not created with an expectation that it will help to create a unification in the teaching of the technology subject. A unification in the technology subject is, firstly, impossible to expect as the teachers have so many different professional backgrounds on the contrary, it should instead be seen as a great asset of the subject. More specifically, the merged language is created as an attempt to create an opportunity for teachers in the technology subject to discuss their practice and subject with each other and the students. Some of the technology teachers are actually using the language, that was written down in a textbook for the technology subject and there have even been made plans to discuss the now three existing text books for the subject against each other in order to get closer to a common direction in the technology subject.

In conclusion it can be said that it is possible to strengthen the disciplinary tradition in the technology subject on HTX through working with the language games used in the technology subject. Through a process of getting to know the language used by the teachers in the technology subject and then together with the teachers identify the key concepts in the subject, it has been possible to merge several existing language games and thereby create one coordinated language that can be used by both teachers and students in the subject and through this coordinated language, the disciplinary tradition in the technology subject can be strengthened over time.

To get the whole story, you have to read the thesis from start to finish, and I hope you find it as interesting as I think it was both to conduct research in the technology subject together with the teachers and write the thesis.

Enjoy the read

DANSK RESUME

HTX-uddannelsen er en erhvervsrettet gymnasieuddannelse, der i sin form er helt unik for Danmark. Uddannelsen har eksisteret siden 1982 og blev oprettet med interesse i at have en gymnasieuddannelse i Danmark, der gav adgang til de tekniske og naturvidenskabelige videregående uddannelser. HTX er et treårigt uddannelsesprogram, der tager udgangspunkt i teknologiske-, videnskabelige - og erhvervsuddannelsesperspektiver. Eleverne undervises i en kombination af teknologiske - og naturvidenskabelige discipliner, samt almindelige gymnasiale fag. De skal i løbet af de tre år udvikle deres evne til at engagere sig i professionel fordybelse og deres forståelse af teoretisk viden som et redskab der kan anvendes til at analysere det virkelige liv. Det er nogle af de evner der på HTX arbejdes på at eleverne opnår gennem en kombination af teori og praksis, hvorefter det afprøves i workshops og laboratorier (Ministeriet for børn og uddannelse, 2020). Som det nedenfor beskrives af en lærer så erfarer de studerende gennem uddannelsen at:

> ’De selv kan sætte noget i værk, at de selv kan skabe og producere noget, som de ikke på forhånd kender forløbet og resultatet af og, at de i den forstand lever fremad i en åben verden. Det giver elever, der vægter kreativitet og innovation, fordi de ikke bare reproducerer, men skaber helt ny viden gennem den indsigt, de får i samspillet mellem fagene. HTX er ikke bare et bestemt pensum, men en uddannelse der har noget med virkeligheden at gøre. På den måde bliver eleverne også på en helt anden måde klar til at navigere i vidensamfundet, som er den virkelighed, de kommer ud i’ (Pedersen, 2007:57).

Det HTX-uddannelsen kan, og den dannelse (Bildung) som eleverne kan tilegne sig gennem den treårige uddannelse taler ind i den eksisterende diskurs om at samfundet har brug for at flere unge opnår STEM-kompetencer, fordi de unge med STEM-kompetencer er efterspurgte både på de videregående uddannelser og i erhvervslivet. Af den årsag vil det også være interessant at få flere unge til at vælge HTX. Men det er ikke den eneste årsag til, at det giver mening at få flere unge til at vælge en HTX-uddannelse. Hertil viser tal fra den koordinerede tilmelding (KOT) (2017) også at der er flest af de unge fra HTX der læser videre i forlængelse af profilfagene; Teknologi og Teknikfag i retningen af en eller anden form for STEM-uddannelse. Det kan ses i en top seks over populære uddannelsesvalg efter endt HTX-uddannelse: 1) Diplomingeniør 2) Civilingeniør 3) Medicin 4) Datamatiker 5) Datalog og 6) Maskinmester (professionsbachelor). Sidst, men ikke uden relevans, er det også HTX’erne der hurtigst går i gang med en videregående uddannelse efter en gymnasietid (Danske Erhvervsskoler og – Gymnasier, 2017).

Derfor er det også vigtigt at forske i HTX. I de studerende, i lærerenes praksis og i fagene, da det kan være med til at hjælpe os til at forstå hvordan vi kan få endnu flere unge til at læse en HTX-uddannelse.

Dette understreger også relevansen af den forskning der er gennemført i forbindelse med denne afhandling. En undersøgelse af hvordan det er muligt at styrke fagtraditionen i teknologifaget på HTX, fordi en stærkere fagtraditionen i teknologifaget kan være medvirkende til at enden flere unge vælger en videregående STEM-uddannelsen og dermed opnår de STEM-kompetencer der er så eftertragtet i erhvervslivet.

Undersøgelsen der er gennemført i forbindelse med denne afhandling er bygget op af en række mindre undersøgelser. Indledende er der gennemført en undersøgelse der underbygger tilstedeværelsen af det initierende problem lærerne gav udtryk for allerede under første møde på HTX. I denne del af undersøgelsen blev det konkluderet at teknologilærernes samarbejde omkring teknologifaget på HTX er udfordret, da lærerne er enige om at være uenige, når det kommer til forståelsen (konceptualisering) af PBL og begreberne her indenfor, f.eks. i forbindelse med elevernes projektarbejde. De enkelte lærere finder derfor deres egne løsninger på hvordan de kan arbejde med problembaseret læring (PBL) i undervisningen, hvilket er medvirkende til at graden af problemorientering varierer fra lærer til lærer. Derudover blev det også tydeligt at lærerne højst sandsynligt aldrig vil opnå nogen form for konsensus eller fuld enighed om hvordan begreberne indenfor PBL skal forstås (konceptualiseres), men at de heller ikke finder en sådan enighed nødvendig. På baggrund heraf blev det konkluderet, at en solid fagtradition inden for teknologifaget endnu ikke er fuldt ud etableret og at der er potentiale for at videreudvikle teknologiundervisningen på HTX.

Efterfølgende blev der gennemført en række undersøgelser der gav en dybere indsigt i teknologifaget på HTX, hvilket blev gjort gennem begreberne; Teknologi, PBL, Bildung og Sprogspil.

Teknologi
Undersøgelsen af begrebet teknologi og den måde det begrebsliggøres på i teknologifaget, på HTX, gennemføres med udgangspunkt i Teknologimodellen[2]. Samlet set kan det ud fra undersøgelsen konkluderes, at teknologimodellen fungerer i henhold til det formål, der er angivet i bekendtgørelsen, men der argumenteres også for, at lærerne skal være opmærksomme på modellens mangler og diskutere disse med eleverne, så de opnår en mere dynamisk og dialektisk forståelse af teknologi.

PBL
Videre undersøges også teknologilærernes rolle når de underviser i teknologifaget på HTX og hvordan denne rolle kommer til udtryk i en praksis hvor anvendelsen af PBL er anerkendt som en vigtig undervisningspædagogik. Ud fra undersøgelsen konkluderes det, at der er behov for at lærerne får ledelsens opbakning til deres arbejde med teknologifaget hvis de skal skulle arbejde med den hybride rolle faget kræver at de håndterer. Med anerkendelse og et detaljeret kendskab til lærernes hybride rolle i faget vil være det muligt at identificere nogle retninger for fremtidig udvikling af teknologifaget.

[2] (Müller et al., 1984)

Bildung

Yderligere undersøges begrebet dannelse - *Bildung* - og herunder om de studerende på HTX gennem deres studietid kan erhverve sig dannelse og på baggrund af denne del af undersøgelsen blev det konkluderet, at det faktisk er muligt for de studerende at tilegne sig Bildung og de studiekompetencer beskrevet i bekendtgørelsen gennem deres studietid på HTX.

Sprogspil

I denne undersøgelse arbejdes der videre med den manglende konsensus der kom til udtryk i den første undersøgelse. Bidraget til begreberne i teknologifaget består af et koordineret sprog eller begrebssæt, der er blevet udviklet sammen med teknologilærerne på HTX. Det koordinerede sprog inkluderer de begreber, der anvendes i undervisningen i teknologifaget, herunder begreber relateret til problembaseret læring (PBL) og produktudvikling. Det koordinerede sprog er ikke skabt med en forventning om, at det vil hjælpe med at skabe en ensretning af undervisningen i teknologifaget. En ensretning i teknologifaget er for det første umuligt at forvente, da lærerne har så mange forskellige faglige baggrunde. Derimod det skal udviklingen af det koordinerede sprog i stedet ses som et stort aktiv for teknologifaget. Mere specifikt er det koordinerede sprog skabt som et forsøg på at give teknologilærere en mulighed for at diskutere deres praksis og fag med hinanden og de studerende. Hvad mere er så bruger nogle af teknologilærerne faktisk sproget, der er blevet nedskrevet i en grundbog til teknologifaget, og det er yderligere planlagt at lærerne diskutere de nu tre eksisterende lærebøger til teknologifaget for at komme tættere på en fælles retning i teknologifaget.

Afslutningsvis kan det derfor også konkluderes, at det ér muligt at styrke fagtraditionen i teknologifaget på HTX ved at arbejde med de sprogspil, der anvendes i teknologifaget. Gennem en proces med at lære de sprogspil, lærerne bruger i teknologifaget og identificere nøglebegreberne i faget, har det været muligt at slå flere eksisterende sprogspil sammen og derved skabe et koordineret sprog, der kan bruges af både lærere og elever i faget og gennem anvendelsen af dette koordinerede sprog, kan fagtraditionen inden for teknologifaget løbende styrkes.

For at få indblik i undersøgelsen som hele er du nødt til at læse afhandlingen fra start til slut, og jeg håber, du finder det lige så interessant, som jeg synes det var både at forske i teknologifaget sammen med lærerne og formidle det efterfølgende.

God fornøjelse

PREFACE

My journey with the Danish Higher Technical Examination Programme started many years ago. It has been over twenty years since I first walked through the doors on HTX in Aalborg. I was 17 years old at the time and had just started studying on HTX. I think back on the three years of study with great joy even after such a long time. The classmates, I even still have occasional contact with some of them today. The unity of all of us classmates built up through countless trips to McDonald's during the breaks, visits to the local HTX pub and of course through a myriad of technology projects. The teachers, some of which are still going strong today and of course the subjects. It's all still very clear in my memory.

Twenty-three years later when a PhD position is advertised at Aalborg University on HTX and the technology subject, a few months after I graduated with a master's degree, there was no doubt in my mind that I had to apply for it.

The purpose of this PhD project is to investigate how we can strengthen the disciplinary tradition within the technology subject in the Danish HTX program. This from an action research perspective with teachers and students as participants in the process. In addition, the ambition is to seek a possible solution to some of the challenges teachers and students encounter in the technology subject with the purpose of strengthening disciplinary tradition in the subject. Throughout the project, I have collaborated with teachers and students from HTX in Aalborg, as well as with teachers from other HTX schools throughout the country. Furthermore, I collaborated with the Ministry of Children and Education's subject advisor for the technology subject. Throughout the project, I have had the opportunity to follow the teaching of the technology subject because teachers and students have been so gracious in opening the doors to the classrooms. Therefore, a big thank you to all of you who have taken the time to participate is in order. Without your participation, this thesis would not have been possible. You have been a constant source of inspiration and I have can truly say that I really appreciated visiting all of you on HTX gaining insight into the technology subject.

This research would also not have been possible without the support of my family, friends, colleagues. It has been a frustrating and educational process that you have supported me throughout and for that I am forever grateful. As the American essayist, lecturer, philosopher and poet once wrote:

> 'Cultivate the habit of being grateful for every good thing that comes to you, and to give thanks continuously. And because all things have contributed to your advancement, you should include all things in your gratitude'
> (*Ralf Waldo Emmerson)*

And why not start cultivating the habit of being grateful right here and now - there are so many I owe a debt of gratitude to.

First of all, I would like to thank my supervisor, Lars Bo Henriksen. We have had many interesting professional discussions over the last three years that I would not have been without. You could almost say that we have lived in a kind of HTX symbiosis where everyone in the office has not always been able to follow what we have talked about. It has been incredibly rewarding in many ways. We are also different people and have had our share of disagreements, but no matter what initiatives I have come up with, you have always remained completely calm on the outside and for that I am grateful.

I would also like to thank my co-supervisor, Jan van Tatenhove. It has been a pleasure to have had you with me on this journey for the last 1.5 years. Your always friendly and welcoming approach have been greatly appreciated, as have our small planning meetings where we have discussed the structure of both articles and PhD. I am grateful you chose to take a chance with me.

A big thank you also goes to all the colleagues in the research group Techno-Anthropology. Without you, the journey would not have been half as interesting. I am incredibly grateful for your willingness to discuss my research and the academic world and thus contribute to me being able to view my research from a broader perspective. In addition, good colleagues outside my own research group must also be mentioned; Troels Jacob Hegland, Kristen Ounanian, Paulina Ramirez-Monsalve, Alberto Huerto Morales, Louise Krogh. Thank you for listening and thank you for the smiles. I am grateful that you have been on this journey with me.

Patience must be the word that first comes to mind when I think of my family. You have a large share in that this journey has been possible. You have been patient even when the work on this PhD has made inroads into the family vacations. A patience I am very grateful for. And last but definitely not least my lovely intelligent boy who has been with me on this journey all the way. He was only 1.5 years old when I chose to start studying again. He has been patient and inpatient at times just as he should be. He is the real measure of what I have achieved.

Mette Møller Jeppesen

Aalborg, marts 2021

TABLE OF CONTENTS

Chapter 1. Introduction.. 24

1.1. Everyday life at the Danish higher technical examination programme 24

1.2. The HTX educational program.. 25

1.2.1. The Ministry of Children and Education, Ministerial Order 26

1.2.2. The history of HTX 28

1.2.3. Study competencies 30

Chapter 2. Teaching technology in an international and danish context.. 32

2.1. Enrolling in a research area 32

2.2. Teaching technology in international an international context...... 33

2.2.1. Conclusion.. 40

2.3. Teaching technology on HTX in Denmark...................................... 40

2.3.1. The purpose of the technology subject 40

2.3.2. The subject of technology... 40

2.3.3. Technology projects.. 41

2.3.4. Technology in the technology subject 43

2.4. The practice of teaching technology on HTX 55

2.4.1. Case 1 – Teacher controlled approach.. 55

2.4.2. Case 2 – Student centered approach.. 57

2.4.3. ´Agree to disagree´: Technology teachers' perceptions and practices of PBL in the Danish HTX 59

2.5. Conclusion... 69

Chapter 3. The problem 69

3.1. The initiating problem on HTX 70

3.2. PBL 72

3.2.1. The role of the teacher in a PBL teaching process............................... 72

3.3. Bildung 84

3.3.1. Bildung at the Danish higher technical examination programme 85

3.4. Language... 99

3.4.1. Language in the technology subject at the Danish higher technical examination programme – Pragmatic contructivism in practice 99

3.5. Problem statement 117

3.6. Delimitation 118

3.7. Walk through of the rest of the thesis 120

Chapter 4. Method 121

4.1. Action Research as an approach 121

4.2. Getting ready for action 123

4.2.1. First meeting with the gatekeeper 123
4.2.2. Meeting with the technology teachers' association 124
4.2.3. The essential pilot study 125

4.3. Gathering data 131

4.3.1. Observations 132
Observation with participation 133
Classroom observations on HTX 134
4.3.2. Interviews 136
Selecting interviewees – teachers and students 136
4.3.3. Further on observations and interviews 139
Ethical considerations before the collection of empirics 139
Collection of empirics 141
The transcription processes 143
Reflections after the collection of empirics 144
4.3.4. Survey 146
Collection of data 147
4.3.5. Critical reflections on the methods 147

4.4. Reflections on the action research approach 149

4.4.1. Language as a decisive factor for Action research: Reflections on challenges encountered in an action research project and the centrality of language, dialogue, and conceptualisation to overcoming such challenges . 149

Chapter 5. Theory 161

5.1. Language 161

5.1.1. Concepts and the conceptualising method 161
The concept of concepts 162
Reality, concepts and language games 163
Dialogue 164
5.1.2. Consequences for social research 165

5.2. Problem-based learning 166

5.2.1. Different approaches to problem-based learning 167
5.2.2. Broadening the philosophy 168

5.2.3. Why use Problem-based learning? 169

Chapter 6. Analysis strategy *171*

6.1. Analysis strategy **171**

Chapter 7. Analysis *172*

7.1. The new textbook – From idea to reality **172**

7.1.1. The process 172
7.1.2. Building trust and collaboration 177
7.1.3. Partial conclusion 181

7.2. Creating a coordinated language for the technology subject **182**

7.2.1. The concepts used in the technology subject 182
Which of the following concepts and competencies should be included in the new textbook on project writing? 182
Are there any of concepts or competencies on the list that are central to include in the new textbook? 186
Are there any concepts in the technology subject we need to conceptualise? 188
7.2.2. The project work – Technology and Technical science subjects 190
7.2.3. Partial conclusion 193

7.3. The textbook and how it is used **193**

7.3.1. The sales figures 193
7.3.2. How is the book actually used? 198
7.3.3. Partial conclusion 205
7.3.4. Summary of the analysis 205

Chapter 8. Conclusions *207*

Chapter 9. Quality considerations *212*

9.1. Validity **212**

9.1.1. Action Research process 212
9.1.2. the conceptualising method 214
9.1.3. Interviews 214
9.1.4. Survey 216

Literature list *217*

APPENDICES *229*

TABLE OF FIGURES

Figure number	Figure text	Page
1-1	Structure of the HTX educational programme	26+93
1-2	The concepts unfolded in the problem analysis	51
2-1	The technology model	53
2-2	The extended technology model	54
2-3	PBL-alignment of elements in the curriculum	60
2-4	PBL-alignment of elements in the curriculum	67
4-1	The differences between abstractions and concepts	95+155
6-1	Are there any concepts or competencies on the list that are central to include in the textbook?	178
6-2	Are there any concepts in the technology subject we need to conceptualise?	180

TABLE OF TABLES

Table number	Table text	Page
1	Types of PBL	44-45
2	Spectra of PBL-curriculum elements	67-68
3	Part of table with four ideal types of teaching	68-69
4	Overview of observations	97-98 + 126-127
5	Overview of the interviews with teachers	98-99
6	Overview of observations in the pilot study	118
7	Overview of interviews with teachers - total	129-130
8	Overview of interviews with students	131
9	List of concepts and competencies	174-178
10	List of concepts missing on the original list from table 10	179
11	List of concepts that need to be conceptualised	181
12	Sales figures for *The Project work – Technology and*	186-187

	Technical science subjects	
13	Detailed list of books sold in the paper edition	187-188
14	Detailed list of licenses sold of the book	189
15	Usage statistics for the book	192
16	Calculation for total pageviews pr. months	192

TABLE OF PUBLICATIONS

In the below table is a list of the publications made in connection with this PhD.

The publications are included as part of the story in the PhD and are therefore inserted in the text. It is clearly shown in the text where an article is included and if and where this is published. Therefore, repetitions may also occur. An example of this could be that I have described the HTX educational programme in several articles, which has also been done in this thesis, although to a greater extent. Please be patient with this structure as the thesis is structured in this way to tell the good story.
All publications included in the thesis appear in a slightly revised version as the language has been edited through the whole thesis before it was handed in.

Working title	Co-authors	Journal	Submission
'Agree to disagree': Technology teachers' perceptions and practices of problem-based learning (PBL) in the Danish Higher Technical Examination Programme (HTX)		Journal of Problem-based learning in Higher Education	In review
Technology in the technology subject	Lars Bo Henriksen	Learning Tech	Approved for publication
The role of the teachers in a PBL teaching process	Henrik W. Routhe, Rikke S. Kristensen & Jutta Prip	Aalborg Universitetsforlag	Published

Bildung at the Technical High School (HTX)	Lars Bo Henriksen	NorDiNa	In review Presented at conference
Language in the technology subject at the Danish Higher Technical Examination Programme – Pragmatic constructivism in practice		Proceedings of Pragmatic Constructivism	Published
Language as a decisive factor for Action Research – Reflections on challenges encountered in an action research project and the centrality of language, dialogue and conceptualisation to overcome such challenges		Qualitative research in Organisations and Management	In review
Books			
The Project work – Technology and Technical science subjects	Lars Bo Henriksen & Henrik W. Routhe	Systime A/S	Published
Videos			
Problem-based learning		AAU Play	Published

‘Had you asked five years ago, I had said that we (the teachers) can discuss well, but never will ... it will never be a kind of consensus (...) But it might not have to be, but we will (...) we will never reach agreement. Now we agree on some things we disagree with and then there are a whole bunch of things we can see in a certain way because we agree that it is probably best to do it this way’ (Interviewee 1, 2019).

CHAPTER 1. INTRODUCTION

As the quotation on the previous page suggests, teachers of technology in the Danish higher technical examination (HTX) programme, hereafter referred to by just the initialism HTX, agree to disagree on how they work with problem-based learning (PBL), which is an integrated part of the subject. This is the starting point for this PhD study.

Before I give a deeper introduction to the lack of consensus among teachers in the technology field, here is a brief story about everyday life on HTX, followed by an introduction to the Danish HTX programme, which introduces the reader to the field before the problem unfolds.

1.1. EVERYDAY LIFE AT THE DANISH HIGHER TECHNICAL EXAMINATION PROGRAMME

Walking into the technical high school, it exudes life. There are students in the hallways even though the clock on the wall informs me that, yet another class has just begun. Right inside the main entrance doors there are students assembled in smaller groups, in an area with sofas. They are talking about last Friday's party, pushing each other around and laughing. Shortly after, the mood changes completely. Now they are talking about homework, assignments to hand in and the projects they are working on right now, all at once. They master multitasking better than most. Walking down the hall, I see students walking in and out of classrooms. There is an almost chaotic stream of young men and women crossing each other, as if this is the most natural thing in the world, even though such chaos may be better suited to a railway station platform. Walking up the stairs, I am met with students running back and forth to the administration office looking for information on forthcoming exams. The air is thick with anticipation, excitement, frustration and panic.

When break time comes, all common areas fill with more students, and the volume is very high. The students now move in and out, between each other, most with the goal of getting lunch before the next class starts. Music is being played from a loudspeaker in the common area, which adds to the already high sound level. In front of the staffroom, students gather during lunch break for a chance to ask their teachers questions. A line forms as more and more students assemble. Some do so because they need to borrow practical tools from the staffroom, some because they didn't have the chance to ask questions in class, others because they work during recess and need supervision in regard to their projects. All students seem to get help from the teachers and the queue dissolves, little by little.

As the break comes to an end, the social groups disperse as the students slowly move back towards the classrooms. The corridors are now deserted for a while, but after teaching starts in the different classes, more and more students quietly begin to come out into the hallways again. Some of the students want to find a quiet place to do group work; others are going to the library, using the 3D printer or walking towards the workshops. Again, the corridors fill with the noise of students talking. Walking past classrooms and looking in, some classes seem very quiet and subdued while in others there seems to be an almost chaotic atmosphere, depending on the subject being taught. Entering a classroom where technology is being taught, the chaotic atmosphere is not only seen but also felt. I very quickly get caught up in the mood because the students show a keen interest in the projects they are working on. The mood seems almost contagious. There is activity everywhere. Some students sit with their computers and write reports; others use the board to illustrate their ideas to other group members; others again build their product on the floor at the back of the room. The students themselves are very much in control of the projects. The teacher walks around, supporting students with any questions they may have.

At the end of the day, when most of the students have left, the school becomes very quiet. Nobody walks along the hallways. Everything is silent, except the staffroom. Some of the teachers are still there, preparing for yet another day of teaching in the Danish HTX programme.

Now with a sense of what it feels like being at the Danish higher technical examination programme it seems pertinent, in more detail under the headline *The HTX educational program*, to describe HTX to provide a background for the further read.

1.2. THE HTX EDUCATIONAL PROGRAM

The HTX educational programme is vocational high school education in Denmark. It is a three-year programme for technical graduates. It emphasises technological, scientific and vocational education perspectives. Students are taught a combination of technological and scientific disciplines and general subjects. Students must develop their ability to engage in professional immersion and their understanding of theoretical knowledge as a tool for analysing real-life relations. This is done by combining theory and practice in workshops and laboratories (Ministry of Children and Education, 2020).

The structure of the HTX educational programme I illustrated below in figure 1-1:

Field of study 2 ½ years	**Field of study 2 ½ years**	**Field of study 2 ½ years**
Compulsory subjects and levels Three specialisation subjects Multidisciplinary teaching courses Electives Specialised study project	Compulsory subjects and levels Three specialisation subjects Multidisciplinary teaching courses Electives Specialised study project	Compulsory subjects and levels Three specialisation subjects Multidisciplinary teaching courses Electives Specialised study project
Basic course ½ year Compulsory subjects and levels: Danish, English, Mathematics Multidisciplinary teaching courses, including workshop teaching		

Figure 1-1 Structure of the HTX educational programme

Figure 1 illustrates the subjects the students follow during their three years of study. The education starts with a basic three-month course, in which students are introduced to various subject areas. The basic course is intended to form the basis for students' choices during the programme and their direction of study and aims to challenge them academically (Ministry of Children and Education, 2020). The students are placed within a system that are made up of three levels: C, B and A level. Focusing on levels a level-C subject is made up by 75 hours of 60 minutes, a subject at level- B is made up by 200 hours and for a subject at level-A subject it is 325 hours (Ministry of Children and Education, 2008:1). In figure 1 it also illustrated that the students have to follow compulsory subjects and levels e.g.; Danish A, Technology A, English A, physics B, chemistry B, mathematics B, technology B, biology B, communication/IT C, social studies C and technology history C (Ministry of Children and Education, 2008:3). During their study the students also have to choose a field of study. In doing so the students can choose between field of study packages that all consists of three subjects. These can be combined in three different ways which give the students the option of choosing either; three level-A subjects, two level-A subjects and one level-B subject or one level-A, one level-B and one either level-B or level-C subject. The field of study packages are composed by the individual schools; thus, the number of fields of study and content can vary. One thing is for sure though and that is no matter which school the students choose, or which field of study is chosen, a student who completes HTX has had a minimum of 2630 hours of 60 minutes. (Ministry of Children and Education, 2008:3).

1.2.1. THE MINISTRY OF CHILDREN AND EDUCATION, MINISTERIAL ORDER

The Ministry of Children and Education, Ministerial Order covers all upper-secondary education in Denmark, and includes the following youth education programmes:

- The 3-year programme for technical high school diploma (HTX)
- The 3-year programme for mercantile high school diploma (HHX)
- The 3-year programme for general high school diploma (STX)

- The 2-year programme for HF-exam (Ministry of Children and Education, Ministerial Order: §2).

The purpose of these education programmes is similar, with minor differences and the starting point for HTX education is therefore, the same as for all upper-secondary education. The Ministry of Children and Education, Ministerial Order states that the main purpose of the programmes is to prepare students for higher education:

> 'The purpose of the teaching (...) is to prepare students for higher education, including acquiring general formation (*Bildung*), knowledge and skills through the combination of academic breadth and depth of education and through the interaction between the subjects' (Ministry of Children and Education, Ministerial Order: §1).

§1 describes the overall objectives of the programmes. It describes how preparing students for higher education includes ensuring students form a general character, or *Bildung,* while acquiring knowledge and a set of skills through the teaching on HTX. Further in the Ministerial Order (§1, pcs. 2) it is stated that:

> 'Through the academic and educational progression of the students, the students must develop professional insight and study skills. They must gain the familiarity of using different forms of work and gain the ability to function in a study environment where the requirements for independence, cooperation and sense of seeking knowledge are central' (Ministry of Children and Education, Ministerial Order: §1, pcs, 2).

§1, pcs. 2 describes how academic and educational progression should enable students to develop professional insight and study skills while becoming familiar with different forms of work and learning to function in the specific study environment. The Ministry of Children and Education, Ministerial Order goes on to state:

> 'The programs must have an educational perspective with emphasis on students' development of personal authority. Students must therefore learn how to reflect and be responsive to their surroundings: fellow human beings, nature and society, as well as their development. The programs must also develop the students' creative and innovative ability and critical sense' (Ministry of Children and Education, Ministerial Order: §1, pcs., 3).

Here, the emphasis is on an educational perspective and the development of the students' personal authority: learning to reflect and be responsive to their surroundings.

Further, the education programmes and their purpose are outlined in pcs., 4 §1:

> 'The education and institutional culture as a whole must prepare students for co-determination, co-responsibility, rights and duties in a society of freedom and

> democracy. The teaching and the whole life of the institution must therefore be based on freedom of spirit, equality and democracy and strengthen the students' knowledge of and respect for fundamental freedoms and human rights, including gender equality. The students must thereby obtain the prerequisites for active participation in a democratic society and an understanding of the opportunities for individually and jointly to contribute to development and change as well as an understanding of both the near and the European and global perspective' (Ministry of Children and Education, Ministerial Order: §1, pcs.,4).

In §1, pcs., 4 the focus is on the education and institutional culture and how these should be based on the concepts; freedom of speech, equality and democracy, and through that focus give students a greater understanding of and respect for the concepts.

1-4 §3 of the Ministry of Children and Education, Ministerial Order specifically addresses HTX:

> 'In the program for the technical degree, the subject is closely related to technological, scientific and vocational education perspectives. The purpose of the program, cf. §1, is thus realized within technological and scientific disciplines in combination with general subjects. The education must develop the students' ability for professional deepening and their understanding of theoretical knowledge as a tool for analysing real-life relationships. In the teaching, emphasis is placed on product development, innovation, problem solving and applied natural science, including the combination of theory and practice in workshops and laboratories' (Ministry of Children and Education, Ministerial Order: §3).

Here it is stated that what separates HTX from the other high school education programmes in Denmark is the emphasis on technological, scientific and vocational educational perspectives.

With at short introduction to the HTX program, to the legislation in the field and the purpose of education the next section describes the history of HTX and the long journey for the education to be accepted as equated with the other secondary education in Denmark.

1.2.2. THE HISTORY OF HTX

> 'It was not with tail wind when in 1982 the HTX education was born as a child of a Social Democratic government. It should take eight years before it was officially recognized – and it wasn't until 1995 that it got its current form as a three-year education with direct access from primary school' (Jans, 2007:10).

In 1982, the first technical high school was inaugurated as an experiment. Its study programme heavily influenced by Problem-based learning (PBL) principles, and was inspired by the founding principles of both Aalborg and Roskilde Universities, both of which started in the 1970s, about ten years earlier. PBL is inherently interdisciplinary, with project work central to the curriculum (Henriksen, 2016a:122). Problem-oriented project work has been a defining HTX characteristic since day one, and is central to the two profile subjects on HTX: technology and technical science (Ulriksen et al., 2008:28). The initial idea was to have a high school education stream directed towards science and engineering while simultaneously and innovatively combining theory and practice, but '(…) it was far from everyone who agreed that there should be a technical high school at all' (Jans, 2007:10). The trade union movement was one party that did not agree as they feared it would create a lot of pressure for internships on vocational apprenticeship education at technical schools (Jans, 2007:10). As Jans (2007:12) stated:

> 'The reluctance in the system was great. The trade union movement did not like the idea because they had felt how the introduction of HHX had made it more difficult for their students to get practical apprenticeships in, among other things the banking sector and the insurance industry, where HHX students were suddenly more popular. Now they feared a repetition with HTX'.

At the time there was no legal basis for the education and no Ministerial Order. It was not before November the same year that a course plan with descriptions of goals were sent out. It was pioneering work (Jans, 2007:16).

In 1989, the HTX became a permanent addition to high school education in Denmark, and it was established that it provided direct access to higher education. Previously, it had only provided direct access to selected technical educations. The HTX-education was just as slowly approaching equality within the high school education are. For HTX, this equality meant that education continued to grow both in terms of the individual schools but also in the number of schools that offered the education (Jans, 2007:21).

Until 1990, technical schools were subject to ministerial control. For HTX, this meant both economically and regarding the supply of education at the national level, as engineering disciplines and the number of seats in schools around the country were regulated by the Ministry of Children and Education. However, in 1991, schools gained autonomy. This meant they could now decide on the supply of education on their own and could prioritise their own financial areas of interest. Because of that, HTX became an area of interest at technical schools, and HTX education therefore grew steadily (Jans, 2007:22). In 1995, technical schools were designated as colleges, with direct access to HTX from primary school. At the same time, a three-year high school diploma in line with the general high school. This gave HTX a status boost (Jans, 2007:23). The year 1995 was also when HTX at each high school year had its own Ministerial Order. As the programme was subject to many changing orders in the short time it had been in existence, it had become readily available and the pioneering spirit of the program was maintained (Jans, 2007:34).

In 2004, the government created a broad settlement for a comprehensive high school reform. From 2005, HTX became part of an overall high school structure in Denmark. At this time, all three-year upper-secondary education was given the same legal basis, structure, purpose and detail regulation, and all HTX subjects were made high school subjects (Jans, 2007:37). In 2007 and 2008, with the implementation of structural reforms, HTX was politically equated with high school reforms, both legally and structurally, with STX and the structural reform also making the programmes equitable in terms of ownership and financially (Jans, 2007:38). As Jans stated,

> ‘Although HTX, despite continuous growth since 1982, has never been that big a part of the student’s image of high school education, where the very big magnet has been STX, the education nevertheless left its clear imprint educational policy wise’ (Jans, 2007:40).

The education has thus managed to be part of the system, but at the same time is also completely independent (Jans, 2007:40). HTX has proved its eligibility and will continue to do so. It will never attract as many students as STX as the STX profile is too strong for that. It is also not necessary for it to do so. Its sharp profile is a strength, and it has helped provide an exciting and experimental education that has inspired other programmes (Jans, 2007:42).

1.2.3. STUDY COMPETENCIES

The main purpose of HTX, and all other high school education programmes in Denmark, is to provide students with study competencies and to help in the general formation of character (*Bildung*) (Ministry of Children and Education, Ministerial Order §1). The development of study competencies is supported by technology, which helps students in their further education, especially in natural science, health science, engineering and other technical studies. Technology aims to develop an awareness of methods that lead to an understanding of, and an ability to work in, a project and problem-oriented education system. The emphasis is on the production of knowledge (Henriksen, 2016a:127). Technology as a subject intends to provide students with an understanding of the relationship between science, technology and society, including the following competencies:

(1) a critical approach to technological development and social conditions;
(2) knowledge and understanding of technology as a solution to problems;
(3) knowledge and understanding of technology that creates problems;
(4) knowledge and understanding of the need to involve various stakeholders in technology development;
(5) experience working on the connection between scientific theory and practical training in workshops and laboratories;
(6) knowledge of and experience with a selection of production processes;
(7) knowledge of the development of ideas and innovative creative processes important in product development;

(8) experiences with PBL in larger projects, both individually and in cooperation with others, and study and work methods relevant in higher education (Ministry of Children and Education, Ministerial Order §1).

Therefore, the objectives for the technology subject are that students achieve study competencies through the study of technology as a subject. Students work with problems; not only do they present problems they must clarify and solve but they also help find, identify and formulate such problems. The emphasis on problems on HTX suggests that elements from PBL in teaching and project work be addressed. For example, examination of notices and guides dealing with the HTX programme makes clear that PBL principles related to technology and technology projects were in the minds of those who formulated them (although PBL is not explicitly mentioned). The subject of technology, associated technology projects and PBL are inextricably linked (Henriksen, 2016a:127).

Following this introduction to the Danish HTX programme, the abovementioned questions concerning technology teachers agreeing to disagree will be validated through two key observations made in the technology subject.

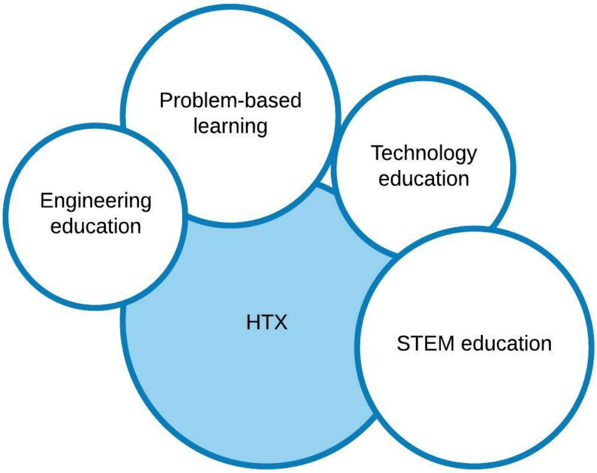
CHAPTER 2. TEACHING TECHNOLOGY IN AN INTERNATIONAL AND DANISH CONTEXT

Teaching technology is an area of pedagogy in emergence internationally. The research conducted in this thesis does not naturally fall within an existing research area, but rather places itself at the intersection of a number of newer, and also not well-established, areas. Its emergence in many ways parallels the increasing emphasis in political and economic circles on STEM (science; technology; engineering; mathematics) education and training. Further, the available literature on applications of problem-based learning (PBL) to technology education at second level or high-school level is also limited. Danish HTX pedagogy, itself in emergence, is positioned here at the intersection of STEM education, Engineering education, Technology education, Problem-based learning (PBL), and the Teaching of Technology. This initial positioning is facilitated here by drawing on some relevant international and Danish literature in these areas.

2.1. ENROLLING IN A RESEARCH AREA

The Danish HTX educational programme is a high school education that streams directly towards many different higher educational programmes within STEM education, engineering education in particular. In recent years STEM (science; technology; engineering; mathematics) has become an area to receive much attention from politicians, businesspeople, and decisions makers of all kinds (European Commission, 2011; Jenkins & Pell, 2006). The reason being that the labour market more than ever in a foreseeable future will demand precisely the kind of skills obtained through education within the STEM areas. But it seems that many young people in their choice of education and future occupation do not share the same enthusiasm for STEM: insufficient numbers are attending education programs within the fields of science and engineering.

This chapter takes a closer look at the literature revolving around STEM to embed teaching technology at an HTX in Denmark in its broader international context. Doing so I will also touch upon other research fields that are related to teaching technology such as the field of ‘technology education’. The field is extensive but at the same time very much in-the-making, as an attempt to establish this research field within the broader field of educational fields (Jones et al, 2013; de Vries et al, 2016); more specifically, technology education and problem based learning (PBL). This range of literature is characterized by descriptions of completed courses / experiments or by descriptions of how-to ‘manuals’ (Putnam, 2001). Danish HTX is initially positioned here in the light of related international debates as presented in the simple graphic below.



The research fields here (white circles) are all international fields that in different ways relate to the research in this thesis on the Danish higher technical examination programme (HTX). Section 2.2 will argue how the three fields - Technology education, STEM-education and Engineering education - relate to the research on HTX and why they are relevant for this specific field.

2.2. TEACHING TECHNOLOGY IN INTERNATIONAL AN INTERNATIONAL CONTEXT

To get an overview of the current state of implementation of STEM-education in technology education in international debates, I draw on the 'international state-of-the-art' review by Ritz and Fan (2014) of STEM and technology education. This study concluded that of the 20 international participants most of the country's educators, around 80%, are seriously discussing STEM-education and involving the school subject of technology education. In addition, several of the respondents have indicated that technology education in combination with science education is part of the work revolving around STEM-education. Other respondents simply try to incorporate engineering concepts into the technology education curriculum in their respective countries. It is further noted that a lot of the involvement in STEM-education is pushed by a political or governmental posturing or by an agenda in the educational system (Ritz and Fan, 2014:444). In addition, it is also emphasized in this review that there is a need for a more open discussion about the STEM education area before any kind of change can be implemented. This is both to ensure that teachers are included so that relevant resources can then be identified and provided to implement the planned changes (Ritz and Fan, 2014:445).

By incorporating science and mathematics, both content and principles, it is clear that attempts have been made to make changes in technology education programs to improve students' understanding of analytical concepts. Some teachers within technology education incorporate different concepts to increase such student understanding. In addition, the incorporation of different concepts should also increase student ability to solve real world problems by applying those concepts and principles. Additional research should be conducted to draw out the benefits of STEM-education for student learning. Improving student learning through suitable design and activities could also help position technology education more centrally in the curriculum (Ritz and Fan, 2014:445). However, it is clear that there remains much work to be done for the educational communities worldwide in refining, let alone applying, the meaning of STEM-education. The same is true when it comes to developing material to help student learning and instruction along the way and in addition train teachers in relevant methods so that they can best disseminate this knowledge. Ritz and Fan (2014:445) further argue that when all these resources have been built up, it will be possible to provide good STEM education to young people all over the world - but there is still a very long way to go.

Ritz and Fan's (2014) international review provides an overview that shows that in many countries around the world there is a focus on STEM education and on how to create quality STEM education so that young people have an interest in further STEM-education. The picture presented is also a picture of a very scattered and uncoordinated effort around STEM and technology education (Ritz and Fan, 2014:448). Although this review was published in 2014, there is not much to suggest that the totality of the efforts within STEM and technology education has become more of a cohesive effort. The construction of this effort, and its research area, is still in its infancy. This assumption is based on the fact that a plausible approach has not yet been presented for the teaching of technology education within STEM education. In other words, little has been done yet to reform educational systems to deliver this type of education (Ritz and Fan, 2014:429). Hence the interest in the pedagogy of teaching technology education in Danish HTX.

Jones, Buntting and de Vries (2011) provide an overview of developments in the field of technology education over the previous 20 to 25 years. This overview provides insight in the areas that have a research focus within technology education and how these overlap with the research areas concerned in the present thesis. In this chapter, different shifts in recognition in the discipline of technology education are examined to provide an insight into how the field might be further developed. Areas such as philosophy of technology and technology education; school curricula; teaching, learning and assessment; teacher education and professional development and research approaches (Jones, Buntting and de Vries, 2011:191-192). Starting with the area of philosophy of technology is a challenge to identify and locate a disciplinary tradition within technology education, which among other things, requires the main characteristics of technology to be conceptualised. This is important point of departure in terms of conceptualisation. In the relatively short history of the philosophy of technology four areas of interest have been conceptualised; technology of artefacts, as knowledge, as activities and as an aspect of humanity (Jones, Buntting and de Vries, 2011:192). With the technology as artefacts category, there is an overlap with the dissertation and the research that has been carried out here in the sense that work is also being done here to conceptualise technology, however, in the very specific Danish context of HTX. The starting point for the work in both cases is that there is interest in creating a strong professional teaching tradition in this field. In relation to technology education, it is about creating a sound disciplinary tradition; in relation to HTX it is about creating a strong disciplinary tradition within the subject of technology. One could argue that the process is quite similar in both as there is an interest in defining/conceptualising technology because if not, how can we know how to work with technology education or how to work in the subject of technology at HTX? However, there is also a difference in the understandings of technology in the sense that Jones, Buntting and de Vries, (2011) take an exclusively philosophical starting point, whereas the work of defining the concept of technology in the technology subject takes its starting point in the technology model (Müller, 1980). However, this approach to defining technology in the technology subject at HTX can be questioned or challenged. Even though the technology model provides a wider perspective on technology than other simple models, it also lacks a more dynamic focus and it is further not clear how the model handles technology's impact on humans and in turn how technology affects our thinking and acting (Jeppesen and Henriksen, 2021). Another point of criticism is that the model can be used rather mechanically by some students. For some students, but certainly not all, it just becomes a question of filling out the boxes in the model. However, the research presented in this thesis strongly suggests that the technology model works and seems useful for the students at HTX (Jeppesen and Henriksen, 2021).

In the Columbian context Molina-Vásquez (2021) explores seventh-grade students' construction of the technology concept through a practical case study. The result is that the concept of technology, as constructed by seventh-grade students combines relationships: '(…) among the types of artifacts that comprise technology, the objectives in its advance, the needs it satisfies, the problem it solves, and its symbolic relationship with society and culture (…)' (Molina-Vásquez, 2021:33). This study is very relevant in connection with a common conceptualisation of technology within technology education, but also within STEM-and Engineering education although the study was conducted with primary school, not high-school, students. What it does show, is that the concept of technology in education is multi-faceted and complex. There is also some support here for Jones, Buntting and de Vries (2011:193) who argued that technology as an aspect of humanity is an important area for technology education as: "(…) it informs about how technology is shaped by, and also shapes humans, human culture and society (…)". Again some support here for the critique of the technology model noted above, where it is concluded that it can be used and may live up to its purpose, but that it can also be argued that it lacks the key element of how technology affects people and people's everyday lives.

Now to engineering education. Engineering education was simply not a key element of pre-university engineering education: the E in STEM in pre-university engineering education may be described as being largely non-existent even after the term STEM-education was introduced as a rather political term in the early to mid-2000s (de Vries, Gaumaelius & Skogh, 2016:1-12). Brophy, Klein, Portsmore & Rogers (2008) also referred to the 'missing E' and Miaoulis (2014) goes further in referring to the 'missing discipline'. While implied above that the 'T' in STEM has yet to find its identity, The 'E' in STEM appears to have no extant identity yet is viewed as one of its key constituents. The inclusion of 'E' also raises the question of differences between E and T because it becomes a central point of reflection when relating both to practice. And one must note that both Science and Mathematics are also at times re-conceptualised. Positioning the T and E in STEM is still an area of research and in the article *Positioning the T and E in STEM: A STL analytical content review of engineering and technology education research* (Asunda and Quintana, 2018) the focus is on position the T and E in the context of the *Standards for Technological literacy* (STL) in engineering and technology and STEM education. The findings in the article showed that areas like; Design, The Nature of Technology, and The Designed World of the STL is a good platform from which both educators and researchers can draw on evidence-based strategies that can help create successful STEM learning (Asunda and Quintana, 2018).

Why is pre-engineering education then important? In the article it is argued that pre-engineering education can motivate students to focus on studying or getting a career in engineering, therefore; it is also very important to give the students an insight into engineering. It is further argued that the engineering profession in both the traditional curriculum and in current technology education is not represented or portrayed (de Vries, Gaumaelius & Skogh, 2016:3). I do not fully agree with this argument as we actually in Denmark have pre-engineering education in the HTX programme and have had that program for around 40 years. This is also mentioned very shortly by referring to Henriksen's work and in addition is mentioned other countries that has pre-engineering education as part of an educational practice, such as Australia, USA, England and the Netherlands (de Vries, Gaumaelius & Skogh, 2016:5-7) The fact that several countries do have pre-university engineering education as part of their educational practice show that pre-university engineering education is a reality, but at the same time is also becomes visible that there is still a long way until pre-university engineering education will be a well-established part of the different countries educational practice. This is even the case for the before mentioned countries that already have examples of pre-university engineering education. Pre-university engineering education is therefore also a vulnerable concept along the lines of technology education as it is no way near as established as for an example mathematics is the curriculum. This also means that the better pre-university engineering education and technology education are tied with math or other well-established subject, the better they will be anchored in the curriculum – without giving up on their own identities of course (de Vries, Gaumaelius & Skogh, 2016:5).

In conclusion, research areas such as STEM education, Technology education and Pre-university engineering education are not yet well established and therefore not well defined. In relation to the research area in this dissertation, they also function as peninsulas, as they relate to the HTX research area, but do not fully overlap and revolve around the core of the Higher Danish Technical Examination Program. In this context, they lack, among other things, a focus on problem-based learning, which is an applied pedagogy in HTX. Yet, active learning increases student performance in science, engineering and mathematics (Freeman et al., 2014). And on gender issues, sponsored research on 11,500 women strongly suggests that one of the most important factors in promoting children and young people's interest in STEM and IT is by working with the didactics and teaching methods in the STEM subjects (Microsoft, 2016).

The Danish literature on HTX usually consists of reports for the occasion, e.g., comments on a change in the ministerial order, commentaries on pilot schemes, evaluations of specific experiments and the like (e.g., Henriksen, 2014; Ulriksen & Holmegaard, 2008; Ministry of Children and Education 2013, Elmeskov et al., 2013) and summary literature, e.g., in connection with anniversaries (see e.g., Larsen, 2020; Nielsen, 2007). The Danish literature is therefore also often descriptive and/or evaluative but may be viewed as lacking a coherent academic foundation. It is descriptive, and no attempt has been made in the sparse Danish literature to analyse the deeper underlying issues concerned the teaching/pedagogy of HTX and HTX education in general.

Returning to the Danish context, HTX has been using project work and PBL now for some time. Ulriksen and Holmegaard (2008), on the basis of interviews conducted with both teachers and students, as well as observation of teaching, on what challenges the students have in meeting with the problem-oriented project work at HTX. This problem-oriented project work most often takes place in the technology subject. They also focus on the action options the teachers have in order to create a balance between a continued student-centered approach and a more visible structure (Ulriksen and Holmegaard, 2008:28-29). This is a comprehensive study, and it is also drawn on in more detail below when discussing project work. Problem-oriented project work is conceptualised as participant-driven project work that is organized around problems that the students themselves choose and formulate. In some detail the experiences of both HTX students and teachers are addressed in terms of the following themes: experiences with project work, cooperation problems, forming groups, reputation and qualities, summary on problems with the group process, schedules and self-management, and project supervision. All seven themes that they set out in the research report are all included as part of the technology subject that this thesis deals with; but not all are addressed in detail in this thesis which has a somewhat more specific brief. The research conducted in the thesis focuses on gaining insight into the technology subject and thereby, together with the teachers, create a coordinated language – such a language to assist in creating a stronger disciplinary tradition and thus create a positive change in the technology subject. There is some overlap, in the 2008 research report, the focus is on describing difficulties and pointing to action possibilities, whereas the focus in the dissertation is on creating a common language and positive pedagogic change.

This Danish report, prepared on the basis of a research project by the Center for Youth Research in collaboration with Danish business schools; *Learning environment and science at HTX - qualities and challenges*, (Ulriksen et al., 2008) presented the main results from the research project that was carried out to gain insight into the experiences from HTX. This is useful as it can actually be used more broadly in relation to STEM and to highlight some elements at HTX that could use some re-conceptualising. The report focuses on selected themes from the study such as students on HTX, learning environment, and interests in engineering and science. Under the theme *of students at HTX*, it is noted that students are generally content to attend HTX and that a large group of students have chosen to attend HTX based on an interest in technology and science. Some, however, have considered leaving the program. The students themselves point out that the form of work at HTX and planning one's own time are crucial. They also note that the lesson pressure is great and that the level is high and there is certainly a challenge for education here (Ulriksen et al., 2008:20). In terms of the serious issue of drop-outs and potential drop-outs it is found that students whose parents do not have a high school diploma or a higher education who have mainly considered quitting; so there are class issues. Students also have different interests in relation to technology and science and it is important to be aware of such a range when HTX is being presented to new potential students (Ulriksen et al. 2008:20-21).

Under the theme *learning environment* HTX is described as having a good one. The students mention, among other things, that the project work form at HTX gives them the opportunity to have close contact with the teachers, on the basis that many of the HTX schools are often small. In addition, students experience HTX as having an unforced environment. The students do not care about how they look and therefore they are also allowed to look the way they want. The girls at HTX in particular emphasize this, as they at HTX can avoid the ‘girl culture’ they often know from primary school (Ulriksen et al. 2008:22). The students' story about HTX also includes the term "nerd", but with two different understandings of the term 1) the outside world's understanding of a student on HTX, and 2) the students' own understanding and the fact that several of the students place both themselves and the teachers under the term in a positive fashion (Ulriksen et al. 2008:22-23). However, the students also have a picture of the "bad nerd". Contrary to the students' understanding of the good nerd, the bad nerd is so focused on the interest in computers that he / she isolates himself / herself from the community. It is thus a general understanding that HTX contains a social environment where it is acceptable to have interests in technology and science, where you do not have to be or look in a certain way, as long as you can function socially (Ulriksen et al. 2008:22-27)

Under the theme *learning environment* the students' relationship to teaching is also touched upon and it is one of the areas in the research behind the Danish report which overlaps with the research area of the present thesis. The report describes that the students are happy with the project work form, and that what they like more specifically about this teaching form are the practical examples, exercises in groups, and the elements where they themselves have an influence. In addition, students also understand that blackboard instruction is necessary, but that there should not be too much of it for too long (Ulriksen et al. 2008:28). In this dissertation, I also research the project work form at HTX, which is based on PBL; I do, however, adopt a different perspective. In the thesis, I look into project work from a teacher's perspective by looking at what the project work form does for the teacher's role when teaching the technology subject. In an article based on the findings of the thesis - *The role of the teacher in a PBL teaching process* -it is found that technology teachers have a role where a very hybrid skill set is required; '(…) *the teacher's role and the teacher's tasks change as the students develop their skill set from a more teacher directed role to a more student-centered facilitator role* (…)' (Jeppesen et al., 2020). The research underpinning the Ulriksen et al. (2008) report has a student perspective; the research around the PBL project work form in this thesis is based on an HTX technology teacher perspective.

In addition, many of the challenges describes by students in Danish report under the theme; *learning environment* revolving around the project work form at HTX such as students managing their own time, not enough supervision, and issues concerning the groupwork process have been considered in the development of the book; *The Project Work—Technology and Technical Science Subjects* (Jeppesen, Henriksen and Routhe, 2020) based on the broader research underpinning this thesis. Here, the whole idea of the book was to write down, to record, the coordinated language so that it can be used, but the discussions during the development of the book have also shown that an application of the book and the language could help make the students more independent when working with project work. This is supported by a student as follows: '*I just follow the book—when I have been through it, I have written our entire report. It is ingenious that the book can be used for that*' (email, 12.05.2020). This thesis, therefore, also addresses some of the recommendations suggested in the report by Ulriksen et al., (2008).

The final theme deals with *interests in engineering and science*. In exploring student interests and future potential career paths, gender differences emerge. One third of boys would like to study an engineering education and every eighth a science university education. A large proportion of the girls will also apply for technical and science educations, but for the girls the health field is also of interest. Students note that teachers are good at showing that the content they are presented with can be applied. It is not always the teachers themselves who are good at giving examples, but the students experience that they can usually ask about it and thus get the examples they need (Ulriksen et al., 2008:34). The students further note that the application- and practice-oriented element embedded in teaching is strengthened by the teachers' professional background. Teachers, therefore, also often function as role models for HTX students.

2.2.1. CONCLUSION

It becomes clear from reading into the existing international literature that the research conducted in relation to this thesis does not fall naturally within an existing research area. There are, rather, a number of different research areas that function as peninsulas and that are to some extent very relevant to HTX research; these were noted above and all are addressed in this thesis as they impact on its focus. In relation to the Danish research literature on HTX, it is noted that most of this is very descriptive and evaluative.

Before the HTX research area is outlined on must describe how the subject of technology is taught at HTX in Denmark, what the purpose of the teaching is, what the content of the teaching is, and how projects are written in the technology subject? Two cases from practice assist in illustrating how the subject is taught.

2.3. TEACHING TECHNOLOGY ON HTX IN DENMARK

The way the technology subject is being taught at the Danish higher technical examination programme (HTX) is very specific for this high school education programme. No other high school programme in Denmark teaches using the combination of problem-based learning and product development.

2.3.1. THE PURPOSE OF THE TECHNOLOGY SUBJECT

The purpose of the technology subject is described in the curriculum for technology levels A and B. First and second-year students (17–19 years old) in HTX have technology at level B, while for third-year students (19–20 years old) the subject:

> ‘Contributes to the purpose of the HTX education. This by strengthening the students’ prerequisites for higher education, especially in engineering, technology and natural sciences’ (Ministry of Children and Education, Curriculum, Technology A and B, 2017:1).

The subject further enhances students’ innovative competencies. This happens through project work, in which students are engaged in problem solving that involves developing and manufacturing products in workshops and laboratories, so students get to know about various technologies and have knowledge of the importance of innovative and creative processes in product development. The working methods in the subject contribute to general study competencies and *Bildung* as students gain experience with working methods relevant to higher education. Students gain an understanding of theoretical knowledge as a tool for analysis of socially relevant issues. In this way, students gain insight into the relationships between science, technology and social development. The subject further provides students with knowledge and understanding of technology as the cause and solution of problems, and with insight into the need to involve stakeholders in the development of technology and to consider the societal impact of specific technology (Ministry of Children and Education, Curriculum, Technology A and B, 2017:1). In technology level-A, students gain experience working with the connection between scientific theory and internship in workshops and laboratories, as a background for choosing manufacturing processes. The purpose is for students to gain knowledge of starting up, planning and marketing a product. They must also gain an understanding of the relationships between technology, business, society and internationalisation (Ministry of Children and Education, Curriculum, Technology A, 2017:1).

2.3.2. THE SUBJECT OF TECHNOLOGY

The subject of technology is only offered by HTX, and can be taken at levels A and B.

> 'The technology subject deals with the connections between technological solutions and societal problems in a national and global perspective. Further, the subject deals with technological innovation, that is, the development of products based on analysis of societal issues. In the interaction between technology, know-how, organization and product, social science, technical and scientific knowledge and knowledge are combined with practical work in workshops and laboratories' (Ministry of Children and Education, Curriculum, Technology A and B, 2019:1).

In this subject area, students address the relationship between technology and society. As Henriksen (2016a:125) puts it, the subject's goal formulations are all characterised by a 'social–technical' concept of technology (Trist & Bamforth, 1951; Müller et al., 1984). That is, technology is composed of knowledge, organisation, technology and product. The core material in the subject consists of the following:

Problem identification: Students must select a societal problem they want to work with within a theme.

Problem analysis: Students must collect, select and process information on the problem. For that they must use quantitative and/or qualitative methods and analyse and document the problem, including working with the causes and consequences of the problem.

Product principle: Students must collect information about competing products and identify the pros and cons of these products. Further, they must explain how and in what context their product should be used, and in doing so they should include different actors' perspectives. The students also have to work with regulatory requirements and determine which are relevant to the product. They must prepare requirements for their product based on what was previously described above and on the basis of these requirements they must justify their chosen solution. Throughout the process they must be able to use methods for idea generation, sorting and selection.

Product design: Students must perform technical documentation using digital tools. They must work with selected materials, components, software elements, their properties, structure and suitability in various contexts, as well as in processes, machining and joining methods. The students must also perform an environmental assessment, and it is mandatory that they work within safety and health standards in the labs and workshops.

Product preparation: Students must be able to plan the manufacturing process, which should be structured through concepts, technique, knowledge and organisation.

Realisation: Students must manufacture a product in a workshop, test it in accordance with the stated requirements and assess its interaction with society.

Evaluation: Students must test the product in relation to the stated requirements and assess its interaction with society.

Some of the core material is also included in projects, either as a topic for problem-based projects or in shorter discipline-based projects such as project management, communication and other core materials, as follows:

Project management: Students must learn about time management, professional forms of collaboration and digital collaborative writing tools.

Communication: Students must write a technical report that includes argumentation and documentation. They must search for, assess and use sources and visual tools, and work on oral presentations.

Other core material: Students must also work with global, regional and local environmental impacts, work environment, technology assessment and technology as interactive development, including technology from an international perspective (Ministry of Children and Education, Curriculum, Technology B, 2017:2–3).

In the curriculum for the technology subject on HTX, level B, it is further noted:

> 'The students will not be able to meet the academic goals alone with the help of the core material. The supplementary content deepens and perspectives the core material and new projects can be included in projects. Supplementary content will be content that relates to the chosen problem and product. In addition, parts of the core material and supplementary material must be selected and treated so that it can

contribute to the academic interaction between the subjects and in the field of study' (Ministry of Children and Education, Curriculum, Technology B, 2017:3).

Teaching in the subject is mainly based on PBL in the longer project cycles, where students work with projects in groups. Social scientific, technical and scientific knowledge are thereby combined with practical work in groups (Henriksen, 2016a:125). As teaching is regularly organised in projects, group work, individual work and teacher-led classroom training are the basis for such activity (Ministry of Children and Education, Curriculum, Technology B, 2017:3). This approach provides students with the ability to actively shape the educational content and bring forward suggestions as to how projects should be approached (Henriksen, 2016a:126). Knowledge sharing and collaboration on the production of new knowledge occurs between students when project group work is organised. The students' work in workshops and laboratories must be a significant part of the project work, so the emphasis is also on the link between theory and practice. Students must develop products in workshops in connection with the project work, which must be performed under the expert guidance of professionals. The rest of the project work is supported by the supervisor, both in terms of the working method and the content of the project (Ministry of Children and Education, Curriculum, Technology B, 2017:3). Project work is central to the subject of technology, so it is also important to understand how it is worked with and written into the subject.

2.3.3. TECHNOLOGY PROJECTS

Participant direction is a key element in any technology project. Students not only present a problem they need to clarify and solve but also help find, identify and formulate the problem. This provides a real experience of 'having a problem'; that is, they operate on the understanding that a problem is interesting, challenging and somehow possible to work with (Ulriksen & Holmegaard, 2008:28). Technology projects are conducted in groups of varying sizes and sometimes take up to several months. Typically, students are given a presentation on a project theme, after which they find a topic and formulate a problem. The students then produce a product and a report (Ulriksen & Holmegaard, 2008:31). Through such project work, students make connections and relationships between the various disciplines while developing the skills to organise their own learning processes over a sustained period (Ulriksen & Holmegaard, 2008:28).

Most HTX students like the project work format (Ulriksen & Holmegaard, 2008:29). However, they do meet certain challenges, one of the most common being conflict within groups. Generally, from the beginning of the first year of high school, teachers place students in different groups. Later, students form groups themselves, which requires them to be social, active and outgoing, not least in the first year. Once such groups are formed, the work process can generally be smooth (Ulriksen & Holmegaard, 2008:29–31). As Ulriksen and Holmegaard (2008:31) state,

> ‘Although both teachers and students emphasize project work as a strength on HTX, there are some dilemmas that should be managed and that are largely about the teacher and supervisor role and the students’ basis for taking responsibility for learning processes’ (Ulriksen and Holmegaard, 2008:31).

HTX students perceive the fact that they manage the process themselves as a positive, but this is not unproblematic. Students note that they work on their own roles within their groups, and how they have learned that in a basic course but that they do not learn how to handle conflicts in group work. Guidance is a strong component of teaching if the supervisor has the opportunity to assist students in professional or procedural difficulties. But if students do not ask for help, or if teachers do not see that the students need help, there is a risk that students will not gain the optimum project learning outcomes (Ulriksen & Holmegaard, 2008:31).

2.3.4. TECHNOLOGY IN THE TECHNOLOGY SUBJECT

The concept of technology is central to HTX and the subject of technology. Having the concept of technology as central to the education is one thing that sets HTX apart from other forms of high school education in Denmark. The Ministry of Children and Education (see 1.4.1 The Ministerial Order), under §1, states that ‘the professionalism in the program for the technical high school degree is closely linked to technological, scientific and vocational education perspectives’. Further, ‘the purpose of the education, cf. §1. (Ministerial Order), is therefore realized within technological and scientific disciplines in combination with ordinary subjects’ (Ministerial Order, §3). The profile subject, technology, helps emphasise the importance of the concept of technology in HTX education. In the third year of study, this subject comprises one third of the students’ schedule.

TECHNOLOGY IN THE HTX TECHNOLOGY SUBJECT

Approved for publication in *Learning Tech* as:

Jeppesen, M.M. & Henriksen, L.B. (2020). Technology in the HTX technology subject – The Danish Higher Technical Examination Programme (HTX), the technology subject and the concept of technology.

The Danish higher technical examination programme (HTX) is the only high school program in Denmark that specialises in technology and engineering. Central to the HTX curriculum are the profile subjects; technology and technical science. In this article, we take a closer look at these subjects, or more precisely, we examine the concept of technology embedded within them. The Ministry of Children and Education, Ministerial Order regarding the subjects places the concept of technology within the ‘technology model’. We will examine the background for the model, its potential and limitations and the model's place in teaching through empirical findings from fieldwork in order to examine whether the technology model lives up to its described purpose. Overall, it can be argued that the model works but it can also be argued that the teachers should be aware of the model's shortcomings and discuss these with students, so they obtain a more dynamic and dialectical understanding of technology.

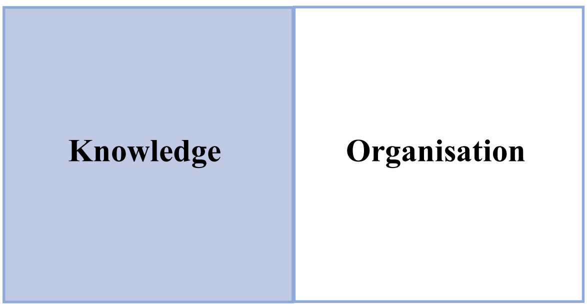
In the Danish secondary education landscape, technical high schools (HTX) have a special place. HTX is the only secondary education that specialises in technology and engineering. Central in the HTX curriculum are the profile subjects, technology and technical science; they define this type of education, and are subjects that no other secondary education can offer to the same extent. In this paper we will take a closer look at these profile subjects, technology and technical science. More precisely, we investigate the concept of technology in these subjects. That is, how the concept of technology is understood and conceptualised, and which role, or roles, this understanding plays in the teaching and learning of the profile subjects.

EXPLORING THE CONCEPT OF TECHNOLOGY IN THE PROFILE SUBJECTS

In the technical high school curriculum, the concept of 'technology' is described in socio-technical terms:

> 'The subject technology deals with the connections between technological solutions and societal problems in a national and global perspective'.
>
> 'The subject deals with technological innovation, that is, the development of products based on analysis of societal issues. In the interaction between technology, knowledge, organization and product, social, technical and scientific knowledge and knowledge are combined with practical work in workshops and laboratories'.

In the Ministry of Children and Education, Ministerial Order the concept 'technology' is placed firmly within what is known as the technology model. As stated in the Ministerial Order, the technology model consists of four elements: technique, knowledge, organisation and product.



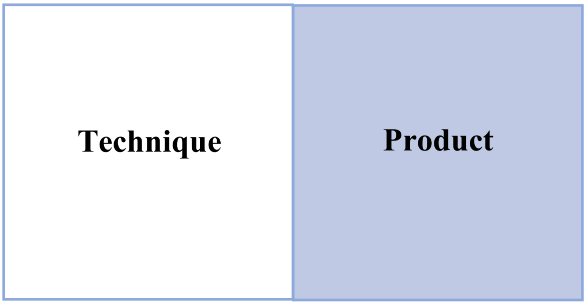


Figure 2-1 The technology model

These basic elements of the model can then be supplemented with other elements such as social infrastructure, social norms, human resources and so on.

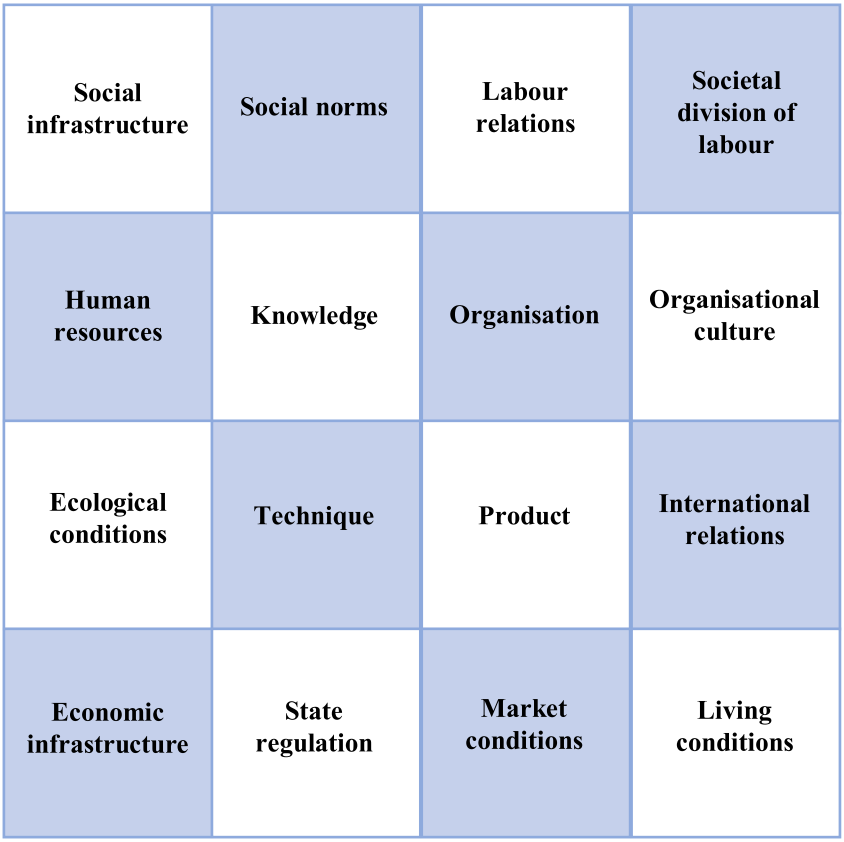


Figure 2-2 The extended technology model

The technology model was developed and came to prominence in the 1980s and 1990s, especially in the research group called Technology and Society at Aalborg University (Müller, 1980; Knudsen, 1983; Lorentzen, 1988; Müller, 1990; Lorentzen, 1994; among others).

Technique: Technique are all those tools, machines and materials that, combined with labour, are necessary for the production process. In Marxist terms these are called the instruments of labour (Müller, 1980:20).

Knowledge: Knowledge is the software component and is also necessary for the production process. It is all skills, intuition, insight, experience and tricks of the trade without which there would be no work or production process. This knowledge can be gained via schools, apprenticeships, experience or in any other way where the production process is taught.

Organisation: In almost any process of production there is some kind of division of labour. Because of this division we also need some kind of coordination and organisation. This concerns the organisation of the production process itself, but also the technology in a wider context; for example, roads and filling stations for cars, rails and stations for trains, airports and security control for aeroplanes. In short, the infrastructure necessary to make the world go around.

Product: The product element is the end result of the production process. Most technologies aim to make a product. Product should be understood very broadly here. In the case of cars, planes or trains we could say that the product is transport. In the case of the factory, it might be some component. The product is the result we want when using technology.

The technology model is a holistic model, meaning that it tries to describe technology as much more than just products or things. The model also tries to capture everything it takes to make technology work the way we want. In this way, the technology model can help give a nuanced view of technology (Lorentzen, 1988:22; Müller et al., 1984).

The technology model appears in the Ministry of Children and Education, Ministerial Order and in several textbooks used in the subject of technology at technical high schools. Therefore, the questions addressed here regard the role this model plays on HTX and if the model is actually able to fulfil this role. The aim of the technology subject, as described in the Ministerial Order, is to teach students about the relationship between technology and society; consequently, the question is whether the technology model can assist this goal.

The technology model gives a wider perspective on technology than other simpler models. One very prominent idea is that technology is applied science, and that technology is developed on the basis of scientific discoveries (Bunge, 1966). This rather simplistic model has been repeatedly contested. For example, Gil-Perez et al.

(2005) argue that the exact opposite is the case: that technology is a prerequisite for science. Both can, under certain circumstances, be right. Today's advanced technologies are unthinkable without science, and almost any scientific endeavour is based on some kind of technological device. However, both are too simplistic, and the technology model presented above in table 2-1 is correct in the sense that it offers a much wider and more nuanced view of technology, such as when it points to the importance of the technological context it is highlighting the importance of much more than the device in question. Despite this widening of the perspective, questions of the model remain.

First is the question of the dynamics of technology. Technologies are developed and used by people, and they change over time. The technology model has no way of capturing this dynamic element of technology. Instead, studies rest on some – albeit very interesting – narratives telling stories of technological innovation and change. But the model is basically static. Lorentzen tries to remedy this by introducing a stage model for technological innovation (Lorentzen, 1988:23), but this then succumbs to the pitfalls of the stage models. Edquist (1977) states, rightly, that 'technology is in itself a process', but then very hastily suggests a stage model beginning with phase one, basic research. Even if this should encompass all elements of the technology model and be based on science, social science and arts, it is doubtful whether all technologies are based on basic research. The next phases are theoretical development (phase 2), application (phase 3), organisers, a phase in which end-users organise technology into their everyday lives (phase 4) and, finally, the use of the end product (phase 5). Questions could be asked of each of the stages, but a more basic criticism could be added. First, the stage models do not explain how one should get from one stage to the next; each stage is not very dynamic and, in general, the stage model could be described as 'sequences of timelessness' (Henriksen et al., 2004:168). That is, even though it is presented as a dynamic model it is not very dynamic, but still rests on empirical narratives to create the kind of dynamics needed.
A second question asked about the technology model concerns the relationship between technology and the human actors involved. It is obvious that technology is human-made, in the sense that no technology exists without some kind of human effort. This is implicit in the technology model. But, what about technology's influence on humans as users of technology? Are we not affected by technology? The world is a very different place with or without technology (Ihde, 1990), and from Actor Network Theory (ANT) and Science, technology and society (STS) we have learned that technologies do have some kind of agency, meaning that they are not neutral entities but can make us change our behaviour, our way of acting in the world and maybe also our way of thinking. Heidegger, in his essay on technology, argues that our way of thinking is strongly affected by technology (Heidegger, 1954/1977). He even calls the modern western world view a technological world view, meaning that we as modern westerners tend to think of efficiency as the ultimate goal and arbiter of almost everything. This view has potentially dire consequences for life on our planet, as we tend to think of everything in the world as material for our use, as objects for our manipulation and consumption, and to do that as efficiently as possible. If this is the case, then technology refers not only to manmade tools and means to an

end, but also determines our thinking and our acting in the world, a very deterministic view. With this critical insight and with ANT's insistence on technology's agency, we can no longer be content with the technology model's four elements alone; we also need to take more critically into account the impact that technology has on us and on our ways of thinking.

We can now conclude that the technology model is an initial valuable contribution to the study of technology. It does not rest on simple explanations such as 'technology is applied science' or similar reductive definitions. Rather, it considers some of the complexities of technology. The question now becomes whether this is good enough in order for the model to function as a pedagogical and didactical device at the technical high school (HTX) given the missing dynamics of the model and its inability to show us the dialectical relationship between man and technology? In the remainder of this paper, we will take a closer look at the Technology subject and address the question of whether the technology model as it is laid out in the Ministry of Children and Education, Ministerial Order is really able to help the students fulfil the learning goals of the technology subject? In order to do so we will visit a class while being taught the subject of Technology to see how the technology model is taught to the students in the HTX classroom.

TEACHING TECHNOLOGY

Is the technology model as it is laid out in the Ministry of Children and Education, Ministerial Order really able to help students fulfil the learning goals of the subject of technology? To answer this, we will first visit a class in which the subject of technology is being taught, to see how the technology model is taught to students in the classroom.

When I enter the class on HTX in Aalborg, the teacher and the 30 students are already present. The teacher starts by informing the students about the plan for the day's lesson. First, the students are informed that the first 90 minutes of the lesson will comprise class teaching. The teacher says:

> 'Today's lesson in this technology A class deal with: the concept of technology, the subject of technology, the technology report and an introduction to an individual assignment' (Field notes, 05.02.2019).

All students in the class must work with the technology model. The model consists of four concepts: knowledge, technique, organisation and product. The teacher has printed the model on paper and cut it out into small puzzle pieces. There are four pieces to the puzzle. Each student is handed one puzzle piece each. They must conceptualise one concept, depending on which piece of the puzzle they received. The teacher refers to a book used in the subject of technology, some of which the students should have read at home before coming to class. They all get 10 minutes to complete the assignment. Afterwards, the students must form groups of four, one for each of the elements in the technology model. In the groups, the students now have to follow

up on the concepts each of them conceptualised in the previous assignment. Together as a group they must conceptualise the concept of technology. Again, they are given 10 minutes for the assignment. Some students leave to complete the assignment in the common area just outside the classroom, while others stay as this saves them time. Once the students have completed the assignment, they all gather in class. Here, the teacher and the students follow up on what the concept of technology contains, based on the concepts from the technology model: knowledge, technique, organisation and product. The students conceptualise knowledge as the knowledge necessary to make a product, such as artisanship. They argue that knowledge has to do with empirical findings, experience, creativity and theoretical knowledge. Technique is conceptualised as the machines and techniques used to create products, materials, processes and methods. The students find organisation to be management and division of labour, which can be technical or societal, and horizontal or vertical sub-processes. The last element of the technology model, product, the students conceptualise as the end result of a manufacturing process, a physical product or service, and as something having utility or exchange value.
After a joint follow up to the four concepts in the technology model, the students now move on to discuss what technology is as a concept in relation to the subject of technology. One student explains that the concept of technology is about working with a societal issue, with product development and with the technology model. The student adds: 'all parts are needed to create a solution' (Field notes, 05.02.2019). As the class finishes following up on the technology concept, the teacher gives them a task. They must now discuss, with the person sitting next to them, what the subject of technology contains. The teacher states that they must focus on the identity and purpose of the subject of technology. In working with the subject, they must use the text they read in preparation for today's teaching. The idea is for students to highlight the most important passages in the text in relation to subject identity and purpose.

After the students have completed the assignment, they are given a short break. One of the students has a birthday and has brought cake. When the break is over, they follow up on the identity and purpose of the subject of technology in class. Some points made about the identity of the subject are: technological solutions, societal issues, local and global perspectives, PBL and innovative competencies. In connection with the purpose of the subject, it was mentioned that it creates prerequisites for higher education and teaches students to work independently and in collaboration with others. Before the class ends, the students work on each other's problem statements. However, before starting, students receive a checklist for a good problem statement. With this list, students work on each other's problem statements to provide suggestions on how to improve them. Among other things, they look at the form of the problem formulation, whether there are sub-questions for the problem formulation, and whether it can be formulated more sharply. While the students concentrate well on the task, the students realise the teaching is ending and leave the room.

After observing how the technology model is taught in the classroom, it is now interesting to see how the students manage to use the technology model in praxis when conducting project work. Before giving examples, it is important to look at what the technology model can be used for, and how.

WHAT CAN THE TECHNOGY MODEL BE USED FOR AND HOW?

When technology students write projects, they must also devise a solution to the problem they are working on. They need to create a product. When thinking about the product, students must also think about production preparation; for this, students can prepare a technology analysis based on the technology model (Jeppesen et al., 2020:114–115). A technology analysis can be prepared at many different levels, and the level relevant to the project the students are working on depends on the problem they want to solve. Based on the four concepts in the technology model, students could analyse the elements through the following questions. Analysis of the *knowledge* element could start from the questions:

- What knowledge must a company have to produce a product the students want to create?
- What knowledge is there among employees?
- What new knowledge must the company acquire to be able to produce the students' desired product? (Jeppesen, et al., 2020:115).

The *technique* element could be accessed through questions such as:

- Which processes in relation to the manufacturing process should be manual, and which automatic?
- Are there new work processes?
- What new production plants are needed? (Jeppesen et al., 2020:115).

In relation to the organisational element of the technology model, this element can, among other things, be unfolded through the following questions: Are there any new professional groups to take care of? What is the readiness to switch from one product to another? The last element, the product element, can also be accessed by examining 'how the production process should proceed, what opportunities and barriers exist with the product, the environmental aspects, economics and marketing etc.' (Jeppesen et al., 2020:115).

HOW CAN THE TECHNOLOGY MODEL BE USED IN PRACTICE?

Now that we better understand how the technology model is taught in the technology field on HTX, and have greater insight into what the technology model can be used for and how, it is now interesting to look at where the students actually use the technology model in practice.

The technology analysis is conducted for production preparation, together with detailed documentation of the manufacturing process (Jeppesen et al., 2020:115). Not all students use the technology model in their projects, nor is it an essential requirement. However, it is applicable to most projects undertaken in the subject of technology on HTX. Every time the students start a new technology project, they must evaluate which methods best help them answer their problem statement. Through this evaluation of methods, the technology model – and thus also the technology analysis – ends up being part of the methodological approach chosen. When this is the case, the technology model is used to perform a technology analysis based on the physical product the students create as a solution to the problem they are working on in their project. The students are very structured when they use the technology model to perform a technology analysis. They base the analysis on the four elements of the technology model: technique, knowledge, organisation and product. Through one element at a time, they analyse their way through the model, asking the questions mentioned above. Table 2 below shows the structure of a technology analysis.

Knowledge			**Organisation**		
Ability	Insight	Intuition	Management	Coordination of work distribution	
Technique			**Product**		
Work Means	Work Items	Labour	Type of product	Does the product have utility value?	Does the product have trade-in value?

Figure 2-3 The four elements of the technology model and the sub-topics students must complete when performing the analysis

Although the method is simple and straightforward to apply, it is still possible to fill the individual elements more or less specifically. Below are several examples of how the various elements of the technology model can be filled in very differently.

Example 1

Knowledge		**Knowledge**
Ability		Ability
Handling of jigsaw or painting		Experience knowledge is based on a previous workshop course. During the course it was learned how to work in the workshop and how to use the machines. Experience is further drawn from previous projects and, in addition, we have also been able to expand our experience by asking the counsellor for advice on specific issues

Box 1 *Box 2*

In the above example, it becomes clear that there are some differences in how students unfold the different elements of the technology model. Box 1 shows an example of students who have described only practical skills; that is, the practical skills the students in question possessed prior to the project work, what they already know. In contrast, box 2 describes how the students concerned draw on existing experience but also notes that they are aware of this drawing on experience from previous projects and, in addition, they have the opportunity to draw on even more knowledge from their supervisor. Here, the students are able to illustrate that they understand the project design process and that they also understand how to incorporate this knowledge into the technology analysis.

Example 2

Technique		**Technique**
Labour		Labour
Human labour and the machines used		Several different machines have been used, all of which have been handled by the same person. In addition, some special machines were also used for the processes in the product development that required it

Box 1 *Box 2*

In example 2, similar differences are noticed. In box 1, the students write very short, specific notes on the workforce in their project. In contrast, box 2 shows that some students describe in more words how labour relates to their project. They mention who handles the machines, and that special machines are used for specific processes in the development process. Again, in evidence are different ways that the elements of the technology model can be completed, and thus the technology analysis can be unfolded. Here, the students are able to illustrate that they understand the process in which they are working and how to incorporate this knowledge into the technology analysis. Some students can illustrate that they understand the process that is part of the project work, and at the same time that they are able to draw that knowledge into the technology analysis.

Example 3

Organization		**Organization**
Coordination of work distribution		Coordination of work distribution
Joint management of the project and work has been carried out vertically		Work has been done on both horizontal and vertical work distribution in the project. Horizontal in the sense that tasks are distributed among the group members so that it has been possible to work on several tasks at once. Vertically in cases where important joint decisions must be made that are important for the project work

Box 1 *Box 2*

This final example supports the previous two. There are essentially two ways to fill out the elements of the technology model and to conduct the technology analysis: either writing very short and specific notes, or being conscious of drawing on experiences from previous lectures and other projects, and so on. This is also illustrated in example 3, above, where box 1 shows the students in question very briefly noted that they worked together on distributing work in connection with the project, and that all work distribution was done vertically. Box 2 shows the opposite, that some students have made deeper reflections on how they have coordinated and distributed the tasks in the project work. Here, the students concerned have worked with both vertical and horizontal distribution of work, and also how it was applied in their project. In addition to the technology analysis based on the technology model, when the product is complete, the students can prepare a technology assessment on how the new technology they created interacts with the rest of the community (Jeppesen et al., 2020:115).

CONCLUSION

Above, we raised the question about the role of the concept of technology in upper-secondary school HTX, especially in the subject of technology. From the Ministry of Children and Education, Ministerial Order we found that the so-called technology model is written directly into the legal basis of the education. Therefore, the issue addressed here was about the role this model plays on HTX, and whether the model is actually able to fulfil this role.

From the above analysis of the technology model, we found that the model is comprehensive and more holistic than simpler models. We also found that the technology model lacks dynamics, and it is not clear how the technology model handles the impact technology might have on users; that is, how it affects our way of thinking and acting. We also saw how it is taught, how the teachers could use it, what it can be used for in the classroom, and how it can be used in the students' projects and assignments. From all this it can be concluded that the model works. With the model, students have access to the design of a technology analysis based on the technology they have developed in their projects; for that, the model seems excellent. However, the use of the model can be problematic in that it can be used very 'mechanically' by the students. The use of the model becomes more about, for some of the students, filling out the boxes so they can say they have completed this part of the project. Therefore, in some cases it will function as a checklist more than a model. Teachers should be aware of this, and make sure that this problem is addressed in classroom discussions. The model can be further criticised for not including a proper and comprehensive understanding of technology, and therefore not forcing students to relate to how the technology they worked on in the project affects them, and the context in which they are included. But, maybe this is too much to ask at the upper-secondary level. Overall, it can be argued that the model works. It aims to help students complete a technology analysis. But it can also be argued that teachers should be aware of the model's shortcomings and discuss this with their students so they get a more dynamic and dialectical understanding of technology.

2.4. THE PRACTICE OF TEACHING TECHNOLOGY ON HTX

2.4.1. CASE 1 – TEACHER CONTROLLED APPROACH

As I enter this first-year class there is a lot of noise, but that changes once the teacher arrives. When the teaching starts it is apparent that this is a teacher-centred classroom teaching environment. The teacher starts by setting the scene with a repetition of PBL and refers to a previous project the students had done, in which they conducted some research to frame their key problem for the project. Further, the teacher reminds the students of the problem tree used to develop and delineate the selected key problem, and that the logbook is an important element for a good project start and process.

After a short reminder about the key elements included in a good project, the teacher proceeds to discuss the requirements for the product the students must develop as part of the project they are working on. The students must reflect on how they perceive four different requirements: nice, simple, not too far and fast. The students' responses include comments like 'nice is very subjective', 'simple does not fit with working with problems' and 'what is long and fast?' After the students' responses are taken in a plenary, they conclude that the requirements for the product they are designing must be measurable. The teacher gives the students some examples of good requirements:

(1) must answer the problem statement;
(2) should be able to be create it in the workshop;
(3) must be done according to drawings;
(4) should be able to be created in two to four hours;
(5) must be within budget.

Now it is time for the students to work in their respective groups for 20 minutes. Their task is to establish five requirements for their product. First, they must individually figure out the requirements they would make for the product. Subsequently, in the group they must agree on five requirements for the product. All groups stay in class as they do not have long for the task. They get started quickly. Some indicate that they have already been working on some requirements, while others are very concentrated on the task. After the assignment is completed, the students are given a five-minute break and the class moves out into a large recess area.

After the break, the teacher distributes blank pieces of paper to everyone in the class. They have to do an individual assignment, and are instructed how to proceed. First, they are asked to fold the paper twice (the teacher demonstrates). Students are asked to have their computer, pencil and the folded paper in front of them for this exercise. Based on the problem they are working on in the project and the requirements they have already set, they must write down the purpose of their project. The timer is set to six minutes, in which time they must write down everything they can think of. Some students do not have a pencil they can use. They think they are outdated. The teacher foresaw this problem and brought pencils for the students to borrow.

The clock rings, the short task is over and there is turmoil in the class again. The students must now find the folded piece of paper. For this assignment they are asked to write down ideas; one new idea every 30 seconds. The ideas should be possible solutions for the project. One student asks what exactly it is they should do as they do not understand. The task is explained to them again and they start working. After the first 30 seconds are up, the students are very surprised by how fast the time went and become unfocused. By the second time around they have gotten the hang of it.

This assignment ends and a new one begins. This time, the students go into their groups and present their ideas to each other, one at a time. After, they must prioritise and combine the ideas using the colours red, yellow and green. They should write down all green ideas in their logbook. The students continue to work on their ideas in their respective groups, followed by another break. Class starts again after 15 minutes. The teacher starts by telling the students about solutions and then presents the students with a choice matrix, which is all about choosing solutions objectively and thinking about the fact that there is not only one solution. The teacher also presents the students with a point element they can add to their choice matrix to get a better understanding of which requirements are most important and which solutions are agreed upon in the group. The final comment is ‘remember to kill your darlings’.

After three hours, the teaching changes from being very teacher-led to being more student-centred. The students are a little slow to start on the choice matrix assignment. The teacher therefore asks for a keyword to get their attention and to get them to stop talking about private topics and start working. One student reply: ‘Our keyword in here is ‘listen’ because they can’t shut up’. Afterwards, the students in the groups begin to set relevant language goals for the project, and the group work now seems very active and dynamic. However, it only lasts a short time as the students’ focus begins to fail as they realise the lunch break is coming up (Field notes, 06.12.2017).

2.4.2. CASE 2 – STUDENT CENTERED APPROACH

Entering this first-year class there is also a lot of noise, and this also changes as the teacher arrives. The teacher starts by following up on what the students have been doing in the Product development course (PU) since the last time he saw them. The students tell the teacher they have been working on a TED talk[3]. They recorded it and gave each other feedback. Afterwards, they had to hand it in and then they formed groups for the next project period. The teacher asks the students what they thought about working with TED talks, and whether they could figure out how to use the supervisors. The students respond that they think it was useful asking the supervisors for advice on academic questions, and everyone used them more than once, even if there was no compulsory question time, and the students only had to get the assignment approved before they could move on.

The teacher starts to circulate the classroom, talking to the students and asking about the teaching. After a short time, the teacher gives the students a small assignment: for five minutes, describe what characterises young people at their age. Students start by discussing this loudly, and come up with several key words and phrases, such as: drinks too much alcohol, rootless existence, does not want to stand out too much but would still like to be special, use of technology, gets stressed at a young age, striving to get good grades, testers of life. The teacher then follows up on one of the comments, asking: ‘Do you drink more than is good for you?’ One student answered, saying, ‘At least I don’t think you have a need to drink like that’ (referring to the previous listed

[3] A TED talk is an influential video from experts on different topics that is 18 minutes long.

keywords). The teacher then asks a second question: 'Do you drink more than you want?' Again, the students are quick to reply with answers such as 'that differs from person to person', and 'we are very different'. Again, the teacher picks up on one of the student's comments and asks, 'How similar are you?' The students reply: 'We are very different, yet very similar'. The teacher continues, 'Okay, so tell me what connects young people at your age?' One student answer; 'Very little practical experience'. At this point it becomes clear that the teacher's questions have been functioning as a brainstorm, and the students are now given a small assignment. They must discuss the following question: What characterises this class? They get three minutes. The students immediately start discussing this loudly across the tables, and they quickly come up with four characteristics of their specific class: many girls (11 is a lot in one class on HTX); study programme – the chemistry of nature; more focused than those attending regular high school; and that they think it is so important to go to school that they all show up every day. The students are then given another short assignment before the first break of the morning. This time they have to reflect upon who they are as students. Unlike the other tasks, this must be done individually. The teacher informs them that they should have answers when they meet again after the break. They then leave the room.

After the break, the teacher follows up on the collective brainstorm done in class before the break and informs the students about their next assignment. The students must translate everything they had talked about in the previous brainstorm session into a description of a persona, in form of a PowerPoint presentation or a Word file that has to be handed in. The leading question should be: What characterises an HTX-student? They get 15 minutes for this assignment and are very quick to get started. They work with pictures on their phones and use their computers to take notes. Some students write their notes by hand. They split into their project groups without mentioning this in words at any point. Some students are very focused on the work; they have a little fun with it by, for example, drawing the average student. Others are less concerned and talk more about their spare time jobs. However, most students seem aware that they will need to continue working with the personas, as they can use them in the next project.

After the 15 minutes have passed and this assignment is complete, the teacher wants to introduce the students to the six phases of product development. Further, the teacher talks about the academic goals of the curriculum, adding that the students should give themselves an assignment. They are instructed to find some information about product development, and it is further suggested that they may find something about this topic in a book called *Problems and Technology*. The teacher talks the students through how they can progress from describing their problem to using the problem tree, through which they can analyse the causes and effects of the problem and talk about solutions. The teacher gets more specific and talks the students through how they can work with idea generation and the requirements of their projects.

The students divide into their respective groups to work on their projects. The teacher leaves the classroom. Some students stay in class while others go out and try to find another place to sit. At first, not many of the groups work on the project. They do everything but what they should be doing, and their focus comes and goes. As they start working on the projects they talk a lot about their chosen topics in their groups. These topics include food waste, stress and so on. The teacher re-enters the classroom. Many students raise their hand as soon as the teacher enters. They need help but the teacher does not notice at first; some students begin to follow the teacher around the classroom to make a supervision appointment. The teacher leaves the classroom again but enters again shortly after. A group of girls asks the teacher what to do with their problem statement, which is: How can we get more children to go to school in Liberia? The teacher says that the formulation of the problem must be narrowed. After this short consultation, the girls continue working on their own. A group of boys does not understand the difference between a problem statement and an issue. The teacher tries to explain that they must formulate a problem statement and identify one problem that can be solved. The teacher further states that he thinks they should remember to work problem-oriented. The teacher then moves on to the next group. The next two hours continues in this manner. The teacher circulates around the classroom, talking to the groups who ask for help and the students who are still defining their problem statement (Field notes, 14.02.2018).

Teachers’ lack of consensus on how to work with PBL in the subject of technology is the starting point of this project. Two different perspectives on teaching technology, representing the two side of the absent consensus, have been described in this chapter through classroom observations, enabling the reader to understand the differences. To further address the lack of consensus, an article highlighting the lack of consensus among the teachers in the technology subject is presented below.

2.4.3. ´AGREE TO DISAGREE´: TECHNOLOGY TEACHERS’ PERCEPTIONS AND PRACTICES OF PBL IN THE DANISH HTX

This article is under review as:
Jeppesen, M.M. (2020) ‘Agree to disagree’: Technology teachers’ perceptions and practices of problem-based learning (PBL) in the Danish higher technical examination programme (HTX). *Journal of Problem-Based Learning in Higher Education*

HTX technology teachers are interested in developing how they facilitate project work; however, there is no shared consensus on conceptualisations of PBL, or about which methods to use. The purpose of this paper is, therefore, to tease out empirical findings based on the following themes: teacher cooperation, degree of problem orientation, project organisation and student centeredness. This is done to identify some avenues for future pedagogical development of technology teaching. This research found that technology teachers’ cooperation is challenged as teachers agree to disagree on conceptualisations of PBL in relation to project work, therefore finding their own solutions. On that ground, it is concluded that a generally accepted disciplinary tradition in technology has yet to fully emerge, or to be comprehensively conceptualised by the teaching profession. There is scope, based on the empirical findings presented here, for the further development of HTX technology teaching.

Keywords: Active learning; Danish technical high school (HTX); project work; technology teachers' perceptions and practices of problem-based learning (PBL)

Every year, in September, new students begin studying at universities in Denmark. Engineering attracts many of these students, especially former students of the higher technical examination programme (HTX), where some of the profile subjects (such as technology) draw on problem-based learning (PBL) principles. HTX education is project-oriented, problem-oriented and interdisciplinary. Established in the 1980s, its purpose was partly to increase participation in technical studies, and partly to provide a more direct access path into engineering studies for students and apprentices from technical colleges (Kjærgård et al., 2007). The core idea was to have a high school education stream directed towards science, technology and engineering, while simultaneously and innovatively combining theory and practice. In 1982, the first technical high school was inaugurated as an experiment, and HTX became a permanent addition to high school education in Denmark in 1995. The study programme was very much influenced by the PBL principles of the new Danish universities at Aalborg and Roskilde (Jans, 2007:12). Krogh (2013) provides a general positive evaluation of the University of Aalborg's PBL model, in terms of its student employability (see also Villesen, 2010; Henriksen & Askehave, 2013).

The HTX study programme is, therefore, based upon PBL principles that are inherently interdisciplinary, with group project work and a high level of student self-direction or student centeredness central to the curriculum (Henriksen, 2016a). Problem-oriented project work – especially in the profile subject's technology and technical science – has been a defining HTX characteristic since its inception (Ulriksen et al., 2008; Jans 2007:18; Ministry of Children and Education (Ministerial Order), 2015; HTX Curriculum, 2017), and is what differentiates HTX from other secondary-level programmes in the Danish educational system, such as STX and HF, which offers broad general education, and HHX, business high school. It is not the intention here to go into great detail about the finer aspects of the curriculum and its origins; this is more adequately addressed elsewhere (see e.g., Henriksen, 2016; Ministry of Children and Education (Ministerial Order), 2015; Ministry of Children and Education (HTX Curriculum), 2017). Henriksen (2016a), for example, explores its original purpose, analysis HTX curricular content, notes some prominent issues, and critically explores and evaluates the ability and potential of HTX technical high school to equip students with the requisite formation of character *Bildung* (Ministry of Children and Education (Ministerial Order), §1) and study competencies such as *episteme*, *techne* and *phronesis,* which correspond to theoretical, practical and social knowledge. His evaluation is generally positive. The general focus in this paper is on one profile subject, technology, and more specifically on the HTX teachers of this subject, particularly their perceptions of, and teaching practices related to, PBL.

Members of four HTX schools whose students scored significantly higher grades in technology than the national average of HTX schools met with a ministry consultant from the Ministry of Children and Education in 2014 to discuss what was special about these high-performing schools (Henriksen, 2014). Their findings can be summarised as follows: management in all four schools take the subject seriously as a profile subject and place it on an equal footing with other subjects. When scheduling, the subject is considered so that it can be placed in the study area (SO), hence encouraging interdisciplinarity across the curriculum. Adequate staffing in relevant disciplines is a prerequisite for such cooperative teaching interdisciplinarity to occur. Significantly, the technology course is led by a group of teachers who collaborate on the subject, and such pedagogical cooperation is deemed central to its success. Such teaching was based on ambitious goals, including participation in competitions and business collaboration, and deemed to be a key tangible source of student motivation. Good school facilities allow for workshop instruction with sufficient room for group work. Finally, all schools noted that they work very consciously with the students on written work and report writing.

In ongoing empirical work on HTX Aalborg, and more broadly, I have found that (a) technology teachers are interested in developing how they facilitate project work; however, (b) there is no shared consensus on conceptualisations of PBL related to technology, (c) nor is there any shared consensus about which methods to use. These initial findings support Henriksen's (2016a:121–140) cogent argument, based on his critical review of HTX, that it is time for a discussion on future pedagogical development of both technology and technical science teaching in terms of (i) teacher cooperation, (ii) degree of problem orientation, (iii) project organisation, and (iv) student centeredness. The purpose of this paper is to tease out these initial empirical findings based on these four themes, with a view to identifying some avenues for future pedagogical development of technology teaching in HTX. The paper proceeds as follows: an overview of the technology subject is followed by a brief outline of PBL, which is initially positioned within a broader pedagogical context. The empirical findings are then presented and discussed related to the four key themes noted above. The paper concludes that a generally accepted disciplinary tradition in technology has yet to fully emerge or be comprehensively conceptualised by its teaching profession, and that there is scope, based on the empirical findings presented here, for some further professional development of HTX technology teaching.

THE TECHNOLOGY SUBJECT ON HTX: OVERVIEW

In HTX technology, students address the relationship between technology and society. The formulations of the subject's goals are all characterised by a 'socio-technical' concept of technology (Ministry of Children and Education (Ministerial Order), 2015); that is, technology is to be conceived of as composed of knowledge, organisation, technology and product. Social scientific, technical, and scientific knowledge are combined with project related practical group work in workshops and laboratories. This profile subject consists of topics such as materials and machining processes, technology and environmental assessment, product development and production. Its general aim is to develop students' understanding of broadly interdisciplinary project work and develop their self-direction, analytical, documentation and presentation skills. Technology A (the highest level) further includes topics such as quality and environmental management, strategy, marketing, logistics, costing, and so on (Ministry of Children and Education (Ministerial Order), 2015). Whereas HTX students comprise around 10% of the Danish high school population, they constitute around 30% of engineering students at university level (Kolmos et al., 2017), hence the importance of both technology and technical science to science, technology, engineering, mathematics (STEM) education (Henriksen, 2016a).

HTX also includes the 'study area' (SO) and the 'study direction project' (SRP), both deemed central to its PBL focus. The study area is an interdisciplinary collaboration between the subjects; partly because of A; the profile subjects are included in the study area activities and B; the study area in its foundation is interdisciplinary and problem-oriented, and therefore central to the development of HTX students' study competencies. In Vygotskian (1986) terms, SO provides a student-centred cognitive and practical group space for self-directed learners to freely develop their own zones of proximal development. The SRP project is a large report that must draw on two different subject areas.

Technology is a relatively new subject within HTX, with only about 20 years of high school context and experience to draw on. It does not have a well-established tradition to build on as other more longstanding, single-discipline, upper-secondary-level school subjects do. Further, the content of technology is so broad and multifaceted that it is open to numerous interpretations, as indeed are conceptualisations of the PBL pedagogical process noted in the following section of this paper. Clearly, both the curricular content and the PBL teaching process itself present some daunting challenges to the teaching profession.

Initial empirical work, and broader research, by the author suggests that the way teachers work with PBL and technology projects varies from teacher to teacher, from class to class, and from HTX school to HTX school. This becomes apparent during the students' senior years, when they must choose a technical science subject. Students arrive from different classes, and students in this new class may have developed somewhat different perceptions of how to work with projects. These initial empirical findings might suggest that a solid, or commonly accepted, disciplinary tradition in technology has yet to fully emerge, or to be in any way comprehensively conceptualised by the teaching profession. Conversely, it may also be argued thon HTX technology teachers will have probably established some form of disciplinary tradition due to its project and problem orientation, its emphasis on student self-direction and its interdisciplinary socio-technical approach (Henriksen, 2016a). Hence the questions: How do HTX technology teachers teach? How are they different? How are they similar? Where do they agree? Where do they disagree? It is argued here that such specific insights may prove to be fruitful to pedagogical discussions on how to begin to create a coordinated language, or generally agreed conceptualisations, on both content and pedagogical PBL methods that would strengthen HTX technology's emerging disciplinary tradition within the teaching profession.

ON PBL

PBL was originally developed based on research into the reasoning abilities of medical students at McMaster University Medical School in Canada (Barrows & Tamblyn, 1980). This study highlighted a new method that used problem scenarios to encourage students to actively engage themselves in the learning process as a response to the criticism that traditional teaching and learning methods failed to prepare medical students for problem solving when practicing medicine outside the classroom setting (Savin-Baden & Howell, 2004; Hung et al., 2008). This deficiency led to a desire that university education within the medical field be structured in a way that helped students become competent in more than simply listening to lecturers, reading and remembering complex concepts (Holgaard et al., 2016). Basically, PBL was conceived and implemented as a response to medical students' unsatisfactory performance in praxis (Barrows & Tamblyn, 1980; Barrows, 1996; Hung et al., 2008). The PBL focus was to facilitate students in developing competencies for solving problems, expand their ability to handle complex and extensive knowledge, and be better able to communicate and collaborate. Ensuing changes included promoting self-directed independent learning and problem solving, reducing lecture hours, reducing schedule time, and evaluating the ability to learn independently with problem-based cases as the basic for gaining the required competencies (Hung et al., 2008; Barrows, 1996; Holgaard et al., 2016). Many medical schools soon followed (Aspy et al., 1993) 'the most innovative pedagogical method ever implemented in education' (Hung et al., 2008:486–7), and this broad pedagogical method soon spread to other universities and to different academic disciplines and professions (Henriksen et al., 2004; Holgaard et al., 2016), including Aalborg and Roskilde Universities and, of course, HTX.

PBL is an instructional methodology and, as such, an instructional solution for learning about problems. The following general characteristics are intrinsic to this pedagogical methodology:

- PBL students learn by addressing problems. The content of what they have to learn, and the skills they have to acquire, are focused around problems.
- PBL is student-centred.
- PBL is self-directed. Individually, and in collaboration, students take on the responsibility of generating learning issues and processes through self- and peer-assessment, thereby accessing their learning materials and becoming self-reflective. Students monitor their understanding and thereby learn to adjust strategies for learning.
- PBL tutors/teachers are facilitators who facilitate group processes and interpersonal dynamics and help students strengthen their knowledge. Tutors

rarely intercede content or provide learners with the answers (Hung et al., 2008:489).

As it has progressed in practice in numerous fields, the concepts associated with PBL have become more flexible and fluid, with different forms depending on learner attributes, discipline, interdisciplinarity and programme goals (Boud, 1985; Barrows, 1986; Walton & Matthews, 1989). Walton and Matthews (1989) argued that there is no fixed agreement on what does, and does not, constitute PBL, and that it is best understood as an educational strategy or philosophy. Barrows (1986) suggested that PBL could be considered a genus in which all forms could be evaluated in terms of issues such as type of problem, assessment methods, learners' autonomy and the ways in which teaching/facilitation and learning occur. The wide variety of active approaches to learning can be seen as a response to the growing dissatisfaction with the traditional teacher-centred paradigm. In a time of increased focus – from government and professions – on what students can do as a result of their high school and university education, these demands have resulted in pressure for change, but they have also ensured that the key issue of 'how' students learn is in focus. Different types of PBL have evolved to reflect such changes, resulting in some understandable confusion regarding which types of PBL are offered.

Some such forms are noted in Table 1, below.

Method	Organisation of knowledge	Forms of knowledge	Role of student	Role of tutor	Type of activity
PBL	Open-ended situations and problems	Contingent and constructed	Active participants and independent critical inquirers who own their own learning experiences	Enabler of opportunities for learning	Development of strategies to facilitate team and individual learning
Project-based learning	Tutor-set, structured tasks	Performative and practical	Completer of project or member of project team who develops a solution or strategy	Task setter and project supervisor	Problem solving and problem management

Problem -solving learning	Step-by-step logical problem solving through knowledge supplied by lecturer	Largely propositional but may also be practical	Problem solver who acquires knowledge through bounded problem solving	A guide to the right knowledge and solutions	Finding solutions to given problems
Action learning	Group-led discussion and reflection on action	Personal and performative	Self-adviser who seeks to achieve own goals and help others achieve their goals through reflection and action	A facilitator of reflection and action	Achievement of individual goals

Table 1- Types of PBL (Savin-Baden & Howell, 2004:7).

As illustrated in Table 1, PBL is now probably best viewed as one of a variety of active approaches to learning with parallels in Brookfield's (1985, 1986) work on self-direction in learning, in Vygotskian's (1986) development psychology, in Engeström's (1994) approach to active learning in activity theory, and in the more philosophically grounded approach of Nørreklit (1986) and Henriksen et al. (2004:145–161) to the collective nature of real-world problem identification, conceptualisation, reflection and solution, to name but a few scholars. Note that this active learning process, also relevant to group work in HTX, 'happens in an ever-continuous process of negotiation, argumentation, dialogue and debate' (Henriksen et al., 2004:147).

Dialogue is central to group work in HTX. Brookfield (1985, 1986) cites research in which successful self-directed learners report that learning networks in which knowledge is transmitted through oral encounters are their most important resources in developing expertise. These networks provide both an evaluative arena and a context in which successful learners can function as skill models and as 'resource consultants to neophyte enthusiasts. Engeström's (1994) approach supports the circular nature of PBL, noted by Henriksen et al. (2004:147) above, in terms of the contexts of criticism, discovery and application. In the context of criticism, HTX students identify problems in a group setting. In the context of discovery, they discover and appropriate intellectual tools and models for somehow mastering the problem. In the context of application, these newly found tools – both practical and intellectual – are applied, thus contributing to the continuous redesign of the project emanating from the original problem definition or problem statement. Following

Engeström (1994) and Henriksen et al. (2004), this learning community can refer to groups of HTX students and their technology teachers/facilitators, who share the same interdisciplinary learning objectives. Rules can refer to given – or preferably negotiated – guidelines, procedures and plans that normatively regulate the learning process; in this case, the broad PBL philosophical approach in HTX. Division of labour can refer to how tasks and roles are distributed among self-directed groups and HTX technology teachers/facilitators, which can be flexibly altered according to the nature of the activity or the stage in the learning cycle or conceptualisation process.

This flexibility inherent in Engeström's (1994) appropriation of Vygotsky's work would appear to be very relevant to the professional role of the technology teacher/facilitator as a highly flexible knowledge/expertise facilitator who can move in and out of the learning process as the situation requires. This paper now presents some empirical evidence based on observation, access to relevant materials and dialogue with HTX technology teachers on HTX technology teachers' perceptions of, and practices related to, PBL. The empirical evidence is presented through the first steps of the 'conceptualising method' (Henriksen et al., 2004:147), which may be presented as follows:

- Symptom of HTX problem
  Action – reflection – (real) problem
  Reflection – conceptualisation
  Action – reflection
  Reflection – conceptualisation
- (Sustainable) solution to (original) problem.

The focus, as noted above, is on key PBL themes related to (i) teacher cooperation, (ii) degree of problem orientation, (iii) project organisation and (iv) student centeredness.

FINDINGS AND DISCUSSION

To start with the symptom, this is often that there is something wrong or out of the ordinary. This is a practical problem. The symptom or the practical problem on HTX is that there are many ways of defining a problem, which is probably natural as there is no one essential way of defining what a problem is. Still, it seems that the teachers – on the basis of the different ways of defining a problem – find their own solutions to work around the missing consensus, making it relevant to focus on *technology teacher cooperation*. One of the ways that challenges regarding technology teacher cooperation become visible is when teachers express that colleagues *just agree to disagree*. As one teacher expressed:

> 'Well, you can say that there are some things like…there are some discussions that are difficult (…) to take and where we may have just gotten to know each other to well, so eventually we just stopped discussing' (Field notes, 2019).

This teacher is very conscious of the fact that many of the teachers at the HTX where he teaches have gotten to know each other so well that they no longer discuss their different perspectives; they simply agree to disagree. Therefore, cooperation among technology teachers is very limited. They do agree on working differently with PBL, and therefore also disagree on how to work with or conceptualise a problem when teaching technology as a subject. A teacher from a different school expressed something similar when saying,

> 'Had you asked five years ago then I would have said yes we can discuss it, but it will never be (…) some kind of consensus (…) But maybe there doesn't have to be (…) but we will never reach full agreement. Now we agree on some things we disagree on and then there are a whole lot of things we can see in a certain way because now we have agreed that it is probably best to do it this way' (Field notes, 2019).

This teacher states that the technology teachers might never reach a consensus and that the goal might not necessarily be agreeing but just doing what was best indicating a possible conflict is existing on this topic.

Another way it becomes visible that teachers find their own solutions around the missing consensus, thereby *agreeing to disagree,* is when they do not trust PBL principles and try to 'help' the students by switching to a more teacher-controlled way of teaching. The *degree of problem orientation* thereby varies from teacher to teacher. In the following quotation, a teacher expressed that this is an area where they often have different perspectives:

> 'That is an area where we do not agree that much (…) in terms of how much you have to get the students to run the group process themselves and how much we as tutors should support it and how much it is you really just need to make deadline' (Field notes, 2019).

The above quote suggests that teachers do not agree about whether they should let students control the project process themselves or whether teachers should control the process to ensure students meet deadlines and complete the project. It seems teachers also do not agree on the degree of the problem orientation to use when teaching technology. When taking over planning and pushing students to meet deadlines, teachers put aside PBL principles, and the supervision and teaching becomes more teacher-controlled. Further, such an approach also places a focus on *project organisation* as it raises the question of who should be in charge of organising the project: teachers or students? It has also been expressed that students learning how to make use of supervision is a discipline, but even with that knowledge teachers sometimes feel the need to take the responsibility:

> 'So, getting supervision is a whole discipline in itself and the first time they encounter it well, then we will of course have to take responsibility for them being in the process so that we actually have the opportunity to teach them what supervision is and also how to use it' (Field notes, 2019).

The teacher feels the need to take responsibility for the students and help them figure out how to get supervision. It is even described as something the teacher feels all teachers must do. *Student centeredness* is thereby also a focus. How much should student centeredness be the centre of the project work, and how much should the teachers take responsibility for? It is further expressed that teachers must teach students what supervision is and how to use it by taking responsibility for it. In doing so, PBL principles are phased out for a period in favour of teaching-controlled supervision, as teachers working from the PBL principles would function more as facilitators and leave the responsibility of figuring out how to get supervision to the students.

The differences in how teachers work in technology as a subject clearly shows that there is no consensus over what PBL is and how to work with it. All teachers know they are working with the concept of PBL but there is no common understanding of what a problem is and how it is conceptualised, for example. If teachers are not explicit about how they work, how they understand and conceptualised key concepts and, in many cases, just *agree to disagree,* then they are not able to discuss amongst themselves how to work in the subject of technology. If that is the case, it is not possible to talk about or develop a common way to work in the subject.

This apparent lack of consensus suggests the need to create a coordinated language and associated conceptual devices or conceptualisations. Technology teachers may use these as enabling tools to focus discussions with students on the subject and its associated PBL methodologies. I argue that such focused discussions can further assist in developing a more substantial disciplinary tradition in technology. Further, I argue that teachers of technology, instead of finding their own solutions around the missing consensus, should trust PBL as an instructional solution for students to learn about problems. If teachers did this and thereby remained facilitators of the process and not overtake the project organisation, they might see some students fail but would definitely see all taking responsibility for their projects and learning from that. Agreeing to disagree, not making it possible to develop a common way of working in technology as a subject and the use of more teacher-controlled teaching and supervision methods is a disservice to students and could negatively affect the realisation of PBL objectives. By not being clear in the communication of PBL principles and trying to ‘help’ students by controlling the project process, the students miss out on taking responsibility for their own learning and learning the importance of communication and interpersonal skills.

CONCLUSION

The focus of this paper was to tease out empirical findings based on the following four themes: (i) teacher cooperation, (ii) degree of problem orientation, (iii) project organisation and (iv) student centeredness. The purpose was to identify some avenues for future pedagogical development of technology teaching on HTX. In relation to the four themes, it was found that technology teachers’ cooperation is compromised as the teachers agree to disagree when it comes to defining a problem in relation to project work, and therefore finding their own solutions. Further, it is argued that teachers will never reach consensus or full agreement on the subject, but maybe this is not necessary. The degree of problem orientation was found to vary between teachers. Teachers do agree on the fact that students must do project work on their own, but how much teachers should control the process during project work, how much the students can control the process themselves, and how much focus should be put on student centeredness is where the teachers disagree. The question of who is actually in charge of organising the project is also raised. Is it the teachers or the students? If it is the students, when should the responsibility be transferred to them? From the start of education, or should they be taught how to handle that responsibility form the beginning? This paper concludes that a generally accepted technology disciplinary tradition has yet to fully emerge or to be comprehensively conceptualised by the teaching profession, and that there is scope, based on the empirical findings presented here, for some further professional development of HTX technology teaching.

2.5. CONCLUSION

The international literature is extensive in the fields of technology education, engineering education and STEM education, but even so, there is not a lot of literature on the specific field that this thesis revolves around. More specifically, not only is the context of HTX not addressed, which in some ways makes sense as the context is very Danish as HTX is a very specific program. On the other hand, there is also little if any attempt to analyse the concepts of 'technology', PBL and Bildung to a level that would make it possible to support the establishment of a professional tradition such as one that could remedy some of the problems that HTX teachers face - the lack of professional tradition and a common language to address such an emerging tradition.

Therefore, there is also a need in what follows in this thesis for a thorough analysis of the concepts of technology, PBL and Bildung, because they are, combined, necessary to develop a solid professional tradition; this analysis must necessarily be carried out in close collaboration *with* the teachers themselves at HTX. This is also the argument for using pragmatic constructivism as a methodology here: it is action research, and it aims to analyse and conceptualize the key concepts that are necessary to implement the change - in this case, to help develop a professional tradition in HTX Technology Teaching.

CHAPTER 3. THE PROBLEM

With the conclusion in the previous chapter that a generally accepted disciplinary tradition in the technology subject on HTX has yet to fully emerge or to be comprehensively conceptualised by its teaching profession it seems pertinent to now follow up on the initiating problem of this project which is described in the following section.

3.1. THE INITIATING PROBLEM ON HTX

Working with PBL and projects in the subject of technology is part of what differentiates HTX from other high school programmes. However, this has proven to be challenging as the way teachers work with PBL and projects in technology varies between teachers, classes and schools. This becomes apparent during the students' third year of study, when they must choose a technical science subject; students arrive from different technology classes and may have developed different perceptions of how to work with projects. A technology teacher from HTX in Aalborg expressed that:

> 'When you have technical subjects as well, then it is quite clear. Last year we had seven different classes and I will have that this year as well. And they have also had seven different technology teachers (…) So when you ask the students to write a problem statement some just write it and others starts analysing for 20 hours and come up with 35 pages which of course should be added to the problem statement because otherwise then it is not documented (…). So yes, we do it differently and it is especially as a technical science teacher that I am made aware of it' (Interviewee 2, 2019).

This quotation suggests that a solid, or commonly accepted, disciplinary tradition has yet to emerge or be formulated. HTX teachers, for example, expressed the following:

(1) that teachers have an interest in working with – and developing – the ways they engage in project work in the profile technology subject;
(2) there is no consensus among teachers about what (PBL) is regarding the subject of technology;
(3) there is no consensus among teachers on which methods to use.

Technology is a relatively new subject, with only about 20 years of history in Danish high schools; it does not have the years of experience of other upper-secondary school subjects to build on. This means that the tradition must first be established, and the content of technology as a subject is so broad that it is open to numerous interpretations (Henriksen, 2016a:125; Jeppesen & Henriksen, 2020).

It can be argued that teachers have established some traditions in the subject based on the project and problem orientation, and its socio-technical approach (Henriksen,

2016a:125). Even so, teachers' lack of consensus and the discussion on whether a tradition has been established highlights the need to create a coordinated language and conceptual devices or conceptualisations relevant to this key disciplinary area.
Based on the initiating problem, I have chosen to unfold the problem analysis even further, and thereby also my understanding of HTX and the subject of technology, focusing on four concepts: technology, PBL, *Bildung*, and concepts and language games. These were carefully chosen by examining my pilot observations and identifying which concepts were mentioned or described through teaching and when having dialogues with the technology teachers.

Figure 1-2 illustrates how the four concepts play into this PhD, and also into the understanding of HTX and the technology field.

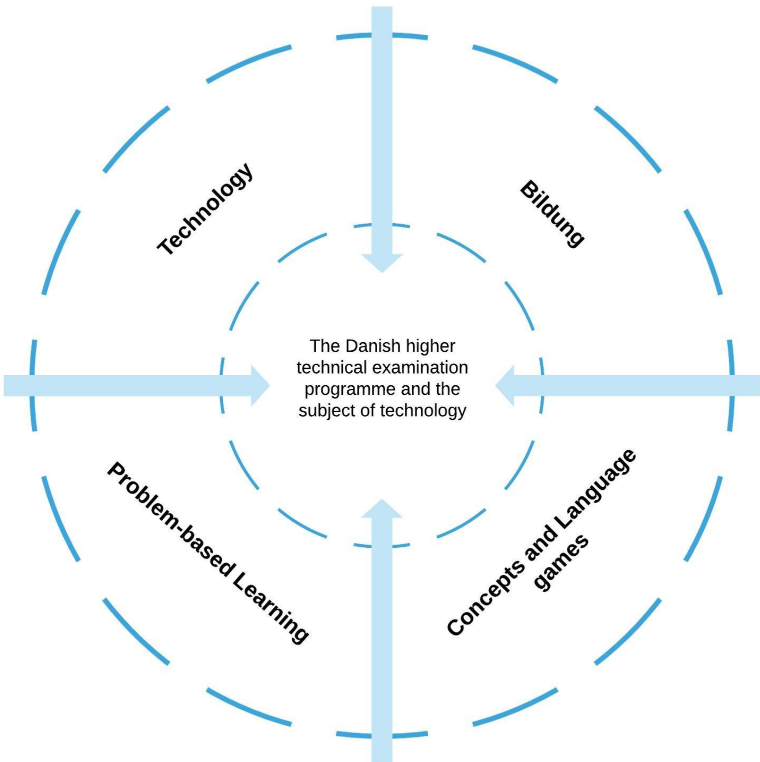


Figure 1-2 The concepts unfolded in the problemanalysis.

In the following sections I, therefore; unfold the four concepts; Technology, PBL, Bildung and Language games and examine them in turn. I do this to get a better insight into the concets and what they mean in realtion to the technology subject.

3.2. PBL

PBL is another concept that is central to HTX education. The work done in the subject of technology is based on PBL principles. When working on projects, students must work in groups, identify a problem they want to work with and unfold a problem analysis; these are all points that can be related to PBL principles. Additionally, §3 of the Ministry of Children and Education, Ministerial Order describes thon HTX teaching emphasises product development, innovation, problem solving and applied natural sciences, including combining theory and practice in workshops and laboratories. Further, the curriculum describes how the subject of technology enhances students' innovative competencies through project work involving problem solving. The working methods in the subject of technology further contribute to the general study competencies (*Bildung*) (Ministry of Children and Education, Curriculum, Technology A and B, 2017:1).

3.2.1. THE ROLE OF THE TEACHER IN A PBL TEACHING PROCESS

This article is published in *Educate for the future: PBL, Sustainability and Digitalisation* as:

Jeppesen, M.M., Routhe, H.W., Kristensen, R.S. & Prip, J. (2020). The role of the teacher in a PBL teaching process, in Educate for the future: PBL, Sustainability and Digitalisation 2020. Guerra, A., Kolmos, A., Winther, M. & Chen, J. (red), pp. 439-452

The purpose of this article is to address the role of the teachers when teaching the technology subject at the Danish higher examination programme (HTX). It is also the intention to address how that role is expressed in practice where use of Problem-based learning (PBL) or some PBL principles is acknowledged as a strong teaching method. Further, it is our intention to discuss the teacher role in relation to readiness of the students evolving from first to third year in the programme. This will be seen in relation to; the development of the students PBL understanding, the cognitive readiness of the students and classroom dynamics. Researching the role of the teachers in the technology subject on HTX we observed in two different classes, in two different schools during a project period and discussed our findings with the teachers. In relation to the role of the teachers, we identified a variety of tasks the teachers have to deal with on a daily basis when teaching this subject. It places the teachers in a role where a very hybrid skill set is required which is a combination of technical and non-technical skills. Further, we have also found that the teacher's role and the teacher's tasks change as the students develop their skill set during the first year until the end of the third year from a more teacher directed role to a more student-centred facilitator role.

Keywords: Teachers' role, Problem-based learning, student readiness, hybrid skill set, Danish higher technical examination programme (HTX)

Established in the 1980s, the purpose with the Danish higher technical examination programme (HTX) was to have a high school education stream specifically directed towards science and engineering (Ministry of Children and Education, 2015). The first HTX was inaugurated as an experiment in 1982; seven years later in 1989 HTX became a permanent addition to secondary school education in Denmark (Jans, 2007; Olsson, 2007). In 1995 it obtained its current form as a three-year high school programme with direct entry from primary school (Jans, 2007). HTX initially struggled with being an unknown educational form and with general image problems. Today, however, this educational form has existed for almost 40 years and is now generally recognised as an equal and indispensable part of Danish STEM (science, technology, engineering, mathematics) and vocational education (Olsson, 2007:7) What differentiates HTX from other secondary school programmes in the Danish educational system (such as STX and HF, which offer a broad general education, and HHX, the business high school) is that project-work is central to the curriculum (Ulriksen et al., 2008) and, therefore; based upon problem-based learning (PBL) (Henriksen, 2016a). This is especially true for the central subject areas ‘profile subjects’; one of these ‘profile subjects’ is Technology.

THE SUBJECT OF TECHNOLOGY

The subject of technology is available to take at both A and B level. The students at the first and second year of their study (age 17 – 19 years) on HTX have Technology at B level, while the students at the third year (age 19 – 20 years) can choose Technology at A level. In this subject area at both A and B level students address the relationship between technology and society (Ministry of Children and Education, 2015, 2017). As Henriksen (2016a:125) puts it, the subject’s goal formulations are all characterised by a ‘social-technical’ concept of technology (Trist & Bamforth, 1951; Müller et al., 1984). The subject area has its basis in social issues and analyses of technology and community development. Further, its starting point relates to the interplay between technology, knowledge, organisation and product. Social scientific, technical, and scientific knowledge are combined with practical work in groups (Henriksen, 2016a:125). The technology subject consists of topics such as materials and machining processes, technology and environmental assessment, product development, production and marketing. Its general aim is to develop students’ understanding of broadly interdisciplinary project work as well as developing their documentation and presentation skills. Technology A also includes subjects such as quality and environmental management, strategy, marketing, logistics, costing, etc. (Ministry of Children and Education (Curriculum), 2017; Henriksen, 2016a:125). As project work is the HTX guiding principle, teaching is regularly organised as projects with the following as the basis for such activity: projects, group work, individual work, and teacher-led classroom teaching. This approach provides students with the possibility of being active in shaping the educational content, and in suggesting how projects could be approached (Ministry of Children and Education (Ministerial Order), 2017; Henriksen, 2016a:126).

With the regular teaching organised as projects and that being mixed with teacher-led classroom teaching the roles of the teachers teaching the subject of technology on HTX becomes one of a hybrid characters as they, when working with Problem-based learning, can be said to be placed in a position between being a teacher in the more classical sense and functioning as a facilitator at the same time. This hybridity presents a challenge for the teachers as they experience that it unfolds an even wider variety of roles for them to fill out within the framework of the subject.

To further understand the challenges that arise for teachers in teaching the technology subject, it is pertinent to first introduce Problem-based learning and afterwards present the realities of what is happening in the classrooms to clarify the breadth of the hybrid role of the teachers but before doing so we firstly unfold the method for collecting the empirical data used in the article.

METHOD

Our empirical data is based on observations and interviews at the Danish higher technical examination programme. The observations were conducted on HTX in Aalborg and Kold College in Odense, Denmark. The observations were conducted as observation with participation as we had an interest in studying the field from the 'inside'. From the 'inside' must be understood as we as researchers interact with the field we want to investigate, in this case the subject of technology (Krogstrup and Kristiansen, 1999:54). We observed in two different classes during a project period and discussed our findings with the teachers. On HTX in Aalborg we observed at third-year level and at Kold College in first-year level. The interviews were conducted as semi-structured interviews with three different teachers from HTX in Aalborg. The teachers from HTX in Aalborg are selected based on two criteria: They teach technology subject and they have different professional backgrounds. The observations were subsequently used directly from the field notes and the interviews were transcribed - both for the use in the article.

PROBLEM-BASED LEARNING AS A FRAMEWORK

In Graaff and Kolmos (2007) Problem-based learning (PBL) is defined as a learning philosophy and a set of learning principles. Graaff and Kolmos (2007) and Kolmos et al. (2009) summarizes the main learning principles that can cross different PBL models in three approaches; learning - contents - social. The problem is the point of departure for the learning process. The problem creates the context and is central for the motivation of the student. Often problems are solved in time limited projects, with contents considered interdisciplinary and in groups where collaboration between students is necessary. In the groups there can be different degrees of participant-directed learning (Kolmos et al, 2009:11-12).
There are many different implementations of PBL. What works at Aalborg University does not necessarily work on HTX. Savin-Baden (2007) defines five PBL models or modes with six dimensions, and with inspiration from that model, Kolmos et al.

(2009:15-16) develops a model based on seven elements, that all need to be aligned in a PBL- curriculum (see figure 2-4).

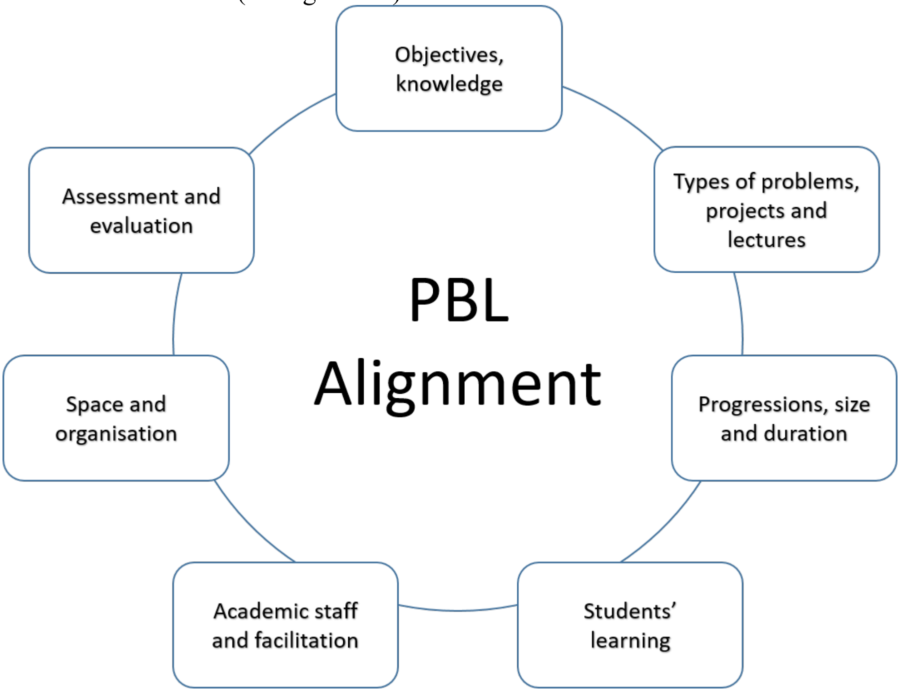


Figure 2-4 PBL-alignment of elements in the curriculum (Kolmos et al, 2009:15)

The alignment of the elements in the curriculum means that changing one element will result in a change in the other elements. Combining the model from Savin-Baden (2007) with the model of PBL-alignments result in a model with many variations of PBL in practice. The many variations in PBL-practices are indicated as seen in table 2. The discipline and teacher-controlled approach and the innovative and learner centred approach (student centred approach) are the two extremes with many points in between.

Curriculum element	Discipline and teacher-controlled approach	Innovative and learner centred approach (student centred approach)
Objectives and knowledge	Traditional discipline objectives Disciplinary knowledge	PBL and methodological objectives Interdisciplinary knowledge

Types of problems and projects	Narrow Well defined problems Disciplined project Study projects Lectures determine the project	Open Ill-defined problems Problem projects Innovation projects Lectures to support the project
Progression, size and duration	No visible progression Minor part of the curriculum	Visible and clear progression Major part of course/curriculum
Students' learning	No supporting courses Acquisition of knowledge Collaboration for individual learning	Supporting courses Construction of knowledge Collaboration for innovation
Academic staff and facilitation	No training Teacher controlled supervision	Training courses Facilitator/process guide
Space and organisation	Administration from traditional course and lecture-based curriculum Traditional library structure Lecture rooms	Administration supports PBL curriculum Library to support PBL Physical space to facilitate teamwork
Assessment and evaluation	Individual assessment Summative course evaluation	Group assessment Formative evaluation

Table 2 - Spectra of PBL-curriculum elements (Kolmos et al., 2009:16)

The above should be seen as a framework for PBL in higher education and the approaches that fall within this framework. Since the article's desire is to gain an understanding of the teachers' roles in relation to working with PBL in HTX we in the following work with four ideal types of teaching in secondary schools (Zeuner et al. 2007) to draw parallels to the above PBL-framework.

METHODS FOR TEACHING IN SECONDARY EDUCATION

Zeuner et al. (2007) defines four ideal working methods for teaching in high school. The communication (mediated) orientation of work, where the teaching is centred around the teacher as a representative of the knowledge - high teacher management. The dialogically oriented way of working, where the teacher is a participant in the learning process. The task-oriented way of working, where the teacher acts as instructor. Finally, the project-oriented way of working, where the teacher acts as a consultant (see table 3).

The Communication oriented **High Steering Distance Representative Classroom**	The Dialogically oriented **Low Steering Proximity Participant Classroom**	The task oriented **High Steering Proximity Instructor Study Room**	The project-oriented **Low Steering Distance Consultant Practice Room**
The lecture The exam (The oral exam) The exemplary experiment	The informal conversation Teacher talks with subsequent discussion Student presentation with subsequent discussion	Management degrees in relation to substance (e.g. questions) Management degrees in relation to communication (teacher-student conversations)	Degrees of management in relation to: - the length of the project - choice of material - problem formulation - product requirements -student-teacher-conversations during the process

Table 3 - Part of table with four ideal types of teaching (Zeuner et al., 2007:371).

Zeuner et al. (2007) mentions that the teacher types of working depend on the situation. The communication-oriented way of working seems to be most suitable when the subject is difficult - abstract, conceptual etc. (Zeuner et al., 2007:372). This way of working is what is considered as the more classical teacher role, whereas the project-oriented way of work is considered as a facilitator role. Regarding project-oriented ways of working Zeuner et al. (2007) comments:

> ’In relation to the 1st grade teaching that we have mainly followed, it becomes clear that the challenge for project work will be to establish the right balance between academic discourses and students' own learning processes’ (Zeuner et al., 2007:374).

Another argument that emphasizes this point is made in Jeppesen (2020) in relation to HTX where the degree of problem orientation is varying from teacher to teacher. Here the teachers do agree that the students have to do project work on their own, but they disagree of how much the teachers should control the process during project periods and introduce academic discourses or the focus should be more on students’ centeredness. The question of who is actually in charge of organising the project is thereby being raised. Is it the teachers or the students? And if the students are responsible, when should the responsibility be transferred to them? The teachers simply agree to disagree. However, what do we see in the classroom

IN THE CLASSROOM

FIRST-YEAR

Working with several teachers and observing in different classrooms on HTX we got insight into the various roles the teachers must take on to teach in the technology subject.

It became very clear from the beginning, visiting these two classes on HTX, that the teachers as part of their role in the classroom must be able to fill the role of a classic teacher and perform classic teacher-led classroom teaching which relates to the discipline and teacher controlled approach as described in table 1- in relation to PBL in higher education and to the communication oriented approach in table 2 - related to ideal types in relation to teaching in secondary school. It is especially clear in the beginning of the first year of the study programme where the teachers make use of classic classroom teaching more often than not in form of lecture etc. and thereby leaning towards a more teacher-controlled approach. When asked about if there is a difference in how much the teachers use different types of teaching approaches and thereby take on different roles as teacher teaching the technology subject a teacher answer:

> ‘Yes, less and less teacher management (...) We start with PU (Basic course in product development at the first year of the study programme) and we are actually there all the time (...) saying: ‘now you have to do this now you have to do that’. And then when reaching the second year of the study programme the good students, especially in the technical science subject, can manage it themselves (...) As I told you earlier when the students reach the third-year of their study they should be able to control it themselves (...) Then I should dare to let them work freely’ (Interviewee 3, 2019).

In the above quote the teacher expresses his way of teaching and thereby also showing that the roles he takes on teaching changes over time. At the beginning of the first-year of the study the teaching is very teacher-controlled (table 2) and communication oriented (table 3) and the teacher thereby takes on the role of a *classic* teacher using a more teacher centred approach. The teacher tells the students what to do and when to do it. It is also expressed in the quote how that all changes during the second-year of the students’ study where the strong students figure out how to manage doing project work themselves. Further, in the students third-year of study all of them should be able to control the project work themselves and the teacher should dare to let them do so; thereby accepting the role as a *facilitator* creating a room for an innovative and learner centred approach (table 2) or a project-oriented approach (table 3) which aligns with the underlying PBL principles in the technology subject.

That fact that the teachers take on the role of *a classic* teacher teaching first-year students is further emphasized when visiting a second school. The teacher in the class we are attending is preparing to teach the students' some theory which they will need later to write their projects and develop their products and then the following happens:

> 'The teacher sets out with very classical teaching-led teaching from the start of the lesson. Today's topic for the lesson is sensory theory and basic tastes, logbook, collaboration contract, groups and Adizes four leadership roles. The teacher starts out with showing the students a program about how to retrain the sense of smell. Afterwards the teacher follows up on whether or not the students have read the material for today's lesson by asking the class directly. Two students raise their hands. Subsequently, the teacher embarks on a thorough review of sensory theory including the five basic flavours; sour, sweet, salt, bitter and umami' (Field notes, 14.11.2019).

From the field notes it is clear that the teacher in this classroom accepted the role as a *classic* teacher and thereby, using a teacher centred approach as the teacher controlled the teaching communicating, in this case sensory theory, to the whole class and leaving room for the students to approach the teacher and the rest of the class and ask questions if needed. It also seems the teacher takes on this role as, when asking the students, only two of them have done their homework and read up on the theory for this specific lesson. Then it seems even more pertinent to give the students a thorough review of the theory as they cannot move forward in the process of their project work without it.
It seems that there are also other reasons as to taking on the role of a *classic* teacher and using a teacher centred approach, then having to repeat material to the student, as they did not prepare from home. One of them is teaching inexperienced first-year students. This is expressed by a teacher in the below quote:

> 'We also have a great challenge when we give the students a project (...) of a three months duration (...) the students cannot grasp it (...) so you have to rush them all the time (...) And that makes it more or less teacher-led and not really project work' (Interviewee 1, 2019).

In the quote the teacher mentions the duration of the projects the students have to work on as a reason why he falls back on the role of the *classic* teacher when working in the technology subject. The students can't grasp or oversee projects that last for months at a time and he as a teacher then has to push the students to finish making it more teacher- led that actual project work as is the intention in the subject. It is also implied that the teacher functions as a *safety net* for the students when rushing them to finish all the elements contained in the projects to make sure they are able to hand in. Another thing that influences the role of the teacher and the teaching method being applied in the classroom is the general formation of the students. In the following quote it is emphasized just how much focus there is on that in the students first-year of study: *'There's a lot of focus on general formation at the first-year level'* (Interviewee 5, 2019). When entering a technology class, at first-year level it is very clear that the teachers have the role of an *educator* e.g. in terms of keeping the level of noise in the classroom down to a minimum. A role that seems to be characterised by a more teacher-controlled approach (table 2) or communication-oriented approach (table 3). A conversation between a teacher teaching technology at first and some of the students visualises the role of an *educator* very well. In this specific example the teacher notices a group of students standing across the room talking to other students when they should be working on their own projects and the teacher initiates communication with the students:

> 'What are you doing over there?' (...) We are helping with the timetable (students) (...) Okay so four is helping three? (...) Yes (students) (...) Okay I think you should go over here again' (Field notes, 14.11.2019).

In the conversation between the students and their teacher the teacher advised the students to go back to their own seats instead of hanging around some of the other students that are still working on their timetable and in doing so the teacher is trying to affect the students' behaviour in the classroom by taking on the role of an *educator*. This is done in a more direct tone when the teacher presently has assumed another role. In this case the teacher has taken on the role of a *classic* teacher, teaching the class from the blackboard, but feels the need to step out of that role because noise starts to spread across the classroom and to stop the noise the teacher says to the whole class: '*You have to look up here now*' (Field notes, 04.12.2019). Further she adds comments for specific students not paying enough attention: '*Martin sit down*' and '*Jonas you are smiling you are not listening*' (Field notes, 04.12.2019) and in doing that shifts to the role of an *educator* before returning to the role of the *classic* teacher. In the first-year of the students' study the teachers also feel they have to do a lot of scaffolding: '*There is a lot of scaffolding at the first-year level. At the second- year level it is much easier. Then you say brainstorm and then they know what to do*' (Field notes, 04.12.2019). The teacher here is indicating that there is a lot of scaffolding to do in the students first-year indicating that the teachers have a role as the students' *safety net* making sure the students acquire the set of competences they need to be able to continue their studies. After the first year it changes as the students then know many of the concepts and methods used in the subject of technology.

SUMMARY FIRST-YEAR

From this first part of the analysis it is clear that a large part of being a teacher teaching the subject of technology in the first-year on HTX is handling a hybrid set of teacher roles such as; the *classic* teacher, the *educator* and the *safety net*. All of which are very teacher controlled and thereby can be identified as a more teacher-controlled approach or communication-oriented approach. At the same time, it is identified that there are different reasons as why the teachers take on these roles. Some of these reasons seem to be; the students are not experienced in doing projects yet, the students need teaching in theory and methods relevant to their projects, the students do not always prepare for the lectures and the students still lack the general formation related to attending an education in secondary school.

THIRD-YEAR

Starting up a project in the students third-year of study takes place differently than the previous years. Below is a description of an observation from a third-year class where they are just about to start up a new project period. This project period covers the last project they will have to do while attending the Danish higher technical examination programme:

> 'The teachers start out by laying out the outlines for the coming project period. Afterwards the teacher emphasises that she now longer is their teacher but only takes on the role of supervisor. Subsequently, the students withdraw to their groups and start working' (Field notes, 03.02.2020).

The teacher therefore in the beginning of the lecture expresses explicitly to the students that her role has changed from the previous project periods. In relation to this last project they have to do the teacher is no longer the teacher implicating that the students should have learned everything they need to know by now and that they now have to prove that. The teacher can therefore no longer take on the role of a *classic* teacher. Instead the teacher, for this last project, will take on the role as a *supervisor*. Thereby the control of the overall project is shifting from the teacher to the students. In the observations from the field notes it is also shown that the students accept that shift of the control willingly and are taking on the responsibility.
A similar statement is made by another teacher in a another third-year level class:

> 'All the students meet in the class in the morning. Eighteen students showed up. Subsequently, the teacher states that the students themselves are masters of their own time in relation to the project. The students manage their projects themselves and ask if they need help' (Field notes, 05.02.2018).

When the students reach the third-year of their study it is very evident that the focus has changed from a more teacher-controlled approach to a more innovative and learner centred approach or a project-oriented approach with low steering from the teacher. This is both evident when looking into the classrooms but also in the questions asked by the students. In the below observation from a third-year technical science class a small detail on the black board makes it clear that what is happening in this classroom is no longer teacher-controlled: '*On the board is a list of groups that need help from the teacher*' (Field notes, 06.04.2018). The students now have to keep track of - and ask for supervision themselves when they need it. The students are now more actively defining the teacher role. The teacher in this class is taking on the role as a *facilitator* letting the students be in control of their own projects.
At the same time, it is also clear that the teachers at the students third-year of study hold back and are very conscious about how much technical information they provide the students with and how much the students gather for themselves which is illustrated in the below quote:

> ’Now you have asked something and I have answered a little too much (Teacher) (...) That has been seen before (Student) (...) Yes, it has been seen before. That's because I get caught up in it (Teacher)’ (Field notes, 06.04.2018).

The teacher is very conscious about the fact that he/she is taking on the role as a *technical wizz* helping the students answer technical questions they themselves should find answers to and at the same time also about the fact that he/she is not taking on the role as a *facilitator* like the teacher should as the students actually can handle a lot themselves at this stage. At the same time the students are also conscious about it and seem to know that the teacher sometimes gets caught up in answering their questions and find it somewhat enjoyable as the comment; ‘*That has been seen before*’ is said with a big smile on the students face. The fact that the teacher is very aware that he/she digs too deep and explains too much when the students ask questions also emphasizes the next quote where another teacher expresses the following; ‘*The attitude is that the students should have learned it by now. If not, it's too late*’(Field notes, 05.02.2018). What is expressed in this quote is that in the third-year of the study programme the students should have learned by now what they need to know to write a good project and create a good product. Even so it seems there is a paradox between knowing the students should know what they need to know to do project-work and what is expressed in the quote before about answering a little too much on the students’ questions and to that a teacher adds; ‘we *can't just let the students crash and burn here either’* (Interviewee 3). In the quote the teachers express a paradoxical situation in which it is implied that they as teachers are caught between the choice of acting as a *safety net catching the students when they fall* or letting them *crash and burn* when doing project work.

SUMMARY THIRD-YEAR

From the second part of the analysis it is clear that a large part of being a teacher teaching the subject of technology in the third-year on HTX is about handling another hybrid set of teacher roles than when teaching the first-year students. Some of the roles the teachers have to take on when teaching third-year students are; the *supervisor*, the *facilitator* and the *safety net*. The first two roles; *supervisor* and *facilitator* are very innovative and learner centred or project-oriented where the students are controlling the projects themselves. The difference from the first- to the third-year is that the roles seem to be taken almost automatically by the teachers and the attitude is; ‘*that the students should have learned it by now. If not, it's too late*’ (Field notes, 05.02.2018). The one role that is still taken on by the teachers in the third-year is the role as a *safety net*. So even though the attitude is that students should know the material by now and if they do not it is too late the teachers in the utmost consequence still function as safety nets for the students - they step in and help if needed.

FINDINGS AND DISCUSSION

What can be seen from the findings in the classroom is that the teachers' role changes very significantly during the three years from first grade to third grade. Compared to table 2 and table 3 there is a movement from left to right in the tables. A move from a classical teacher role to a role that very much is the facilitator role. At the third grade the students know what to do. They know what is expected, when the teacher says 'brainstorm' etc. Still the teachers are caught in a dilemma. Shall they catch the students when they fall or let them crash and burn? That dilemma can be related to table 1 and the alignment of the curriculum in a PBL environment. On HTX the students are not responsible for their own learning, like they are in the higher educations. PBL in higher education is characterized by a student-centred approach whereas in an HTX context it is generally more teacher centred. On HTX it is the teacher that is responsible for the students learning. It is clear when we observe a class where the students did not prepare for the project work. Then the teacher immediately switched for the facilitator role to the classical teacher role. How about preparation for the next time? Do the students read the text or wait until the teacher gives a lecture? Moreover, the alignment of the curriculum is important compared to the different maturity levels of the students. The students in the first year cannot grasp a project duration for three months. It is too long. Whereas for third year students it may not be a problem. The role of the teachers needs and the curriculum need to be aligned with the point of departure of the students. Besides switching between the division of the teachers working areas in table 3 covering from the classical teacher to the project-oriented teacher - facilitator, the teacher in HTX has other roles. Roles that are more social related or technical oriented like the social worker, the educator, the technical wizz, the practical helper, a master role in the workshop and not least the safety net. Roles that cannot be ignored looking at the overall teacher responsibilities in HTX.

What about students in higher education using a PBL learning philosophy? Are the findings in this paper comparable to students in higher education or is it two different worlds? When students enter higher education like AAU they start working in a PBL environment. Students who have studied on HTX are used to the challenge of working problem based. But what about students from other secondary school institutions like STX or HHX? They are not used to the PBL environment. When they enter the university the role for the teachers has changed totally. Now it is a facilitator role and the responsibility for learning has become student centred. The transition from secondary school to the university can be very hard for students not used to the PBL environment. Moreover, the mindset from the different students in a programme at the university cover the same range of PBL understanding as we have seen in table 1. That situation is comparable with the situation of the teachers on HTX, with a very significant difference. On HTX the teacher is responsible for the students learning which put them in a strong dilemma in a PBL context. They are not 'allowed' to let the students crash and burn.

CONCLUSION

The focus of the paper was to draw out empirical findings to clarify the breadth of the hybrid role of the teachers when teaching the technology subject on HTX. The findings did support that the teachers on HTX have a very complex and wide role. A role that changes from teaching first year students to teaching third year students and also a role that changes depending on the strength of the individual students. In relation to this it was found that the teachers not only have to shift between teacher-centred and student-centred learning (and the ones placed in between) the teachers at the technology subject also have to take on many other different roles ranging from the social worker and the safety net to the practical helper and a master in the workshop. Moreover, it became obvious that the role creates a dilemma for the teachers, trying to use PBL as a learning philosophy, however with a teacher centred responsibility for the students learning. This dilemma tends to be a restriction for the teacher in their teaching. They are not allowed to let the students crash and burn and the expectation from the students is that the teacher will be the security net in the end. Looking at figure 1 and the need of alignments of the elements in PBL calls for a clear support for teacher training to be able to work with this hybrid role. With recognition and knowledge of the hybrid role of the teachers of the technology subject on HTX in more detail it is possible to identify some avenues for future pedagogical development of technology teaching on HTX.

At the same time - knowledge of the role of the teachers teaching the subject of technology on HTX in more detail and that being of a very hybrid character is valuable knowledge for the teachers and supervisors teaching at the first semesters at Aalborg University. With that knowledge it is possible to adjust the facilitation in the PBL environment to the different point of departures regarding first year students coming from HTX, STX and HHX.

3.3. BILDUNG

In the technology curriculum, the terms competencies and Bildung are both used but as different entities with different meaning. The reason I focus the term *Bildung* in the thesis instead of competencies, is that *Bildung* represents a much wider concept, while study competencies are understood as the students' real prerequisites for completing higher education with good results. The original German meaning is image (*Bild*), or created after an image, but here it is used as a metaphor for education and the formation of a person's character, most often in an enlightenment context (Nepper Larsen, 2013). If a student is *Gebildet*, they have been through a process of education in which they have become enlightened. Therefore, the concept contains both the process of formation and the result of that process (EVA, 2019). *Bildung,* as understood in connection with the subject of technology, was described in section 1.4.6: Study competencies. With the definition of study competencies in mind, it becomes clear in this section why the concept of *Bildung* is a more comprehensive concept to use in connection with the project.

In the following article, the *concept* of Bildung as it is understood and conceptualised in HTX education is examined. The question is; are the students actually able to reach the goals of the Ministry of Children and Education, Ministerial Order and achieve the kind of technical *Bildung* and study competencies they need for further higher education?

3.3.1. BILDUNG AT THE DANISH HIGHER TECHNICAL EXAMINATION PROGRAMME

This article is in review at *NorDiNa (Nordic Studies in Science Education) as:* Jeppesen, M.M. & Henriksen, L.B. (2020) *Bildung* at the Technical High School (HTX).

This article investigates the concept of *Bildung* and the way *Bildung* is achieved in Danish technical high schools. We do that by first defining the kind of *Bildung* mentioned in the Ministry of Children and Education, Ministerial Order for Danish technical high schools. In the second part of the article we will compare interviews from first-year students to interviews with second and third-year students. The purpose of this article is to determine whether we can detect or trace whether youngsters entering technical high school have the possibility of reaching the goals of the Ministry of Children and Education, Ministerial Order and thereby achieving the kind of technical *Bildung* and study competencies they would need.

In recent educational debates, the concept of *Bildung* (*dannelse* in Danish) has repeatedly surfaced in the Danish press (Kristeligt Dagblad, 2012; Altinget, 2018; and many others). One of the recurrent features of this debate is the contrasting of *Bildung* and disciplinarity (*faglighed* in Danish. See Nepper Larsen, 2013). Those in favour of *Bildung* see the increasing demand for disciplinarity as a threat to the general *Bildung* (formation of character), and those wanting more disciplinarity see all the noise about *Bildung* as an attempt to lower the standard of teaching. What both parties can agree on is that the standards *are* lowered, both in terms of disciplinarity and *Bildung*. Both positions are tales of decline, a kind of nostalgic longing for the good old days when only 5% of all youth went to high school. Problems of these debates include the rather confusing conceptions of both *Bildung* and disciplinarity. It seems that both concepts can mean whatever the participants in the debates want them to mean, and this makes these debates a rather frustrating read. Both positions contribute very little to the future development of teaching and learning, both on the level of individual schools and more generally in the debates about the entire Danish educational system.

In this paper we take a closer look at technical high schools (HTX), upper-secondary level education that prepares students for entry into higher education, especially in science and technology. The Ministry of Children and Education, Ministerial Order for the HTX subject of technology clearly states that upper-secondary-level education has a dual purpose: general *Bildung* and to prepare students to enter higher educational institutions.

THE MINISTERIAL ORDER: THE GENERAL LAW §2

> The subject (*faget* in Danish) gives student elements of a technological formation (*dannelse* in Danish, *Bildung* in German) through an understanding of the interaction between technology and society, as well as a critical sense and ability to solve practical and theoretical problems. The subject's problem orientation develops an understanding of how technological knowledge is produced through analysis and synthesis in an overall process. The subject's working methods contribute to students' general study competencies, as they gain experience with study and working methods that are relevant in higher education, including self-employment, both individually and in collaboration with others pcs., 3. Education must have a *Bildung* perspective, with an emphasis on the development of pupils' personal authority. Students should, therefore, learn to reflect on and be responsible to their surroundings – fellow human beings, nature and society – as well as their development. The programmes must also develop students' creative and innovative skills and critical sense.

Big words, but what do they mean? Are these very ambitious goals really achieved through three-year upper-secondary education?

The Ministry of Children and Education, Ministerial Order set some very ambitious goals for teaching and learning: technological *Bildung*, critical sense, ability to solve practical and theoretical problems, and so on. These are all things that we refer to in this article using the German concept *Bildung*.

A recent report about the development of disciplinarity in general high school education (STX) over the past 50 years concludes that curricula have changed over time from very discipline-oriented teaching to broader learning goals emphasising students' understanding of their subjects and a greater emphasis on what we call modern *Bildung,* and less reproduction of curricula (EVA, 2018). However, the present study is concerned with the intended learning goals as they are found in the Ministerial Order, not the actual outcome of the teaching and learning, as it would be impossible to investigate actual outcomes from 50 years ago.

In this paper, we will take a closer look at *Bildung* in technical high schools. The concept of *Bildung* is rather ambiguous in previous studies. Therefore, in the first part of this paper we will explain the kind of *Bildung* mentioned in the Ministerial Order. In the second part we will compare interviews from first-year students to interviews with second and third-year students. We are aware that any comparison between 15-

year-olds and 18-year-olds will show differences, perhaps even huge differences. These formative years are important in anybody's life. A point of significance here is that it is not the same 15 and 18-year-olds who were interviewed; that would require an interview with the same students in their first, second and third years. We do not know if the first-year students will be as reflective – as *Gebildet* – as the third-year students we interviewed, and we do not know whether the third-year students already knew the things they communicated in the interviews when they started at technical high school. It would have been preferable if we had been able to follow a group of students all the way through their high school years. The focus of this article, however, is whether we can detect or trace the kind of impact teaching and learning in high school might have on students, which does not necessarily require that we follow them over their three years of high school to see if they achieve their ambitious goals.

BILDUNG

Any analysis of the German concept *Bildung* will face the problem of translating it into any other languages (Henriksen, 2006). Translation into Danish is relatively unproblematic, as we can use *dannelse*, literally meaning formation or creation. Translation into English is more problematic. The original German means image (*Bild*), or created after an image, but here it is used as a metaphor for education and the formation of a person's character, most often in an enlightenment context (Nepper Larsen, 2013). That is, if one is *Gebildet*, one has been through a process of education in which one is enlightened. The original German term means both the process of formation and the result of that process. The term has variously been translated as cultural formation, formation of identity and formation of character, but none of these capture the full meaning of the concept.

Bildung is an old concept. In medieval mysticism it was described as a picture of God within man found through prayer and study of holy writings. The concept is best known from the enlightenment, when *Bildung* was described as a process of liberation from superstition and ignorance. In that case, *Bildung* was restricted to a certain stratum of society: the upper classes and scholars. This is also behind our current definition, in which *Bildung* is understood as a special gentlemanly behaviour, in which a person possesses a noble character and good manners, knowledge of the classics, a good education; a cultured person developed after an ideal. This ideal is reached through many trials, such as higher education, journeys to foreign countries ('the grand tour', or *Dannelsesrejse* in Danish), a lot of reading and so on. The end result of this process of *Bildung* is a person who has realised his potential (it is most often a he) and found an identity, has found himself and has become a 'self', and is therefore also ready to take up important (and well paid) positions in business, politics or public administration. In this instance, *Bildung* is a marker of class, where one can distinguish oneself from others through behaviour, dress and, most importantly, language (see *Pygmalion* by George Bernard Shaw (1912/2003), for example).

This somewhat narrow interpretation of *Bildung* is not comprehensive enough when dealing with present-day education. Here the question to be answered is: What kind of *Bildung* will students get when they attend high school? They are, no doubt, *Gebildet*, but how and to what extent should we interpret *Bildung*?

MODERN BILDUNG

> '*Bildung* processes bring us from being one with a given practice to separate ourselves from it, so that we are able to view it from the outside, problematise and reflect on it, to finally be able to return with a deeper understanding, appreciation or development of the practice that was the starting point for the formation. The formation processes become possible when an established practice meets a resistance whose overcoming involves the work of doubt, the effort of thought, the judgment of prejudice. We are formed as cultural creatures through the myriads of these processes in the family, and among playmates, institutions, schools and clubs, in the streets and in the workplaces, in the parties and associations. Formation is not a privilege for the 'Gebildet', it is the process through which we acquire our culture' (Højrup, 2002:541).

This quote from Højrup's *Dannelsens dialektik* (*The Dialectics of* Bildung; Højrup, 2002) strikes on a lot of the themes connected to the concept of *Bildung,* and forms a foundation on which we can base our analysis. We should look for signs that the students are able to separate themselves from their practice, look at it from outside and reflect upon it. Reflection is essential here. Reflection means to bend back (re-flex), so in this case to look back on ourselves, to think about our own thinking (Henriksen, 2010). Are students able to reflect upon their own practice and return to it with a deeper understanding? Have they met resistance that will make them doubt and try to overcome this doubt? Have they, in this process, challenged and changed their worldviews? If we can show this in the interviews – the ability to reflect a deeper understanding and the ability to view one's own practice from the outside – then we might be onto something.

Højrup's description of *Bildung* is in line with Gadamer's (1992:9). Here, *Bildung* is first described as the goal for the humanities, in contrast with the goals of science, which is described as truth seeking through known and tested methods. This will not work for the humanities, as there are no universal 'scientific' methods that can create a clear truth in any project within the human sciences. Instead, the aim of the humanities is *Bildung*: the creation of a self that has the ability to understand the universal in a situation and abstract from the particular, that is able to reflect, be social (Phronesis), can limit immediate impulses and has the ability to work (such as through training in a tradition through apprenticeship, a university bachelor's or master's programme, or through technical high school), development of an independent personality, to become an able and conscious citizen.

The Ministry of Children and Education, Ministerial Order states that the kind of *Bildung* that is the goal of the technical high school is 'technological *Bildung*'. However, nowhere in the Ministry of Children and Education, Ministerial Order is it, however, explained whatever that means. But we could follow the previous description of *Bildung* and conclude that the aim of education is to develop an independent personality, an able and conscious citizen *in relation to technology*. Here we could follow engineer Mike Cooley who, in his book *Architect or Bee?* demanded that engineers should be able to consciously create and relate to technology. In his acceptance speech at The Right Livelihood Foundation he said,

> 'Science and technology are not given (…) It was made by people like us. If it's not doing for us what we want, we have a right and a responsibility to change it (…) We need a clear view of what we want from science and technology and the courage to stand up and do something about it' (The Right Livelihood Foundation, 1981).

This could form the basis of our quest for technological *Bildung*: distancing oneself from one's own practice (in this case, technology), reflect upon it, be critical and work with others to achieve the goal set for the work on technology.

The question is now whether the three-year education of technical high schools makes it possible for students to achieve the kind of technological *Bildung* described above; whether they can become able, critical and conscious citizens in relation to technology. We conducted interviews with students in their first, second and third years of study, and in what follows we analyse the interviews to see whether it is possible to trace the kinds of changes that students undergo during their time at technical high school. In this way, it is possible to trace the effects of school, knowing that teenagers have many other influences, as Højrup mentions.

ANALYSIS - DEVELOPMENT IN A LEARNING PROCESS

Working with the interviews, especially thematising them, gave us insight into the students' thoughts on what they learned during their time at technical high school, and to what extent this can be called *Bildung*. One theme came to mind as it runs through all of the interviews: development in a learning process.

In all the interviews we conducted, the students expressed their thoughts on how they developed as students during their technical high school education. These thoughts were on different topics but all were centred around the personal development they went through while studying. One thing that facilitates this development is PBL, a focal learning principle in the technical high school study programme. PBL is introduced to students very early in their study as a method for working through problems in projects. Not all students are fond of the method in the beginning, though. In the following quotation, a first-year student expresses how hard he thinks the process of developing in a new environment is:

> 'I'm being challenged by it, but I don't really feel like I'm moving (…) As I said, I'm not such a big a fan of the teaching method (…) I find it very difficult to learn

> that way (…) I like being told what to do and afterwards I can use it myself, but that is my comfort zone (…) It is necessary to expand your comfort zone because then you have to get out of the comfort zone and I do get that from it' (Interviewee 1, 1st year:2).

The student talks about being challenged through being introduced to a new learning environment in which he finds it very hard to learn. This seems to be linked to the student's previous experience in primary school, as he states: 'I like being told what to do' which is often also the case when talking about classic classroom teaching. It seems as though the student is almost resisting learning through the new learning environment, and thereby developing through it, or a least he might see it as challenge to be forced out of his comfort zone. He acknowledges the necessity of getting out of his comfort zone and shows he knows he should embrace development as it is important, but he does not think he is moving by working in a PBL environment. This resistance could also be seen as the student not really wanting to expand his worldview and thereby acquiring Bildung. It could also be argued that the student is not reflecting on PBL and why he thinks it is hard to learn that way, but merely stating that is how it is and therefore he is not looking beyond his own worldview. This perspective seems very common among first-year students, as many struggles with the change in learning environment from primary school to technical high school. Many seem to get the hang of the difference when starting their second year of high school. This became apparent when I conducted interviews with second-year students. Here perspective had changed. The learning environment at technical high school revolves around PBL, which is used not only as a new method that the student must apply but one that provides a sense of freedom, combined with security, as expressed by the following student:

> 'Generally, the degree of freedom when being taught this subject is very high and yet it is the case that you have something precise to work with (...) that we get a topic and then we are like now you control yourself what you want here' (Interviewee 5, 2nd year:12).

This student reflects on the advantages of the learning environment and the combination of having the freedom to make choices on his own with what to him is the advantage of classic classroom teaching: precise guidelines. He seems to like to have something tangible to hold onto while working on projects, which could indicate that, even if the struggle of a changing learning environment has settled, he still looks to known methods to get by. This student, even though he draws from different methods, shows that his view on the learning environment has changed as he compares and combines classic classroom teaching with the PBL environment at technical high school. He also shows the ability to reflect on his own practice by viewing it from the outside, as Højrup (2002) states, and manages to expand his worldview.

When interviewing a third-year student, the expansion of her of worldview becomes even more apparent than with the student in the above quotation. She manages to reflect on the whole process of working with projects and comparing the possibilities of problem-oriented study to working with projects in primary school, which had its limitations:

> ‘The whole process of starting with an overall theme or topic and then working your way forward until working with a tiny thing (...) often a project lasts maybe a month or two (…) and you skip some parts because you don’t really have time for it, but here (at technical high school) you have (…) had time to familiarise yourself with it because you have had so many hours (to work with it) and I think that’s nice that you just got a bit further with a project than you would otherwise have had time for’ (Interviewee 3, 3rd year:3).

This student reflects on the issue of time and the possibility of familiarising herself with the project material. The struggle to become familiar with the learning environment at technical high school does not concern this student.

The above quotations are representative of technical high school students. First-year students often struggle to get used to the new learning environment and working with problems, but during the first and second year they get better at grasping what it means to work in this learning environment while still applying familiar methods. Over time, students learn and develop to a point where they are able to expand their worldview. This also fits with Lev Vygotsky’s (1979) point about how learning draws on development. Their expansion of worldview becomes very visible when students are in their last year of high school, when they are able to reflect.

Another aspect that facilitates student development at technical high school is working in groups, which is a big part of studying in a PBL environment. The students normally work in smaller groups: three to four students per group of their own choosing. In some projects, especially within the first year, teachers choose the groups. This creates challenges for some groups regarding collaboration and leaves students to figure out their own role in group work and how to participate. As a first-year student stated:

> ‘If you are good at it then you have to make sure not to just run on your own. You also have to bring the others along. If the others do not really do anything, then you must make sure that they (…) are assigned some tasks and get deadlines for when they must be finished, otherwise nothing will happen (...) If you are too good at it get them on board instead of just running off (…) and if you are not so good at it then try to participate as much as possible (…) and ask: Can I help with something? How does this work?’ (Interviewee 1, 1st year:5).

Here, the student specifically elaborates on how, as a student, to find your own role during a group-work project. He expresses his awareness of the fact that students are often on different levels: some are greatly interested in a topic while others are not. There is also the issue of getting a feel for the learning environment. For many students, working in groups is fairly new and they have not done so much before attending technical high school. They must figure out how to contribute to the group work in the best way possible. This could be seen as trying to learn and develop through the learning environment and trying to expand their worldview by reflecting on their practice. As the abovementioned student stated: 'If you are good at it then you have to make sure not to just run on your own. You also have to bring the others along. If the others do not really do anything, then you must make sure that they (…) are assigned some tasks and get deadlines. This student is thinking about his own role and how he can best participate in group work. He focuses on his own practice and how he relates to group work, so it could be argued that he is not digging deep enough to actually reflect on or expand his own worldview.

When talking to a second-year student, the perspective on group work and how it could be handled for project work widens. In the following quotation it becomes clear that the focus has shifted from one that only looks at the process from the student's perspective to the student being able to reflect on the whole process and the benefits for the whole group:

> 'In regards to how important it really is that you (…) sit down and get tasks delegated (…) at least in the beginning (…) of 1st year where we were not (…) so independent (…). The groups they were very (…) planned where you sort of thought: Well then, I'll do it myself. I can see now that when you are four guys sitting together (…) then you get something done that is better' (Interviewee, 2nd year:1).

This student, when looking back on his first year at technical high school, can see the benefits of the group delegating roles together within the group work setting. It seems that he learned a lot about working in groups in his second year of study, and has gone through quite a bit of development. He further reflects that it now makes sense to him that working together in a group can create a better project than working alone: 'I can see now that when you are four guys sitting together who all look (…) then you get something done that is better'. He is reflecting on both new and former practices, and it is clear that he personally learned and developed. Therefore, he has extended his worldview, as it is described by Højrup (2002). The more you work in groups, the more you get a feel for it and understand the benefits of doing so, which the above quotation emphasises.

In the following quotation, a third-year student pushes this understanding further by articulating how students not only learn in a classic classroom setting but also through self-learning and by learning from each other during group work:

> 'Right now, I have (…) technology, which I have chosen (…) at an A-level as an elective subject (…) and we have worked with a project since the autumn holiday. In that way there is not much learning as in a classic classroom setting but there is a lot of (…) self-learning in the group, but that is also something you (...) can get from

> (…) others because I was together but with other students from the (...) innovation class, and they knew some things they could teach me, so in this way we also learned from each other' (Interviewee 3, 3rd year:2).

This third-year student is expressing her thoughts on how students learn at technical high school. Even though there is not much classic classroom teaching, they still learn. She emphasises self-learning and learning from each other via group work. This student demonstrates that she knows the difference between classic classroom teaching and working in a PBL environment, and now sees that both teaching environments accommodate learning but in different ways. The student gives an example from her own group work: 'I was together but with other students from the (...) innovation class, and they knew some things they could teach me, so in this way we also learned from each other.' The student reflects on former ways of learning, learning through group work and from other students, and expresses herself in a surprised tone that suggests she did not anticipate this at the beginning of her study. She shows that she developed a lot through the learning environment at the technical high school, and that she was able to expand her own worldview.

The above quotations reflect common sentiments among technical high school students. Most first-year students struggle to become familiar with working in groups. It is a struggle for many as it is a very different way of working than most of them are used to from primary school. During the first and second year, they do gradually get better at understanding what it means to work in groups, and start to see the benefits of working with other students on a variety of projects. During this period the students learn a lot and develop accordingly. The capability of the students to expand their worldview becomes more evident when they are in their final year of high school. At this time, the focus is no longer on how to work together or to structure group work, as their perspective has expanded to revolve around learning from different perspectives, and the benefits that can be gained from that.

During the interviews, the students also mentioned language, particularly that they develop quite a bit during their education at technical high school. Language should here be understood as becoming familiar with the language of the school and being able to use it both within and outside the educational institution. For first-year students, the focus when talking about language is very much on getting an understanding of the language used at school, both overall and with the more technical terms.

In the following quotation, Kristian express an understanding of the need to know the language used at technical high school, developing his own vocabulary and language, and thereby learning something new:

> 'I'm not so good at using technical terms. I practice using them in my language every day, but it is hard, and I've also been told in the different subjects to use a bit more technical terms (...) My vocabulary is just not that big. I try (…) to expand it by learning different words from texts and (…) really understanding them so I can

use them in my language, but sometimes there are words that just go in one ear and out the other (…) So if I read a text I don't understand, it just runs like that (student makes a noise)' (Interviewee 1, 1st year:6).

This student explains how he tries to expand his vocabulary but that it does not always work for him. He really tries to learn and develop his language but it is a struggle for him. As he explains, he tries to learn different words but cannot always remember them, thus illustrating the frustrating aspects of learning something new. This first-year student is really trying to expand his own worldview. In different subjects he is being told that he should use more technical terms and thereby expand his vocabulary, but it is difficult for him. This could be seen as an indication that he is not succeeding in expanding his worldview. In the following quotation, the second-year student quoted is more confident in the development of his language over the first couple of years at technical high school:

'In regards to Danish I think I have got a bigger (...) vocabulary (...) I have started talking more and nicer (...) than what I used to do' (Interviewee 7, 2nd year:4).

Here, the student focuses on looking beyond feeling an improvement in his language. He has acquired a bigger vocabulary and is better-spoken. This student seems to have learned a lot during his first year at technical high school. It can be argued that this student has expanded his own worldview as he reflects on his larger vocabulary and the results of this. He is a third-year student and his confidence are discernible. In the following quotation, Camilla seems very confident in the fact that she developed her worldview, vocabulary and learning and understanding:

'In Danish (subject) I have of course (...) developed in terms of vocabulary and understanding, one learns quite a bit, thus it is more formation (...) you learn in the Danish subject rather than (…) analysing a lot of texts (…)' (Interviewee 3,3rd year:9).

She expresses her thoughts on the development of her vocabulary as something natural, which can be seen when she says, 'I have *of course* (...) developed in terms of vocabulary'. Her thoughts on her development are a sign that it has become tacit knowledge. She also reflects on the fact that she thinks one develops more from the subject of Danish than just vocabulary and understanding: 'it is more formation (...) you learn in the Danish subject rather than (…) analysing a lot of texts'. This illustrates that she has expanded her worldview quite substantially. She is very aware that students do not just learn new words and how to use them, but that they undergo a general formation of character: *Gebildet.*

While conducting interviews with the students it was also often mentioned that the concept of communication is hugely significant to how students learn at technical high school, specifically communication from teachers to students. How teachers communicate the curriculum is most important. This relates both to classic classroom teaching, which is sometimes used at technical high school, and the PBL approach.

When talking to first-year student Kristian it became clear how much good communication between teachers and students means to him. He needs the teachers to:

> 'Really makes it short, simple and easy to understand. Retaining the understanding firmly through the whole lesson and not getting on too many side tracks (…) I am a big fan of that (…) There are some teachers who wrap it up a little and I really have trouble unwrapping it again (…) and understanding it' (Interviewee 1, 1st year:8).

This student expresses how he prefers that the communication of the curriculum between teachers and students is simple and easy to understand. He does not appreciate teachers getting side-tracked when talking in the classroom, and he needs clarity in the teaching to be able to follow it. This student prefers classic classroom teaching where students are told what to do, and has a hard time getting used to the PBL environment (also evident in other statements from this student). It also seems that this student is struggling with learning and developing within the learning environment of the technical high school. He does not manage to expand his worldview and reflect on his own practice by viewing it from the outside, as described by Højrup (2002), but merely states his likes and dislikes.

Talking to a couple of second-year students, it became clear that they have some of the same thoughts about communication as the first-year students. However, they manage to reflect on both teaching, the PBL environment and the writing of projects:

> 'Some teach better than others, but (…) there is clearly an attempt to do it well. You can also say (…) there is also a syllabus you have to go through, (…) but the fact that you sit and do a lot of function tasks (…) and then finish off with a project where you actually can picture things from everyday life, it has certainly helped make it a bit more fun (…). Then it is more fun to learn and I also think there are many who are a little more (…) motivated and a little more interested in it (…) because it is something you can relate to.' (Interviewee 4, 2nd year:5).

This student emphasises that he is aware that all teachers are doing their best in regards to teaching, but that, in his opinion, they are not all good at teaching and communicating the syllabus. This could mean he has already got used to being in the PBL environment. He does not need anybody to tell him what to do, and when the teachers attempt a classic classroom approach, it is not sufficient for him. This could be interpreted to mean that he does not learn enough that way any longer. Instead, he favours combining calculations with bringing them to life by putting them into a project, saying, 'you actually can picture things from everyday life'. This makes learning more fun for him. He adds, 'I also think there are many who are a little more (…) motivated and a little more interested in it (…) because it is something you can relate to.' Here, it is clear that the student thinks he learns more by, for example, working on a calculation and then using it in a specific context. This could be interpreted to mean that the student has figured out how he learns best, meaning he has already developed a lot. The student, combining thoughts on old and new teaching traditions with those on teachers' qualifications and outcomes for students, also illustrates that he expands his worldview by reflecting on his own and the teacher's practices.

Another thing that is facilitated by the learning environment at the technical high school is responsibility. The students feel a high sense of responsibility through some elements of the PBL environment. Most are good at expressing their development from the end of primary school to the present. In the following quotation, a first-year student expresses how he thinks attending the technical high school has changed his sense of responsibility:

> 'I feel I have become better at taking responsibility and making sure my assignments are done properly (…) I think it is the seriousness of it, because it is a very important thing to make it through high school and (…) your grades in high school have a great influence on what you are going to do later in life (…) and (…) then I feel there is a little pressure on you when you do group work (…) because you of course want to make sure you get something done and you don't want to be the person who doesn't really get something done in a group' (Interviewee 2, 1st year:7).

This student is expressing his thoughts on how he has gotten better at taking responsibility and making sure his assignments are done properly. He also adds that it is his impression that you have to be serious to get through high school because it has an influence of your possibilities afterwards. It could be argued that this has nothing to do the with the specific education or high school he attends; the same would probably be the case for most students as they get older. But, this student elaborates further: 'I feel there is a little pressure on you when you do group work (…) because you of course want to make sure you get something done and you don't want to be the person who doesn't really get something done in a group'. In this part of the quote he expresses how he thinks his personal development is partly due to working in groups and the commitment that involves. He feels he must do the work so he is not the only one not participating. This could be interpreted to mean that this student has learned a lot already, that he has developed through the seriousness of attending high school, and because of the PBL environment and group work. The student argues that developing and being serious adds pressure as none of the students want to be the only ones not participating or being excluded. Therefore, it could also be argued that he did learn and develop after attending technical high school, but it seems he only manages to reflect on why he thinks he has developed personally. Through this quotation he is not really showing that he has expanded his worldview, but one could say he is on his way and has started the process.

A third-year student also reflects on personal development. She shows she is very capable of reflecting on her own practice, as Højrup (2002) states:

> 'You also become (…) more independent in regards to learning (…) it is not every day you have lectures (…) there is also some material you have to get familiar with by yourself. So that way it also helps you to (…) have some methods to (…) learn

> by yourselves' (Interviewee 3, 3rd year:4).

This student expresses how she thinks students become more independent by attending technical high school, which, as a PBL environment, does not have many classic lectures. There are some material students must become familiar with on their own, which puts the responsibility on them. This could be interpreted as the student understanding and liking that responsibility, which could also indicate she is not holding on to the concept of classic classroom teaching. This student also expressed thoughts about having methods from the PBL environment to help students learn by themselves so they are not just left on their own. The above quotation clearly shows that the student has developed. She shows an understanding of how she is responsible for her own learning, and that the learning environment has helped her be able to do that. The student manages to reflect on her own practice; she knows and understands the importance of self-learning and is able to expand her own worldview.

The last theme that became visible through the interviews with the students was how the learning environment helps students learn or become better at using different tools and study techniques. All students mentioned how important they felt it was to follow what was going on during classes. It is not enough for them to understand what is being said; they must organise their knowledge so they know where to find it when they need it for projects and exams. It does not take students long to realise that this practice is necessary to be successful at technical high school, and being organised themselves and in their notes is helpful in many ways. In the following quotation from a first-year student, he expresses how he changed his way of developing games after starting technical high school:

> 'Before when I was going to make a game, then I just started. I didn't really have any plan for what I wanted to do and (…) I just started (…) and then it almost always ended with the result that the game got finished because I didn't have a plan (…) But then now I have got some tools for how (...) I can plan for what I want to do. I can see what my next step will be' (Interviewee 7, 1st year:2–3).

This student states that before attending technical high school, he just started when developing new computer games, without really planning anything, and as a result often did not finish the task. After starting technical high school, he learned some methods and developed some tools that now help him organise and plan projects, and help him visualise his next step. In this process he learned a lot and developed by gaining some tools to help him handle the organisation and planning of his study. It could also be argued that he would have gotten these tools whatever kind of education he had chosen, but the fact that he actually manages to use these tools in a very technical context (for developing computer games) speaks to the fact that he has been able to apply his skills to another field, which shows understanding. He has already expanded his worldview through learning new methods, but as he says nothing about how he manages these tools in relation to developing new computer games, or how that has changed, it could also be argued that he has not expanded his own worldview yet as there has been no visible change.

The following comments from a second-year student highlight how big an impact organisation tools have had on his study:

> 'At least I have gotten better at writing notes (laughs) because, I quite quickly found that you have to do so a little, because otherwise then... There are quite a few things to remember in the different subjects and with the different formulas. They use the same variables with names so you have to remember a little about what the different things are' (Interviewee 5, 2nd year:13–14).

Anders mentions that he got better at taking notes, which is quite a practical approach to learning. He elaborates on how he thinks these tools can actually help him. He uses the organisation tools he learned for remembering, such as for organising the knowledge he acquires through study, and consequently knows where to find it when he needs it for projects and exams. This quotation could be interpreted as meaning this student realised how necessary it is to organise his study at technical high school to thrive there. This student learned and developed a lot as he worked out how to apply these tools to his study and use them to his benefit, thereby expanding his worldview. A third-year student reflects, in the following quotation, on the differences between being able to use study tools in primary school and how that changed after starting technical high school:

> 'A small thing I have taken with me from primary school is when I made notes you know, I can remember it was a mud pile. I can remember it was really disorganised, wow! And (…) now that you know some techniques. (…) It is for yourself, so it (…) doesn't just have to be that kind of… (…) Me I am really bad with small cue words, so you know you learn to get it structured better' (Interviewee 6, 3rd year:13).

This student expresses that her notes from primary school were a mess. Looking back, she is not satisfied with the way she used to take notes. This shows a change: she has moved on from taking notes in a disorganised way. She reflects on the difference between her note-taking in primary school and at technical high school. Before, it was disorganised, but she thinks she has learned to be more structured at technical high school, which indicates that she has developed a lot through the learning process. Therefore, she has expanded her worldview by reflecting on her own practices. It could be argued that she would have learned this no matter what kind of high school she attended, but this has also been the case at technical high school.

CONCLUSION

The concept of *Bildung* is comprehensive but also difficult to translate into other languages. The comprehensiveness and untranslatability make the concept difficult to do justice to in a single research article, and even more so if one wants to use it in an investigation into the formation and development of young people through a high school programme. Nevertheless, here we have used this very important concept to describe exactly that: the impact that technical high school may or may not have on young people attending it. As mentioned, we are aware that any comparison between 15 and 18-year-olds will contain differences, but the point of this article is whether we can detect or trace the kind of impact the teaching and learning at high school might have on students, and see if they achieve the very ambitious goals of the Ministerial Order. We did this by looking for signs of the students' ability to reflect on their situation and change their worldview, well knowing that *Bildung* cannot be reduced to reflection and a change of worldview.

Examining the interviews with the students it is obvious that there is a huge difference between the first, second and third-year students. The older students are able to reflect on their own learning in a way the first-year students cannot, even if they seem to know there is something they might need to reflect on. Based on that, it is easy to conclude that in respect to the goals of the Ministerial Order, *Bildung* and study competencies can be achieved at technical high school. It is also evident that there is a huge difference in the ways first, second and third-year students are able to talk about their life at technical high school. The third-year students were able to reflect upon their own learning, change their worldviews, expand their vocabulary and learn how to use new words and concepts. They could also reflect on PBL and group work and were able to reflect on this type of pedagogy. Further, they showed that they had acquired the study competencies outlined in the Ministerial Order. Therefore, there is plenty of evidence in the interviews that make us conclude that a youngster entering technical high school would be able to reach the goals of the Ministry of Children and Education, Ministerial Order and achieve the kind of technical *Bildung* and study competencies they need.

3.4. LANGUAGE

The fourth and final concept addressed in this last part of the problem analysis is language. Here, language should be understood as Wittgenstein's concept of language games, a concept he used for different uses of language. Different groups have different language games (Henriksen, 2018:2). Teachers of the subject of technology are one group with their own language game. Their language games allow them to communicate with each other. They also have special terms and expressions only they know and understand. Learning their language game requires being part of their community and lifeworld, and following their practice. The following article presents how I became a part of the technology teacher's lifeworld and thereby got to be familiar with their language games.

3.4.1. LANGUAGE IN THE TECHNOLOGY SUBJECT AT THE DANISH HIGHER TECHNICAL EXAMINATION PROGRAMME – PRAGMATIC CONTRUCTIVISM IN PRACTICE

This article is published in *Journal of Pragmatic Constructivism* as:

Jeppesen, M.M. (2020) Language in the technology subject at the Danish Higher Technical Examination Programme – Pragmatic Constructivism in practice.

Working with problem-based learning (PBL) in the technology subject differentiates HTX from other secondary school programs in Denmark. Challenges include interpretation of different elements which vary from teacher to teacher which has consequences for the students and indicates that a solid disciplinary tradition have yet to be developed. This stipulates the need for creating a coordinated language but making this possible I need to know the technology teacher's language games. Doing so will enable me to create a conceptual framework through the use of PC which will be helpful in developing the missing coordinated language. In conclusion, it can be said that it has been possible to use PC in practice to unfold the language games used in the technology subject and through that create an opportunity for technology teachers to discuss their practice and subject with each other and the students enabling a change in the subject and organisation.

In the 1980s the Danish Higher Technical Examination Programme (HTX) was established. The purpose was introducing a high school education stream specifically directed towards science and engineering (Danish Education Ministry, 2015). The first higher technical examination programme was inaugurated as an experiment in 1982; later in 1989 HTX became a permanent addition to high school education in Denmark (Jans, 2007; Olsson, 2007). The study programme was very much influenced by the problem-based learning (PBL) principles of the new Danish universities at Aalborg and Roskilde (Jans, 2007:12); therefore, based upon problem-based learning (PBL) principles which are inherently interdisciplinary with group project work and a high level of student self-direction or student centeredness (Henriksen, 2016). Problem-oriented project work, especially in the profile subjects Technology and Technical Science, has been a defining HTX characteristic since its inception (Ulriksen et al., 2008; Jans 2007:18; Ministerial order, 2015; HTX curriculum, 2017) and is what differentiates HTX from other second level programmes in the Danish educational system these include STX and HHX ('STX' and 'HHX' are acronyms for other second level programs. The differences are explained in the following). Where STX offers a very broad general education with a focus on many different disciplines such as social and natural sciences, HHX offers business and social economics in combination with more classical teaching subjects and foreign languages but none of the other second level educational programs work problem-oriented as done on HTX. HTX is a three-year educational programme (Ministry of Education, 2008) and is structured as illustrated in figure 1-1:

Field of study 2 ½ years	**Field of study 2 ½ years**	**Field of study 2 ½ years**
Compulsory subjects and levels Three specialisation subjects Multidisciplinary teaching courses Electives Specialised study project	Compulsory subjects and levels Three specialisation subjects Multidisciplinary teaching courses Electives Specialised study project	Compulsory subjects and levels Three specialisation subjects Multidisciplinary teaching courses Electives Specialised study project
Basic course ½ year Compulsory subjects and levels: Danish, English, Mathematics Multidisciplinary teaching courses, including workshop teaching		

Figure 1-1 Structure of the HTX educational programme

In figure 1 is illustrated the subjects the students follow during their three years of study and they are placed within a system consisting of three level; C, B and A level. Focusing on levels a subject at level C consists of 75 hours of 60 minutes, at level B this is 200 hours and at level A subject consists of 325 hours (Ministry of Education, 2008:1). As illustrated above the students also have to follow compulsory subjects and levels and those include; Danish A, Technology A, English A, physics B, chemistry B, mathematics B, technology B, biology B, communication / IT C, social studies C and technology history C (Ministry of Education, 2008:3). Later in their study the students also have to choose a field of study and in doing so they can choose between different field of study packages that all consists of three subjects. The subjects can be combined in three different ways and the students can therefore, choose; three subjects at A level, two subjects at A level and one at B level or one subject at A level, one at B level and one at B or C level. The schools compose the field of study packages themselves which means that the number of fields of study and the content can vary but no matter the school or the choice of field of study a student that finish HTX has at least 2630 hours of 60 minutes (Ministry of Education, 2008:3).

Doing problem-oriented work on HTX presents as challenge for the teachers as I found in ongoing empirical work on HTX there is no shared consensus on conceptualisations of PBL related to the technology subject or nor is there any shared consensus about which methods to use. This presents some challenges for the students as the way they work with PBL and technology projects varies from teacher to teacher and from class to class. This becomes apparent during the students' third year of study when they have to choose a technical science subject; students arrive from different classes and students in this new class may have developed different perceptions of how to work with projects and in the same way it creates challenges for the students when they go to the exam and the teacher and examiner do not agree on what constitutes a good technology project - a disagreement that can also be expressed in the grading of the projects.

Basically, PBL requires that we take our starting point in working with problems; we wish to know more about the problem with the missing consensus between the teachers in the technology subject. We want to investigate this challenge and in doing so, it is pertinent to know the language of the technology subject as the language is our entrance ticket to getting to explore and obtain information about what is going on in the lifeworld of the technology subject. Wittgenstein uses the term 'language game' about all the different uses of language which also can be applied for the language in the technology subject. Different social groups use different language games. This I also the case within the same national language.

They have their different language games which allow them to communicate with each other and thereby they also have special terms and expressions which only they know and understand. This is though not only for communication purposes, it also demonstrates that they are a member of this particular group. Learning the language game of the technology subject thus requires me to be a part of the technology subject community, by following their practices (Henriksen, 2018:2).

The purpose of this paper is to unfold the language games used in the technology subject on HTX by applying Pragmatic constructivism (PC) and exemplifying how PC can be applied in practice and thereby adding to the existing research field with a more methodical approach to research in PC.

The paper proceeds as follows: a theoretical framework for creating a coordinated language is presented followed by a method section; the empirical findings are then presented; ending with a conclusion that states that it is possible to use PC in practice to unfold the language games in the technology subject and through that create a change in the organisation.

CREATING A COORDINATED LANGUAGE USING PRAGMATIC CONSTRUCTIVISM

With an interest in getting to know the language game in the technology subject, it is important as a starting point to take a step back and start by focusing on the content of the language used in the technology subject. 'Content is necessary – word in themselves are worth nothing' (Henriksen et al., 2004:22).

CONCEPTS AND THE CONCEPTUALISING METHOD

For the language in the technology subject to work it has to express facts, logic, values, and communication which are all aspects of reality, to function. The distinction between abstracts and concepts is central here as can only describe parts of reality while concepts can describe reality as a whole (Henriksen et al., 2004:22).

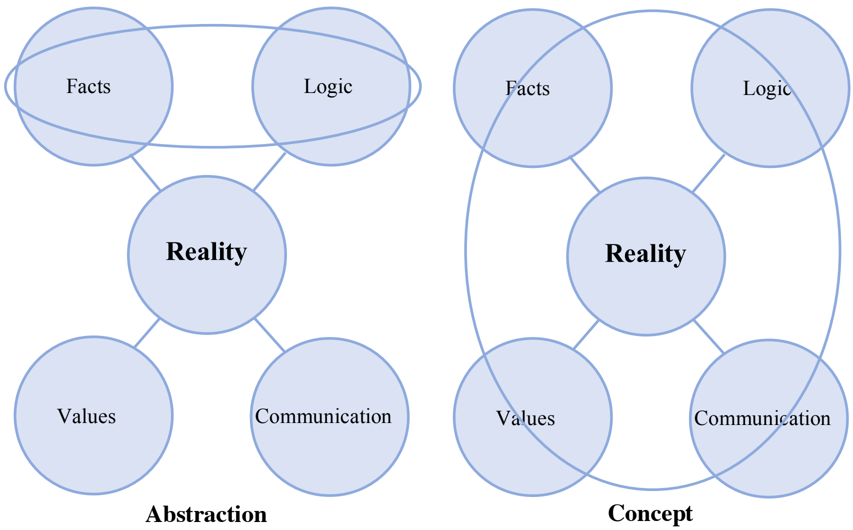


Figure 4-1 The difference between abstractions and concepts is illustrated.

In order to become familiar with the concepts used in the technology subject, I have to step into their lifeworld as concepts do not just exist but are something that is handed down to us. This happens in a process of conceptualization as when we are given concepts we change them and create new ones (Henriksen et al., 2004:23). In terms of creating useful concepts it is helpful to draw on Nørreklit's (1979) seminal 'conceptualising method'. This method is about taking ordinary words from everyday conversations and changing then into social scientific concepts. Nørreklit (1973) describes concepts as something we possess and can act on: 'Concepts in this sense, are vital to our language games, to our ability to act and change things, and to our ways of understanding the world and our realities' (Henriksen 2016b:30). Preferably, concepts should be precise descriptions of realities, free from possible misinterpretations and ambiguities. In everyday conversations we use concepts and they are often ambiguous and, therefore, often the reason for misunderstandings to such an extent that such concepts are used indifferently in different language games.

The purpose, in a social scientific investigation, is to remove as many ambiguities as possible which is a real challenge; but this should not prevent us from trying and through our research and using the conceptualisation method create knowledge and concepts (Henriksen, 2016b: 31).

REALITY, CONCEPTS AND LANGUAGE GAMES

'Any encounter into a field of interest is to enter into a lifeworld' (Henriksen, 2018:2). Language is our entrance ticket to getting to explore and obtain information about what is going on in such lifeworld's – in this case the technology subject on HTX. Wittgenstein uses the term 'language game' about all the different uses of language.

Different social groups use different language games, even within the same national language. Different groups have their different language games which allow them to communicate with each other and thereby they also have special terms and expressions which only they know and understand. This is not only for communication purposes but in a sense also to demonstrate that they are a member of this particular group. In the case of the technology subject the teachers do not have one language game which is representative of the whole subject and are thereby not able to communicate – they talk past each other.

Learning the language game of the technology subject requires me to be a part of the HTX community, by following their practices. To learn a language does not require us to follow a set of rules, to be understood as we don't first learn grammar when learning a language, and then speaking it. No, we learn it by using it (Henriksen, 2018:2). This is not to say that there are no rules (Henriksen, 2018:2; Lyotard, 1979:9). There are rules, and we need to know how to use the rules of a specific language game in order to participate in a language game; we are just not necessarily able to account for the rules (Henriksen, 2018:2-3). Language is an integrated part of our lifeworld's; it enables us to do a lot of things like asking questions, telling stories and communicating with our fellow human beings. The way to learn about the lifeworld's is, therefore, to learn the language games which constitute, or are constituted by, the specific lifeworld (Henriksen, 2018:3). Language games can change – it rarely remains the same as lifeworld's constantly develop and change. 'Language games change as lifeworld's change and lifeworld's change as language games change' (Henriksen, 2018:3). Such changes happen in the interactions between members of the lifeworld and are often unnoticed. In some cases, language games and lifeworld's diverge which either leaves the members of the community confused and bewildered or in need of changing their language game to fit the new conditions and it may even be necessary to change the lifeworld in some way which is most likely what happened on HTX in the technology field. The language game and the world of life differ, which has led the teachers to come up with their own solutions in the teaching and slowly they have agreed to disagree (Author, 2020). What Nørreklit (1978) calls a real problem becomes visible here; a real problem is defined as confronting the actors when their language can no longer guide their actions in the lifeworld (Henriksen, 2018:3). As a researcher I should be able to assist in solving real problems if I take part in the process of developing the language game. If I can do so, then I am also able to create a plausible account of the process and turn the process into a social scientific endeavour (Henriksen, 2018:4).

DIALOG

As noted above, to be able to assist in solving real problems we need dialog (Henriksen, 2018:4) as access to the reality on HTX is possible through language and communication. Gaining that access is then the next problem I face. Conversations with and between me and the technology teachers therefore seems to be the way to move forward. Conversation here must be understood broadly and can be; small talk, interviews, argument and dialog with the technology teachers which are all important components but in the following a short description of dialog will be made as it is through dialog we become able to create concepts that's need to develop the language game in the technology subject (Henriksen et al., 2004:152). Dialog in relation to the conceptualizing method can be described as a conversation that is carried out on the logic of question and answer. 'The true question is characterized by its authentic nature and its openness. Openness must help to reveal the inner logic of the subject matter' (Henriksen et al., 2004:158), in this case the technology teachers on HTX, and this is only possible if I and the participating teachers involved in the dialog actually use the openness to actively search for the logic of the individual technology teacher. This also means that inauthentic questions which is about showing who is right or rhetorical issues therefore here is not involved in the understanding of dialog (Henriksen et al., 2004:158).

METHOD

The present article is based on empirical data collected on HTX. The empirical data consists of both observations conducted in the classrooms and interviews with teachers. Over a period corresponding to a full academic year, the observations were carried out on HTX in Aalborg, Denmark. The observations were conducted in twelve different classes while during that period of time also discussing the findings with the technology teachers. Both first-year students and third-year students were observed. In selecting the classes in which I was going to observe I took as my starting point some of the introductory meetings I had with the technology teachers. Subsequently, the strategy became applying the snowball effect. It had the practical significance that the technology teachers who from the start had chosen to be participants in the project started talking to other teachers about their participation while I was still in the process of completing the observations and little by little more teachers started to report that they also would like to open up their classrooms and participate.

Observing the teachers in such a series of observations was truly interesting and provided me the access to the lifeworld of the technology subject and allowed me to get to know the language games.

Below in table 4 is an overview of the observations:

Year	Field of study	Department
1st. year students	GAMETECH	C. A. Olesens Gade /Nyhavnsgade 14
1st. year students	International	C. A. Olesens Gade
1st. year students	Chemistry	Øster Uttrup Vej

1st. year students	Industrial design	Øster Uttrup Vej
1st. year students	Product development	Øster Uttrup Vej
2nd. year students	The world of physics	C. A. Olesens Gade
2nd. year students	The world of physics	Øster Uttrup Vej
2nd. year students	GAMETECH/ 1. del	Øster Uttrup Vej
2nd. year students	GAMETECH/ 2. del	Øster Uttrup Vej
3rd. year students	Technology A	Øster Uttrup Vej
3rd. year students	Technology A	Øster Uttrup Vej
3rd. year students	Technical science (B&E)	Øster Uttrup Vej
3rd. year students	Technical science (B&E)	Øster Uttrup Vej
3rd. year students	Technical science (B&E)	Øster Uttrup Vej

Table 4 - Overview of observations

In addition, insight into the life world and the language games of the technology teachers was also gained through interviews. Supplementing the extensive observations with qualitative interviews I am able to gain a deeper knowledge and insight into the lifeworld and the language games of the technology subject. Nine different teachers, from six different HTX schools throughout Denmark participated in the interviews.

Below table provides an overview of the conducted interviews.

High school	Interviewee	Subjects taught	Years on HTX	Previous experiences/ education	Place
HTX 1	Interviewee 1	Design, Technology & Technical Science	15	Cand. Polyt.	Staffroom

		(Construction & Energy)			
HTX 1	Interviewee 2	Technology, Communication /It & Informatics	25	Cand. Polyt.	Staffroom
HTX 1	Interviewee 3	Technology & Technical Science (Construction & Energy)	25	Construction engineer	Staffroom
HTX 1	Interviewee 4	Social studies, History of ideas and Technology	17	Cand. Mag.	Staffroom
HTX 2	Interviewee 5	Technology	7	MSc in Economics	Meeting room
HTX 3	Interviewee 6	Technology & Mathematics	5	Comes from business	Open area
HTX 4	Interviewee 7	Technology & Technical Science (Construction & Energy)	21	Building constructor	Meeting room
HTX 5	Interviewee 8	Biology, Technology & Food and Health	18-20	Master in Biology	Meeting room
HTX 6	Interviewee 9	Technology & Chemistry	3	Comes from business/DVM/medical industry	Meeting room

Table 5 – Detailed overview of interviews with teachers

The ‘conceptualising method’ (Henriksen et al., 2004:147) has been used to collect the empirical data. The method can be presented as follows:

- Symptom of HTX Problem
  - Action – Reflection- (real) Problem
    - Reflection – Conceptualisation
      - Action – Reflection
        - Reflection – Conceptualisation
- (sustainable) Solution to (original) Problem.

The problem that was set forth by the technology teachers; There is a lack of consensus between the teachers in the technology subject on how to work in the subject has been the offset of the use of the conceptualising method. The question is now how to move further from being proven that there is no consensus between the teacher on how to work in the technology subject, the identification of the need for a coordinated language and on to being able to act on that need. The method can also be of value here as it is used for creating concepts and through the conceptualising process four elements are integrated; facts, logic, values and communication (figure 2). This is done so that the actors involved can create in this case a merged or common language which can enable teachers to at least discuss how they work in the technology subject.

FINDINGS

In HTX, teachers in the technology subject appear to have no coordinated language in regards to how to work in the subject; it could possibly be argued that teachers' communications here on the subject, on PBL and on project writing are only abstractions and not concepts. To solve these problems, it seems pertinent to apply the conceptualising method (Nørreklit 1973), as it is sought to create useful and precise concepts free from possible misinterpretations and ambiguities as a contribution to a coordinated language in this area. In HTX I have now obtained some knowledge about the use of everyday words related to the technology subject by observing in several different classes (see. Table 1), interviewing teachers and have entered into dialogs with both teachers and students.

In the following I, through the collected empirical data, will show what I found.

The starting point for the work was that the teachers expressed that there is no consensus between the teacher about how they work in the technology subject. The teachers seem to ‘Agree to disagree’ (“Author”, 2020). One of the ways in which this became visible was through the following quote:

> ‘Well, you can say that there are some things like…there are some discussions that are difficult (…) to take and where we may have just gotten to know each other to well, so eventually we just stopped discussing’ (Interviewee 8, pp. 12, 2019).

The teacher who was interviewed here was very conscious about the fact that some discussion between the technology teachers can be difficult and that it some cases the teachers just stopped discussing. This clearly underlines the lack of consensus between the teachers and a further study of 'Agree to disagree' can be read in “Author”, 2020. With it, the symptoms of the problem’s technology the teachers on HTX have expressed became very clear.
Having been able to identify the symptoms of the problems I continued to observe in the different technology classes subject to different fields of study. Observing and talking to the technology teachers slowly began to give me an insight into the technology subject and during that time I had many interesting dialogs with the technology teachers about how they each teach the technology subject. *Product or project*, *teacher backgrounds* and *PBL* can be mentioned as examples of topics the dialogs I had with the technology teachers revolved around which are unfolded below.

PRODUCT OR PROCESS

Both during the observations in the classes and during the interviews with the teachers, it was very clear that the technology teachers placed different emphasis on what was most important for the students to focus on in their projects - product or process. This is very clear in the below statement:

> ‘In my teaching I do not have a big focus on the product and whether the students can make a nice product. I know some of the other teachers have that focus. I'd rather have the students illustrate that they have understood the process and they then stand with a poor product than I want them to spend all their time making a nice product and they therefore have no understanding of the process and thus end up making a bad report’ (Field notes, 2018).

The teacher here clearly indicates that he, along with the rest of the teachers, have different perspectives on what students need to focus on and learn in this HTX discipline. Following these brief observations, the research goal is to assist in the creation of a coordinated language. To do so now demands that observations and dialog continue with an adjusted focus due to the awareness of the different materials teachers bring into use in the subject and how the methods and concepts from these materials are articulated in the classroom. With this renewed focus, the intent is not to create a uniformity in teachers' approach to the subject as one of the greatest strengths in the technology subject relates to the teachers' different skills that are brought into play in the students’ project designs. The intent is rather to assist in developing a coordinated base for both teachers and students from without the materials used in the subject – and with the teachers and the students’ expertise in play - a broad base with a conceptualisation of all the main methods and concepts.

Another teacher mentions that he finds the process of writing projects as well as preparing products in the workshop equally important (Interviewee 7, 2019:11). He further adds that he is however concerned with the development of the technology subject:

> 'Now it's opened up a bit with all this with apps and such that I think damn it's a pity (…) Because I think the practice part disappears. And that's actually what our profile subject (technology subject) is about. It is about the practice parts … that they have some theory and then go out and try it in practice' (Interviewee 7, 2019:3).

The teacher thus thinks that it is a shame that the students have been allowed to develop apps as a product for their project, as he believes that the practical part of working with products disappears. The teacher thus connects the work with products in the technology subject with something physical, where the students go to the workshop to create the product.
Another teacher also addresses the theme of; when is a product a product. As he says: 'after all, it is for eternal discussion when a product is a product' (Interviewee 8, 2019:10). He then continues:

> '(…) basically, I would say that there is the very engineer-like approach to it, and then there is the more scientific approach to it (…) Now I am a biologist so it is clear enough where I stand but I can well recognize the others and I can also well recognize the concerns of their appeal. I also do not think there is much craft in a student making a 3D printing of something (…) But there I would like you to think more scientifically and then say: what is that model for? What can you use it for? (…) Not really for anything (anticipated student response) well which model should you then have made instead?' (Interviewee 8, 2019:10).

The teacher here also expresses that there are different approaches among technology teachers to what students should focus on when preparing projects. The quote expresses a great focus on the product, but that the teacher also sees that the colleagues do it very differently, which he attributes to the teachers' different educational backgrounds.

DIFFERENT EDUCATIONAL BACKGROUNDS

The teachers having different backgrounds and that having to do with the fact that they see things differently will further be confirmed in the below quote:

> 'So of course, we are different and we are also a professional group where we are in that way very different in relation to some of the other subjects because yes, we have significantly more different backgrounds than many others' (Interviewee 1, 2019:10).

The teacher expresses here that it is very obvious that they as teachers are very different and that the professional group for the technology subject is in many ways also different from many of the other subjects and on the basis that they in the professional group for the technology subject have significantly more different backgrounds than in many other professional groups.

That the teachers have very different professional backgrounds is also confirmed in the next quote:

> ‘It's a very interesting group of teachers because most of us have at least two years' work experience (…) from a private company or organization type other than a public educational institution (…) And that means that we have a lot of different experiences and draw on and it provides a good professional environment. But it also provides interesting conversations (…) That you are so different (…) and have been to different places have different approaches on how to approach the world (…) I experience it as a strength yes, I actually do, because we largely agree on what the Ministerial Order is about and what the goal is (...) I would say. But the road leading there is very different. And this is where we have to learn to accept that we have different ways of doing things, unless there are some colleagues who have problems making their teaching work and getting their students through’ (Interviewee 4, 2019: 13-14).

Here the teachers focus om the fact that the group of technology teachers is an interesting group as they all have at least two years of work experience, as this is a requirement to become a technology teacher on HTX. This is from teachers’ point of view seen as a positive thing as this means that the teachers have a lot of different experiences to draw from which he believes helps to create a good professional environment. Further the teachers see it as a strength that the teachers have such different backgrounds because they largely agree on the Ministerial Order. The way forward to everyone having the same understanding of what the Ministerial Order contains just varies from teacher to teacher and it is his position that it is important that they learn to accept that this is how it is. The teachers have different approaches and it should be ok unless there are some teachers who have a hard time making their teaching in the technology subject work and it affects the students. Then action must be taken.

Another teacher agrees that the teachers are different and express that they have different profiles and personalities, but do not see this as a problem:

> ‘No, I think it may well be we each have our profile we each have our personality. We have slightly different educational backgrounds. We each have our work experience but I think we agree on the concepts. I actually think so’ (Interviewee 9, 2019:13-14).

It is further explained that despite differences in profiles, personality and educational background, she believes that the teachers agree on what the concepts they use in the technology subject contain. During the interview, I therefore ask whether the teacher also believes that it applies to the PBL concepts, e.g. how to define a problem:

> ‘I think so too. But it may well be that if you walk around and interview us now (...) then it may well be that you can found someone, but I actually believe it’ (Interviewee 9, 2019:13-14).

The teacher agrees again. She expresses that she also believes that the teachers agree on what the PBL concepts used in the technology subject contain. At the same time, however, she is unsure whether the other teachers would agree with her statement if I walked around the school to interview them as well, but still sticks to her statement that she believes there is agreement on understanding the concepts.

PROBLEM-BASED LEARNING

During an interview with a technology teacher from another HTX school, I ask the same question; What is a problem and is there agreement on it matter among the technology teacher group:

> ‘Well, that's where we can still be in doubt about what is a problem and what is a problem analysis and what has to be included in a project description so we can say that it is approved (…) we can still get into discussions about that’ (Interviewee 8, 2019:13).

It is expressed here that the teachers can still have doubts about what it really is a problem is, what a problem analysis is and what should be included in a project description. In the statement there is also expressed a difference in how the different teachers view the content of the different concepts and in cases where disagreements arise, teachers may well get into discussions about the content of the concepts. However, the same teacher also expresses a little later that there are actually some of the discussions surrounding the content of the PBL concepts and the concepts in the technology subject in general may be to take:

> ‘Well you can say there are (…) some discussions which are hard to take. Where we gradually might have just gotten to know each other so well so we also gradually just stopped taking the discussion’ (Interviewee 8, 2019:12).

He expresses here that some of the discussions about the concepts are sometimes so difficult to take that they, perhaps based on the fact that the teaching group gradually knows each other so well, along the way have stopped taking the discussions. That there are many different ways of working with, among other things, PBL in the technology subject is also illustrated in the next quote. Here a technology teacher expresses the following:

> ‘Last year we had seven different classes (…) And they have had seven different technology teachers (…) So when you ask the students to write a problem statement there are some who just writes one and others start to analyse for twenty hours and return with thirty-five pages which of course have to do with the problem statement

> because otherwise it is not documented (Laughs)… it becomes so very very clear and in general the problem formulation that the students have learned in technology they know how to do that so there is no reason for me to get them to do it as I would do it. The students that have followed me can do that, but they are welcome to do it in other way. But then to get them to understand that there is something called a problem analysis which comes before (the problem statement) that can be a challenge (…) But no, it is (…) the experience from technology the students draw on in the technical science subjects and it is very versatile' (Interviewee 1, 2019:11-12).

That there are many different ways of working with, among other things, PBL in the technology subject is also illustrated in the next quote. Here the teacher gives an example of what happens when she gives the students the task of writing a problem statement. When that is the case the students work very differently with the task because they come from different classes and have had different technology teachers. The teacher is aware of this and chooses not to force the students to do it the same way or do it the way she herself would have done it. But this presents some challenges as the students (third level students) have trouble accepting and being told that they have work in a different way with PBL than they have had the last two years of their study. In the example the teachers tell the students that there is something called a problem analysis and it seems that the students have a hard time taking that in as it creates challenges and, in the example, lies the understanding that it may be because they have never been asked to prepare a problem analysis before, again because of the different ways of teaching the technology subject. and teachers suggest that it also affects other subjects, as several of them are based on the knowledge they gain in the subject of technology.

Another teacher gives an example of the disagreement that unfolded about what PBL, what the concepts in connection with PBL contain and how to work in the subject:

> 'Well I have had a student who broke down (…) I had some vacation and then one of my colleagues took over. And I had said she (the student) wanted this problem statement and then he (the teacher) changed it to his interpretation of how it should be. He then tells her and then I come back from vacation and I say no. Well, he said that yesterday (student comment). Well then, he was in one of the classes next door so I said I'll go get him so that we can just talk it through. And when we were standing there talking in front of her and all of a sudden, she broke down' (Interviewee 7, 2019:22).

In this very concrete example, disagreements between two teachers have serious consequences for a student who breaks down on the basis of different expectations from the teachers. The teachers expect different things and it becomes too much for the student. However, the teacher elaborates and says that since that happened, the teachers have become better at communicating.

THE CONCEPTUALISING METHOD IN PRACTICE

Through this dialog with the teachers about differences, different educational backgrounds and approaches to PBL and teaching materials, the idea arose of making a new basic text book for the technology subject. The idea arose one day I was in dialog with one of the technology teachers. He mentions that it could be nice that he uses educational material from several different basic books for the technology subject and on top of that he uses a lot of copies from other books he therefore thinks it could be nice with a new basic text book for the technology subject which gathers the materials. '(…) We are missing one book that brings it all together. I use many different books, but only a few things from each plus I have a large library on the computer with copies, assignments, etc. (…)' (Field notes, 15.03.2018). The plan to focus on the language and write it down in a new basic text book for the technology subject starts, what in the conceptualization method is also called *subjectivization* (Henriksen et al., 2004:25). We also have a dialog about what the teacher thinks such a basic text book should be able to do in addition to collecting all the materials used in one place. The teacher adds that he believes there is a need for: '(…) a book that is built on the process in the technology subject and which leads all the way to the exam project (…)' (Field notes, 15.03.2018). More specifically, it is also his opinion that a new textbook would have to contain more about environmental assessments, good manageable examples that students can relate to and it must not be too far-fetched as there are some students who are not good at reading (Field notes, 15.03.2018).

The next day I am back on HTX to observe in another class of another technology teacher. However, I meet the teacher who came up with the idea for a new basic text book in the teacher's room, where we again have a dialog about the idea of a new basic text book for the technology subject. Here we talk about, among other things, whether it should be a method book, i.e. one that gives students the "recipe" for how to make a technology project, whether it should be a printed book or an e-book and whether, for example, a reference work should be included (Field notes, 16.03.2018). Later the same day, I have dialog with the teacher who teaches the technology class that I am observing in that day. In this way, I begin to quietly tell others about the idea with a new basic text book for the technology subject where the common concepts developed in the dialog are written down and this where the *externalisation* begins (Henriksen et al., 2004:25). On March 21, 2018, I sent an e-mail to the chairwoman of the technology teachers' association, which is an association for all technology teachers on HTX schools throughout Denmark to present the idea with a new basic book:

> '(…) The reason for this is that I hear from some of the teachers I have contact with that they miss a complete book for the subject Technology (I know there are some pieces and it should not be seen as a critique of the existing ones). The idea is to make a reference work with methods that are used in teaching combined with PBL. In this way, everyone will be able to have the same starting point in PBL, language / concepts, but at the same time it will be one

very dynamic approach / model that all teachers / students can draw on for their teaching / project writing. I think that it will be able to substantiate this idea by creating a common language / conceptual apparatus (…)' (E-mail, 21.03.2018).

After three days, there will be a reply to an email from the chairwoman of the technology association and where she explains what she initially thinks about the idea of a new basic text book for the technology subject:

'(…) I think it sounds very exciting with a book, with the challenges it can present in terms of choice of form, content and target group. My personal point of view is that when teachers miss a book that represents the whole subject, it stems from the fact that they cannot identify themselves (and the subject) in the two books that already exist (…). The two existing books, in fact, cover the entire subject (Technology B), but of course based on the authors' perception of the correct choice of methods for the phases of the project processes. So, writing a book that covers 'everyone's desires is almost utopia (sorry, but that's how I see it). Conversely, a new (kind of) book can be quite justified (…)' (E-mail, 24.03.2018).

Subsequently, I plan a meeting with the chairman of the technology association to talk the possibilities of a new basic text book through. During the meeting, we talk about ideas for the structure of the book, content, possible partners and how we can start working on the book. Here it is suggested which publisher I could contact to make an agreement on publishing the book. The idea of noting the language we are constantly developing in a basic text book gradually changes here from being a subjective idea to becoming a shared idea between the technology teachers and myself and the idea is thereby *legitimised* (Henriksen et al., 2004:25). The book and the idea of a coordinated language for the technology subject are thus well on the way to becoming an objective given fact. I then contact a publisher who already publishes books for high school to hear if they might have an interest in publishing such a book. At the same time, work continues on the book idea through my dialog with the technology teachers while I am observing in the classrooms. It is by a teacher suggested that the book should be interactive that the students themselves can adapt and move around in and save so that they have their own template or that they should at least be able to make notes in their own edition of the book. Furthermore, the teacher emphasizes that the book must provide some case examples that are completely down to earth. Nothing with calculations on wind turbines - students can not relate to it (Field notes, 06.04.2018). After a few days I get the first email from the publisher and they are interested in the book and in hearing more about the idea. Here, more specifically, we start by making plans and entering into agreements about the book but authorisations are not put on paper yet. It will not happen until 13.08.2018 where we get a confirmation from the publisher that they would like to publish the book: '(…) Systime would like to publish an upcoming textbook for Technology together with you based on Problem-based learning. We would therefore like to invite you to a meeting at the publisher, where we will start the process together (…)' (E-mail, 13.08.2018). The idea is therefore *institutionalized* and since the book is therefore also now a fact - the language <u>must</u> be written down in a book, the idea is also *objectified*

(Henriksen et al., 2004:25). At this time, I have had many exciting dialogs with the technology teachers about the development of the idea of a new basic text book for the technology subject and through those dialogs we have created a language - one we can handle the idea with. Together we have transformed the abstracted idea of a new basic text book into concepts which frames some possibilities and constitutes a tool that can contribute to creating action. We are therefore also ready to *materialise* the idea, as efforts are now being made to put together the team of writers and editors to be used to materialise the idea. The original idea of a new textbook for the technology subject will thus be coupled with the resources that are available and which can help to materialize the idea. Thus, the people who actively participate in the process of developing the book create a routine around the work with the book a so-called; *routinisation*. In this way, it will now be possible to change the original idea into reality (Henriksen et al., 2004:25). ‘Through such a process the actors were able to create things, to change things’ (Henriksen et al., 2004:26). We have also in the process together created a new language or in the case of the technology subject on HTX closer to a coordinated language or a merged language based on the existing fractions and in the process the teachers have also changed themselves in relation to the language which enables them to now handle the teaching of the technology subject based on the “new” language. Finally, it is about inaugurating the other technology teachers and other possible new colleagues in the project. After the book's publication, that process is well underway, for example on HTX in Aalborg, where the book the book is introduced to the other teachers by being discussed at subject group meetings and, among other things, included as a fixed teaching material in the teaching of the basic course; *Product development* (Henriksen et al., 2004:26). A work that continues to take place.

In creating this broad base for addressing both teachers and the students creating new it is the intentions that useful concepts will emerge, a coordinated language, which will enable the teachers to act. With coordinated conceptual devices teachers will obtain a toolbox enabling a focused discussion on the technology subject and its methodological features; a discussion that can help create a more solid disciplinary tradition on HTX through identification and creation of a coordinated language.

CONCLUSION

The article contributes on different levels. The conclusion is therefore divided into different sections; contributions on a local level, contributions on a national level and finally a general conclusion which are all are unfolded below.

The contribution to the concepts in the technology subject consists of a merged language or merged conceptual device which was created with the technology teachers on HTX. This has taken place continuously through the dialog we have had during the time I have spent on HTX and in the technology subject. The conceptual device that have been merged include the concepts used in the teaching of the technology subject, including concepts of problem-based learning (PBL) and product development. The merged language is not created with an expectation that it will help to create a unification in the teaching of the technology subject. A unification in the technology subject is, firstly, impossible to expect as the teachers have so many different professional backgrounds on the contrary, it should instead be seen as a great asset of the subject. More specifically, the merged language is created as an attempt to create an opportunity for teachers in the technology subject to discuss their practice and subject with each other and the students; therefore, the merged language was also written down and made into a basic text book for the subject technology. That way, the merged language became tangible for technology teachers and easier to start working with.

For the Danish Higher Technical Examination Programme and the technology subject, the development of a coordinated or merged language has had a significant impact on the teaching of the subject. At a local level, technology teachers are working on making the use of the merged language a routine through the developed textbook. This is done by the teachers gradually starting to use the book when teaching and referring to it when the students have to read about different topics. The new merged language is now also used to for the basic course in product development which serves as an introduction to the Technology subject, as well as to some extent in the Technical science subject. At a more national level, it was planned by the subject consultant for the technology subject before the first corona shutdown that the new basic text book together with the existing books for the subject should be discussed against each other in order to get closer to a common direction in the technology subject.

Through the use of the conceptualising method and thereby the description of reality and the change process that is included, it has been possible to study the change in the language game that has taken place in the technology subject on HTX. A change that also took root in the organization and has helped to start up small changes in the form of; enabling discussions on the use of books and materials in the field of technology and changes thereto and a joint decision to use the new basic text book as a basis for the teaching of the new students. In conclusion, it can therefore be said that it has been possible to use PC in practice to unfold the language game used in the technology subject on HTX and through that create a change in the organisation.

3.5. PROBLEM STATEMENT

After unfolding the four concepts; Technology, PBL, Bildung and Language games in the problem analysis and examining them in turn I have gained a greater insight into the technology subject. Based on this, I now have an in-depth knowledge of:

1) how the concept of technology is conceptualized in the technology subject
2) what the teacher's role is in a PBL learning process is in the context of the technology subject

3) that a student entering HTX is be able to reach the goals of the Ministry of Children and Education, Ministerial Order and achieve the kind of technical *Bildung* and study competencies they need for further education
4) the language of the technology subject

Through the problem analysis it became clear that there is no consensus on the conceptualisation of PBL, or about which methods to use when teaching technology, among teachers of the subject. The lack of consensus was expressed by a technology teacher as follows:

> 'In my teaching I do not have a big focus on the product and whether the students can make a nice product. I know some of the other teachers have that focus. I'd rather have the students illustrate that they have understood the process and they then stand with a poor product than I want them to spend all their time making a nice product and they therefore have no understanding of the process and thus end up making a bad report' (Field notes, 2019).

Here, the teacher clearly indicates that he and other teachers have different perspectives on what students need to focus on and learn in HTX. Further, it was found in the paper ''Agree to disagree': Technology teachers' perceptions and practices of PBL in Danish HTX programme (HTX)' that technology teachers' cooperation is challenged as they agree to disagree on conceptualisations of PBL in relation to project work, instead finding their own solutions. That article concluded that a generally accepted disciplinary tradition in the subject of technology has yet to fully emerge or be comprehensively conceptualised by the teaching profession.
The problem statement for the projects is therefore formulated as:

> *How can we strengthen the disciplinary tradition in the subject of technology in the Danish HTX programme?*

The next section describes how, in this thesis, I delimit myself in relation to the problem statement.

3.6. DELIMITATION

The target group in this thesis are teachers teaching on HTX. More specifically the teachers have to teach the technology subject, but can also teach more subjects. The teachers who participate, based on the fact that they teach technology, must primarily teach on HTX in Aalborg, as this is where the research project unfolds, but teachers who teach technology at other HTX schools in the country can also be included as part of the target group. The target group also includes the students who receive teaching in technology on HTX in Aalborg.

In relation to the concepts used in the formulation of the problem statement, it is also relevant to delimit oneself in relation to the meaning of two of these concepts.

Disciplinary tradition:
The word disciplinary tradition refers to the fact that there is a tradition behind each subject being taught - in relation to this thesis what is interesting is the disciplinary tradition of the technology subject. It is though interesting to dive further into this composite concept and focus on the word tradition as there are many ways to view the concept. According to Polanyi (1958) lies within the word tradition a form of tacit knowledge.

> ‘An art which cannot be specified in detail cannot be transmitted by prescription, since no prescription exists. It can be passed on only by example from master to apprentice’ (Polanyi, 1958:53).

This understanding of the concept of tradition is based on this thesis, which means that disciplinary tradition is seen here as something that is handed down from teacher to student within the technology subject.

Strengthen: Strengthen is in this context related to the fact that some form of disciplinary tradition already exists in the subject technology as it is being taught and it has been for the last almost 30 years. When it is nevertheless referred to that this must be strengthened, it is because there is something that suggests, based on the problem analysis and the teachers' formulation of a lack of consensus, that at present there is no strong disciplinary tradition in the technology subject. The focus is therefore on strengthening the already existing disciplinary tradition.

3.7. WALK THROUGH OF THE REST OF THE THESIS

To illustrate how I intend to answer the problem statement, I will briefly brush up the structure of the rest of the thesis.

Chapter 4 Method
The chapter describes how I approached the study with a background in Action Research and Pragmatic Constructivism.

Chapter 5 Theory
In this chapter the two main theories of this thesis are unfolded even further than in the articles attached in the problem analysis.

Chapter 6 Analysis strategy
This chapter describes the strategy for the unfolding of the subsequent analysis

Chapter 7 Analysis
Here, the three-part analysis unfolds under three main headings:

1) The textbook – From idea to reality
2) Creating a coordinated language for the technology subject
3) The textbook and how it is used

Chapter 8 Conclusion
Chapter 7 summarises the three sub-conclusions that emerged from the analysis the project's problem statement will be answered. Furthermore, the conclusion is viewed from several different perspectives to clarify that the results relate to several fields.

Chapter 9 Quality considerations
In this chapter I will make some quality considerations in regards to the research conducted in this thesis based on the concepts of validity and reliability.

Chapter 10 Reflections on the entire project
In this last chapter, I reflect on the whole process, and on whether, now that I look back, I would have made other choices than those this thesis is made up of.

In the following chapter 4, I start with unfolding the method.

CHAPTER 4. METHOD

The starting point was to conduct this thesis as an Action Research (AR) project, in close collaboration with teachers and students on HTX in Aalborg and teachers from other technical high schools from across Denmark, as I was interested in being part of the solution to the problem statement. This method was further chosen as I through the dialogue obtained in the AR process would be able to have an actual influence and in addition, I could through the problem analysis, the problem statement and the chosen solution, see that AR here could be useful. This chapter will unfold how.

4.1. ACTION RESEARCH AS AN APPROACH

Kurt Lewin is perceived by many researchers as the father of Actions Research (Greenwood and Levin 2007,16) but AR consists of a variety of approaches, and various books conceptualise AR differently. In *The SAGE Handbook of Action Research – Participatory Inquiry and Practice,* AR is described as a set of practices of living inquiry with the aim to be the connection between real-life practice and ideas that can be used to create human flourishing (Reason & Bradbury, 2013:1). Reason and Bradbury describe AR as more of an orientation to inquiry than a methodology, an orientation that aims to:

> ‘Create participative communities of inquiry in which qualities of engagement, curiosity and question posing are brought to bear on significant practical issues’ (Reason & Bradbury, 2013:1).

They emphasise that AR is about creating change *with* others and not about changing the ones in the field of interest (Reason & Bradbury, 2013:1). In *Introduction to Action Research – Social Research for Social Change,* AR is described as a set of collaborative ways of conducting social research that both help promote democratic social change and meet stringent scientific requirements (Greenwood & Lewin 2007:1). Further, AR is described as:

> ‘A set of self-consciously collaborative and democratic strategies for generating knowledge and designing action in which trained experts in social and other forms of research and local stockholders work together’ (Greenwood & Lewin 2007:1).

The Danish-language *Action Research – Inside and Out* provides yet another conceptualisation of AR:

> ‘Action research is a participant-centred and democratic research process that at the same time seeks to create knowledge about – and change – the subject field. Action research seeks to bring action, reflection and theory together in a concrete context. This process is initiated with the aim of finding solutions to practical and everyday

> problems, while at the same time providing learning and development opportunities for individuals, groups and social communities' (Sunesen 2019:7).

The author of *Action Research – A Basic Book* describes AR as:

> 'A scientific research approach that seeks to create knowledge through change of the world in an active and democratic interaction between researchers and the people involved in this change' (Duus, 2014:13).

Even though AR is often presented as a diverse and often divergent set of practices (as illustrated in the four quotations above), some similar characteristics, considered to be central to all such approaches, can be identified. These include:

(1) The understanding that the subject field is being developed while the subject field is itself changing (Nielsen & Vogelius, 1996; Jarvis, 1999; Sunesen, 2019; Duus, 2014).
(2) Participants in AR are involved co-constructors, which makes AR participant-centred, both democratically and reflexively (Jarvis, 1999; Reason & Bradbury, 2013; Sunesen, 2019; Duus, 2014).
(3) The role of the researcher is to take an active part in creating the change (Tiller, 2000; Henriksen et al., 2004; Greenwood & Lewin, 2007; Duus, 2014).
(4) AR aims to find solutions to practical everyday problems while providing learning and development opportunities for the participants and communities involved (Reason & Bradbury, 2013; Sunesen, 2019).

Questions about the conception of reality and the human view in AR garner ambiguous answers, because different researchers conducting AR start at different points (Nielsen, 2014:329). However, based on the general characteristics of AR described earlier, it can be said that the ontology of AR is in line with the human view of hermeneutics, with a focus on opinion formation and understanding as basic elements in interpersonal relationships and social systems. However, a stronger concept of action must be added, as well as a concept that deals with the fact that action or practice itself contains the possibility of human and social empowerment (Nielsen, 2014:332). In light of this, action researchers have a very specific task with AR: to make people more socially competent in their work and everyday lives (Nielsen, 2014:333).

What is the basis for AR? To try to answer this, we can begin with Hans Skjervheim (1971). Starting from the idea that the researcher must engage in the practical and be change-oriented if it is to be possible to recognise or interpret social reality, according to Skjervheim it is possible to conceptualise a scientific recognition theory that is based on joint action. Even action researchers describe the process of recognition as establishing a practice horizon between the participants and the researcher in which knowledge development is viewed as an ongoing dialogic process (Nielsen, 2014:333). However, AR has also drawn inspiration from the Frankfurt School (Nielsen, 2014:335).

AR is a practice-oriented research framework that somewhat disrespectfully uses all three paths of cognition, but often in practice orients itself toward the abductive and inductive (Hermansen, 2019:16–17). In the below quote Induction is described as:

> 'Induction is knowledge production based on exploration. The aim is to start with the aim of a prerequisite of open-mindedness in relation to openly examining, what differences or distinctions that are manifested in the often chaotic and incomprehensible field, which we have now begun to investigate in order to better understand it or explain possible contexts' (Hermansen, 2019:16–17).

4.2. GETTING READY FOR ACTION

Before contacting the technical high school in Aalborg to suggest a collaboration, I thought about how to handle the project. I decided it was very important for me, and the realisation of the project, to be realistic about four focus points: what I wanted to achieve with the project, how to get there, who to involve and how to create a good relationship with the people involved in the project. In all of the four focus points, collaboration and the involvement of other people in the project seemed to be the biggest challenge, as these were crucial for me being able to implement the project together with the technical high school. The process of developing a collaboration and getting people involved turned out to be much harder than I first anticipated.

4.2.1. FIRST MEETING WITH THE GATEKEEPER

The first meeting with the gatekeeper was held at the HTX in Aalborg. I was invited to the school, together with my supervisor, to meet with the gatekeeper who was the chairperson of the technology association and a teacher, both of whom taught the subject of technology. When we arrived at the school, we walked directly to the staffroom to meet them. They had prepared a table at the back of the staffroom for the meeting. After introductions, we ate a late breakfast; one teacher had brought freshly baked buns. While eating, we slowly started the meeting. I asked the teachers: What is it that you experience as being the problem? (Referring back to the starting point of this project; The technology teachers' lack of consensus on how to work with PBL in the technology subject) (Field notes, 17.11.17). After they presented their perspectives, we further discussed the possibility of me observing different technology classes from mid-November until Christmas, and conducting interviews with students and teachers (Field notes, 17.11.17). We also discussed the possibility of me participating in the teaching of technology at both A and B levels in 2018 (Field notes, 17.11.17).

As we got deeper into the conversation, the two teachers also suggested how I could be part of the activities at school. After talking about how I could conduct research on HTX together with the teachers and students, the gatekeeper presented a proposal for a project she was interested in that both my supervisor and I had participated in. The gatekeeper introduced us to a research and development (R&D) project for which material should be developed for the continuing education of technology and technical

science teachers, called 'Product development as a systematic and iterative process'. This contained the phases problem identification, problem analysis, product principle, production preparation and realisation. The purpose of this project was to look at the progression from the course in product development (PU) over technology and to the technical science profession, with the aim of developing teaching materials for continuing education and teaching of the subject didactic modules (Field notes, 17.11.17). Concluding the presentation of the project, the gatekeeper mentioned that the end result could be presented through articles and, in my case, one could fit into this PhD.
The meeting concluded with the teachers saying I was welcome to conduct research for my PhD project at the school, that they would very much like to participate in it and that we should soon have another meeting to follow up on the R&D project.

4.2.2. MEETING WITH THE TECHNOLOGY TEACHERS' ASSOCIATION

My first meeting with the Technology Teachers Association[4] was on 4th December, 2017. I arrived alone at the meeting this time. It was held in a classroom at the technical high school in Aalborg, in the north-west corner of the school. The atmosphere in the room was tense. I may have felt that because some days before the meeting, I had been informed that more than one teacher had questioned my interest in and knowledge of HTX.

When the meeting started, eight technology teachers and I sat around a big table in the middle of the room. The agenda for the afternoon and early evening started with me presenting the plan my research. I began by telling the teachers how I was a former student of this technical high school in Aalborg myself. Through this story, I tried to give the teachers an initial reason to trust me, basically telling them that I was not new to this. I knew this secondary education institution. I was one of them. It was an attempt to establish myself as a trustworthy person, an approach recommended in *You and Your Action Research Project*: *'Establish Right from the Start that You Are a Person to Be Trusted'* (McNiff et al., 2003:52). After, I explained my idea for the PhD according to what the gatekeeper and I had arranged at my first meeting on 17th November. In light of my introductory story, the mood seemed to ease slightly, and the attendees of the meeting listened, interested. After the presentation I was met with a series of follow-up questions and comments, including:

(1) Is it your goal for technology to be a competence-giving subject?
(2) Consider your audience. Who do you want to observe? There is a difference between new first-year students and former ones.

---

[4] The Technology Teachers' Association was an association for all HTX teachers in Denmark who taught in the subject technology, where the teachers discussed the subject, developed courses, etc. Today, the association is called Technology and Technical sciences subjects Teachers' Association and includes both the teachers who teach technology and those who teach technical science subjects.

(3) Previous students can maybe be used to say something about the contributions of the subject of technology.
(4) Why choose HTX? Can the PhD say something about that?
(5) Should it be called technological *Bildung*?
(6) Recruitment for the subjects of technology and engineering. It is difficult to get teachers because, among other things, the minimum professional requirements. Will the PhD project look at this? (Field notes, 04.12.17).

The teachers' questions and comments were about the actual PhD project, but they also raised a number of questions about the technical high school context. Having a discussion afterwards about the questions and comments became a negotiation of access to the most important participants to the project: the teachers. Through this discussion I tried to obtain permission from them to move on with the project, and for them to agree to participate. Here, I was trying to adhere to McNiff et al.'s directive: 'Obtain permission from the people whom you hope to involve in your research' (2003:50).

By the end of the meeting, three teachers decided to participate in the pilot study and let me into their classrooms. This suggested that I had managed to make them feel comfortable with me and my PhD project plans. Again, I wanted to follow McNiff et al.'s recommendation:

> 'Make it clear from the start that they are participants and co-researchers, and not 'subjects' whom you are studying. You are studying yourself, in relation with them. Explain this carefully, and as many times as necessary for them to become comfortable around what you are doing' (McNiff et al., 2003:50).

4.2.3. THE ESSENTIAL PILOT STUDY

After negotiating access at the first meeting with the Technology Teachers Association, I started conducting my pilot study on HTX in Aalborg. It was planned for the pilot study to start on 6th December, 2017. Three teachers chose to open the door to their classrooms to me, giving me the opportunity to get an insight into the subject of technology.
On the next page is a list of technology classes I observed during the pilot study. The classes are listed by date, study direction and department on HTX Aalborg.

Date	Time	Study direction	Department
06.12.17	08.30–11.30	GameTech	C. A. Olesens Gade
07.12.17	08.30–15.30	International	C. A. Olesens Gade
13.12.17	10.30–14.00	Technical science subject	Øster Uttrup Vej
14.12.17	08.15–15.00	Technical science subject	Øster Uttrup Vej
18.12.17	08.30–11.30	Technical science subject	Øster Uttrup Vej

Table 6 – Overview of observations in the pilot study

The observations made during the pilot study are described below, and my immediate reflections written down after each observation are stated afterwards, followed by a brief summary of the three observations. In relation to the dates 13/12, 14/12 and 18/12 2017, only the first date of observation is described in detail as all three observations were made in the same class with the same teacher.

6TH DECEMBER, 2017

Entering this first-year class there is a lot of noise, but that changes when the teacher arrives. As the teaching starts, it is apparent that this is based on teacher-centred classroom teaching. The teacher starts by setting the scene with a repetition of PBL, and at the same time referring to a previous project the students had done where they did some previous research in order to frame their key problem for the project. Further, the teacher reminds the students of the problem tree to be used to develop and delineate the selected key problem, and of the fact that the logbook is important and a key element for a good project start and process.

After the short brush-up on key elements included in a good project, the teacher proceeds to talk about requirements for the product they have to develop as a part of the project they are working on now. The students have to reflect on how they perceive four different requirements: nice, simple, not too far and fast. The students' responses include comments like 'nice is very subjective', 'simple does not fit with working with problems' and 'what is long and fast?' After the students' responses are taken in a plenary, it is concluded that the requirements the students develop for the product they are designing must be measurable. The teacher then gives the students some examples of good requirements: (1) must answer the problem statement; (2) you should be able to be create it in the workshop; (3) must be done according to drawings; (4) you should be able to create it in two to four hours; (5) it must be within budget.

Now it is time for students to work in their respective groups. Their task is to set up five requirements for their product in relation to their project. They get 20 minutes. First, they each need to figure out what requirements they would make for the product themselves. Subsequently, in the group they must find five requirements that they can agree on for the product. All groups stay in class as they do not have a long time to complete the task. All groups get started quickly. Some indicate that they have already been working on some requirements, while others are very concentrated on the task. After the assignment is completed, the students are given a five-minute break and the class is immediately transformed into a large recess area.

After the break, the teacher distributes blank pieces of paper to everyone in the class. They have to do an individual assignment. The students are subsequently instructed on how to proceed. First, they are asked to fold the paper twice. The teacher shows them how. The students are further asked to have the following three things in front of them for this exercise: computer, pencil and the folded paper. The task now is that, based on the problem they are working on in the project and the requirements they have already set, they must write down what the purpose of their project is. The timer is set to six minutes, and they have to write down everything they can think of. Some students do not have a pencil they can use. They think they are outdated. The teacher had foreseen this problem and had therefore brought an entire box of pencils the students could borrow for the assignment. As the clock rings, the short task is over and there is again turmoil in class. The students now have to find the folded piece of paper again. For this assignment they are asked to write down ideas. One new idea for every 30 seconds. The ideas should be possible solutions for the project. One of the students asks what exactly it is they need to do. They do not understand. It is explained to them again and they start working.

After the first 30 seconds are up, the students are very surprised by how fast the time went by and they get very unfocused. The second time around, the students have gotten the hang of it. The assignment ends and a new one begins. This time, the students should go out into groups and present the ideas they have got to each other, one at a time. Afterwards, they have to prioritise and combine the ideas using the colours red, yellow and green. They should write down all the green ideas in their logbook. Subsequently, the students continue to work on their ideas in their respective groups. Another break is held.

Class starts again after 15 minutes. The teacher starts by telling the students about solutions, and then also presents the students to a choice matrix. It is all about choosing solutions objectively and thinking about the fact that there is not only one solution. The teacher also presents the students with a point element, which they can add in their choice matrix and thus get an impression of which requirements are most important and which solutions are agreed upon in the group. The end comment is ‘remember to kill your darlings’.

After three hours, the teaching changes from a very teacher-led approach to more student-centred teaching. The students are a little slow to get started on the choice matrix assignment and the teacher therefore asks for a keyword to get their attention and get them to stop talking about private stuff and start working. A student replies: 'Our keyword in here is 'listen' because they can't shut up'. Afterwards, the students in the groups begin to set relevant language goals for the project and the group work now seems very active and dynamic. However, it only lasts a short while as the students' focus begins to fail as they find that the lunch break is right around the corner (Field notes, 06.12.2017).

My immediate reflections written right after the observation were:

(1) The teaching is the class is characterised by classical classroom teaching.
(2) The project work form is not a natural 'tool' for the students.
(3) Students are unsure of what to do. They have to get help from the teacher to get started and to move forward in each step of the project.
(4) Switches between classic classroom teaching and project work in groups.
(5) Administrative groups present some challenges for the students.
(6) The students' group work alternates between being active and dynamic and being unfocused.

7TH DECEMBER, 2017

I join the class at 8:30. The teacher is working with the students on how to design a material list for their project when I arrive. The students are very active in the class review and ask many elaborate questions. The teaching is very similar to classic classroom teaching. Subsequently, technical drawings are reviewed. examples from a previous 'birdhouse' project are shown by the students. It is explicit that the students must remember to show length measurements, distance from screws, etc. In addition, they must also remember to carry out assembly drawings. Further, they are told that they must specify each small part, and that the numbers must be in the specification list and in the drawings. Technical drawings of the product must be depicted from above, front and left. One of the students puts his hand up to ask which program the drawings should be made in. The teacher replies: Onshape. Onshape is a computer-aided software system the students have been given little instruction on how to draw in. Another student adds to the conversation that AutoCAD also can be used to draw the technical drawings. Afterwards, the students are told that the written part of their assignment must be completed on January 24th, as they will then be in the workshop. Further, the technical drawings must be completed when the day is over.

Teaching continues at a leisurely pace. Most students actively follow it. The teacher informs the students that she will come and talk to all groups during this class to hear about their logbooks and group contracts. As the teacher finishes telling them about the plan for the rest of the lesson, the students quickly get into their groups and start working. They quickly choose where they want to sit (inside or outside the classroom), and have it written on the board so the teacher can find them. The teacher starts walking around to the different groups. The students sitting in the classroom are very calm and seem to work in concentration. The students who have placed themselves in the corridor make more noise. As the teacher starts her rounds, she starts with group five and moves on to group two, as both groups are in the classroom. After supervising the two groups, there is a short break. During the break, several of the students seek additional supervision. Some with extra questions for the assignment, while others ask more practical questions. After the break, the teacher starts walking around again to talk to the groups she hasn't reached yet. The teacher starts with group four and afterwards she talks to group one and then group three, six and seven. When the teacher is finally back in the classroom, group three reports back to the teacher that their project is now back on track. Although the teacher is now back in class, she must also keep track of all the students who, while the teacher was talking to the other groups, have gone down to the workshop. The teacher therefore asks in class if anyone has any questions right now. As all the groups in attendance state that they do not need help right now, the teacher needs to go into the workshop to see how things are going down there. As the teacher comes down to the workshop and finds the students, she immediately begins asking critical questions about the performance of their product for the project. While doing that, the students are more preoccupied with arguing about why they should get more time to do their project. However, it was rejected. The students then come regularly and ask questions. Technical questions, practical questions about the workshop and specific questions for the written work. Back in class, there is a group reporting that they would like feedback on what they are missing before they can deliver the day's assignment. The groups begin to hand in their assignments at the end of the day's teaching. The mood lifts, with a mixed sense of relief that the task is complete and joy over the fact that they can now go home.

My immediate reflections written right after the observation were:

(1) The teaching in the class is characterised by classical classroom teaching.
(2) The working method (PBL) requires some control in the students' first year.
(3) There is a very creative and independent environment in the classroom.
(4) The students ask interested and relevant questions.
(5) The students need very specific instructions on what to do.
(6) Administrative groups present some challenges for the students.
(7) The students' group work alternates between being active and dynamic and being unfocused.
(8) The group process is very dynamic and changeable.

13TH TO 18TH DECEMBER, 2017

I show up at the classroom at 10:30. The classroom is almost empty. A few students are working, but the teacher is nowhere to be found. I walk down the aisles as I see some people gather at the other end of the school. As I get closer, I can see that the students are about to start a Lucia parade on the lower floor, and it will surely take some time before they return to the classroom as they have walk around the whole school, and the students who do not attend work as support along the route. After the Lucia march, all students and teachers return to their classes.

After a short time, all the students are actively working in their groups again. There is a lot of activity in the class. At first glance it seems very chaotic, but it is more of a constant buzz of activity, only interrupted by small social conversations, after which the students return to work. The teacher walks around the classroom talking to the groups, who express that they would like help and supervision. The students themselves set the agenda for the guidance, so have the opportunity to ask relevant questions. Therefore, the supervisor does not have a set routine or set of questions for the students. At the end of each of the short supervision sessions, the teacher follows up by asking whether or not the students have what they need for the time being. While the teacher is supervising different groups, there is still a lot of activity in the classroom. None of the students are walking in and out of the classroom; they are all focused on working on their projects. One of the groups discusses solutions and they have a good talk about them and the drawings of the possible solutions. After the discussion, the students each return to the tasks they were working on before starting the discussion. The students also use each other across groups. They look for answers and guidance from the other groups, even if the teacher is present in the classroom.

At 11:30 it is time for a lunch break. Most of the students leave the classroom to buy lunch but return to the classroom to eat. When the break is over and the teacher is back in the classroom, the students immediately start asking for supervision. One group would like supervision on rafters and main rafters. The teacher helps, and as they talk about how the students can handle their challenges, the teacher draws and explains to better illustrate what he means. After he explains himself, another group approaches him to ask whether they can shop for materials for their product themselves. He replies by saying that it would be okay if going out and buying it themselves is the fastest way to get the materials. Put another way, if the materials cannot be ordered home, it is okay to spend time picking them up. Subsequently, the teacher first speaks to another group inside the classroom and then goes off to speak to a group located outside in the common area. The group that is going to pick up materials decides to drive, and while they are on their way out the door there is yet another group asking for supervision. Subsequently, there are several students who come continuously and ask questions. They all seem to be very active and engaged. They ask technical questions, ask about technical drawings and specific questions in relation to their project, and the teacher answers with questions and urges the students to reflect.

In class the groups sit together well enough but work very individually on their own computers. However, the group members still help each other to remember which drawings to draw and when the various items should be handed in. They distribute the tasks among themselves. Although the students themselves should seek guidance from the teacher, the teacher walks around the class, talking to the students, watching what they are doing and asking critical questions. While the teacher walks around the class he tells me that there is a difference in the teaching methods used by teachers in the subject's technology and technical science, adding that he and his colleague who co-teaches this class would like to teach students to think for themselves, which refers to

the form of teaching. He further adds that he does not apply classical class teaching as other teachers do. He thinks it's boring. Discussions in the groups continue in the background as the teacher talks about how he teaches. When he finishes, he goes to talk to another group of students. They have some questions about some drawings they have on the table in front of them. The students are asking whether it is mandatory to hand in all of four drawing mentioned in the material that has been handed out. The teacher explains that they should not hand in all four drawings; they should focus on floor plans of all floors and plan the placement of rafters, but a drawing of the location of the house on the ground is not necessary. The teacher repeats this same routine most of the day, pacing around the class and listening to the group discussions. As the clock strikes three, the students start to pack up their stuff. Teaching ends at 2pm, but the teacher informs me that the students often stay longer to work on their projects.
Below is a summary of my immediate reflections for each of the three observations made in this class:

(1) The students in this class function very well within the 'loose' structure.
(2) The students structure their own time.
(3) The students are very focused when they work, and they stay in class.

In summary, it is clear that the teachers have different ways of teaching technology and technical science. Some of the differences I observed will be discussed below.
Some teachers prefer to teach technology and engineering in a classical classroom manner. They often use classical class teaching to teach theory and methods that can be used in students' projects, but also for the testing of selected theories and methods through teacher-controlled exercises. Other teachers find classical classroom teaching unnecessary and even boring. They do not feel that they benefit from this type of teaching, and do not believe it benefits the students, either. They prefer innovative, learner-centred approaches.

The above findings support the teachers' statement that there is no consensus on how technology and technical science teachers work, or on the materials and methods used to teach these subjects. To further explore where there are differences I relation to the lack of consensus, I collected both qualitative and quantitative empirical data, described below.

4.3. GATHERING DATA

Collecting data involves several processes. Gathering data requires knowing where and when to look for data, and also observing what is happening, recording and storing it and afterwards sorting the data and knowing how to retrieve it later (McNiff & Whitehead, 2006:138). The following describes the process of what happened on HTX through observations, interviews and a survey.

4.3.1. OBSERVATIONS

Based on the pilot study conducted, which generated a number of observations in technology and technical science subjects on HTX, it was decided that more empirical data on teaching should be collected, and that this should be done through further observations as observations are one of the most direct methods of collecting empirical data on social behaviour in natural settings (Krogstrup & Kristiansen, 1999:57). Essentially, undertaking observations involves performing anthropological fieldwork, where the researcher stays in the field they would like to investigate over an extended period (often several years). The researcher learns the language of the field and participates in everyday life in the field and associated social events (Ingemann et al., 2019:230; Krogstrup & Kristiansen, 1999:25). One of the foremost goals of anthropology is to gain an inside understanding; to gain such understanding, observation as a method can be used (Krogstrup & Kristiansen, 1999:26–27). Therefore, an observational study provides access to very in-depth and practice-oriented empirics (Ingemann, 2019:232) on all non-verbal behaviour, which also covers empirics generated by senses other than sight (Krogstrup & Kristiansen, 1999:45).

There are many different approaches to observational studies, just as observation as a method is often included in a practice composed of several different methods. Therefore, instead of talking about one observation method, one can say that there are different types of overlap (Krogstrup & Kristiansen, 1999:45). This is the case in this project. Here, the observations are part of a methodological practice that, in addition to observations, consists of interviews and a survey study (the interviews and the survey study will be described in the following sections). Also, during the observations on HTX, I experienced the importance of the more routine work done in connection with the observations for data collection, because it is a large part of my experience with HTX. This is emphasised in the following quotation:

> 'The participant observation was supplemented with an ongoing contact (...) in the form of interviews and more formal conversations, correspondence, telephone conversations (...) but there are also many informal lunch meetings, telephone conversations, gossip on the street, pleasant and private gatherings that never was written down on paper, but still plays a significant role in the data collection because they simply form essential parts of my experience' (Krogstrup & Kristiansen, 1999:46).

The observations from HTX include not only the planned observations but also all meetings held with teachers in the technology field from HTX schools across the country, the informal dialogs with teachers in the staffroom, the dialogs with teachers during the observations and in the workshop, the participation in various social events on HTX, and lunch dialogs and informal dialogs with students in the hallways. Not everything was planned, so therefore not everything was included in the method description of the observations that were made, but nevertheless were still part of them. When I describe observation with participation as separate from the rest of the methodology, this is not to neglect that the observations in this project also form part of a common methodology, but to better illustrate this part of the study.

Observation with participation

> ‘In observation with participation, the actors in the field are regarded as subjects, and it is considered a prerequisite for an adequate understanding that social phenomena are understood ‘from within’ (Krogstrup & Kristiansen, 1999:54).

‘From within’ or ‘from the inside’ must be understood in the way that I as a researcher interacted with the field I was investigating (in this case HTX), and by doing so, I played an active role as a participant in the environment on HTX where I also conducted my observations. The observations were unstructured and conducted in the teachers’ natural environment, the classroom (Ingemann et al., 2019:230). By unstructured it is meant that I as an observer took as my starting point a blank notebook (or in fact many) in which I noted down all my observations as a kind of running logbook (O’Leary 2020: 80). Classroom observation can be understood as: ‘The purposeful examination of teaching and/or learning events through the systematic processes of data collection and analysis’ (Bailey, 2001:114) and a similar conceptualisation from Tilstone (1998): ‘The systematic, and as accurate as possible, collection of usually visual evidence, leading to informed judgements and to necessary changes to accepted practices’ (Tilstone, 1998:6). Through such an observational study done in classrooms over a limited time, I was able to, very systematically, observe the teaching in the technology subject. Krogstrup and Kristiansen (1999) mentioned that through an observation study it is possible to observe how:

> ‘Social actors interpret their experiences and observations, define the situation they are in, identify the problems they face or plan actions by pulling on their exciting stock of experience and knowledge’ (1999:57).

In the natural environment of the classrooms, it was a prerequisite that I, as a researcher, participated in the field in order to observe ‘everyday routines’ in relation to teaching (Krogstrup & Kristiansen, 1999:57). In relation to such observations of participation, a distinction can be made between total and partial participation (Krogstrup & Kristiansen, 1999:54). I find this distinction between total and partial participation difficult to put into practice, because such a sharply divided distinction is more suitable as a clear description of a method than an actual practical approach. This is because it is my conviction, from my experience with practice, that many projects contain elements of both total and partial participation, which was also the case in this project. I performed total participation in the field on HTX as I stayed there for extended periods. This was especially true at the beginning of the project, when I was present on HTX many days a week for several months. At other times I performed more partial participation, when I only attended some activities on HTX. For me as a researcher, it was important to recognise in each period how present it was possible to be, both for the school’s capacity and for the development of the research project. This is supported by Krogstrup and Kristiansen (1999), who state that the researcher's 'participation may be total or partial, but in certain cases the researcher may advantageously switch between total and partial participation' (1999:57–58). By continuously evaluating how present it was possible to be at the school, and weighing this against how necessary it was for the project that I was present, it was possible to balance a good relationship with the school and the teachers.

Classroom observations on HTX

The strategy for selecting which classes I observed is largely related to the first meeting with the technology teachers about the pilot study, described earlier. At that meeting, I obtained permission from the technology teachers to move on with the project and to observe at the school. Three teachers decided at that time to participate in the pilot study and to let me into their classrooms. The strategy afterwards was to apply the snowball effect. In practice, it meant that I let the pilot study do the work. The teachers who participated in the pilot study talked to the other technology teachers while I was still doing observations on HTX, and I also spent a lot of time in the staffroom at that time. This combination of the participating teachers finding that the pilot study was not 'dangerous' and communicating this to their colleagues, and my presence in the staffroom, encouraged many other teachers to come and talk to me about the project, thus becoming participants. It happened over an extended period and as the project developed: one teacher and class at a time.

Below is an overview of the observations. The teachers' names are not included on the list as they wanted to remain anonymous. Neither are the names of the classes I observed, as this would identify the teachers. Instead, the observations are listed by year, study direction and department. Table 4 below provides an overview of the observations.

Teacher	Year	Study programme	Department
Teacher 1	1st-year students	GAMETECH	CAO/FRIIS
Teacher 2	1st-year students	International	CAO
Teacher 3	1st-year students	Chemistry	ØUV
Teacher 4	1st-year students	Industrial design	ØUV

Teachers (many teachers teach this course)	1st-year students	Product development	ØUV
Teacher 5	2nd-year students	The world of physics	CAO
Teacher 6	2nd-year students	The world of physics	ØUV
Teacher 1	2nd-year students	GAMETECH/ 1. del	ØUV
Teacher 7	2nd-year students	GAMETECH/ 2. del	ØUV
Teacher 8	3rd-year students	Technology A	ØUV
Teacher 9	3rd-year students	Technology A	ØUV
Teacher 8	3rd-year students	Technical science (B&E)	ØUV
Teacher 10	3rd-year students	Technical science (B&E)	ØUV
Teacher 11	3rd-year students	Technical science (B&E)	ØUV

Table 4 – Overview of observations

CAO	C.A. Olesens Gade
FRIIS	Nyhavnsgade
ØUV	Øster Uttrup Vej

4.3.2. INTERVIEWS

As mentioned earlier, observations rarely stand alone as a method, but form part of a common method practice. The following describes the second part of the composite methodology used in this project: qualitative interviews. Generally, you can say about qualitative interviews that:

> 'A qualitative interview is a conversation with a specific purpose, the purpose of which is that we as investigators must obtain knowledge about the problem that is taking us from. the persons we have selected to be included in our survey' (Ingemann et al., 2019:148).

The qualitative interview method was chosen here because by supplementing the observations with the qualitative interviews, what I was investigating gained depth. I could gain a deeper knowledge of and insight into the field of technology on HTX through interviews with both teachers and students.

After deciding that I wanted to conduct interviews as part of data collection, I tried to make some very general reflections about who it made sense to interview for this project and how the interview should be conducted. All reflections were related to the problem statement, upon which the project was also based (Ingemann et al., 2019:165–166). By reflecting on the selection of interviewees, I made a qualified consideration, also called a *purposeful selection* (Ingemann et al., 2019:166; Brymann, 2016: Chapter, 18; Harrits, 2012; Neergaard, 2010). In doing so, I sought to find the right interviewees to provide me with knowledge that could help answer the problem statement (Ingemann et al., 2019:166).

With qualitative interviews, one of the first considerations is about the number of participants to include in the same interview: single interview, group interview or focus group interview. I chose to conduct single interviews where; as the name implies, only one person is interviewed at a time (Ingemann et al., 2019:153). I chose single interviews as it was important for me to be able to give each interviewee my full attention, and to give them space to tell me about the technology subject and for the students what they have learned by attending HTX. Conducting single interviews enables to collect their opinions and assessment of the topic.

Selecting interviewees – teachers and students

Interviewing is a relatively flexible method of collecting empirical data. This also means that the selection of interviewees can be done in several ways (Ingemann et al., 2019:169). A starting point could be the snowball effect, where one selects and contacts a meaningful interviewee and conducts an interview with this one person; from new-found knowledge, another relevant interviewee is chosen. It is also possible to perform a selection strategy, where one interview is conducted at a time. Based on the knowledge gained from that interview it can be determined what further knowledge the researcher needs, and the choice of the next interviewee is based on this. The final choice is to select all interviewees at once, and conduct the interviews sequentially (Ingemann et al., 2019:170). I selected interviewees for different parts of this project based on a mix of these three strategies. So, although the three strategies can be very deliberately divided, in my experience this is not always the case in practice, and was not for this project.

The strategy for selecting the teachers to interview combined the three aforementioned strategies. Since I worked closely with HTX in Aalborg and was there every week, it was natural to select some interviewees from here. The four teachers from HTX in Aalborg were selected at the same time, based on the following criteria: (1) they teach the subject of technology and/or technical science; (2) they have different professional backgrounds; (3) they are interested in participating in this project. The first criterion was central to the interviewees' ability to express their views on the subjects, and how they as teachers teach those subjects. The second criterion was based on knowledge I gained during the observations, where it was clear that the teachers had different approaches to the subjects. Further, these differences were often mentioned by teachers themselves, who stated that teachers approach the subjects differently depending on their professional background. The third criterion may seem irrelevant, because if a teacher agrees to be interviewed then it does not really matter whether they want to participate or not. But, based on AR, which has a strong focus on participatory orientation it is crucial that every participant in the project is in an equal relationship, so that participating means being part of a democratic process (Nielsen, 2014: 205).

The interviewees from the other participating HTX schools were selected according to the same criteria as those on HTX in Aalborg. The difference was that they were not all selected at the same time but over time, as the project progressed. Selection was made by contacting schools and teachers, and also by applying the snowball effect. Interviewees, schools and professionals referred me to specific teachers in the technology and engineering profession who they felt would be interested in participating in the project. Table 7 below provides an overview of the participating interviewees.

High school	Interviewees	Place	Interview length
HTX Aalborg	Interviewee 1	Staffroom	44:28 mins
HTX Aalborg	Interviewee 2	Staffroom	1:07:30 hrs/mins
HTX Aalborg	Interviewee 3	Staffroom	24:29 mins
HTX Aalborg	Interviewee 4	Staffroom	32:15 mins

HTX Køge	Interviewee 5	Meeting room	1:27:11 hrs/mins
Kold College	Interviewee 6	Open area	1:06:39 hrs/mins
HTX N. Falster	Interviewee 7	Meeting room	35:00 mins
OTG	Interviewee 8	Meeting room	39:06 mins
NEXT Vibenshus	Interviewee 9	Meeting room	52:57 min
Slotshaven	Interviewees 10+11	Meeting room	Not recorded

Table 7 Overview of interviews with teachers – total

In the next section the details about the strategy for how the students were selected for interviews.

The strategy for selecting the students, on the other hand, was composed of only one of the three aforementioned strategies. As I worked closely with HTX in Aalborg and spent a lot of time observing numerous classes, I got to know the students. It seemed natural to select interviewees from some of the classes in which I was already acquainted with the students. The students were selected based on the following criteria: (1) they are students on HTX; (2) they are taught technology and/or technical science; (3) they are 1st, 2nd or 3rd-year students (equal numbers of each were selected); and (4) they have an interest in participating. The first criterion is self-explanatory. The second criterion is not, necessarily; all students are taught technology on HTX, except for new 1st-year students who take product development for the first couple of months, while technical science is only taught to 3rd-year students. For the third criterion I selected an equal number of 1st, 2nd and 3rd-year students so I could ensure there would be students who represented both technology and technical science. In regard to the fourth criterion, the reflections are in many ways the same as for the teachers, in that I needed participants to be actively willing. The difference, however, is that when dealing with young people, there is a greater need to ensure they actually want to participate, as it is significant to the empiricism that emerges from the interviews. This will be discussed further later. Table 9 below provides an overview of the participating interviewees.

High school	Interviewees	Place	Interview length
HTX Aalborg	Interviewee 1	Meeting room	20:58 mins
HTX Aalborg	Interviewee 2	Meeting room	20:34 mins
HTX Aalborg	Interviewee 3	Meeting room	22:32 mins
HTX Aalborg	Interviewee 4	Meeting room	20:19 mins
HTX Aalborg	Interviewee 5	Meeting room	12:35 mins
HTX Aalborg	Interviewee 6	Meeting room	19:01 mins
HTX Aalborg	Interviewee 7	Meeting room	22:20 mins

Table 8 - Overview of interviews with students

In addition to setting criteria for the selection of interviewees, I also considered how many teachers and students it was necessary to interview. Different literature on methodology gives different answers to such a consideration. Some literature recommends between 20–30 as an appropriate number of interviewees, while other literature suggests between 12–60, and others again mention 60 interviewees as a minimum (Ingemann et al., 2019:170). In this project I drew on Ingemann et al. who state:

> 'The number is not that important, but (…) we instead have to look at the knowledge we gain from interviewing and then decide the number based on that' (2019:170).

Therefore, as I conducted the interviews, I was aware of the saturation point, where I no longer gained new knowledge by interviewing more teachers and students, and where more interviews also did not help answer the problem statement (Ingemann et al., 2019:170). Put another way, I interviewed the number of teachers it took to get the knowledge I needed (Kvale & Brinkman, 2009:133).

4.3.3. FURTHER ON OBSERVATIONS AND INTERVIEWS

In this section are further reflections and information on the collection of empirical data, followed by reflections and a review of the transcription process, all of which is important for the transparency of the research process.

Ethical considerations before the collection of empirics

Prior to the collection of empirical data through interviews and observations, some ethical reflections were made. I, as a researcher, have the responsibility of ensuring that the knowledge I produce is valid. It is also my responsibility that the knowledge the interviewees convey does not reflect negatively on them (Kvale & Brinkmann, 2009:80). As a basis for these ethical pre-reflections, I used Kvale and Brinkmann's four concepts: confidentiality, informed consent, consequences and the role of the researcher (2009:86).

I decided from the beginning that all interviewees – both the teachers and students being interviewed and the teachers whose classes I observed in – would be guaranteed anonymity, to the greatest extent possible. By this I mean thon HTX in Aalborg knows I conducted a study about HTX and technology as I was a regular part of the school for a long time; they were also aware that many teachers of technology participated. Therefore, the teachers from HTX in Aalborg cannot be completely anonymous. They are anonymous only to the extent that their names and class names have not been included anywhere in the project, and it is not possible to identify which of the teachers made the various statements I quoted. The teachers from other HTX schools around the country are more anonymous, as only individual teachers were involved in the project, rather than the whole school. In relation to the students, it was important that the school and individual teachers knew about their participation because they were responsible for the students while at school. However, as with the teachers from HTX in Aalborg, nobody can identify the students from the quotations used as their names are not mentioned anywhere.

All interviewees were made aware of their anonymity either at a joint meeting (observations) or through a consent statement (interviews) (Appendix A). The statement of consent also informs the interviewees that they voluntarily attend, and that they may at any time withdraw their consent to participate (Appendix A). Additionally, a letter was sent home to the students who participated in the interview; not to get parental approval, as HTX is responsible for the students during school hours and because many students were over 18 at the time of the interview, but for students to inform their parents about their participation (Appendix B).

For these reasons, it is my assessment that participation for both teachers and students came with very little risk. For the students, a small risk could be associated with participation when, for example, they speak about their teachers in connection with their statements about what they have learned while studying on HTX. For the teachers, participation is also associated with a small risk when commenting on the subject of technology and how the frameworks drawn from the school affect that teaching. The risk was assessed as small because the school approved the study and teachers' participation. The school showed interest in the study and what it may entail.

Prior to the collection of empirical data, it was also important for me to consider my role as a researcher. Kvale and Brinkmann (2009) wrote: 'The role of the researcher as a person (...) is crucial to the quality of scientific knowledge and of the ethical decisions made in qualitative research' (2009:93). Therefore, I considered where and how my role as a researcher may have affected both my observations and interviews. Qualitative research is an interactive form of research, where I, as a researcher, interact with the participants and where I can also be influenced by them (Kvale & Brinkmann 2009:93). These are important considerations when the researcher becomes part of an organisation, as when conducting AR. It seems almost impossible in this context not to be influenced by the participants that I, as a researcher, interacted with daily. It is not so much about whether the researcher is influenced by the participants as it is about not acting on that influence. For example, I was definitely influenced by visiting HTX and being inaugurated in the different perspectives on teaching technology. What was difficult was to relate objectively to the different perspectives and not to choose sides. Therefore, it is very much about balancing the knowledge I was presented with; to remain objective and still direct the project. I cannot say I was not affected by my interactions with participants, but I can emphasise that I sought to be objective throughout.

Collection of empirics

This section provides a description and some reflections on the collection of empirics through observations and a description of the framework on which the interviews with the teachers and students were conducted. The section also includes a description of the observation and interview situations and locations and a reflection on what significance these may have had for the empiricism.

Observations

There was no set framework for the observations beforehand as the intention with the interviews was to get an insight into the technology subject and to learn about the technology teacher's life-worlds. Initially, the only thing planned was therefore also that the observations should take place in the classrooms while the teachers were teaching the technology subject and what teachers I could start observing with. When conducting participatory observation, those who are observed are naturally aware that one is present in space. Of course, that was also the case on HTX. My starting point in placing myself at the back of the classroom every time I arrived was therefore not chosen so that I could 'hide' myself, but to show respect for the technology teachers' work and try to disturb 'as little' as possible. This was especially the case when I started conducted observations back in 2017, where teachers and students did not know me so well. When I had observed in the classes for a few months this started to change. I still placed myself at the back of the room as a starting point, but as the teaching progressed, there was also room for dialogue with teachers and students about the technology subject. My presence has certainly during most of the observations influenced the teaching, but it has not been of importance to be able to observe how one works in the technology subject. So even though both teachers and students have been affected to some extent by my presence, the fact that they have been nervous or curious has not affected the image I have of the technology subject to such an extent that it has been distorted. In the event that it should have become it anyway I have not been aware of it, I have had observations in many different classes which have been able to be compared to a whole picture of how to work in the technology subject.

In conducting the observations, the students were in some cases briefed on who I am, where I come from and the purpose of the project, beforehand and in some cases I presented my-self when class was in session. It was done in this way because it seemed important to the teachers that they had a say in how it should go. That's how they seemed to feel most secure. Reflecting upon it, I do not think that the difference in approach has changed the students' behaviour in the higher grade and even if it does not have their behaviour that has had a focus, but how to work in the subject.

The topics raised during the observations were then included when formulating in the framework for the interviews.

Interviews

In advance, a framework was set for the interviews with both the teachers and the students. This was done to try to ensure that the empirical data collected only helps answer the problem statement of the project. In laying out the inductive approach in the project, the framework on which the interviews with the teachers and students were conducted is not based on theory but rather on the observations made in HTX. The topics raised during the observations were included when formulating the interview questions. The framework for the interviews with the students was based on a more open approach, placing it somewhere between the semi-structured interview and the narrative interview. The main question creating the frame is: What have you learned during your time studying on HTX? It can thus be argued that the framework for the interviews with both teachers and students is predominantly open. However, the framework for the interviews with the students is more open as students were given free rein to tell me what they felt they had learned during their time studying on HTX.

The interviews were held in several places as I interviewed two different groups. The interviews with the teachers from HTX in Aalborg were held in the staffroom, some on sofas in the middle of the room and others in small open meeting rooms at the back of the room. The interviews with the teachers from other HTX schools around the country were conducted in the teachers' respective schools, both to make it easier for the teachers and ensure a higher participation rate, and also so I had the opportunity to visit the different schools and get guided tours of areas central to the subject of technology. The teachers were in a familiar environment, so I presumed they would be comfortable here and would find it easier to tell their stories (Kvale & Brinkmann 2009:81). In contrast, I am also aware that the interviews being conducted at the teachers' own schools may have had an impact on what they felt they were able to tell me. Thus, the physical framework for conducting all teacher interviews may have had an impact on the empirical data collected. The student interviews were all been held on HTX in Aalborg, where all of the students were enrolled. More specifically, they were held in a small meeting room in the school's library. This was chosen to make it easier for students to participate. With that choice, I became aware that the location could have an impact on what the students would tell me during the interviews. But, as the interviews were about themselves and what they thought they learned during their HTX study, I assessed that the impact on what the students said would be minimal.

In conducting the interviews with both teachers and students, the interviewees were briefed on who I am, where I come from and the purpose of the project. The prepared consent statement was reviewed with the interviewees to ensure that they agreed with the framework for their participation (Appendix A).

During the interviews with the teachers, the focus was on asking in-depth and clarifying questions to gain a deeper insight into how the individual teachers work in the subject of technology. Similarly, during interviews with students, the focus was on in-depth and clarifying questions, both to gain a deeper insight into what they felt they had learned through HTX study, but also to have students tell their story. (Kvale & Brinkmann, 2009:175). The interviews with both teachers and students ended with the same question: Is there anything you would like to add or tell me before the interview ends? This was done as a form of debriefing, which is important to end the interviews in a good way and so the interviewees had the opportunity to take up topics they had thought about during the interview (Kvale & Brinkmann, 2009:149).

The transcription processes

Both the interviews with the teachers and students were transcribed afterwards. This section describes the practical aspects of that transcription.

To ensure it was possible to transcribe the interviews, they were recorded. Before each interview with both the teachers and students, I asked whether it was okay for the interview to be recorded, and I pointed out that the recordings would be deleted after the end of the project. This was also written down in the consent declaration form that all interviewees filled out before the interviews. To ensure a good quality recording, I tested the quality of the recordings beforehand, and decided to record the interviews with a telephone as this provided the clearest sound recording and felt more natural in this situation, especially when interviewing young students. This is in line with what Holstein and Gubrium suggest when they emphasise that to enhance transcription quality, it is important to ensure a high-quality original recording (Holstein & Gubrium, 2003:276). The transcriptions were done in the same order as what was said in the recordings, in an attempt to capture as much of the interview situations as possible. Notes were also taken during each interview, which was done to further ensure high-quality transcribed material. In this way, it has been possible to follow up on the interview and the interviewees' statements on an ongoing basis, and it has been possible to note small additional observations along the way. By writing down notes in two parts it was possible during the interview for the interviewee to clarify previous statements or validate the interviewer's initial interpretation (Holstein & Gubrium, 2003:282). According to Holstein and Gubrium (2003), both the transparency of the transcription and the fact that notes were taken during the interviews helped ensure a higher quality transcribed material (Holstein & Gubrium, 2003:276).

As an interviewer, I was responsible for some of the transcripts, while others were transcribed by a student assistant. I chose to transcribe some interviews myself because I conducted the interviews and therefore have an insight into them that an outsider cannot have. Nevertheless, I decided that a student assistant should transcribe some of them in order to save time. To ensure a high-quality transcription, some ground rules for transcription were laid out, including that everything from the recorded interviews should be transcribed, and if there was uncertainty about what was said, the transcriber should write this as '(uncertainty)?' The degree of uncertainty was to be denoted by adding additional question marks, such as: 'where???' or '(uncertainty)???' The latter would mean that the recording was verging on incomprehensibility. In the event that the uncertainty could be ambiguous, this was to be written with a forward slash (/) between the possibilities, for example: '(Proposal 1 / Proposal 2)?' Following transcription, I read through the full materials to ensure understanding of each interview and uniformity in transcription throughout. This was done to ensure an even higher quality transcription.

The fact that the interviewees were promised anonymity also had an impact on the transcription process, which is why the interviewees' names do not appear in the transcribed material, articles or in the subsequent analysis. This was also based on the understanding that the names of the teachers and students had no bearing on the knowledge they brought to the project. In the transcribed material, articles and thesis, the interviewees are referred to as Teacher 1, 2, 3, and so on, and Student 1, 2, 3 and so on. In this way, it was ensured that the interviewees cannot be identified by other persons.

The collection of empirical data and the transcription of this gave rise to further reflections, which are presented in the next section.

Reflections after the collection of empirics

After the collection of the empirical data I can see that my role as a researcher has had an impact on both the observations and the interviews conducted. I assumed that all participants in both the observations and interviews were very open. I assumed this because both teachers and students sometimes expressed very direct views on, among other things, the government, management, teachers and so on. It is therefore also important to note the possibility that some participants may have passed on sensitive information that could potentially harm them. This creates a possible ethical dilemma (Kvale & Brinkmann, 2009:196) regarding how much of the knowledge I gathered I can pass on while still protecting the participants. It is important to pass on the valuable knowledge I gained about the field of technology, especially as there is little previous research in the field. But, of course, this should not be at the participants' expense. As I anonymised all participants, it was also possible to pass on as much information about the subject of technology as possible.

I also noted that, at the start of each observation in a new class, I did not start from the same point. In some classes I was asked to introduce myself and the PhD project. In other classes, the teachers had told the students about me in advance. In others again, I was not introduced at all, and the students themselves asked me why I was there. I believe this did not make any difference to the process as a whole, but it had an impact at first and on the creation of trust between me and the students. In some classes it seemed to take longer to build a trusting relationship with the students; relationships in which we could interact without them being overly curious about my presence and whether I was writing down what they said.

In addition, I noted that the way I asked questions in the interviews may have influenced the interviewees' answers. The framework that was created for the teacher interviews was in the form of an interview guide (Appendix C). The questions included in this guide naturally guided the teachers' narratives. Follow-up questions were also influenced by the framework, as well as by the empirical data collected. The framework created for the student interviews (Appendix D) and the follow-up questions asked during interviews also naturally guided the students' narratives, as the interest was hearing what the students felt they learned during their HTX study. However, it is a natural part of preparing an interview guide to guide it in a particular direction dealing with a particular topic, which therefore naturally also refines the interviewees' answers.

In gathering the empirical data, some similarities between the interviewees were identified. All of the teachers teach the subject of technology and at least one other subject. They have all been teaching technology for a number of years and have hands-on experience. These factors may indicate some common features in the teachers interviewed. However, they previously had very different professions. Some are trained engineers, while others have a science education, and so on. The empirical data contains teachers of technology on HTX schools across the country. Jutland, Funen, Zealand and Falster are all represented. However, I was able to talk to more HTX schools and technology teachers. So, even though the teachers who participated in the interviews represented a wide area of Denmark and teach the subject of technology differently, it is possible that there are other perspectives represented by teachers who did not participate. However, I did conduct interviews until I felt the material was saturated, meaning that – also informed by my observations – I could clearly see a dividing line between two perspectives on teaching technology. Within the perspectives were differences, but the overall perspectives were similar.

Similarities between the students who were interviewed were also identified: they were all students on HTX in Aalborg and were taught the subject of technology. However, there were also differences, as they did not all have the same technology teacher. Further, some were first-year students while others were second or third-year students, meaning they were not all the same age. The first-year students are 16 or 17 years old, while the second-year students are 18 or 19 and the third-year students 20. The empirical data only consists of students who study on HTX in Aalborg. I could have included more students from HTX schools around the country, which might have provided more perspectives about what students feel they have learned through their

HTX study. The intention, however, was to gather students' individual stories about what they felt they had learned, to identify whether it is possible for students to gain technological formation from attending HTX.

4.3.4. SURVEY

The observation study and the interviews for a common method practice, together with the last component in this project (the questionnaire-based surveys), are described in this section. In a questionnaire-based survey, the following is considered:

> 'Data collection methods based on the questioning of the selected individuals, whether the questioning is conducted during a visit or telephone interview or by the respondents themselves filling out a sent or distributed questionnaire' (Hansen and Andersen, 2009:101).

The quantitative method survey was chosen here as it supplemented the qualitative data collection that had already been completed. In this way, I had the opportunity to address a specific topic that emerged through the qualitative collection of empirical data, and to perform a systematic and broad data collection of this specific topic.

After deciding that I wanted to conduct a survey, some of my first thoughts were about whether this survey should be a traditional mail survey or a web-based survey. I chose the latter (Appendix E), which is also a widely used data collection method. This method was chosen because it is a rapid form of data collection and is also cheaper than mail surveys, but these were not the only reasons why this method was chosen (Hansen and Andersen, 2009:102). With internet-based surveys it is easier to manage respondents' answers, as it is possible to see who answers and to send a reminder to those who received the survey. A further strength of internet-based questionnaires is that the data quality is often better than the data from mail surveys, because on-screen questionnaires are as clear as they would be on paper but respondents do not have to decide for themselves which questions are relevant and which can be omitted. A further advantage of internet-based surveys is that no more than one answer per question can be given, when appropriate (Hansen and Andersen, 2009:156).

Regarding the problem of representativeness, this challenge arises when conducting purely internet-based studies (Hansen and Andersen, 2009:157). However, this is not a purely internet-based study. Although the survey was conducted via the internet, qualitative methods such as surveys and interviews were also used. Therefore, the study did not focus on sending the internet-based survey to a representative sample of technology teachers affiliated with schools around Denmark. Instead, the aim was to get a certain number of technology teachers to express which concepts are central to the subject, and which they believe lack a coordinated conceptualisation, to get an idea of which concepts should be focused on and thus gain a deeper insight into the subject. Concurrently, this gave teachers on HTX schools across the country the opportunity to take part in the project and have an impact on the outcome, even though I was based on HTX Aalborg.

In choosing an internet-based survey, it was important to consider how many people to send the survey to. As it was not possible to get the email addresses of all technology teachers at Danish HTX schools, the study population was restricted to those I could contact via email (Hansen and Andersen, 2009:157). I was able to get email addresses for 80 technology teachers, so the survey was sent to all of them. Upon reflection, I realise I might have instead sent a common email to each HTX school, and the secretary handling the email could have forwarded my email containing the link to the internet survey to the technology teachers in their school. That way I could, in theory, have reached out to more teachers. The downside would have been that I could not have kept track of how many teachers received the email. Secretaries may not have forwarded the emails to the right teachers. Further, I would also not have been able to keep track of who answered the survey as I could with the approach I took, which sent emails to teachers individually. Additionally, the method I chose enabled me to send reminders to each teacher.

Collection of data

This section describes the framework on which the survey was conducted, and reflects on the significance this may have had for the data.

A framework was set for the survey in advance, and sent out to technology teachers. This was done to try to ensure that the data collected would help get insights into the language of the technology teachers – which concepts are central to the subject and which need further conceptualisation. The framework is not based on theory but on the observations and interviews conducted. From the pilot study, and later through observations and interviews, it became clear that the technology teachers did not have a coordinated language. It became part of the project to seek to create this together with teachers. To do so, it was important to hear from the teacher's which concepts are central to the subject and which need a common conceptual equation. The survey was sent to 80 email addresses belonging to technology teachers on HTX schools around Denmark.

4.3.5. CRITICAL REFLECTIONS ON THE METHODS

As previously described, the methods used were chosen because they could help answer the project's problem statement. It is also important to reflect on the possibilities and limitations of the methods.

The observations in the classrooms on HTX were made with me as research functioning as a participating observer. This approach is often criticised on the grounds that:

> 'Only covers a limited field; the observer will be selective in his data selection; the observer can influence the social situation he is studying; the researcher is not able to collect his data systematically' (Krogstrup and Kristiansen, 1999:203).

However, the critique from the quote above cannot be generalised, as this kind of critique often has its starting point in a particular paradigm that lies outside the approach in this project. Instead it is central that the observations and interpretations in this project actually reflect what I as a researcher have been interested in gaining insight into, in this case the subject of technology, and observations as a method has been ideal for that. Furthermore, the method has also been able to help shine a light on the raised problem statement.

An interview creates a very special space for a conversation: a small, confined space in which time and place stand still for a moment, allowing the researcher to collect empirical data. That is one of the strengths of the interview method (Ingemann et al., 2019:215). In this way, researchers can gain insight into and get in-depth with the specific topic they are investigating, and can design the whole process around this themselves. The interview method is also very flexible and open, but because of that can also be a challenge to work with. We do not know what will happen when we enter the room to conduct interviews. It is important that researchers consider the interviewees in interview situations, while ensuring that they get the knowledge they need themselves. The researcher is therefore in a field of tension, which places some demands on them (Ingemann et al., 2019:216). If they are not careful, this tension can affect the interviewees and thus also the empiricism.

The interview method, of course, also has limitations. It can be difficult to grasp human relationships and interactions in an interview with a single interviewee, even if the researcher asks for these. Similarly, a practice can be difficult to capture through interviews, such as technology teachers' practice with HTX. Therefore, as previously mentioned, in this study interviews were combined with observations of the teachers' practice. I was able to gain some insight by asking questions and interviewing teachers about their practice as they reflected incredibly well on how they work and why they do what they do. But, observing how technology teachers work provided a deeper insight into their practice, as interviews could not necessarily capture this (Ingemann et al., 2019:216).

Internet surveys had the obvious advantage that I, the researcher, could more easily control the respondents' answers to the questionnaire than would be possible with a mail survey. But internet surveys also had a weakness in dealing with population boundaries, and therefore also reducing probability committees. Therefore, the representativeness of the study is under question (Hansen and Andersen, 2009:156), although this criticism is not relevant to the present study.

With the chose methods, it has not been the intention to arrive at a definitive truth, but instead to arrive at the best interpretation that was valid when the application of the methods was implemented.

A deeper reflection on validity can be seen in Chapter 8 Quality considerations.

4.4. REFLECTIONS ON THE ACTION RESEARCH APPROACH

Upon conducting the AR project, I reflected on my practice as an action researcher. In doing so I found several challenges related to conducting AR in organisations. These reflections are discussed in the article below.

4.4.1. LANGUAGE AS A DECISIVE FACTOR FOR ACTION RESEARCH: REFLECTIONS ON CHALLENGES ENCOUNTERED IN AN ACTION RESEARCH PROJECT AND THE CENTRALITY OF LANGUAGE, DIALOGUE, AND CONCEPTUALISATION TO OVERCOMING SUCH CHALLENGES

This article is in review at *Qualitative Research in organisations and Management* as:
Jeppesen, M.M. (2020). Language as a decisive factor for action research.

The purpose of this article is to address the methodological implications of the use of AR, based on my experiences in an AR project on the Danish HTX programme, and to further challenge the methodological discussion by pointing to the importance of having a focus on language when doing an AR project in any organisation. Conducting an AR project in the Danish HTX programme, I used several different methods – mainly classroom observations and interviews with teachers and students – to gain a deeper insight into the HTX community, and more specifically the subject of technology. Regarding the role of the action researcher, I identified seven challenges that I encountered in the process of conducting such research over time. These related to my initial desire to create change, initial distrust, use of language, relationship building, power dynamics, vulnerability and participant selection/attraction/retention. I have argued – and provided some empirical evidence in support of this argument – that language, dialogue and conceptualisation are key to meeting and overcoming such challenges. It is further argued (constituting the main methodological contribution of this article) that Nørreklit's (1973) philosophically grounded 'conceptualising method' provided not only guidance in meeting such challenges but also the dialogic pathway to finding reasonably sustainable solutions to the real research.

Keywords: Action research; challenges in action research; language conceptualising method; Danish higher technical examination programme (*HTX*); reflection on role; technology teaching

There are many different approaches to AR: there is no one right way to conduct such research, and researchers adopt their own particular approaches to employing the methodology. Although action researchers come from diverse disciplinary backgrounds in exploring a range of research questions in various contexts, they share a common methodological purpose and a belief in its efficacy (Greenwood & Levin, 2007). Even though AR is often presented as a diverse and often divergent set of practices, some similar overall characteristics, considered central in all such approaches, may be identified. Such overarching characteristics include (a) knowledge that the subject field is being developed while itself changing (Nielsen & Vogelius, 1996; Jarvis, 1999; Sunesen, 2019); (b) participants in AR are involved co-constructors, both democratically and reflexively, in the process of change, which is the impetus for such research (Jarvis, 1999; Reason & Bradbury, 2013; Sunesen 2019); and (c) the role of the researcher is not reduced to simply describing, understanding or explaining factors in the subject field, but this role demands that the researcher take an active part in interventions for change (Tiller, 2000; Henriksen et al., 2004). Sunesen (2019) provides a concise overview:

> 'Action research is a participant-centred and democratic research process, which at the same time seeks to create knowledge about – and change – the subject field. Action research seeks to bring action, reflection and theory together in a concrete context. This process is initiated with a view to finding solutions to practical and everyday problems, while at the same time providing learning and development opportunities for individuals, groups and social communities' (Sunesen, 2019:7).

This overview provides the initial guidelines for an AR project at Danish higher technical examination (HTX) programme high schools, with a particular focus on the profile subject technology and its pedagogy. The purpose was to create positive change within HTX, with the managers, teachers and students as co-constructors. In conducting AR in an educational institution, it was pertinent that problem definitions and possible solutions to perceived problems were identified by the HTX participants themselves. In this case, technology teachers initially identified a problem regarding a perceived lack of consensus amongst themselves about what problem-based learning (PBL) is, and which pedagogical methods to use. Notably, in terms of AR facilitation, these teachers expressed a strong interest in both working with and developing the ways in which they approach projects in HTX technology, as largely self-directed group project work in central to the curriculum. This problem was presented as having consequences for the school, the teachers and the students. It was deemed to be especially the case in students' senior year of a three-year cycle, when they must choose between different technical subjects; students come from different classes and may have developed different perceptions of how to work on projects. This would plausibly suggest that a commonly accepted disciplinary tradition in HTX technology pedagogy has not yet been comprehensively developed or fully conceptualised. This is the multifaceted AR context that I, as an action researcher, was initially presented with.

In undertaking such a research methodology, it became clear to me that I had to face, and somehow come to terms with, different challenges throughout the research process. This led to a number of reflections on my own practice. In reflecting on my own practice, I identified several key themes that, while they may not easily fit into some of the general ideas of AR, proved to be vital in conducting a reasonably successful research process. The aim of this article is, therefore, twofold: first, to reflect on my own experiences in this particular AR on HTX, to identify some of the challenges of both doing AR and being an action researcher; and, second, based on such self-reflection, to make a modest contribution to existing methodology and to suggest some recommendations on how to focus and position oneself as an action researcher with a particular focus on the centrality of language, dialogue and conceptualisation of the process.

The structure of the remainder of this article is as follows: the overall context is introduced in part 2, by presenting a brief overview of the Danish HTX high school, the broad HTX technology curriculum, and the initial pilot study. In part 3, I reflect on and identify seven challenges related to my role as an action researcher throughout the process. In part 4, the main methodological contribution of the article, I provide a concise summary of how I overcame such challenges through adopting and applying Nørreklit's (1973) conceptualising method to the entire research process. Part 5 concludes the article by suggesting that such a methodology provides a substantive guide to the role of an action researcher.

DOING AR IN HTX

In this section, the HTX research context, the technology curriculum and the initial pilot phase of the AR project is introduced.

THE DANISH HTX PROGRAMME

HTX was established in the 1980s, with the purpose of introducing a high school education stream specifically directed towards science and engineering (Danish Education Ministry, 2015). The first HTX programme was inaugurated as an experiment in 1982; seven years later, in 1989, HTX became a permanent addition to high school education in Denmark (Jans, 2007; Olsson, 2007). In 1995, it obtained its current form as a three-year high school programme with direct entry from primary school (Jans, 2007). HTX initially struggled with being an unknown educational form, and with general image problems. Today, however, it has existed for almost 40 years and is now generally recognised as an equal and indispensable part of Danish STEM and vocational education. While HTX students comprise around 10% of the Danish high school population, they constitute around 30% of engineering students at university level (Kolmos et al., 2017), hence the importance of both HTX and technology to STEM education. Project work is central to the curriculum, and the HTX study programme is based on PBL principles, which are inherently interdisciplinary (Henriksen, 2016a). Problem-oriented group project work is what differentiates HTX from other secondary-level programmes in the Danish educational system (such as STX and HF, which offer a broad general education, and HHX, or business high school). It has been a defining HTX characteristic since its inception, and especially so for the profile subject of technology (Ulriksen et al., 2008).

TECHNOLOGY SUBJECT

In HTX, technology students work with the relationship between technology and society. In the Ministerial Order, the relationship between technology and society is formulated as a 'socio-technical' concept of technology (Ministry of Children and Education, 2015, 2017); that is, technology is to be conceived as composed of four elements: knowledge, organisation, technology and product. In HTX technology, social scientific, technical and scientific knowledge is combined with practical work in both workshops and laboratories. Topics such as materials and machining processes, technology and environmental assessment, product development and production are all central to the curriculum. Its general aim is to develop students' understanding of interdisciplinary project work, as well as developing their self-directed documentation and presentation skills (Henriksen, 2016a).

AR ON HTX

My initial interest in HTX was about how they work with PBL, and especially in technology where PBL principles are applied. I visited a local HTX high school before the overall research endeavour became a concrete reality, and a conversation with one of the teachers revealed a potentially real problem, as he claimed that there was no apparent consensus amongst HTX technology teachers on how to actually teach or facilitate it (Jeppesen, 2020). This conversation triggered my curiosity. I then contacted HTX in Aalborg, and got in touch with the chairman of the HTX Technology Teachers Association. A meeting with the chairman and with the technology teacher who originally identified the pedagogical issue (a real problem) was then set up. The focus of the first meeting was to hear what they perceived the pedagogical problem to be. At this meeting, both the chairman and the teacher again noted the lack of consensus amongst HTX technology teachers on what PBL is, and on which methods to use in teaching and facilitating it. The next meeting, I attended was with some teachers from the Technology Teachers Association. These teachers were somewhat sceptical at first, but when confronted with the problem identified at the earlier meeting, there was unanimous agreement on both aspects of the pedagogical issue identified. However, not all teachers identified these issues as problematic. Some expressed an interest in keeping things as they were, regardless of the lack of consensus. This made me even more curious about how both issues in the initial problem statement identified above could be observed in classrooms.

I therefore decided to conduct a pilot study by participating in different HTX technology classes. Three teachers, out of the eight who attended the meeting, expressed their willingness to open their classrooms for me to observe in their teaching and to being part of the pilot study. The pilot study was conducted over three weeks. After my participation in the three teachers' classes I gathered the empirical data I had collected and requested a meeting with the three teachers. I wanted to present my experiences from the pilot study and talk to them about my experiences and how they might align, or not, with their perspectives on the issues. What I observed when participating in different classes was that the way teachers work with

PBL and technology projects varies between teachers and classes; this supported the earlier identification of a lack of consensus. At the meeting, my experiences in the pilot study were supported by the teachers. The problem was now re-defined and conceptualised as: HTX technology teachers lack a coordinated language, or conceptual devices, that they can use when working or conversing with other teachers on the subject.

With the support of and general validation from the teachers of the initial problem statement, I wanted to expand my level of active participation. After this meeting, doing so became a possibility as more teachers invited me to participate in their classes. Eleven teachers out of the total 15 HTX technology teachers invited me to participate in their classes, and a further two participated through joint teaching of workshops. Over a period of six months, I participated in 12 different classes while simultaneously communicating with the teachers about my experiences. After the six months and the summer holiday, I started participating again, this time in the subject of product development (an introductory course for 1st-year HTX technology students). I spent one full academic year teaching and experiencing the entire process of HTX technology teaching with managers, teachers and students. In this way I gained entry to the HTX lifeworld and became both an active participant and a reflective observer. That said, I encountered a number of challenges along the way, some of which will be discussed in the following section.

CHALLENGES IN AR

How does one ‘bring action, reflection and theory together in a concrete context’ (Sunesen, 2019:7), such as in the multifaceted HTX context introduced above? The role of the action researcher is to facilitate development and positive change in a certain direction in a dynamic and democratic interaction with participants themselves and, in so doing, also become an active, engaged and reflective participant oneself. Adopting such a role has brought me a lot of valuable experiences as a researcher, particularly related to some challenges I encountered throughout the research process. On reflection, these challenges include the desire to create change, initial distrust, use of language, relationship building, power dynamics, vulnerability, and participant selection/attraction/retention.

One of the first critical challenges I needed to address early in the process was my desire to create change on HTX. To meet this challenge, I conversed and negotiated with the HTX community, in particular with HTX technology teachers. I did so by arranging meetings in which we talked about the focus of the potential project, how they defined or conceptualised relevant issues and perceived problems, and the kind of positive change that could be achieved by addressing the issues and problems identified by these teachers. The pace of such change correlates to such conversations and negotiations, as it is vital to be aware of the expectations of the pace of any changes sought from both the researcher’s and the participants’ perspectives (Grant et al., 2013). Through discussions it became clear that none of the involved parties expected quick results. Throughout the project, however, I found it necessary at times to *remind* participants – or at least to briefly revisit the negotiations – about the pragmatic pace of any expected change. An AR project is very dynamic and subject to change; some participants are part of some of the process while some are involved in the entire process. This creates some natural breaks in the process and often makes it relevant to go back and revisit previous discussions and negotiations, and to perhaps reconceptualise certain aspects as new insights emerge. It was also important for me to continue to motivate and encourage continued participation, and in doing so to attempt to establish credible accounts that reasonably accurately capture the experiences and perceptions of the participants (Grant et al., 2013). Regular communication at the HTX school and via email updates was deemed central, as was active involvement by the HTX community in all stages of the project, from problem definition to text material as co-constructors of knowledge. As an action researcher I was aware of the imperative of seeking input from the target HTX community before bringing any of my own knowledge into play in the process. Most participants were very dedicated and maintained their involvement throughout most of the project. A few pulled out due to new employment or for health reasons. Some variation in participant involvement levels is an expected part of any AR process over time.

A second challenge related to initial distrust. One of the first experiences I recorded in my field notes, and that really stuck with me, was being met with distrust by HTX technology teachers in the initial phase of the project. When attending meetings on HTX, on several occasions I was confronted with comments such as: Does she know anything about HTX? Does she know about technology? Who is she really? It was somewhat difficult to work my way through such comments. Something was clearly at stake here for teachers, and they reacted to the fact that I was entering their community and trying to understand something sensitive, and perhaps central, to their identity as professional technology teachers. Or, as Grant et al. (2013:595) note, they may have felt somewhat intimidated or perhaps overwhelmed at the possibility of adding to their already heavy workload through participating in a project with an unknown researcher, and the unpredictability of any changes that might follow. Seeking credibility and buy-in from these professionals was an initial daunting challenge. In addressing this challenge, I made a point of regularly being on-site and available in the HTX staffroom. Through conversations, the community of teachers got to know me, and I got to know the individual technology teachers (I discuss this initial stage of relationship building further below). This assisted greatly in building trust and providing credible transparency about the emerging, and eventually proposed, AR project. Further, I tried to be clear in my communications and conversations about the project while being flexible and offering various options or levels of engagement, to encourage active participation.

A third challenge –and perhaps the most important – identified related to how I used language, how I communicated verbally with the relevant HTX actors and how I reacted to how they communicated with me. Language here means the choice of which concepts to use; as humans we need mutually understood 'language games' (Wittgenstein, 1953; Nørreklit, 1973; Henriksen, 2016b; Henriksen et al., 2004) to be able to substantively discuss any topic with anyone. In the early stages of the research

I was often fairly quickly interrupted both verbally and non-verbally when communicating the aim of the project. One illustrative example: when using the Danish word *ensretning*. *Ensretning* means 'regimentation', and can suggest either doing something the same way or exercising power. I explore the issue of power dynamics further below. The responses, both verbal and non-verbal, made it very clear to me that the teachers I was conversing with did not appreciate this particular word or the conceptual meanings they may have associated with it. This particular example highlights the fact that a poor choice of word or concept may have negative consequences in AR; it brought conversations to a halt, making it much more difficult to gain any relevant insights or to garner any support. I had to change and reflect, so I did. I replaced *ensretning*/regimentation with *fællesretning,* meaning 'common direction'. This resulted in no further verbal or non-verbal interjections, and soon teachers started opening up more to me about technology, contacting me in the staffroom, discussing the project and, most importantly, signing up to become part of it.

What did I learn here? Concepts are key to AR communication. Further, one needs a coordinated language to assist mutual understanding between researcher and participants. In terms of coordinated language, a key initial finding in conversations was thon HTX technology teachers themselves apparently lacked a coordinated language, or mutually understood conceptual devices, for discussing technology pedagogy amongst themselves. This represents not only a key research finding but a significant challenge for conducting the entire project, as well as a potential focus for somehow achieving some positive change. Lack of a coordinated language or mutually understood conceptual devices made it very difficult for HTX technology teachers to discuss perceptions of, and practices related to, pedagogy amongst themselves, with their students and with me as the action researcher. So, what did the teachers do? They simply 'agreed to disagree' and continued with their own individual approaches (Jeppesen, 2020). This challenge was not one that could be easily or quickly solved, yet, it could not be ignored and became a key focus as the overall research progressed. I continued to work with the teachers who had agreed to participate, and I joined their classes, which also demonstrated that I was really interested and committed to gaining insight into HTX technology teaching. In this way, dialogue and observation revealed how individual teachers approached their daily practice. I gained insight into their language, their use of various concepts and their particular life-worlds. I return to this theme of the centrality of language, dialogue and conceptualisation in AR in more substantive detail below, but first, some further challenges should be outlined.

The fourth challenge identified at the early stage of the AR process, when I became an active participant in HTX technology teaching, related to building relationships over time. In attempting to build such relationships, I tried to communicate openly and honestly about expectations and discussed mutual expectations to avoid misunderstandings, approaches also noted by Grant et al. (2013). I demonstrated my interest in what both technology teachers and students were working on by politely intervening at appropriate times, asking questions but not disturbing either teachers or students, modestly contributing to the pedagogical process. Such a diplomatic approach went down well with both teachers and students, resulting in teachers inviting me to return as they became more comfortable with my presence. As positive reputational word spread, other teachers decided to join in and become part of the project. Relationship strategy basically encourages, facilitates and cements active participation. Without such positive relationships, an AR process will rarely, if ever, succeed.

Staying with relationships, a fifth challenge identified related to the power dynamics within such relationships between the action researcher and members of the HTX community. Power can be held by both the researcher and participants in a research relationship; this varies depending on content, context, personality and time. Power can be used *over* others as domination, or it can be used *with* others to create positive change (Grant et al., 2013:592); this applies to both researcher and participant(s). Therefore, I took time to consider such power dynamics within these relationships and how I could ensure power is reasonably shared yet remain aware that power dynamics do not disappear. To address this challenge – or, more accurately, to address it before it became a challenge or impediment to progress – I communicated strongly to the HTX teachers from the outset that I was not there to create a project with a problem statement that I had formulated but, conversely, was there to create a research project *with* them around a problem statement that they themselves would formulate following substantive discussions. I emphasised that this had to be a perceived ‘real problem’ (Henriksen et al., 2004) that they themselves experience in their daily professional pedagogical practice. Further, it was important to communicate that the overall project represented a possibility for learning and positive change for all involved (teachers, students, managers, researcher), and that I valued all knowledge and insights shared with me throughout the project. Such actions facilitated a mutuality and reasonable equality of interests within such inescapable power dynamics within the diverse range of relationships encountered throughout the project. Ignoring such power dynamics within any AR project will, inevitably, lead to negative consequences.

Again, staying with relationships, a sixth challenge related to the fact that an action researcher is both cognitively and emotionally vulnerable (Billund & Alrø, 2017) to the uncertainty inherent in the AR process itself. This was especially so in the early stages, as my position in the HTX community started from a very open and malleable position. Such vulnerability is in the openness, and ‘the touch and sensitivity that arises through this must be addressed by the researcher as part of the research process’ (Billund & Alrø, 2017). Vulnerability must here be viewed not in a negative sense, but as a positive resource as it is a prerequisite for the development of participant relationships, which are essential to any AR process. In the relationship between me as a researcher and the participants, there is a connectedness and a mutual dependency that requires some self-surrender; when we leave something of ourselves to each other we become vulnerable and hold some of the other’s life in our hands (Billund & Alrø, 2017:71). An action researcher, on the one hand, must always be prepared for unpredictable events, such as new teachers coming in and others leaving. On the other hand, researchers can always be challenged in how they act in the field. Such vulnerability may be viewed as two-sided: it leads to the research process being more dynamic, as it assists project development, but adds to the uncertainty of the process.

A seventh challenge related to participant selection/attraction/retention, once the broad research context had been identified. I selected HTX technology; I could have selected another subject. This became notable as the process continued and teachers from other subjects talked with me; some suggested that such research could also be helpful in their HTX subjects. For this particular project, participant attraction was probably more central than selection but, as Laursen (2019) notes, both are unavoidable, and ethics demands that all participants must be protected by the researcher. As noted above, attraction was facilitated by how I overcame challenges related to distrust, building relationships, power dynamics, careful and thoughtful use of language, and gaining buy-in to the desire for positive change. Once I had attracted such participants, it was equally important to retain their interest and involvement in the project so that reasonable 'solutions in practice' (Henriksen et al., 2004; Lehmann, 2018) could ensue.

FURTHER REFLECTIONS ON CENTRALITY OF LANGUAGE, DIALOGUE AND CONCEPTUALISATION

Reflecting further on the seven challenges related to the role of the action researcher noted above, it becomes apparent that central to all are language, dialogue and conceptualisation. All seven challenges have been reasonably addressed in the extant AR literature, but as the example related to the Danish word *ensretning* noted above and the somewhat negative meanings thon HTX participants may have associated with this concept makes clear, language is actually central to *all* challenges one can expect to meet in any AR project, as well as to the possibility of reaching any reasonably successful solution to any perceived problems it is designed to solve. Digging deeper, the main methodological contribution of this article, beyond the reflective identification of challenges, demands that one needs a more substantive view of how language, dialogue and concepts operate in the real world of AR. The language and concepts I used in dialogue as a researcher were essential, as concepts are both a form of knowledge and an insight into capabilities we possess so we can describe, understand and capture realities within the life-worlds of HTX technology teachers and their students. I draw inspiration here from, and draw heavily on, the seminal work of Nørreklit (1973, 1978, 1986) on the 'conceptualising method' and its elaboration and application in the work of Henriksen (2016a, 2016b, 2018; Henriksen et al., 2004). These scholars focus on the collective dialogical nature of real lifeworld problem identification, conceptualisation, reflection, action and solution.

We need useful concepts so that we are able to understand, to know and to act; when we study everyday life, we are concerned with actions of people in their normal, everyday lives (Nørreklit, 1973). How we understand and represent these actions presents an overarching challenge, and we must do so in a way that is reasonably valid, reliable and capable of developing concepts that work, that are useful, that allow us begin to create a common HTX technology language, useful conceptual devices, which was the general purpose of the HTX AR project identified by participants early in the process. AR method, therefore, begins with a focus on a perceived real problem. Note that this active learning process by both researcher and technology teacher participants, which is also relevant to student group work in HTX, 'happens in an ever-continuous process of negotiation, argumentation, dialogue and debate' (Henriksen et al., 2004:147). This conceptualising methodology, following Henriksen et al. (2004:147), may be presented as follows:

- Symptom of HTX Problem
  Action – Reflection – (Real) Problem
  Reflection – Conceptualisation
  Action – Reflection
  Reflection – Conceptualisation
- (Sustainable) solution to (original) problem

Henriksen et al. (2004) cogently argue that problems must be conceptualised, reconceptualised and, very often, substantively discussed with other participants connected to the problem and, therefore, are also constantly negotiated. It is a circular, changing and ongoing process within the lifeworld context being researched. They further argue – and provide empirical evidence drawing on a range of organisational case studies in support – that 'the conceptualising method is both a problem-solving method and a research method; consequently, it is also an AR method. It follows that it may be submitted to different agendas' (Henriksen et al., 2004:149), in this case, the active learning environment in HTX technology. As noted above with my experience using the Danish word *ensretning*, concepts have both content and meaning, and they are necessary for understanding participants' realities and life-worlds. *Ensretning* did not work; both verbal and non-verbal responses were negative. I had a problem. I had to reflect and act, and tried a different concept, *fællesretning*. Reflecting on this usage in dialogic practice, I could state that this was a good concept, and it provided a sustainable solution to this particular challenge, allowing AR to proceed. With good concepts, we can 'grab' phenomena and thereby hold on to them; they allow researchers to act accordingly. Without concepts, we know nothing and can, therefore, do nothing (Henriksen, 2016b:31). Without focusing on my use of concepts, I might not have been accepted into the HTX community, gain its trust, retain its interest or continue this research, as I would not have been able to demonstrate any insights, hence mutual understanding, into their daily pedagogical lifeworld.

'Any encounter into a field of interest is to enter into a lifeworld' (Henriksen, 2018:2), and in this sense, language through dialogue is the entry ticket. Wittgenstein (1953) used the term 'language game' to refer to how different social groups – such as HTX technology teachers – use different language games. HTX technology teachers have their own language games that allow them to communicate with each other. They also have special terms and expressions only they know and understand; this forms part of their identity. Learning such language games demands that the action researcher enters into, and becomes actively part of, such a community by following their practices, including participating over time in their everyday teaching. To learn a language does not require us to follow a set of rules; we learn it by using it. The way to learn about a lifeworld is, therefore, to learn the language games that constitute, or are constituted by, the specific lifeworld being researched (Henriksen, 2018). Dialogue, following the teachers' practices and consciously working with my choice of concepts enabled me to become part of the HTX community, to enter into their lifeworld and to overcome the challenges noted above. Learning the language games was essential to conducting this AR project. Had I not done so, I would not have been able to conduct a reasonably successful project with the support of the participants themselves.

Returning to Nørreklit's (1973) 'conceptualising method', the focus is on taking ordinary words from everyday conversations and changing them into social scientific concepts. Nørreklit describes concepts as something we possess and can act on: 'Concepts in this sense, are vital to our language games, to our ability to act and change things, and to our ways of understanding the world and our realities' (Nørreklit, 1973; Henriksen, 2016b:30). Henriksen (2016a) describes concepts through a number of examples with different meanings in Danish. In Danish, the word 'concept' is *begreb*, which means 'to hold onto something' or 'to grab something'. This can also be viewed as a metaphor for grabbing or holding onto something with words. We can also say in Danish, '*at have begreb om*', which means 'to know something'. *Begreb* can also be used negatively, as in '*du har ikke begreb om*', which basically means 'you haven't got a clue'. When used in this way, *begreb* is about understanding, knowledge and knowing. Therefore, '*at have begreb om*' is to understand and to know. In an older form of Danish, we also used *begreb* instead of the word 'doing', as in '*han er i begreb*', which means 'he is doing something'. In the above examples a connection between *begreb* and understanding, knowing and doing, is evident. Taking the word *begreb* literally, it also denotes a close connection between a concept and a phenomenon – to grab something with words (Henriksen, 2016b:31). With good concepts, we can 'grab' phenomena, and thereby hold onto them. We can also describe and understand realities and lifeworlds and, therefore, act accordingly. We can now view concepts as things we have and are able to do things with, as capabilities or skills. Paradoxically, we can state that without concepts we know nothing and can, therefore, do nothing (Nørreklit, 1973; Nørreklit, 1986; Henriksen et al., 2004; Henriksen, 2016b).

CONCLUSION

In this article I have reflected on my experiences conducting an AR project in Danish HTX high schools, with a particular focus on technology teaching. In terms of the role of an action researcher, I identified seven challenges that I encountered while conducting such research over time, related to my initial desire to create change, initial distrust, use of language, relationship building, power dynamics, vulnerability and participant selection/attraction/retention. I have argued – and provided empirical evidence in support of this argument – that language, dialogue and conceptualisation are key to meeting and overcoming such challenges. The main methodological contribution of the article is my argument that Nørreklit's (1973) philosophically grounded 'conceptualising method' provided not only guidance in meeting such challenges, to coping with the uncertainty inherent in AR, but that it also provided the dialogic pathway to finding reasonably sustainable solutions to the real research problems identified by the HTX technology teaching participants themselves.

CHAPTER 5. THEORY

The theoretical part of this thesis relates to the four concepts that have previously been unfolded as part of the problem analysis: Technology, Problem-based learning, Bildung and Language. The further treatment of the theory is focused on language and problem-based learning and therefore does not deal with technology and Bildung as these concepts deal more with the content of the technology subject than they theoretically contribute to the solution of the problem statement.

After reading the method section, the reader should now have a clear understanding of how important language is for this project. To emphasise the importance of language, I, here in the theory section, will first present a theoretical substantiation of language and action, based on pragmatic constructivism, as these concepts are closely related. Subsequently, the theory of Problem-based learning (PBL) is presented as the pedagogical framework that is very central to the subject of technology, and in order to understand the language used in the technology subject we also need to understand PBL.

5.1. LANGUAGE

Language is central to change in organisations (Henriksen et al., 2004:30). This is also the case in relation to this project, in which it is desired to create a disciplinary tradition in the technology subject in HTX. In addition, it is through language that we can get access to organisational change: therefore, it is also necessary to 'know about language in order to know about organisational change*'* (Henriksen et al., 2004:30).

The following presentation of a theoretical support for language and action is based on concepts.

5.1.1. CONCEPTS AND THE CONCEPTUALISING METHOD

For language to work in the technology subject, or any other language for that matter, it has to express facts, logic, and values, all of which are aspects of reality. Concepts can describe this reality as they contain all aspects of reality, and furthermore they are important to the communication of this reality. To be able to get to know the concepts used in the technology subject, it is pertinent to be part of the technology teacher's lifeworld, as concepts are something that are passed on to us. Through the process of conceptualisation, we are handed concepts, we change them and then create new ones (Henriksen et al. 2004:23). When it comes to creating good and useful concepts it makes sense to draw on Nørreklit's (1979) 'conceptualising method'. The 'conceptualising method' can be presented as follows:

- Symptom of HTX Problem
  Action—Reflection—(real) Problem

Reflection—Conceptualisation
Action—Reflection
Reflection—Conceptualisation

- (sustainable) Solution to (original) Problem
  (Henriksen et al., 2004:147).

The method deals with taking ordinary words and changing them into social scientific concepts. Concepts are described by Nørreklit (1973) as something we can possess and act upon: 'Concepts, in this sense, are vital to our language games, to our ability to act and change things, and to our ways of understanding the world and our realities' (Henriksen 2016b:30).

The concept of concepts

When we study everyday life, we are concerned with actions of people in their normal everyday lives. How we understand and represent these actions presents a challenge; and we need to do so in a way that is valid, reliable, and capable of developing concepts that work and that are useful. Concepts have content, and they are necessary if we have an interest in understanding actors' realities and life-worlds (you can read an in-depth description of the concepts by Henriksen (2016b) on pp. 151). With good concepts, we can 'grab' phenomena and thereby hold on to them. We can also describe and understand realities and life-worlds; therefore, we can act accordingly. We can now view concepts as something we have and with which we are able to do things, as capabilities or skills; paradoxically, we can state that without concepts we know nothing and can, therefore, do nothing (Henriksen 2016b: 31; Nørreklit 1973).

Now that we have some knowledge about concepts, it is possible to distinguish between concepts and abstractions (Henriksen 2016b:31; Henriksen et al. 2004:22; Nørreklit 2004:34). See figure 4-1 on the following page.

'By an abstraction is meant a term which ignores significant reality-constituting conditions' (Nørreklit 1986:5).

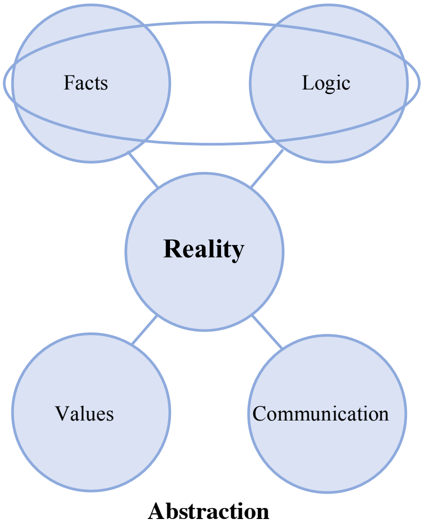


Figure 4-1 The difference between abstractions and concepts is illustrated.

As illustrated in figure 4-1, abstractions are necessary for any communication but they do not describe realities whereas 'concepts actively describe realities with their facts, logics and values' (Henriksen 2016b:31). Preferably, concepts should be precise descriptions of realities, free from possible misinterpretations and ambiguities. As free as possible. In everyday conversations we use concepts and they are often ambiguous and, therefore, often the reason for misunderstandings to such an extent that such concepts are used indifferently in different language games. The purpose, in a social scientific investigation, is to remove as many ambiguities as possible which is a real challenge; but this should not prevent us from trying and through our research and using the conceptualisation method create knowledge and concepts (Henriksen 2016b:31).

Reality, concepts and language games

'Any encounter into a field of interest is to enter into a lifeworld' (Henriksen, 2018:2). Language is our way of getting to explore and obtain information about what is going on in such lifeworlds—in this case, the technology subject in HTX. It is our entrance ticket, so to speak. The term 'language game', used by Wittgenstein, is used in regard to all the different uses of language (Henriksen, 2018:2). Different language games are used by different social groups and thereby people engage in many different language games (Nørreklit 2020:12). The language games allow the groups to communicate with each other and thereby also use special terms and expressions which only they, as members of the specific social group, know and understand. Such terms and expressions exist not only for communication purposes but also to indicate which individuals are members of this social group. When looking at the technology subject, the teachers here do not have only one language game that is representative of the subject, and thus they are not able to communicate; they simply do not speak the same language.

For me to learn the language game of the technology subject, I am required to be a part of the HTX community, following the technology teachers' practices. To learn a language, however, does not require me to follow any set of rules, as we normally don't learn grammar first when studying a language, before speaking it; we learn language by using it (Henriksen, 2018:2). Thereby, it is not said that no rules exist (Henriksen, 2018:2; Lyotard, 1979:9). Rules do exist, and it is pertinent to know how to use the rules to be able to participate in a specific language game, but we are not always able to account for the rules (Henriksen, 2018:2-3). Language is an integrated part of the life we live, and we would not be able to function without it; it enables us to communicate with our fellow human beings. If we are interested in learning about the lifeworlds, it is, therefore, pertinent to learn the language games, both those that constitute or are constituted by the specific lifeworld (Henriksen, 2018:3). Language games rarely remain the same as lifeworlds constantly develop. 'Language games change as lifeworlds change and lifeworlds change as language games change' (Henriksen, 2018:3). The changes take place in the interactions between members of the lifeworld, and often go by unnoticed. Sometimes, language games and lifeworlds diverge and thereby don't match each other. When this is the case, the members of the lifeworlds are left confused and bewildered. In some cases, the members of the lifeworlds are left in need of adjusting their language game to accommodate the new conditions, and it may even be necessary to change the lifeworld, which is most likely what happened in HTX in the technology subject. The language game and the lifeworld differ, which has led the teachers to find their own solutions to the problems presented to them, and slowly they have started to agree to disagree (Jeppesen, 2020). A real problem becomes visible here (Nørreklit, 1978) as a real problem is defined as confronting the actors when their language can no longer guide their actions in the lifeworld (Henriksen, 2018:3). As a researcher, I should be able to assist in solving such a real problem if I take part in the process of developing the language game. If I can do so, then I am also able to create a plausible account of the process and turn the process into a social scientific endeavour. To be able to achieve such an outcome, I need dialogue (Henriksen 2018:4).

Dialogue

To be able to assist in solving real problems, as noted above, we need dialogue (Henriksen, 2018:4), as access to the technology teacher's reality in HTX is only possible with the use of language through communication. Getting access was then the next problem. The way to proceed, therefore, seemed to be to engage in conversation with the technology teachers. Conversation should be understood broadly as: small talk, interviews, arguments, and dialogue with the technology teachers, all of which are very important components. In the following, a short description of dialogue will thus be made, as dialogue enables us to create concepts that are needed to develop the language game in the technology subject (Henriksen et al. 2004:152). From the point of view of the conceptualising method, dialogue can be described as conversation carried out on the logic of question and answer. The good question is defined by its authentic nature and its openness. Openness also has to help reveal the inner logic of the subject at hand, the technology teachers in HTX. Thus, this is only possible if the participating teachers and I, who are involved in the dialogue, use the openness to sincerely search for the logic of each of the individual technology teachers. This also means that showing who is right, or rhetorical issues, therefore, are not involved in the understanding of dialogue, as these are seen as inauthentic questions (Henriksen et al., 2004:158).

5.1.2. CONSEQUENCES FOR SOCIAL RESEARCH

Having a dialogue implies having a conversation, which is based on language. Engaging in a dialogue, we meet ‘the Other’ on equal footing, and thereby we address ‘the Other’ (Henriksen 2018:7; Code, 2002). Looking at the interview, this is much more perceptive or observational. This is the way we establish a distance to the situation and, furthermore, we might even fool ourselves into believing we are being ‘objective’ by observing from outside of the case.

> ‘We do not perceive, but we engage in a dialogue, we do not see or observe, but we are in a dialogue. Language is the medium. “The Other” is not an object or a medium for obtaining answers but is a partner in a conversation’ (Henriksen 2018:7).

Henriksen’s (2018) core focus is whether we, as social scientists, can help to solve real problems through the development of language games, and if dialogue is the way do that.

Gadamer’s analysis of dialogue, as found in Truth and Method, may be able to assist here:

> ‘What characterises the dialogue, in contrast with the rigid statement that demands to be set down in writing, is precisely this: that in dialogue, spoken language—in the process of question and answer, giving and taking, talking at cross purposes and seeing each other’s point—performs the communication of meaning that, with respect to the written tradition, is the task of hermeneutics’ (Gadamer 1992/1960:368).

This stands in direct contrast to interviews where the questions are directed towards the interviewee and the answers towards the researcher. This requires some skill from the researcher, and the researcher also needs to be well prepared to ask good questions and to provide good answers (Henriksen 2018:8).

> 'What emerges in its truth is the logos, which is neither mine nor yours and hence so far transcends the interlocutors' subjective opinions, and even the person leading the conversation knows that he does not know' (Gadamer 1992/1960:368).

We need to transcend our subjective meanings and instead find a common meaning to be expressed in new concepts and in a new and improved language game. In this way, we can try to assist in solving real problems (Henriksen 2018: 8), and this is the purpose here with this research on HTX in the technology subject.

The first section of the chapter on theory revolving around language is very much connected to how I approached the study of language in HTX and the technology subject.

In the following section, the theory about problem-based learning (PBL) is presented, as it is the pedagogical framework that is taken as a starting point in the subject. To understand PBL, from where it emerges, and its principles, is therefore also to understand some of the language of the technology subject.

5.2. PROBLEM-BASED LEARNING

PBL was originally developed as a response to the criticism that traditional teaching and learning methods failed to prepare medical students for problem-solving when practicing medicine outside of the classroom setting (Hung et al., 2008: 486). This deficiency led to a desire that university education within the medical field be structured in a way that helps students become competent in more than reading and remembering complex concepts (Holgaard et al., 2016:16). Along these lines, PBL was conceived and implemented to answer students' unsatisfactory performance in praxis (Barrows 1996; Barrows & Tamblyn, 1980; Hung et al., 2008:486). The PBL focus was to facilitate students in developing competencies for solving problems, in expanding their ability to handle complex and extensive knowledge, and in being better able to communicate and collaborate together. This was described in the GPEP report (Report of the Panel on the General Professional Education of the Physician and College Preparation for Medicine), in which recommendations were made for changes in medical education. Changes included promoting independent learning and problem solving, reducing lecture hours, reducing schedule time, and evaluating the ability to learn independently (Barrows 1996; Hung et al., 2008:487). In an attempt to provide students with the possibility of obtaining these competencies, problem-based cases were introduced as a basis for student learning (Holgaard et al., 2016:16).

Many medical schools have since developed alternative parallel PBL curricula, and a number of medical schools even changed their entire curriculum to PBL (Aspy et al., 1993; Barrows, 1994,1996; Hung et al., 2008:487). The problem-based approach later spread to other universities around the world and to different academic disciplines (Holgaard et al., 2016:16). Since its first implementation, PBL has become a prominent pedagogical method in medical schools and health programmes and is, perhaps, 'the most innovative pedagogical method ever implemented in education' (Hung et al., 2008:486-7).

PBL was introduced for the first time as a guiding philosophy at Danish Universities in 1972, beginning at Roskilde University (RUC) and closely followed by Aalborg University which was founded two years later. The problem-based approach offers the possibility of supporting increased student involvement, the democratisation of what and why something should be learned, as well as new ways of thinking about education (Holgaard et al., 2016:16).

PBL is an instructional methodology and as such an instructional solution for learning about problems. The following characteristics are a part of the methodology.

(1) Students learn by addressing problems. The content of what they have to learn and the skills they have to acquire are focused around problems.
(2) PBL is centred around the students.
(3) PBL is self-directed. Individually and in collaboration, students take on the responsibility of generating learning issues and processes through self- and peer-assessment, thereby accessing their learning materials and being self-reflective. Students monitor their understanding and thereby learn to adjust strategies for learning.
(4) Tutors are facilitators who facilitate group processes and interpersonal dynamics and help students strengthen their knowledge. Tutors rarely interfere with content or provide the learners with the answers (Hung et al., 2008: 489).

5.2.1. DIFFERENT APPROACHES TO PROBLEM-BASED LEARNING

PBL has now spread widely and the concepts associated with this approach have become more flexible and fluid. Boud (1985) and Barrows (1986) attempted to move beyond narrow and prescriptive definitions in outlining some of PBL's much broader characteristics. Both argued that PBL should be seen as learning that has differing forms; therefore, it should not be seen as a particular way or method of learning. Boud (1985) further suggested that applications of PBL differ depending on the discipline and the goals of the programme. He outlined eight characteristics of PBL courses that elaborate on the pedagogical beliefs underlying the approach, in contrast to more rigid definitions:

(1) an acknowledgement of the base experience of learners;
(2) emphasis on students taking responsibility for their learning;
(3) a crossing of boundaries between disciplines;
(4) an intertwining of theory and practice;
(5) a focus on processes rather than the products of knowledge acquisition;
(6) a change in the tutor's role from that of instructor to that of facilitator;
(7) a change in focus from tutors' assessment of learning outcomes to student self-assessment and peer assessment;

(8) a focus on communication and interpersonal skills so students understand that, in order to relate their knowledge, they require skills with which to communicate with others, skills that go beyond their area of technical expertise (Boud, 1985; Savin-Baden & Howell, 2004:4).

Barrows (1986) concluded that the term PBL could be considered a genus with categories and subcategories, on which basis he suggested that there could be an endless number of design variables for PBL when linked to educational objectives. For this reason, all types of PBL must be evaluated in terms of issues such as type of problems, assessment methods, learners' autonomy, and the way in which teaching and learning occur. Based on these findings, Barrows proposed a taxonomy of PBL methods explaining different meanings and uses. This taxonomy enables a focus on the educational objectives that could be addressed through PBL. The following shows the possible combinations of varieties in use:

(1) lecture-based cases—students are presented with information through lectures, and case material is used to demonstrate the information;
(2) case-based lectures—students are presented with case histories or vignettes before a lecture, which then covers the relevant material;
(3) case methods—students are given a complete case study, which they must research and prepare for discussion in the next class;
(4) modified case-based—students are presented with information and are asked to decide on the forms of action and decisions they may make. Following their conclusions, students are provided with more information about the case;
(5) problem-based—students meet with a client in some form of simulated format which allows for a free inquiry to take place;
(6) closed-loop problem-based (extension of the problem-based method)—students are asked to consider the resources they used in the process of problem-solving to evaluate how they may have reasoned through the problem more effectively (Barrows, 1986; Savin-Baden & Howell, 2004: 5).

5.2.2. BROADENING THE PHILOSOPHY

Others also sought to define PBL. Walton and Matthews (1989) argued that PBL should be understood as an educational strategy or a philosophy more than merely a teaching approach. Furthermore, they argued that there is no fixed agreement as to what does and does not constitute PBL; however, for PBL to be present, the following three defined components must be able to be differentiated:

(1) essential characteristics of PBL that comprise curricula organisation around problems rather than disciplines, an integrated curriculum, and an emphasis on cognitive skills;
(2) conditions that facilitate PBL such as small groups, tutorial instructions, and active learning;

(3) outcomes that are facilitated by PBL such as the development of skills and motivation, together with the development of the ability to be life-long learners (Savin-Baden & Howell, 2004:5-6).

Walton and Matthews' (1989) interpretation of PBL provides an understanding by which the complex nature of learning has been considered, but at the same time the interpretation also manages to capture the different ways in which students learn in different professions and disciplines across institutions (Savin-Baden & Howell, 2004: 6).
To untangle the apparent complexity of PBL illustrated in the above paragraphs, it does not suffice merely to list specific characteristics. Instead, there has been a change towards understanding PBL as one of a variety of active approaches to learning, all of which can be seen as a response to the growing dissatisfaction with the traditional teacher-centred paradigm. In a time of increased focus from government and professions on what students can do as a result of their university education, demands have resulted in pressures for change, and have also ensured that the issue of 'how' students learn in higher education is in focus.

5.2.3. WHY USE PROBLEM-BASED LEARNING?

In regard to how students learn in higher education, PBL pedagogy ensures that students acquire a range of competencies that are relevant to working life (Holgaard, 2016:157; Kjærsdam and Enemark, 1994). One of these competencies relates to cooperation in teams. Studies show that students who work in small groups during their studies become good at teamwork-based work processes. This competency is important because large parts of today's labour market are organised based on team-based solution strategies (Holgaard, 2016:157; Molly-Søholm and Storch, 2005). Another important area of competence is the ability to work in a project-oriented manner, which is also important in working life as most employees with an academic background have a work life which is built around a series of often overlapping projects. Work life is characterised by its level of complexity and by the fact that workplaces are in a constant interaction between production and development, which is also the case in problem-based project work (Holgaard et al., 2016:159). Learning to learn is another important competency acquired through PBL, in which students develop the ability to acquire new knowledge and new competencies. The labour market has an insatiable need for new knowledge, and it changes at a pace that means knowledge is limited by durability; this demands that students not only have current knowledge of a subject but also learn how to acquire new knowledge. Last, but by no means least, working with real problems is a most important competency. A problem has to be defined before you can solve it. One must be able to collect the knowledge needed to clarify the problem and subsequently choose the appropriate method or theory for solving it (Holgaard et al., 2016:161).

Taking this further, it is not enough merely to be able to work with real problems, although this is not to say that the competency of being able to work with real problems is not important. It definitely is important, because working with real problems expands the student’s horizons, and the students have thereby learned something. To have gained full understanding of the knowledge of the problem, the knowledge should be applied. A quote from Gadamer underlines this: ‘all true understanding is application’ (Gadamer, 1992). Herein lies the understanding that it is not enough that students can reproduce the curriculum that is relevant to their education, but that the students must go through a process of Bildung that enables the students to produce new knowledge. Applying knowledge to a specific situation enables the students to do so. It becomes a kind of tool the students can draw on. This indicates that having learned something means that one can produce new knowledge in relation to a specific situation, on the basis of a tradition (Henriksen, 2013:54-56)

Having presented the theory about language and language games, and subsequently having presented the ideas behind PBL, it now makes sense to unfold more specifically how the previously presented methods and theories have been used to analyse the language games of the technology subject.

CHAPTER 6. ANALYSIS STRATEGY

In the following section, the structure of the analysis will be described before the analysis is unfolded in chapter 6.

6.1. ANALYSIS STRATEGY

In the first part of the analysis (6.1, The New Textbook—From Idea to Reality), I will analyse the background of how the idea of a new basic textbook for the technology subject became a reality. This is done on the basis of observations and dialogues with the technology teachers, which is why the analysis is built on quotes from here. The purpose is to arrive at the technology teachers' use of language about a new textbook for the technology subject and to show the development of the idea of the new textbook through the teachers' use of language. Through this I also analyse the participation of, and the collaboration with, the technology teachers, as this is central to the Action Research (AR) project, as participants in an AR project are considered to be involved co-constructors. The purpose is therefore also to validate the project process (6.1.1 The process).

The second part of the analysis (6.2, Creating a Coordinated Language for the Technical Subject) will be an analysis of the language used in the technology subject based on the extensive observations I have made during the teaching of the subject. This will be based on the conceptualisation model to draw out the concepts that are central to the technology subject, in which the definition of central will depend on repetitions, not only verbally expressed repetitions but also repetitive uses in the classroom. The purpose is to arrive at the technology teachers' use of language in the technology subject and, by drawing out the central concepts, create a merged or coordinated language for the teachers and students to use in the subject, all the while being transparent about the process.

Furthermore, after a description of the new basic textbook (6.2.2, The Project Work—Technology and Technical Science Subjects), I analyse whether the new textbook for the technology subject that the technology teachers and I have developed together is actually applied in practice. I will do this by conducting a two-part analysis in which I first look at the sales figures for the book to see if the teachers use it (6.3.1, The Sales Figures), after which I make short observations on HTX in Aalborg and thereby analyse whether the book is used actively, and if that is the case, then how it is used in teaching (6.3.2, How is the Book Actually Used?). That is, the point here is to look at whether the project has "captured" the meaning that the teachers have expressed. If so, the teachers will work with the material that has been developed, develop new ideas, and gain new perspectives on the work in the technology subject.

CHAPTER 7. ANALYSIS

In the following three sub-analyses, analysis is performed first on the background of how the idea of a new basic textbook for the technology subject became a reality; secondly, on the language used in the technology subject; thirdly, on if and how the new textbook is used in practice. The analysis as a whole must therefore also be seen as an overall narrative about the result of the co-construction process that has come out of the close collaboration between the technology teachers and me.

7.1. THE NEW TEXTBOOK – FROM IDEA TO REALITY

During the observations conducted in the technology subject and the dialogues I had with the technology teachers during that time, it became clear very quickly that there was a difference in the language used about the technology subject between the teachers and that the teachers therefore also used quite different materials for teaching the technology subject. Only two months after I started conducting observations, I made one of my first notes in my field notes on the development of new teaching material. The process of development from the idea of new teaching material to actual realisation of that idea is described in the next section.

7.1.1. THE PROCESS

I was having a conversation with teacher 1 in the staffroom in HTX during a lunch break, at which time we talked about creating a coordinated language and concepts for the technology subject. Here I noted the following:

> 'Reflections on the development of material after a talk about creating a coordinated language and concepts (...) *The good report* (a book about how to write a good report) in an HTX perspective?—Clarify concepts, project structure and PBL' (Field notes, 14.02.2018).

Within the same week, I wrote down more about the idea of a new textbook for the technology subject. First, I followed up and wrote down what observations I had made that emphasised the need for a new textbook:

> '(1) Lack of a visible disciplinary tradition in the subject of technology, (2) No coordinated language or concepts, (3) No common direction in project writing—the product development process is the same but it is not taught in the same way, (4) Some teachers call for firmer but dynamic frameworks, (5) A project manual has been made, but perhaps it is too fixed—there is not space for the students to "think for themselves"' (Field notes, 19.02.2018).

Subsequently, I wrote down some ideas for what the book should contain, among other things:

> 'The book must combine (1) PBL—problem identification, problem analysis, etc., (2) How to write a good assignment on HTX, (3) Writing processes, (4) Problem statement, (5) Reading / note writing—Logbook, (6) Sources, (7) Empirical, (8) Method, (9) Assignment / structure, (10) Dissemination, (11) Technology' (Field notes, 19.02.2018).

At a meeting with, among others, the subject consultant for the technology subject as well as subject consultants for other HTX subjects concerning theoretical pedagogy, I briefly mentioned the idea of a new textbook for the technology subject in HTX and the idea was positively received. This was when I decided to take the idea out into the classrooms in HTX, where my observations took place. The first time I spoke to a teacher about the idea for the book during my observations in technology subject was in March of 2018. Here, teacher 7 expresses that, in the technology subject, there is a need for: 'a new book that brings it all together' (Field notes, 15.03.2018). It is further emphasised that the teacher uses many different books, but only a few materials from each book. On the other hand, the teacher has a large library on the computer with copies, assignments, etc. During the conversation, the teacher states that, if a new book is to be developed for the technology subject, it will be a good idea for the book to have the following qualities:

> 'A book that is built around the process in the technology subject up to the exam project. It should contain good manageable examples to which the students can relate' (Field notes, 15.03.2018).

Furthermore, teacher 7 adds that the existing material lacks something more about environmental assessment.

The next day I was again in HTX to observe, in the technology subject, the GameTech class taught by teacher 1. While the teaching was in progress, I had a good talk with the teacher about a new textbook, and the teacher pointed out that he thinks it would be a good idea to collect methods from the different technology subject teachers for use in the book. At the same time, however, teacher 1 emphasises that no book can be used alone when it comes to the technology subject. Later that day, I spoke to teacher 7 during the lunch break in the teacher's room, where we discussed the idea of a new book and, among other things, the idea that the new book could be a method book and that, according to teacher 7, it should function as a reference work. We also spoke about the pros and cons of whether it should be a classic paper book or an eBook (Field notes, 16.03.2018).

After receiving some good feedback on the idea for a new teaching book for the technology subject from teachers 1 and 7, I decided to present the idea to the chairman of the technology teachers' association (Teacher 9) at a meeting in April 2018. During the meeting, we discussed who could be partners in the project and whether the chairman herself should be part of the development work. The chairman stated that it would be interesting to be part of the project, but that it would be to a limited extent, as her calendar was already full. We also brainstormed on how material can be collected for the book and how the structure of the book can be built up.

> 'In terms of collecting material, which teacher do I need to get a hold of, and is there anything else to be obtained? In relation to the structure of the book, should it then be built up as an alphabetical circulation work or should it be built up according to the product development process?' (Field notes, 04.04.2018).

Before the meeting ended, we also turned to the question of how to get the book started practically, and whether we should 'start by drafting the book and whether it should be submitted and approved by the publisher or whether we should just call and talk to the publisher' (Field notes, 04.04.2018).

After the meeting with the chairman of the technology teachers' association, I decided to contact the publisher Systime A/S to hear if they have any interest in publishing a new textbook for the technology subject. Systime A/S is a publishing house that publishes books for upper secondary school (STX, HF, HHX and HTX), vocational education (EUD and EUX), preparatory basic education (FGU), and adult education (AVU). I sent an email to the publisher on 5 April 2018 with a short description of the idea for the book and partners (Appendix G).

While I was waiting to hear from the publisher, the teachers and I together further developed the book idea. I went back to HTX the next day to observe in a GameTech class, taught by teacher 2. Right from the start, the teacher came up with suggestions for the book idea, as he had been thinking about the book since the last time I was in this class to observe. He suggested that we do 'An interactive book that students can customise and move around and save so they have their own template. Or a book that students can at least comment on' (Field notes, 06.04.2018). He further added that it might make it attractive for teachers to contribute if: 'it could be added that teachers can suggest sections, etc., if they think something is missing and if it is approved, they get a piece of the pie (teachers must be remunerated financially for their contributions)' (Field notes, 06.04.2018).

Three days later I was back on HTX to observe, at which time I was in a class with the study direction of the world of physics. Here, teacher 5 teaches the technology subject. The teacher has a lot of ideas for the book, therefore we brainstormed about the content. During the brainstorming, many ideas emerged for the development of the book. Among other things, teacher 5 mentioned:

> '(1) Flowcharts for each section (used as an overview), (2) The text must be dynamic. It must be based on reflections by the students, (3) Concrete, socially relevant examples must be used (referring to examples in previous books) (4) Bloom's taxonomy is lacking in existing books; the level must not be taxonomically too low, (5) Students must document their group work, (6) Students must perform

> group contracts and it must be made explicit that they must do so for their own learning, (7) The process of project writing must be made visible; it must be possible for the students to assess how far they are and how far they should be, (8) The iterative process in project writing must be stated, (9) The order in the book is central, (10) Feel free to add a description of a search guide, (11) The students must be able to make argumentative choices and it should be described in the book, (12) It could be a good idea to have election material, (13) Method descriptions may be attached as an appendix together with the argumentation, (14) The problem tree must be included in the book' (Field notes, 09.04.2018).

Later in the day, I got the first email back from the publisher. In general, the publisher would like me to elaborate on the book idea. Additionally, they have some in-depth questions they would like to have answered before deciding on whether they want to help develop and publish the book (Appendix H). I then chose to address the chairman of the Technology Teachers Association again to discuss the feedback from the publisher.

While I was waiting to hear from the chairman, I went back to HTX the next day to observe a new class, in which teacher 3 was teaching the technology subject. While observing in different classes, I usually have a good chat with the teacher and this time is not an exception. We had a long talk about the technology subject and the complexity of the subject. Furthermore, we spoke about the idea of a new textbook for the technology subject and what such a book should contain. I recorded the teacher's statements as follows: '*He thinks the book is a good idea but he thinks it should be a paper book*' (Field notes, 10.04.2018). In addition, the teacher states that in the book we must remember the 'dynamics' or the elasticity, meaning that: '*It must be arranged for the students to reflect on what they do*' (Field notes, 10.04.2018). In addition, we must, if possible, differentiate between the information, that is: '*the basics must of course be in the book, but there must also be some material for the students who want to excel*' (Field notes, 10.04.2018).

On April 11, I met with the chairman of the technology teachers' association again, to follow up on the questions from the publisher (Appendix H). During the meeting, we agreed that the book should be written for the students, and thus the new book will also be intended to be a new basic book in the technology subject. We also concluded that we need to work with a longer time perspective for the book. November 2018 is too short a time to have a new basic book written, especially considering that the publisher's production processes shortens the timeframe by two months. We therefore only expect the book to be completed in the summer of 2019. In addition, I make the following follow-up notes from the meeting:

> '(1) Can one ask for another project manager on the book, and should we then choose another? (2) The deadline for the book is pushed to April 2019, (3) I have to go out and visit schools (possibly through subject group meetings), (4) The technology teachers must feel that they are heard' (Field notes, 11.04.2018.).

Over the next few weeks, I observed, as usual, in the technology subject. The book was paused for a while, meaning that we were waiting to hear from the publisher whether or not they were interested in publishing the book. The development work with the book continued as I still observed in the technology subject several times a week, but the book and the work with it were not brought up by me during the observations during this period. I behaved expectantly and listened instead.

A lot of emails were sent back and forth between the publisher, the co-authors, and myself during this period. The publisher had a few more pressing questions in relation to the structure of the book, and since all questions have been answered, the author team of the publisher held a meeting about the publication. In the meantime, the project manager of the book at the publisher suggested that we hold a meeting between the authors and the publisher. As he writes in an email:

> 'A clarifying process can take time. It does so in this case as we would like to meet with you to get a little closer to a common understanding of the potential of a possible release. Before a final decision on the realisation of the project' (email, 08.05.2018).

The entire writing team therefore met with the project manager from the publisher to talk about a common understanding of the potential of a possible publication. The meeting went well and joint notes from the meeting included:

> '(1) Lars Bo Henriksen contacts Peter Larsen with a view to a possible meeting about a possible collaboration, (2) Establishing an organisational framework for a project is a key issue, as we both want synergy in the process, with technology teachers from all over the country, and because technology teachers must be included for content development (at some currently unknown level), (3) The concentric model developed by Michael Petersen (HTX Aalborg) can play a major role in the spirit of the book, (4) Klaus will put it to a decision at an editorial meeting as soon as possible (awaiting a meeting with Peter, however), (5) The goal is a decision during June, after which we will need to meet to set a schedule and for a first start of the project etc.' (email, 28.05.2018).

After the meeting, the email correspondence with the project manager from Systime was intensified again. There are still many details that need to be in place before the publisher is ready to make a final decision on a possible release. A teacher who had previously published a book for the technology subject by the same publisher was not interested in a new textbook for the technology subject being published. Therefore, we were forced to discuss whether the book we had intended to publish for the technology subject should function as a supplement to an already existing book, or whether it should be an independent publication. At the same time, we had to rethink the idea of the book in the sense that the plan so far had been that the book should only be for the technology subject, but to get beyond the challenge with a new textbook for the technology subject, it was chosen that the book should be a 'project book' and that it must be able to be used in several subjects in connection with project writing (email, 18.06.2018). After the above considerations, the proposal for a new textbook could finally come at a scheduled meeting with the publisher. However, the summer holidays also ended up having to be completed first, before we got a final feedback on the release. In August, however, confirmation was finally received from the publisher. It reads:

> 'Hi Mette, Lars Bo, Henrik and Carsten, Systime would like to publish an upcoming textbook for Technology together with you based on PBL, etc. We would therefore like to invite you to a meeting at the publisher, where we will start the process together' (email, 13.08.2018) (Appendix I).

With the analysis of the process from the idea of a new textbook to the technology subject started and until it was realised, it is now clear that the idea started in the dialogue with the technology teachers in HTX in Aalborg. Quietly, the idea spread and the dialogue with the teachers developed to deal more with the content of the book. After a dialogue with the chairman of the technology teachers' association, I began the dialogue with the publisher about a possible new publication for the technology subject, and on 13.08.2018, the publisher of the new textbook was approved and the development of the book's content began.

However, the process would not have been possible to work through if a trusting relationship had not first been built between the technology teachers and myself.

7.1.2. BUILDING TRUST AND COLLABORATION

As stated earlier in section *3.1, Action research as an approach,* AR is a variety of approaches, but even though it is often presented as such, some similar overall characteristics were identified, one of which is about participants in AR:

> 'Participants in action research are involved co-constructors which makes AR participant centred, both democratically and reflexively' (Jarvis, 1999; Reason & Bradbury, 2013; Sunesen 2019, Duus 2014).

It also means that, without active participants to be part of this co-creation process, there would be no AR project to carry out. This is because it is the ideal in AR that: '*The citizen is actually a participant and co-creator of local change'* (Nielsen, 2014:206; Nielsen and Nielsen, 2007). This is further elaborated in the following quote where the importance of that participation is mentioned: 'The action researcher's interaction with the practitioners is absolutely crucial for both the local and the general knowledge the collaboration can generate' (Schumann, 2017).

Therefore, it was also extremely important to create a good starting point for a good collaboration with the higher Danish examination programme in Aalborg from the beginning of the project. As described earlier in section *3.2, Getting ready for action,* this was done through an introductory meeting with the chairman of the Technology Teachers Association, as well as through a meeting with the technology teachers from

HTX in Aalborg who are active in the Technology Teachers Association. Both meetings helped me set up an 'entrance' to HTX—a gatekeeper in the chair of the Technology Teachers Association. In addition, during the meeting with the teachers from the Technology Teachers' Association, three teachers chose to register as participants in the project by giving me permission to come and conduct my pilot study in their technology teaching. This created a good basis for further collaboration with the technology teachers in HTX.

I remember that, following the two meetings, I subsequently reflected on the low number of teachers who expressed that they would like to participate in the project. Three teachers out of eighteen possible active teachers in the technology subject constituted a start, of course, but it seemed like very few. I therefore considered how I could create an interest in more teachers to want to participate, and one day after I had observed earlier in the day in the technology subject in HTX, it became clear to me what the challenge was:

> 'There is very much a feeling of "she (me) writes down everything we say" (the teachers) and at the same time the teachers seek "confirmation" (look at me and ask if I agree)' (Field notes, 07.12.2017).

The after-reflection made it clear to me that it was about building a relationship of trust with the teachers, if I wanted them to participate. I therefore decide to spend much more time on HTX, not only to observe, but also 'just' to stay there, make myself more familiar with HTX and the teachers, and be 'available'. I chose to place myself in the staffroom at all three different HTX locations in different periods of time. In all of the locations, I tried to place myself where I wouldn't disturb anybody, but where I would still be seen when entering the staffroom. Even so, it still gave me the opportunity to be present if and when the teachers wanted to talk, and at the same time, show my interest and commitment in HTX and to the research project. Not long after I decided to intensify my presence on HTX by spending more time in the teacher's room, I could begin to feel the results of that choice. The teachers slowly started coming to me in the staffroom to talk about the project: *'maybe you could observe in the laboratory subjects? (…) Also try to look at what SO*[5] *is. PBL is not for a specific subject. It's over disciplinary'* (Field notes, 14.12.2017). In this case, as seen in the quote above, teacher 1 and teacher 9 come up with suggestions for what we could focus on in the project. Later that day, I had another talk with teacher 1, this time during the lunch break, at which the teacher mentioned: '*that you could make a course with a focus on group work and problem-based learning (as a subject); one class clearly lacks those competencies'* (Field notes, 14.12.2017). Both of these situations, in which the teachers came to me and explained how and what we can work with, in the project, can be seen as a matter of slowly building a relationship of trust between the teachers and me in the technology subject, as they began to engage

[5] SO stands for study area. The study area is a series of interdisciplinary courses between all subjects except the student's elective subjects. During the students three years of study on HTX they have to work on six SO projects.

(Moltke and Graff, 2014; Lehmann 2018:59). The same applies when I spoke to teacher 8 later the same day, at which time it was added that: '*the teacher will talk to another teacher to see if this teacher could be interested in having me observing in her class'* (Field notes, 14.12.2017). In my after-reflections from the same day, I noted the following reflection: are the teachers who sign up the ones who are already active in the technology subject? This was in the first phase of the project in HTX, in which I thought a lot about the importance of getting so many technology teachers to participate in the project, not just those who are already very active in the development of the subject. This was another note that emphasised the importance of being more present on HTX.

Then it was time for Christmas break, and since I have been back on HTX after the Christmas break, I can feel that the teachers and I just need to get the collaboration going again, which again speaks to the building of trust, as this requires frequent communication (Moltke and Graff, 2014; Lehmann 2018:59). The research project is still very new at this time, and the teachers and I still do not know each other so well, and it takes some energy to get the relationship back on track, but putting all that energy into building the relationship with the teaching staff yields results. In February, the expansion of collaboration with teachers, for which I had hoped, began to show. After a talk with a technology teacher in the teacher's room, I was invited into his classroom to follow the lessons. We agreed that I would write an email so we can plan when it could be possible (Filed notes, 15.02.2018). Again, right at the beginning of March, the collaboration with the teachers developed even more, when another teacher announced during a conversation in the teacher's room that I was welcome to observe in his classroom. The teaching took place on Monday, so it must be included in the calendar. In addition, I spoke to one of the education leaders in the teacher's room the same day and was also invited to observe his teaching (Field notes, 02.03.2018). By this time, I was starting to feel the results of my more intense presence on HTX. This was underlined a few days later when I made a note of the following in my field notes: '*It's nice now getting into the staffroom and people know who I am and want to talk*' (Field notes, 06.03.2018). And again, a week later, when I met two of the teachers out in the parking lot in front of HTX, I got an offer to sit and work at their team office as they have a vacant table (Field notes, 13.03.2018).

After approximately the first three and a half months of intense work on HTX in Aalborg, collecting empirical data and trying to establish trust and a relationship with the technology teachers, I could finally feel that all the hard work started to pay off.

Eleven teachers ended up participating directly in the project from HTX in Aalborg, where the observations and some of the interviews were conducted (See table 4 and 5). Two additional teachers are partially participating, in the sense that, in some cases, there are two technology teachers attached to each class; of these, in some cases, only one teacher has actively chosen to participate in the project, and the other teacher has then been asked if it is okay for me to be present and observing while they are teaching, for which they have granted approval. In addition, there are two other teachers who have also been partially participating, as they have been in the workshop while I have been present with other teachers. In addition to approving that I am present and observing what is happening in the workshop, they have also spoken to me about the project and have provided their input. Therefore, out of eighteen possible technology teachers at the HTX in Aalborg, fifteen teachers have been fully or partially participating in the project, in addition also to one leader.

However, creating a good starting point for a good collaboration with the technology teachers was not only important on HTX in Aalborg. In the project, I also had an interest in talking to technology teachers at many other HTX schools in the country as well. This becomes especially interesting after the technology teachers on HTX in Aalborg and I have begun to shape the idea of a new basic textbook for the subject in which the developed coordinated language can be incorporated. I therefore researched online to get more knowledge about where HTX schools are located around Denmark. Here I found a list of 52 HTX schools or departments spread across the country. For some of the schools, it was possible to find information about which teachers teach the subject of technology, including their contact information. For some, that was not the case. I decided initially to focus on the schools where I could find contact information online for the teachers in the form of email addresses. Then, I sent an email to approximately ten teachers, to whom I presented the study that I am in the process of conducting, to hear if they would like to participate and provide input through an interview. Here is an excerpt from the long email (Appendix J):

> 'The idea with the book is to create a common language and a common set of concepts in relation to project work on HTX across the HTX schools in Denmark. Furthermore, the idea is that all the schools and teachers who have an interest in participating and contributing to the development of the book should be able to participate in the project.
>
> 'It is you as teachers who are experts, and therefore we are very interested to learn if any of you are interested in participating in the project, and thus in helping to determine the content of the book' (email, 30.08.2018).

Creating trust and building a relationship via email with people I have never met was quite different than creating a trusting relationship of the type described in the previous section, with the technology teachers on HTX in Aalborg whom I saw on a daily basis. With the knowledge that, if you have an interest in building a collaboration with a high degree of trust, it requires frequent communication and that you get to know each other really well (Moltke and Graff, 2014), I was aware from the start that creating this trust relationship via email would require a sharp focus on my choice of words, even more so than when interacting face to face, as communication by any form of text can lead to many misunderstandings. I therefore chose the content, especially of my first email, as well as the choice of words in it, very carefully. This very specific focus seemed to have a positive effect, as I subsequently got in touch with five technology teachers who would like to participate in an interview. An excerpt of a couple of the messages I received from the teachers can be seen below:

> 'Thanks for your mail. We are a couple from the teaching team in Technology who would like to participate and provide input for a new textbook. You are welcome to come down to (…), and see our facilities, as well as have a chat about input for your project and the further course' (email, 26.09.2018).

> 'That sounds interesting. I would like to contribute to that' (email, 25.09.2018).

> 'It sounds really interesting and I would like to hear more and contribute if possible' (email, 30.08.2018).

Of course, there were also teachers who clearly stated that they did not have time to participate, and several who reported back that they thought it sounded interesting, but that they did not have time to participate themselves, but would pass the information on to their colleagues. However, none of the teachers were dismissive and they all thought the project was relevant. Subsequently, I was contacted by the subject consultant for the technology subject who also teaches the technology subject herself—she and a colleague would also like to make themselves available for an interview.

When the technology teacher who wanted to participate in an interview was finally found, the next task was to get a visit planned for all of them. In this way, I had the opportunity to gain a greater and broader insight into the technology subject on HTX schools across the country, and at the same time show an interest in the teachers, their schools, and the subject, and thus create a good framework for an upcoming interview and collaboration. This way of working is well in line with what McNiff et al. (2003) write about: making sure to let the participants in a given research project know and feel they are valued.

7.1.3. PARTIAL CONCLUSION

As mentioned at the beginning of section 6.1.2, Building trust and cooperation, the participants in an AR project are involved co-constructors, and if this were not the case, there would be no AR project. Furthermore, it is described how the interaction between the participants and me as a researcher is crucial for the local change that our collaboration can generate. The process described in section 6.1.1, The Process around the development of the idea of new teaching material for the technology subject and the creation of a trusting collaboration with the technology teachers, therefore also happens simultaneously in a non-linear process, and one cannot be without the other.

Based on the analysis, it can therefore be concluded that creating a trustworthy collaboration between the technology teachers and myself has been successful, as many of the technology teachers have had an interest in participating to a greater or lesser degree in the project. This is also emphasised by the development in the number of teachers who wanted to participate, which started with three teachers choosing to participate, and ended up with fifteen out of eighteen possible on HTX in Aalborg at the time of the observations, not counting the number of teachers from other HTX schools who have also participated.

7.2. CREATING A COORDINATED LANGUAGE FOR THE TECHNOLOGY SUBJECT

On the basis of the good trusting relationship that had been created for the participating technology teachers and the signed contract with the publisher Systime A/S on a new textbook for the technology subject on HTX, the teachers and I could start creating a coordinated language for the technology subject.

7.2.1. THE CONCEPTS USED IN THE TECHNOLOGY SUBJECT

The following analysis of which concepts are central in the technology subject takes its starting point in PBL and the concepts that relate to PBL, as these form the basis for the pedagogy in the subject, and the basis that it is the concepts related to PBL that form the framework for the lack of consensus among teachers in the subject. As a background for the analysis, a survey was conducted and sent to a large number of technology teachers on HTX schools throughout the country (Appendix E). In the survey, the technology teachers were, among other things, presented with a number of concepts relevant to the technology subject and asked which of the concepts they thought should be included in the new textbook, and if any relevant concepts were missing on the list that should be included. Additionally, technology teachers were asked if there were any concepts in relation to the technology subject for which a common understanding was needed. The results of the survey are analysed below. The point of the survey was to get an indication of which concepts were considered as the most important in the technology subject by the teachers.

Which of the following concepts and competencies should be included in the new textbook on project writing?

When the technology teachers in the online survey were asked which of the following concepts and competencies should be included in a new textbook on project writing, and at the same time were presented with a list of concepts and competencies related to the technology subject, the answers were distributed as shown in table 9 below.

Concepts and competencies	Respondents	Percent
Agile methods	6	22,2%
Association technique	22	81,5%
Work drawing	23	85,2%

Belbin	16	59,3%
Brainstorm	23	85,2%
Circle technique	12	44,4%
Documentation	24	88,9%
Self-insight	10	37,0%
External cooperation	13	48,1%
Elevator speech	9	33,3%
Packaging	7	25,9%
Field work	16	59,3%
Focus questions	15	55,6%
Business model	15	55,6%
Business plan	14	51,9%
Manufacturing process	21	77,8%
Group dynamics	16	59,3%
Idea generation	26	96,3%
Idea sorting	17	63,0%
Table of contents	19	70,4%
Interview	22	81,5%
Source indication	24	88,9%
Conflict management	15	55,6%
The conflict ladder	13	48,1%

Requirements	25	92,6%
Logbook	24	88,9%
The traffic light	13	48,1%
Learning styles	6	22,2%
Maslow's pyramid of needs	12	44,4%
Material list	23	85,2%
MEKA	19	70,4%
Milestones	12	44,4%
Environmental assessment	24	88,9%
Model	16	59,3%
Motivation	10	37,0%
Target group	25	92,6%
Key problem	26	96,3%
Reverse brainstorm	21	77,8%
Problem description	22	81,5%
Problem statement	26	96,3%
Problem	22	81,5%
Problem tree	26	96,3%
Product	25	92,6%
Product part	13	48,1%
Product requirements	26	96,3%

Product solution	17	63,0%
Product specification	22	81,5%
Product strategy	10	37,0%
Project description	20	74,1%
Project management	16	59,3%
Project proposal	17	63,0%
Prototype	22	81,5%
Risk management	5	18,5%
Assembly method	13	48,1%
Assembly drawing	17	63,0%
Scorecard	11	40,7%
Service	1	3,7%
Scale model	10	37,0%
Sketch	24	88,9%
Model	7	25,9%
Survey	21	77,8%
Stage gate model	4	14,8%
SWOT-analysis	19	70,4%
Technology assessment	22	81,5%
Test model	14	51,9%
Time schedule	23	85,2%

Knowledge sharing	14	51,9%
Total	27	100,0%

Table 9 – List of concepts and competencies with the number of respondents who have chosen this answer option and how many this corresponds to in percent noted in the two columns to the right (www.systime.dk).

From the respondents' answers in the table, above, it can be clearly seen that there are some concepts that are considered important by many, and then there are concepts that only a few of the participating teachers consider important for the subject. The teachers have been able to choose as many options as they thought were relevant, i.e., they have had to relate to all concepts and not just select x number that they considered most important. This is one of the reasons why the answers are distributed very broadly across all the answer options. However, there are still some response options that have received far fewer votes than the others. These include the following; Risk management (5/18,5%), Service (1/3,7%), and Stage gate model (4/14,8%). The remaining options in table 9 are all chosen by six respondents or more, meaning they have received more votes than those of every fifth teacher. This indicates that these concepts are part of the language game of a relatively large proportion of the technology teachers.

Are there any of concepts or competencies on the list that are central to include in the new textbook?

Subsequently, the technology teachers in the questionnaire were asked if there were any concepts that they considered to be central to the subject and thus should be included in the book, but which were not represented on the list (Table 9).

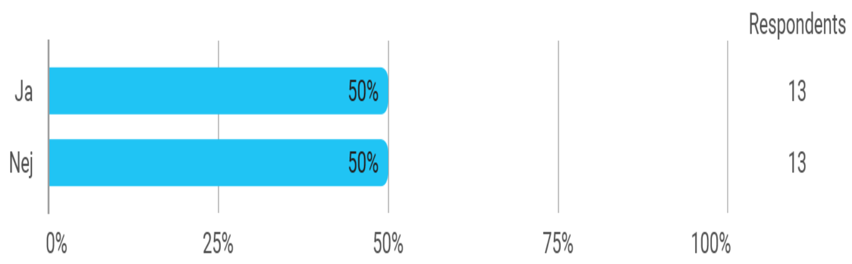


Figure 6-1 Are there any of concepts or competencies on the list that are central to include *in the new textbook? (www.systime.dk).*

The answer above, in figure 6-1, seems almost unlikely. Exactly 50% of the respondents think that there are concepts or competencies that are not on the list that are relevant to the subject, and the other 50% answer that they do not think this is the case. The respondents or participants who answered that they believe that key concepts are missing from the list have further added the concepts or competencies they believe are missing. A list of the concepts can be seen in Table 10 below.

If yes, which ones?
Phase model in product development
The more general as PBL, IPU, definition of the concept *project*, what is a good report (within the technical subjects)
Project(phases)
LCA, Technology Analysis, Delimitation, Idea Generation, Gantt
Economy and sustainability
Gantt plans, sensory profiles of food, measurable requirements, (for product solutions) conclusion, perspective, documentation of problem
Sure, I just have to think about it :-). I think it should be for Technology B, so it should not be filled with A content
Report writing, partial conclusions, product testing, workshop journal, delimitation, requirements matrix
A technology analysis - and a score- and weighting chart and a problem tree
The current phase model for product development, cf. the curriculum and guidelines
User-driven innovation, material analysis, stakeholder involvement and analysis
The spiral method, Adizes leadership roles. The future belongs to biological products. It will have a huge impact on how we think about products, materials and product manufacturing
Problem description must be replaced by problem analysis

Table 10 List of concepts missing on the original list from table 9 (www.systime.dk).

In the table above, it can be seen that the teachers mention many different concepts which, in their opinion, are missing from the list. However, there are also a number of concepts that have been noted by several teachers. Product development can be mentioned here, which is mentioned four times. Two of the teachers have noted that the phase model for product development is central, and another noted Integrated Product Development (IPU). The last of the four wrote ‘product manufacturing’, which is also a part of product development. Another term that is mentioned several times is Gannt charts, which is mentioned twice. One teacher has simply written Gantt and the other Gantt plans. Technology analysis is another concept that is mentioned twice. Both times, the teachers have just noted technology analysis in the questionnaire. The last concept that more than one teacher has noted is PBL, or something that is related to PBL. Concepts related to PBL are mentioned by three teachers. One teacher mentioned PBL in general, while the other two mention documentation of the problem, problem description, and problem analysis. In addition to IPU, Gannt charts, technology analysis, and PBL, many other relevant concepts are mentioned for the technology subject, and all of them are mentioned only once. This part of the analysis thus provides an indication of, and an insight into, which concepts the teachers consider to be central to the technology subject, and thus also an indication of which concepts are part of the language games used in the technology subject, and therefore also which concepts we must consider to include in the new textbook.

Are there any concepts in the technology subject we need to conceptualise?

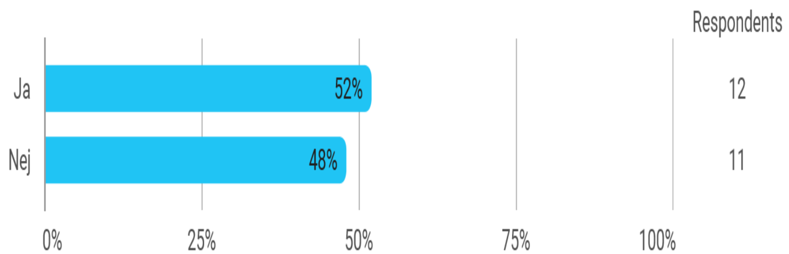


Figure 6-2 Are there any concepts in the technology subject we need to conceptualise? (www.systime.dk).

This figure is based on the question in the survey that deals with whether teachers believe that there are concepts in the technology subject that need to be conceptualised. The answers are almost as precisely divided as in the previous figure. From the figure, it can be seen that 52% of the teachers believe that there is a need for a conceptualisation of certain concepts in the technology subject, whereas 48% do not express that this should be the case. The respondents who answered affirmatively to this question have added the concepts, which can be seen in the table below.

If yes, which ones?
Problem statement
Problem and problem statement, technical report, process and product
IPU or similar
Problem, problem statement, problem analysis
No one but those mentioned, and those from the textbook by Peter Larsen[6]
Pretty much everyone
Problem analysis, problem statement, environmental assessment
All the basic concepts of the subject
Product
PBL as the pedagogical basis for the subject, our model for systematic and iterative product development, not the old ones but cf. new curriculum
Time schedule
Lots of innovation methods. In fact, everything that has been in the hands of the HR and communications industry. The product definition and purpose of the product for technology purposes

Table 11 - List of concepts that needs to be conceptualised (www.systime.dk).

Some of the things the teachers noted very clearly indicate the lack of consensus that exists between the technology teachers. To the question about the conceptualisation of concepts in the technology subject, one of the teachers wrote 'pretty much everyone' while another wrote 'all the basic concepts of the subject'. A similar note was made by a third teacher, who wrote 'No one but those mentioned and those from the textbook by Peter Larsen'. All of the notes highlight the lack of consensus just mentioned and indicate the need for the new textbook even more. What the answers in the table also indicate is that there is a need to conceptualise concepts related to PBL, as five out of twelve teachers noted concepts related to PBL as 'problem', 'problem statement' and 'problem analysis' (on HTX, called problem description).

[6] (Larsen, 2017)

The results of this survey cannot be generalised, given the low number of respondents. However, doing so was never the idea behind preparing the survey. The idea was to collect answers from technology teachers from all over the country, and not just from HTX in Aalborg. This way, there would be a broad representation of technology teachers as participants in the development of a new textbook, which could both have an impact on the answers, and also on the implementation of the new textbook and on the coordinated language afterwards. However, the analysis here can give an indication of which concepts are relevant to focus on, in the development of the coordinated language.

This analysis could not stand alone, and the results have therefore been compared with observations made on HTX and with interviews of the teachers, and have been discussed in the author group. The result of this process was *The Project Work—Technology and Technical Science Subjects*.

7.2.2. THE PROJECT WORK – TECHNOLOGY AND TECHNICAL SCIENCE SUBJECTS

The Project Work—Technology and Technical Science Subject, is a book that, as previously mentioned, is written specifically for the technology subject, but a focus in the development process of the book has also been to make sure that the book can be used in the Technical Science Subjects, as these subjects are based on the same pedagogy and work process. The book is built around some general PBL principles and IPU. On the back of the book, it is stated that:

> 'The project work provides a number of professional and educational instructions on how to implement good project work with a problem-oriented approach. A project is a defined and targeted process where collaboration, problem-solving, and product are associated sizes. All the concepts in the project work from start to finish and are described with both student examples and practical instructions on implementation. The project work is also a textbook that deals with the concept of technology. Through cooperation and the critical assessment of the significance of the technologies, the ethical and societal are linked to the concrete and solution-oriented. The chapters target the technology subject on HTX, but can be widely used in all kinds of PBL and project work, including the technical science subject on HTX' (Jeppesen et al. 2020).

The book is divided into twelve chapters, all of which cover areas that are part of project work and report writing on HTX. In the beginning of the book, a section has been written on technology and how technology is to be understood in the technology subject—a section that is crucial to students' understanding of the subject. Next comes a section called 'Why do we have to do projects?' This section gives students a brief introduction to PBL, problem orientation, project management, group work, and education. It ends with a conclusion on what students actually get out of working on projects.

After the introduction comes a long section on how the students can start their projects, and they are further introduced to different methods that can help them both in terms of project management and in collaboration on doing projects. The idea of the section is to show the students that the start-up is important for the project getting off to a good start, and that they should therefore give themselves plenty of time for the start-up process so it will not be rushed. The time they spend on the start-up of the project will prove important for the rest of the project.

The third chapter is about problem identification, and this is where the students really get started on the project and can identify which problem they would like to work on. Here, students are introduced to various methods within idea generation that can help them get ideas for what problem they can work with. Once they have identified a lot of possible problems, they must then sort through the ideas. Once they have done so, they must select the problem they would like to work with, and to that end they will be introduced to several more options and examples that may be helpful. The result, after working on this chapter, should be that the students have identified their key problem.

In Chapter 4, students must complete a problem analysis. Here, the students are introduced to different methods that can help them. First, they are introduced to the problem tree, which they must work out on the basis of the key problem that they identified in Chapter 3. Here, we work on causes and effects in relation to the key problem in order to test whether there is enough to work on in relation to the chosen problem. Subsequently, the students must prepare a stakeholder analysis through which they will identify possible stakeholders and subsequently draw on the knowledge that the stakeholder analysis has conveyed to the problem analysis. After this, the students must have expanded the problem analysis even more, in order to expand their knowledge of the problem. In other words, they must have mapped the problem field. For this they are introduced to the hv-model. It helps the students to ask a lot of hv-questions, in order to investigate their key problem in more detail. Afterwards, the students are presented with various quantitative and qualitative methods that can help them to further develop the problem analysis. Furthermore, before they start formulating the final problem statement for the project, the students must make some environmental considerations in relation to the key problem they have taken as a starting point. When these considerations are done, they may then design the final problem statement.

In Chapter 5, the students have to start working with IPU. At the beginning of a development process, it is important to get all aspects of the problem you want to solve or of the need you are trying to cover. Therefore, the students in this section should work on defining the target audience for which they are developing the product. Once they have done so, they must prepare a requirements specification that clearly describes the requirements for the product. After this is done, they must again work with idea generation; this time, however, it is in relation to new possible product solutions. At the end of the section, it is also described how students should study the competitors in the market and work out solutions in the form of sketches and prototypes.

In Chapter 6, the students then have to work on product design. By now they have established a product principle based on the requirements they have made for the product, and now they have to design their product. As they begin to do so, as a first step, they must consider some environmental consequences of developing the product. Here, they must both think about environmental consequences during development and production, but also when the product should be discarded. Once they have made these considerations, they must start thinking about materials. Here, they must consider which materials they would like to use and then prepare a list of materials. After that, they must prepare working drawings, collection drawings as well as technical drawings which of course differ from group to group, according to the product they develop. Subsequently, they are presented with different charts. These include both flow charts that they can use to map activities, electrical diagrams that can be used to visually present an electrical circuit, and principle diagrams that can be used to visualise a system's principle or functionality. All charts that they can use in their projects but do not necessarily have to use. The chapter concludes with the students being presented with a business plan and how they can unfold it in the project. This is only a requirement for those students who have Technology A.

In Chapter 7, the students must start production preparation. For the production preparation, the students must, as a starting point, prepare a technology analysis based on the technology model. Then they have to work with the manufacturing process, which means that they have to consider production forms, production layout, and quality control.

Chapter 8 deals with the realisation of the product, which means that this is where the students must go to the workshop to create their product. For this, it is important that they remember to document the process.

Chapter 9 deals with assessment and evaluation. A final part of project work is the evaluation of the project. In this chapter, students are presented with ways to test their product, different types of technology assessment, and a process evaluation.

Chapter 10 focuses on dissemination and documentation. One aspect is how the students have prepared their study and constructed their product. Something else is how they convey what they have done. Therefore, the focus here is also on how they get structured and how they have structured the technology report. In addition, they are also presented with collaborative writing as a tool that can facilitate the process and collaboration. It is also explained why it is that they document the process as well as prepare workshop documentation. Finally, in the chapter, tips are also given on how to write a conclusion for the entire project and how to draw up a solid literature list.

Chapter 11 explains what a source is, what the function of sources is, as well as the professionalism and science of sources.

Chapter 12 is the list of literature for the entire book.

7.2.3. PARTIAL CONCLUSION

In summary, it could be seen from the internet-based study that there were many concepts of which we should be aware, in addition to those on the list that were part of the study—both in relation to whether the concepts should be included in a publication or whether they should be omitted. Based on the first question in the study, 'Which of the following concepts and competencies should be included in the new textbook on project writing', it could be seen that there were three concepts that got very few votes from the teachers: Risk management, service, and Stage gate model. The opposite was true for the question, 'Are there any concepts or competencies on the list that are central to include in the new textbook, and if yes, which ones?' In this case, teachers noted several concepts for consideration in relation to the development of a new textbook, which included IPU, Gantt, Technology analysis, and PBL. In relation to the last question in the survey study, 'If there are any concepts in the technology subject we need to conceptualise', there was a proportion of the teachers who noted PBL concepts in relation to PBL, whereas others noted that there was a need for all concepts relevant to the technology subject to be conceptualised.

These concepts were then compared with the observations made on HTX, with the interviews with the teachers, and were discussed in the author group. The result of this process was *The Project Work—Technology and Technical Science Subjects*.

7.3. THE TEXTBOOK AND HOW IT IS USED

With the publication of the new textbook for the Technology subject, *The Project Work—Technology and Technical Science Subjects*, it was interesting to analyse whether the book is actually being sold, because an analysis like that can give an indication of whether anyone is actually using it when teaching. In this third part of the analysis, therefore, I will, firstly, take a look at the sales figures. How many papers and ibook's have sold? Afterwards, I am using observations made on HTX in Aalborg as well as dialogues with feedback from the technology teachers, to analyse whether the book is used in practice, and if so, how it is used. This third part of the analysis can help to say something about whether I, with the project, succeeded in implementing the coordinated language through the new textbook—or, in other words, if I succeeded in helping to enable the technology teachers to discuss and solve their problem with a lack of consensus.

7.3.1. THE SALES FIGURES

In the execution of an AR project, it is central that the project and the change initiated during the project live on after the AR project is completed. That is, the change that was initiated should be able to live on by the teacher's hands alone, if the implementation of the book was successful. This does not mean that everybody should use the book, as the idea for creating a coordinated language was to enable the technology teachers to discuss how to work in the technology subject, not to create unification. The sales numbers can still give some sort of identification of where the book is being used, which is important, because, if it is not being used, I have not been successful in enabling the technology teachers to discuss and solve their problems with a lack of consensus.

When you first just look at the total turnover for the book, it is 80.000 DDK. The turnover for the publication of the basic textbook for the technology subject can then be divided into two different categories: turnover for the ibook, and turnover for the paper edition. If we first take a closer look at the turnover for the ibook, this can then be further divided into two subcategories: iLibrary turnover, and license turnover. The iLibrary is an online library to which schools can buy access to a lot of different ibooks from Danish educational publishers, including ibooks that are relevant to fields of study and subjects on HTX. This is undoubtedly where there is the highest turnover on the book. In table 6-3, below, it can be seen that the iLibrary for the book *The Project Work—Technology and Technical Science Subjects,* has a turnover of around 52.000 DDK.

The project work - Technology and Technical science subjects (iBook)	**Quantity**	**Turnover DDK**
iLibrary turnover		100.973,44
License – 1 year	128	8.800,00
License – 2 years	116	9.744,00
License – 3 years	8	768,00
License – 4 years	1	200,00
Total	**253**	69.526,52
The project work - technology and subjects (Book)	**Quantity**	**Turnover DDK**
Book	248	37.470,00

Total turnover	501	157.955,44

Table 12 - Sales figures for The Project work – Technology and Technical science subjects from the time of publication until November 2021(www.systime.dk).

For the licenses where the schools buy access to the book for a specific number of years at a time, the turnover is somewhat lower. Here, the total turnover for licenses of 1, 2, 3 and 4 years is only around 17.000 DDK. This means that the ibook has a total turnover of around 69.500 DDK. And finally, the turnover for the paper edition of the book is the lowest, at around 11,000 DDK. There are undoubtedly many different reasons why there is such a big difference between the turnover of the ibook and the paper edition of the book. One of the obvious reasons must be found in different preferences between teachers and students. This is backed up by statements from dialogues with teachers and students during the previous observations, in which the students have expressed that they would prefer to have the books online so they always have the material at hand and do not have to remember to have the book with them when they go to school (Filed notes, 01.06.2018), and in a statement from several teachers who expressed that they are probably more "old school" and therefore prefer to have a physical book. In addition, there is also something that may indicate the importance of the number of paper editions of the book sold. Quite generally, it can be seen in the above table 12 that the number of sold editions of the paper edition of the book is very low; only 74 editions. Table 13 below shows a specified list of the number of books sold and who bought them.

The project work - technology and subjects (Book)	Quantity	Turnover DDK
Total	**74**	**11.366,00**
20828 Group Buy ApS	2	360,00
8910 Imusic	1	180,00
Audio Visionary Music ApS	32	5760,00
Audio Visionary Music ApS	1	180,00
BibMedia - ODENSE	2	360,00
Birk Studieboghandel	3	540,00
Bøger og Papir Nykøbing Mors	1	180,00
Campus Bornholm - htx	1	148,00

CELF - Nakskov	1	74,00
Den Jydske Håndværkerskole	1	148,00
E-handel private	2	254,00
EA MidtVest	1	148,00
Erhvervsakademi Midtvest	1	148,00
EUC Nordvest	7	1036,00
EUC Sjælland	1	148,00
Factum Books	1	180,00
Frederikssund Gymnasium	1	148,00
Gucca og DVDOO	2	360,00
GUX Sisimiut	1	148,00
Hansenberg	1	74,00
Herningsholm Erhvervsskole	1	148,00
Holstebro Bog og Idé	1	180,00
Institut for Naturfagenes Didaktik	1	148,00
Kold College	2	148,00
NEXT Uddannelse Kbh - Sukkertoppen Gymnasium	1	74,00
NEXT Uddannelse Kbh - Sydkysten Gymnasium	1	74,00
Polyteknisk Boghandel	1	180,00
Saxo.com	1	180,00
Skive College - HTX	1	148,00

Svendborg Erhvervsskole & Gymnasier - erhv.sk	1	74,00
Syddansk Erhvervsskole	1	74,00
Syddansk Erhvervsskole	157	23.162,00
Teknisk Gymnasium - Grenaa - Viden Djurs	1	148,00
UCN Teknologi & Business	2	360,00
Uddannelsescenter Ringkøbing-Skjern	1	74,00
Willam Dam I/S – Bog og Idé	1	180,00
ZBC Slagelse - HHX/HTX	1	148,00
Aalborg Tekniske Gymnasium	1	148,00
Aalborg Tekniske Gymnasium	1	74,00
Aarhus TECH/Aarhus Gymnasium Aarhus C	4	518,00

Table 13 - Detailed list of books sold in the paper edition from the time of publication until November 2021(www.systime.dk).

Who bought the books is not what is interesting here, but rather, it is the fact that the vast majority of schools that have bought the book have bought one or two copies. Only very few have bought more. This could indicate that the physical books are bought as shared copies for the teachers.

If we take a closer look at the numbers of licenses sold in table 14, we can see that the most sold are 2-year licenses (116), and after that, 1-year licenses (98). Not many 3- and 4-year (8 and 1, respectively) licenses are sold.

The project work - Technology and Technical science subjects (iBook)	Quantity	Turnover DDK
iLibrary turnover (89 different institutions)		100.973,44
License – 1 year	**128**	8.800,00
Ecommerce private	3	200,00

EUC Sjælland, HTX	61	4.148,00
GUX Sisimiut	40	2720,00
Hansenberg	24	1.632,00
License – 2 years	**116**	9.744,00
EUC Sjælland, HTX	93	7.812,00
Aalborg Tekniske Gymnasium	23	1.932,00
License – 3 years	**8**	768,00
H.C. Ørsted Gymnasiet	8	768,00
License – 4 years	**1**	200,00
Ecommerce private	1	200,00

Table 14 - Detailed list of licences sold from the time of publication until November 2021(www.systime.dk).

This also means that most licenses that are sold are for the shortest license periods: the 1- and 2-year licences. Of course, there can be many reasons for this, but one of the possible reasons why most schools only buy a few copies of the book could be the constantly changing times in the education system. Between changes in the executive order and in the curriculum, as well as development at the individual schools that must be in constant development, buying licenses for books for a shorter period of time seems more flexible.

To sum up, the sales figures clearly show that the book is being sold. A turnover of around 80.000 DDK is quite a bit, especially taking into consideration that most of that turnover is coming from the iLibrary. What is just as important in this case is how many schools and institutions actually found this book interesting enough to buy. In that context, it is interesting to take a closer look at how many people actually use the book, and how.

7.3.2. HOW IS THE BOOK ACTUALLY USED?

The point here is to look at whether the project has 'captured' the meaning the teachers have expressed. I will look at that by analysing whether or not the book actually is being used in the classrooms, and how. To do that, I arranged with two technology teachers from two different schools in which I could observe in their classes when teaching technology during the autumn / winter of 2019. If this is the case, the teachers will work with the material that has been developed, develop new ideas, and gain new perspectives on the work in the technology subject (Henriksen et al., 2004).

The first day I went back to the schools to see and hear how they work with the book, I meet up with teacher 10 in the staffroom While we were standing in the teacher's room talking, teacher 5 came in the door, and when she saw me, she walked toward us and the first thing the teacher said is: '*You have reached a good result'* (Referring to the book) (Field notes, 16.01.2020). Subsequently, teacher 10 informed me that the students in the class that I am going to enter and observe this day have been given homework for today's teaching. They have had to read 6 pages in the book about business models and SWOT analysis. The teacher further states that in the class right now they are going through the syllabus again and that they are using the book for that. Teacher 5 then adds to the conversation that the book is also used when she teaches, as she refers to it, and therefore right now uses it as a reference work. The teacher subsequently adds, '*but if you meet me again next year and I am more into the material in the book then, I think I will use it even more*' (Field notes, 16.01.2020).

What I observed in the classroom emphasises what I just spoke to the technology teachers about in the staffroom. The students use the book as a reference work, and they are good at using the book in the context in which they are working. The teachers also use the book by referring to it when the students have to read up on something, or update themselves on a concept. An example of this can be seen when a teacher reviewing a business model mentions that there is inspirational material to be found in *The Project Work—Technology and Technical Science Subjects*. The teacher subsequently asks if there is a need for the topic to be reviewed further, or if what the students have read in the book has been clear enough. The students nod in agreement that the material read has been comprehensibly described (Field notes, 16.01.2020).

The next time I was on HTX, I met teacher 1 in the staffroom. The teacher told me that he was not familiar with the material in the book yet, and therefore is not so much into the process of using the book (Filed notes, 20.01.2020). As I later entered a classroom, students were introduced to the theme of the first lessons: IPU. The students were given an A3 sheet which deals with IPU—a sheet they had to work on together in pairs. On the sheet, students should put headings on the different phases of the IPU process, and then they should write the content of each phase down in keywords under each heading. Students are reminded to: 'use *the book and familiarise themselves with it*' (Field notes, 20.01.2020). The book was also on the projector. The students from that time on worked thoroughly based on the book. As the students finished putting headlines on the phases and adding content below, they subsequently had to change focus. They now had to work with actors in product development in groups of four. The students were asked to take as their starting point the work of a chair. They had to work with the chair in relation to the phases of product development (PU). The actors were pre-identified as being: Marketing employee, Designer / constructor, Production manager, and a specialist, if any, and occupational therapist. The task was now that all students in the four-person groups must be assigned a role that corresponds to one of the actors identified above. Subsequently, the individual student then had to first work alone to find out his / her role in relation to the different phases in PU. When they finished, they afterwards had to work together in the groups of four on the four roles in the phases of PU. During this period of time, they did not work actively with the book as they had already written down the phases of PU and their contents on a piece of paper. The teacher subsequently asked if any of the students had understood why she asks them to do this assignment. One of the students raised his hand and explained that it must be because the work with the assignment illustrates or clarifies the processes in IPU. After a short talk in class about this consideration, the teacher asked the students to do yet another task. The teacher then introduced the students to two concepts: iterative technology development, and linear technology development. After the introduction, the students then had to look up the concepts to find out how they are conceptualised. After the students had looked up both concepts, the teacher followed up by outlining her understanding of both concepts. The teacher subsequently reviewed the extended technology model (Müller et al., 1984) and then followed up on the day's goals to make sure all of the students understood. Before the teaching ended, the students had to review the academic goals to get a sense of their development (Filed notes, 20.01.2020).

In observations from 16.01.2020 and 20.01.2020, you can hear that the book is actually used by both teachers and students. Although at this time it is 6 months since the book was published, some of the teachers are only getting acquainted with the material and others have started using the book, among other things, as a reference to the students' homework. Table 15 below shows how much the book is actually used.

Number of page views	**2021 Students**	**2021 Teachers**	**2020 (S)**	**2020 (T)**	**2019 (S)**	**2019 (T)**
Total	101284	18268	86.176	18.738	12.310	7.100

Table 15 - Usage statistics for the book from the time of publication until January 2021(www.systime.dk).

In the table it can be seen that, in the approximately four and a half months after the book was published in 2019, the number of page views was 7.100 for the teachers and 12.310 for the students. For the year 2020, the number of page views has increased quite considerably, if one just immediately looks at the figures presented. If we look closer and calculate how many page views have been made per month for both students and teachers for both 2019 and 2020, we get instead a number we can better compare, so it is easier to give an estimate as to whether the use of the book has increased. The calculations are shown in table 16 below.

	2021 Teachers	2021 Students	2020 Teachers	2020 Students	2019 Teachers	2019 Students
Total number of pageviews	18268	101284	18738	86176	7100	12310
Number of months the book has been used this year	10	10	12	12	4,5	11
Number of pageviews pr. month	**1826,8**	**10.128,4**	**1561,5**	**7181,3**	**1577,8**	**2735,6**

Table 16 - Calculation for total pageviews pr. month (www.systime.dk).

With the table, we can see that there is a slight decrease in the number of pageviews for teachers from 1577,8 in 2019 to 1561,5 in 2020 and there is an increase in 2021 to 1826,8. However, there is an all over increase in the number of page views when it comes to students. Among the students, the number of page views in the book is increasing from 2735,6 per month on average in 2019, to 7181,3 pageviews per month on average in 2020 and 10.128,4 in 2021. Based on this very simple calculation, it can be said that there is something to suggest that some of the students have at least taken the book with them and used it. On the other hand, we cannot conclude from the figures that the teachers have not embraced the book, because the number of page views has not increased as much for them. If we consider the calculation that several of the teachers have stated that they would rather use the paper version, and at the same time that the teachers undoubtedly also have a large share in the students using the book, so much as it is the teachers who encourage them to do so by referring to the book, then it must be said that it seems that the book is being used. From the numbers, however, it cannot be seen by how many. However, one can get an impression of which schools use the book and how much, in Appendix K. The figures in the table, the number of page views per school in percent, in Appendix K, however, are not static numbers, but on the contrary, are very changeable and thus only show the use of the book right now. The numbers may look different after the next update on Systime's website. However, the numbers can still give us an impression of who and how many use the book and to what extent. Appendix K lists 112 of the youth educations / schools / institutions / departments that have used the book the most.

Based on the timing at which the Coronavirus made its entrance, the period in which an evaluation could be carried out in the autumn / winter of 2019/2020 was very short.

In the following period, I had constant contact with some of the technology teachers from HTX in Aalborg. During that period, I received an email from technology teacher 10 (see table 5. pp. 15-106 for a list of teacher numbers), from which the following quote is taken:

> ‘The exam project has—like everything else—been affected by corona, but I actually think that the course went well. The students have used the *The Project Work* and have greatly enjoyed it. One of the students said: ‘I just follow the book—when I have been through it, I have written our entire report. It is ingenious that the book can be used for that’. So, it has probably been student approved?’ (email, 12.05.2020).

In the email, teacher 10 expresses that she believes that the new textbook for the technology subject has been approved based on this student's statements. Of course, a student's statements are not enough, although it can be seen as quite special that a textbook is referred to as ingenious.

This gave me incentive to conduct more observations to get a better idea of whether the book has actually been received so well, especially by the students, as both the numbers in Table 13 and the quote above indicate.

I therefore started the evaluation process again at the end of the summer of 2020. Here, the colleges slowly started reopening for teaching with physical presence. I chose at that time to observe the teaching during the PU course for the new first-year students. This was partly because I had been informed by the technology teachers that the material from the book was used in the teaching of this course, even though it was not written for that particular course.

I arrived on 04.09.2020 at 9.50, spending some time finding the technology teacher who teaches the class in PU on that day, and subsequently the classroom where they should be, because I was a little in doubt about whether they had gone on break. However, I found them in the classroom and when I entered the large room, I could see that there were two teachers who taught approximately 60 first-year students together. Students were in the process of identifying sources. Since I had not observed from the first day when the PU course started, the students were already well underway with the first part of a project. The class, therefore, already had papers with performed stakeholder analyses, problem trees, and mind maps that the students had made on that Friday, 04.09.2020. To be able to conduct all these assignments, the students had to read chapter 3 and 4 in *The project work—Technology and Technical Science Subjects.* The book has thus been used here as a reference for the students' homework. After a break, one teacher began to present qualitative and quantitative methods to the students. After the presentation of the different methodological approaches, the students were asked to reflect on whether they needed additional data collection for their problem analysis, and whether such should be of qualitative or quantitative data. Such a reflection should then lead to the execution of a new questionnaire, an interview guide, or something else. Some groups worked in a very focused manner on the task at hand, while others had a harder time with it. Among other things, some groups were a little stuck in naming the group of people they would like to interview. Are they nursing home residents, citizens, or what do you call them? The teachers subsequently circulated around the class to talk to the students and help if there were any challenges with the task set. The students do not use the book for the assignment in class, nor have they been asked to read about qualitative and quantitative methods in the book, even though there is a chapter in the book about methods. As the teachers circulated around the class and talked to the students, one could hear the students having a hard time relating to the importance of spending a lot of time designing the questions in relation to their questionnaire or interviews. At one point, one of the teachers asked, in regard to one of the group's ongoing work, 'Why do you ask about it', to which the student replied, 'I just personally think it is extremely important' (Fieldnotes 07.09.2020).

On 09.09.2020, I will again visit HTX to observe how the book is used in practice. The introduction to this day's class begins with one of the teachers saying, 'Today we have to start solving the problem' (Field notes, 09.09.2020), with reference to the problem that the students are trying to solve in the projects that they are currently working on. The teacher then followed up by saying, 'I assume that all of you yesterday formulated a problem statement and set some requirements' (Field notes, 09.09.2020). As a brief introduction was given, the day's programme was as follows:

> '1) Sketching course, 2) Idea generation, 3) Persona, 4) Idea development and detailing, 5) Documentation of the process, and 6) Portfolio' (Field notes, 09.09.2020).

The teacher then handed out paper to the students and asked them to find something with which they could draw, after which there was an outburst from several students: 'Shall we draw by hand!' (Filed notes 09.09.2020). The short answer to that was yes. The sketching course began. The idea was to give students tips and tricks on how they can become good at outlining possible product solutions in their projects. On the piece of A3 paper that had been handed out to the students, a number of circles had been drawn in advance. The first sketching task for the students was that within 5 minutes they should continue on as many of the circles as possible the teacher gave further examples of what circles could be made into, such as a sun, the yolk in an egg, etc. A student then exclaimed: 'Fuck this is stupid' (Field notes, 09.09.2020). The teacher subsequently came up to me. I stood at the back of the room up against the board where I had a good view of the whole class. She said, 'Welcome to high school—here we draw. Do you also want a sheet?' (Field notes, 09.09.2020). After the students had completed the first sketching assignment, they were given a new and task, until the first lesson and thus the sketching course ended. Everyone took a break before the second lesson and in that break the other teacher (teacher 8) who teaches came over to me to talk. He expressed that he was happy with the book. He further said that some of his students were happy with the book and that this also applied to some of his colleagues to whom he had spoken. He also taught some students in another class who were in the process of developing a method book that could help them when they have to write a project in Technology A. They work from *The Project Work—Technology and Technical Science Subjects* (Field notes, 09.09.2020). After the break, preparations were made to start on point two of the day's programme, and the students were therefore asked to find their problem statements on their computers. Students were asked to prepare a persona. First, they had to reflect on who it was for whom they were trying to create a solution with the problem statement, and then they had to prepare and collage with pictures, ideas about what clothes they wear, what their values were, whether they are physically active, etc. In addition, the students were told that they should write small texts for the persona, with which to explain their choices. Before the students started the task in their groups, an example of a persona collage was also shown in class. After the students finished their persona, the teaching changed to focus on idea generation methods. After this, the students first worked with the method Brain pool and idea sorting, then with reverse brainstorm and association technique, all in relation to their own projects. During the teaching, teacher 10 mentioned the material from the book. She said several times: 'You should have read this for today / tomorrow' (Field notes, 09.09.2020). There was thus a lot of references to the book in the teaching and the students had also been asked to read a certain number of pages so that they could be prepared for the teaching, but I did not see so often that the book was used actively in the teaching. Teacher 10, however, expressed that the book was used in several different ways: 'Sometimes the students just have to read the book before the lesson, other times it is used more actively. In later projects, the students used the book themselves for the development of their projects' (Field notes, 09.09.2020). Before the teaching was completed, I also observed that there was actually a group who sat with the book in front of the computer and used it in relation to requirement specifications (Field notes, 09.09.2020).

The last day I observed on HTX was 11.09.2020. Here, teacher 1 started the day by giving the students a brief introduction to the plan for the day. The theme for the day was: modelling and drawing. Included in the plan for the day that the students had to work with were: detailing, material selection, model building, drawing, documentation, and portfolio. After the introduction, the teacher asked a group to start working on their project on exoskeletons. The rest of the groups wanted to develop apps, and the teacher therefore collected them and gave the groups one for AppLab. The students then worked until 09.20, after which everyone took a break. When the teaching started again, teacher 1 started by introducing the students to a new mind map method, after which the students were asked to make their own mind map of the methods used in PU. Although the students in the mind map exercise worked very actively with the methods and process in PU, which is also described in the book, they did not use the book. When it was time for a break again, I bumped into another technology teacher in the hallway, one who otherwise had not been part of the research project. She told me that she had received a link to the ibook but that she could not make it work and therefore asked if I could send her a new link. She then explained that she had to use it as she had to assess whether the book or some of the material from the book could be used for the Pedagogical Basic Course (PG) for the technology teachers as well. When I got back to the classroom, I talked further with some of the students to hear how they used the book. One of the students replied: 'We primarily read in the book so that we are prepared for the teaching' (Field notes, 11.09.2020). I then asked if they also use the book when they are at school. The answer was: 'Yes if we cannot remember what we have read, but otherwise no' (Field notes, 11.09.2020). However, I did observe that some of the students had opened the ibook on the computer during the lesson (Filed notes, 11.09.2020).

7.3.3. PARTIAL CONCLUSION

Based on this three-part analysis, it can be concluded that the new textbook for the Technology subject, *The Project Work—Technology and Technical Science Subjects,* is being sold both as a paper edition and as an ibook. It is difficult to compare the sales figures with sales figures from other textbooks from Systime, as I only have access to my own sales figures. In reality, however, it also does not matter whether the sales figures are high or low compared to other releases. What was interesting was through the sales figures to get an impression of whether the book was actually being bought, if it can be concluded that this is the case. If we look exclusively at the turnover, we can conclude that the book or access to the book is bought mostly through the iLibrary and then through licenses. The paper version is the one that is bought the least, in relation to the turnover. It can further be concluded that the stroke numbers give an indication that the book is actually being used. This conclusion is further confirmed through the second part of the three-part analysis, where it becomes clear through observations that the book was used in practice in the classrooms. Finally, it can also be concluded from this part analysis that the book is used in relation to the teaching in three different ways: 1) the teachers refer the students to the book when they have to read up on specific topics for the teaching, 2) it is actively used in the teaching of the students, 3) when students become more self-motivated in writing projects, they use the book to drive the process in projects.

The conclusions in this sub-analysis also give an indication that the implementation of the coordinated language through *The Project Work—Technology and Technical Science Subjects* has therefore to some extent succeeded in enabling the technology teachers to discuss the subject and its premises and to help them with solving the initial problem of a lack of consensus.

7.3.4. SUMMARY OF THE ANALYSIS

Overall, it can be seen from the analysis that it has been possible to build up a trusting relationship between the technology teachers and myself. This is especially the case with technology teachers in HTX in Aalborg. Here, many of the technology teachers and also students have engaged in participating in the project, and it is the participation of all of them that has made it possible to develop the idea of making a new textbook for the technology subject from beginning to end. Without their participation in relation to both observations, interviews, and surveys, it would not have been possible to seek to create change through the development of a coordinated language. Furthermore, the analysis gives an indication that the implementation of the coordinated language through *The Project Work—Technology and Technical Science*

Subjects has to some extent been successful, and that I, to some extent, have also succeeded in enabling the technology teachers to discuss the subject and its premises, thereby helping them to solve the initial problem of a lack of consensus.

CHAPTER 8. CONCLUSIONS

Throughout this thesis, all the steps that have been taken have been taken to seek answers to the problem statement on which the thesis is based. The problem statement reads as follows:

How can we strengthen the disciplinary tradition in the subject of technology in the Danish HTX programme?

In order to be able to answer the problem statement, studies of the technology subject have been carried out through the concepts Technology, PBL, Bildung and Language. The conclusion that can be drawn from the studies of these concepts (Chapter 2, pp. 52-110) is that it is possible to strengthen the disciplinary tradition in the technology subject on HTX through working with the language game used in the technology subject. Through a process of getting to know the language used by the teachers in the technology subject and then together with the teachers identify the key concepts in the subject, it has been possible to merge several existing language games and thereby create one coordinated language. Through the coordinated language written down in a new text book, it has now become possible for teachers to discuss their subjects both between teachers but also between teachers and students. This has created the opportunity for a more common direction[7] in the technology subject, which can help to alleviate some of the challenges that teachers and students have otherwise encountered in the past. Through this common direction with a coordinated language, the disciplinary tradition in the technology subject will be strengthened over time. A work that is already underway locally on HTX in Aalborg where the book is already in use in the technology subject and other subjects but also nationally where the subject consultant for the technology subject has shown interest in gathering the technology teachers for a discussion about the subject based on the new text book and the other two books[8] that can be used for the technology subject. This underlines that it is been possible to develop a coordinated language for the technology subject on HTX, and through this development create a change in the teaching of the technology subject and in the organisation.
In addition, however, it is important to add to this conclusion that, as also mentioned in Chapter 3, there are some teachers who have chosen not to be participating in. In relation to this, it seems central to reflect on what voices it is I am bringing forward in this thesis as this may also help to nuance the conclusion further. I have not actively

[7] *Common direction* must be understood as the teachers, with the help of the coordinated language, are now able discuss their subject with each other and the students and thereby gain a greater insight into each other's understandings of the subject and with that insight be able to figure out how to work in the technology subject in the future.

[8] Larsen, P. (2017). *Problems and technology* and Frandsen et al. (2014). *Technology – A handbook*

chosen which classes I could observe in. I applied the snowball effect and let my initial research through the pilot study do the work. This means that the teachers who from the very beginning chose to be participants in the research project, began to talk to other teachers about their participation and thus became confident by also participating themselves. They found that it was not ‘dangerous’ to participate. Participation from the teachers in relation to opening the doors to their classrooms has therefore taken place at their own request. And even though in relation to the Action Research approach, it is considered to be a validation of the process, it still seems relevant to question whether it is the already very committed teachers and those who agree that there is a lack of consensus between the teachers about the technology subject who have chosen to participate. If that is the case it would mean that the teacher perspective presented in the thesis and the voices I bring forward represent a delimited image. The majority of the active technology teachers in the period when the research project ran were participants (15 out of 18 possible) and therefore it can be argued that the perspective presented in the thesis is broad in terms of the technology teachers on HTX in Aalborg. Even so, it is still important to keep in mind the marginal voices. In this case, the rest of the teachers that did not want to or did not come forward to participate. There might be something that has not being said as some of the teacher’s voices has not been heard. However, it must be kept in mind, but reference to the high number of teachers who have been participants in the studies prepared for this thesis that no matter what research study it is, it cannot be expected that all the possible participants choose to participate.

With the above conclusion, I have answered the problem statement on which the thesis has been based but what is set forth in this above conclusion does not contain everything that can be concluded in this thesis. Therefore, conclusions follow on each of the four key concepts: Technology, PBL, Bildung and Language.

Technology

In relation to the concept of technology and the way the concept is conceptualised based on the Technology model in the technology subject it can be concluded that the Technology Model works according its purpose. Through the study it became clear that the students use the Technology Model to analyse the technologies they develop in their projects just as described in the Ministerial order. It though can also be argued that the technology teachers should be aware of the model's shortcomings which can be attributed to the fact that the model is very static and thus discuss these with the students so that they gain a more dynamic and dialectical understanding of technology.

PBL

Furthermore, the role of technology teachers is also examined when they teach the technology subject on HTX and also how this role is expressed in a practice where the use of PBL is recognized as an important teaching pedagogy. Here it was found that the teachers have a lot of different tasks that they have to handle daily when they teach the technology subject. It places teachers in a role where they need a wide range of hybrid skills in the form of both technical and non-technical skills. Furthermore, in this part of the study, it was found that the teachers' role and tasks continuously change from a more teacher-led approach to a more student-centred facilitator role as the students develop their competencies. Based on this, it is concluded that there is a need for management support for the teachers in their work with the technology subject if they are to work with this hybrid role. With recognition and a detailed knowledge of the teachers' hybrid role in the subject, it will be possible to identify some directions for future development of the technology subject.

Bildung

The concept of a general character of formation - Bildung - is further investigated, including how students on HTX Bildung during their studies. Based on the study, it can be seen that the third-year students are able to reflect on their own learning in a way that the first-year students are not able to. The third-year students prove to be able to reflect on their own learning, change their worldview, expand their vocabulary, apply new learning tools and acquiring new words and concepts. They were further able to reflect on problem-based learning and group work and clearly showed that they have acquired the study competencies mentioned in the Ministerial Order. Therefore, on the basis of this part of the study, it was concluded that it is actually possible for the students to acquire the Bildung and study competencies described in the Ministerial Order, through their study time on HTX.

Language games

In this study, work continues on the lack of consensus that was expressed in the first study. This lack of consensus underlines the need for the development of a coordinated language or conceptual device. Based on the development of a coordinated language for the technology subject, it is concluded that the development of a coordinated language in the form of a new textbook for the subject has had a significant influence on the teaching where the book is used. At a local level, it can be seen from the study that the technology teachers, especially on HTX in Aalborg, have begun working on making the use of the developed coordinated language a routine through the new book. Furthermore, it can be seen that the new text book is also used for the basic course in Product Development (PU) which serves as an introduction to the technology subject for the first-year students as well as it is also to some extent used for the Technical subjects. At a national level, it is further seen that the subject consultant in the subject of technology before society was shut down by the corona, planned that the new text book, together with the existing books for the technology subject, should be discussed against each other in order to get closer to having a common direction in the subject. In conclusion, it can therefore also be concluded from the study that it has been possible to develop a coordinated language for the technology subject on HTX, and through this development create a change in the teaching of the technology subject.

However, the conclusions on both the problem statement and on the key concepts can also be related to the following areas; The technology teachers, STEM, Organizational change and Methodological innovation in a form of extended conclusion to emphasize a broader perspective the conclusions in the thesis can also contribute to.

The technology teachers

As concluded above, it is possible to develop a coordinated language for the technology subject and thus also initiate a change in how the teachers work in the technology subject but such initiated change must be maintained if it is to remain lasting. Here it would be a recommendation that, the technology teachers and what used to be called the Technology Teachers 'Association, but during writing the thesis has become the Technology - and Technical Science subjects Teachers' Association, have a very central role. If they are to succeed in driving the change that has been initiated, both the teachers and the association must be instrumental in creating a forum for conversation and dialogue where the technology teachers can discuss their subjects. If they can create such a free discussion forum, they can also continue the work with the new coordinated language and ensure a development in the technology subject and a strengthening of the subject tradition.

STEM

It has long been discussed how we can ensure that in the future more people are trained with the coveted STEM competencies so that Denmark can take the lead in a green transition. We can already see now that we will be short of talented young people with STEM competencies who want to be able to create, develop and produce the products and (digital) solutions needed to ensure this green transition. Over the years, many initiatives have been initiated to get the very young to choose a vocational education after finishing primary school, but we have seen the results of that work yet. It is therefore proposed by the Association Danish Industry and Danish Metalworkers union that we must re-think details in the educational system and show the students a clear path from upper secondary school and into vocational education, the practice-oriented higher education and the labour markets (Association of Danish Industry, 2020). This way of thinking is already an integrated part of the way HTX education was originally thought and the education therefore also speaks very naturally into the discourse that DI, but also the Danish Government expresses when they speak of a need for more students to acquire STEM competencies, because the students with STEM competencies are in demand in both higher education and in the labour market. The students studying on HTX are therefore also central in relation to achieving the Danish Government's and the Technology Pact's goal that 20% more students must have completed a higher STEM education by 2028. This is because many of the students from HTX study further in continuation of the profile subjects; Technology and Technical Science in the direction of some form of higher STEM education. This is underlined by figures from the coordinated registration (KOT) (2017). Further, this tendency can also be seen in a, for the students, top six of popular education choices after completing an HTX education: 1) Diploma Engineer 2) Master of Science in Engineering 3) Medicine 4) Computer scientist (Datamatiker) 5) Computer scientist (Datalog) and 6) Mechanical engineer (professional bachelor). And if this was not enough to underline the importance of the HTX education it is also not without relevance that it is the students from HTX who start a higher education the fastest after finishing high school (Danish Business Schools and - Colleges, 2017).

It is therefore also very relevant to research HTX - both in the students, in the teachers' practice, in the subjects and certainly also in many other perspectives on the education because such research can help us to understand how we can get even more young people to study an HTX education, subsequently choose a higher STEM education and thus obtain the STEM competencies that are so coveted in the labour market.

This also underlines the relevance of the research conducted in connection with this thesis. A study on how it is possible to strengthen the subject tradition in the technology subject on HTX, because a stronger disciplinary tradition in the technology subject can contribute to the before mentioned goal.

Methodological innovation

Methodological innovation is by Xenitidou and Gilbert (2009) defined as new research practice that is outside what is mainstream in which emphasis is placed on a transfer of concepts and practices across both disciplines and contexts (Xenitidou and Gilbert, 2009:107). On the basis of this definition, it is therefore also argued here that the methodological approach in this thesis can be described as methodological innovation.

The thesis is based on working with how it is possible to strengthen the disciplinary tradition in the technology subject in HTX and through that work it has become very clear how central language is in relation to being able to drive a successful Action Research process. Action research is most often used in the social sciences and humanities, where this thesis is also placed. The theory brought into play in the thesis about language is commonly applied within accounting and economics[9] but can be used in all research areas where the research relates to language and change in organizations and is combined with PBL which is a pedagogical teaching approach that is used across many areas including Engineering and social science. Something similar is the case in the use of methods in the thesis. Here are brought both classic methods such as; observation and interview in use together with the 'conceptualizing method' which, like the theory of language, is often used in accounting and economics. Both the application of theory and methods in the thesis is therefore an exchange of concepts and practices that crosses disciplinary boundaries which therefore can be describes as innovative methodological innovation.

[9] Nørreklit et al. (2016). Qualitative research in accounting and management and Falconer and Nørreklit (2019). How to take action for successful performance management: a pragmatic constructivist approach

CHAPTER 9. QUALITY CONSIDERATIONS

In the following section, validity will be discussed in relation to the thesis with an interest in assessing the quality of the method used, as well as the results. It must be emphasized that validity in this section is not seen as in a traditional positivist sense, but must be understood as a concept that relates to qualitative research.

9.1. VALIDITY

With a focus on the validity of the research carried out in this thesis, the following subsections deal with whether I researched on the area that I had actually set out to investigate. In the following, the argumentation for the validity of the thesis is unfolded on the basis of; Action research, interviews and surveys.

9.1.1. ACTION RESEARCH PROCESS

In relation to action research, what we say we are investigating is a change-oriented research question. The methodological approach then becomes a representation of how I actually investigate the change-oriented research question and in that way the methodology helps to emphasize if I am actually investigating what I set out to investigate (Duus, 2014:116). The intended goal of change from both the researcher and the participant and their joint influence on the field has a very crucial significance in this regard. To that, Hans Skjervheim argues that we as humans and therefore also as researchers cannot choose to be engaged: 'Because we are in the world, we are already engaged in one thing or another. Commitment is a basic structure in human life' (Skjervheim, 1971:21; Duus, 2014:117). In principle, we cannot choose an observational position to the world. As described in the quote, it is not possible because engagement is a fundamental condition of human life. The only thing we can chose is how to participate (Duus, 2014:117). This can be related both to the action research process but also to the choice of one of the primary methods used in this thesis; observation. As a researcher, I have therefore also been a participant throughout the action research process and with my participation I have also had an influence on the technology teacher's lifeworld I sought to gain insight into. Within some paradigms this will be seen as negative, among other paradigms the positivistic where the ideal is to be as objective as possible but in an action research process where participatory observation is used as a method, it is the subjective approach that creates the space that gives access to the lifeworld. Skjervheim add to this when referring to Kierkegaard when he argues that we as humans cannot stand outside of time either: 'However, our situation in the world is precisely that we are not impartial and timeless spectators, but time-bound and finite participants in history' (Skjervheim 1971, 34-35). In this understanding, we are all as human beings bound by time, which has the

implication that nothing is in a certain way as it is in constant change and that we are all participants and therefore also basically subjective (Duus, 2014:118). In addition, Skjervheim believes that we as researchers should not strive for neutrality or independence. If the researcher strives for neutrality or independence in e.g. an interview situation, the researcher creates a 'frozen' (Duus, 2014:118). Instead, it is therefore more about *how* the researcher participates as discussed above.
In the above, some basic considerations have been made in relation to validity and the action research process. Further considerations regarding validity can be made based on a model containing five questions, prepared by Reason & Bradbury, 2001. The model should not be seen as fixed but rather as a framework from which it is possible to gain an understanding of which areas can further be considered in validity in the action research process (Duus, 2014:121). The five questions are:

- *The significance* the project has had and has in relation to *human well-being*.
- *The relational practice* related to *participation and democracy*.
- *Results for practice* in relation to *solving practical questions / problems.*
- *Several types of knowledge forms*, especially in relation to whether *knowledge-in-action* has been developed.
- Emergens and sustained consequence, the project has had an *emergent evolving form* (Duus, 2014:121; Reason and Bradbury, 2001).

There is one of the above questions that make sense to unfold further as it has not been touched upon earlier in the thesis. The question relates to; *The importance the project has had and has in relation to human well-being*. By taking as a starting point working with the lack of consensus between the teachers on how to work in the technology subject, part of the interest in the project has been to get the teachers to start discussing their subjects and thus work better together and thus both teachers' students and not to mention the technology subject should be strengthened. It is difficult to say with certainty that the work in connection with this thesis is a direct reason for an increased well-being of the teachers, especially as conceptualising the concept of well-being can be quite complex. However, if the International Labour organisations (ILO) conceptualisation of workplace well-being is taken as a starting point, it is possible to get a little closer to where and how the work done in this thesis actually affects teachers' well-being on HTX. The conceptualization reads as follows: 'Workplace Wellbeing relates to all aspects of working life, from the quality and safety of the physical environment, to how workers feel about their work, their working environment, the climate at work and work organization' (International Labour Organisation). Based on this conceptualisation, it can be argued that the development of a coordinated language for the technology subject that enables the teachers to discuss can have an impact on: 'how workers feel about their work, their working environment, the climate at work and work organization' in the long term. This as understanding your fellow teacher colleagues and being able to work closely with them can increase the teacher's well-being.

9.1.2. THE CONCEPTUALISING METHOD

In the following, the validity of the concept in relation to 'the conceptualising method' is unfolded. This is done to make it clear that the criteria for validity in the conceptualizing method are different from conventional theories and methods. The validity of the conceptualizing method and is by Henriksen et al., 2004 conceptualized as:

> ‘The theory of reality and the conceptualising method is not de-constructive, nor destructive. On the contrary it is explicitly constructive, as it’s aims to facilitate changes in real life organisations for the benefit of the actors involved. Achieving such changes represent the validity of the conceptualising method’ (Henriksen et al., 2004).

Validity is achieved through the relationship between researcher and participant. In this thesis, the validity is therefore also achieved through a joint development of a co-ordinated language. A development that, I as a researcher and the technology teachers have created together and which has enabled the teachers to discuss their subject with each other and with the students. Through this development of a coordinated language for the technology subject were also enabled to create change in the technology subject and in the HTX organisation. The fact that it has been possible to facilitate and create this change in the technology subject validates the research process (Henriksen et al., 2004:177).
The validity of the reporting of the dissertation in the form of both an article collection and a textbook for the technology subject depends on whether one is able to present the development of the conceptualisation process through a thorough reporting. Therefore, in the preparation of the collection of articles and the unifying framework for it, I have sought to keep the process of developing a common language for the technology subject completely open. The idea behind it has been to provide a deep insight into the whole process and clarify how the coordinated language is conceptualized. In this way, the process also becomes clear to the reader and it becomes possible for them to assess the validity of the work.

9.1.3. INTERVIEWS

In relation to the validity of the interviews with both teachers and students, it is a matter of whether I investigate the right thing. Two questions are central here: Does the linguistic statements I have collected actually say something about what I am investigating and are the interpretation I make of the linguistic statements true to what is meant by these statements? (Ingemann et al., 2019:217).

When getting a deeper insight into how the teachers work in the technology subject, the teachers selected are teachers who teach the subject and thus have experience they can draw on during the interviews. In relation to the students, it was interesting to get a deeper insight into the Bildung the students attain by studying on HTX. Here, I in reality could have chosen any of student attending HTX to take part in these interviews as they were about getting the students' assessment of what they learned during their study on HTX. In practice, however, I considered it important to have students from both first, second and third year of study to see if it was possible to ‘see’ how Bildung is attained year by year. Based on all of the above reflections, I would thereby asses that for this part of the research it has been possible to select interviewees who have been able to contribute with knowledge that was valuable for the study as can also be seen in both the thesis and in the empirical data collected.

If I reflect on the interview guide used for the interviews conducted then the question is whether these are constructed so that I actually ask questions that gives me insight into what I wanted to investigate (Ingemann et al., 2019:217). In relation to the interview guide used for the interviews with the teachers in the technology subject (Appendix C), the questions listed as an introduction in the framework of the interview are not questions that are directly linked with what I would like to investigate. Instead, it is the questions that gets the conversation going in a calm and natural way. Where the interviewees and I can get to know each other and where the interviewees can get a better understanding of me as an interviewer which requires interviewees to want and feel that they can speak freely and open up to experiences and feelings (Kvale, 1997:132). Questions like: Can you tell me about how you work in the technology subject? or what do you see as the strengths of the technology subject? which are questions that are included in what is defined as ‘the core’ of the interview guide are questions that deal with and ask about exactly what I want to investigate: the technology subject.

Reflecting upon whether or not the interview guide for the interviews with the students (Appendix D) also have been constructed so that the questions asked gives me an insight into what I want to investigate the answer is not quite as clear as for the interview guide for the teachers. This is because this interview guide only asks the students one very open question: What have you learned during your three years of study on HTX? which gives the students the opportunity to talk openly about the topic. So even though the question directly asks what I as a researcher would like to investigate there is only one question which diminishes my opportunity as a researcher to ensure that the interview stays on the topic. However, some follow-up questions were asked during the interviews to ensure this. At the same time, this way of conducting the interview allowed me to be clearer on the topic and discover something new from the students I wasn't even aware of from the start.

In the interview situations with both the teachers and the students, I would further argue that it has been possible for the interviewees to have a conversation with me about what I am interested in investigating. This is assessed both on the basis that all the interviewees in the interview situation seemed interested in sharing their story and on the basis of the length of the interviews conducted. The interviews with the teachers vary in length between 30 minutes and 75 minutes. The interviews were initially estimated to last 40-45 minutes. All interviewees can thus be said to have had something to say and some of them really had a lot they wanted to share. The interviews with the students also vary in length between 12 minutes to 22 minutes and were initially estimates to last around 20 minutes. One interview with a student only lasted 12 minutes which is far less that the rest of the interviews which was due to the fact that the student was quite nervous in the beginning and therefor talked very fast. The interview was therefore conducted quicker than the rest.

9.1.4. SURVEY

Validity in relation to the more quantitative research methods is about whether I actually measure what I intended to measure. In the thesis I have made use of survey as a method. This has been done to a very limited extent and to get an indication of which concepts the technology teachers think are central to the technology subject. It therefore also does not make sense to hold this limited use of the survey method for the collection of data up against the requirements of the validity that a quantitative study is generally to live up to. However, this does not mean that critical reflection on the method haven't been relevant and these can be seen in Chapter 3.

LITERATURE LIST

Altinget (2018) Retrieved June 25th, 2019, from www.altinget.dk

Aspy, D.N., Aspy, C.B., & Quinby, P.M. (1993). What doctors can teach teachers about problem-based learning. *Educational Leadership, 50*(7), pp. 22-24.

Association of Danish Industry (2020). Jensen & Graugaard: Gymnasiet skal vise flere vej til tekniske uddannelser til erhvervslivet. [Jensen & Graugaard: The high school must show more paths to technical educations for business]. https://www.danskindustri.dk/di-business/arkiv/nyheder/2020/9/jensen--graugaard-gymnasiet-skal-vise-vejen-til-tekniske-uddannelser/ (accessed 5 February 2021).

Asunda, P.A & Quintana, J. (2018) Positioning the T and E in STEM: A STL analytical content review of engineering and technology education research. *Journal of Technology Education,* Vol. 30(1), pp. 2-29.

Bailey K.M. (2001). Observation. In *The Cambridge guide to teaching English to speakers of other languages*, (Ed.) Carter, R. and Nunan, D., pp. 114-119. Cambridge: Cambridge University Press.

Bakhtin, M.M. (1984). *Problems of Dostoevsky's poetics*, In C. Emerson (Ed. & Trans.). Minneapolis University of Minnesota Press.

Bakhtin, M.M. (1986). *Speech genres and other late essays*, In V. E. McGee (Trans.). Austin: University of Texas Press.

Barrows, H.S. (1986). A Taxonomy of problem-based learning methods. *Medical Education, 20*(6), pp. 481-6. doi: 10.1111/j.1365-2923. 986.tb01386.x

Barrows, H.S. (1994). Practice-based Learning: Problem-based Learning Applied to Medical Education. Springfield, IL: Southern Illinois University School of Medicine.

Barrows, H.S. (1996). Problem-based learning in medicine and beyond: a brief overview. In *Bringing Problem-based Learning to Higher Education: Theory and Practice* (Eds., L. Wilkerson and W. H. Gijselaers, pp. 3-12) San Francisco, CA., Jossey-Bass. doi:10.1002/tl.37219966804

Barrows, H.S. & Tamblyn, R.M. (1980). *Problem-based Learning - An Approach to Medical Education*. New York, Springer.

Billund, L. & Alrø, H. (2017). 'Aktionsforskerens sårbarhed' [The vulnerability of the action researcher] In Alrø, H. & Hansen, F.T. (Eds.) *Dialogisk aktionsforskning i et praksisnært perspektiv* [Dialogical action research in a practical perspective]. Aalborg Universitetsforlag: Aalborg Øst.

Boud, D. (Eds.) (1985). *Problem-based Learning in Education for the professions*. Sydney: Higher Education Research and development of Australasia.

Brookfield, S.D. (Ed.) (1985). *Self-Directed Learning: From Theory to Practice*, Jossey-Bass, San Francisco.

Brookfield, S.D. (1986) *Understanding and Facilitating Adult Learning*, Open University Press, Buckingham.

Bryman, A. (2016). *Social Research Methods*. 5th edition. Oxford. Oxford University Press.

Bunge, Mario (1966). Technology and Applied Science. Technology and Culture 6. 329–347.

Code, L. (2002). *Feminist interpretations of Hans-Georg Gadamer*. Penn State University Press.

Cooley, Mike (1980). Architect or bee?: the human/technology relationship. Langley Technical Services.

Cunliffe, A.L & Scaratti, G. (2017). Embedding Impact in Engaged Research: Developing Socially Useful Knowledge through Dialogical sensemaking. *British Journal of management, Vol. 28,* pp. 29-44.

Danish Business Schools and - Colleges (2017). *Profilfag i gymnasiet afgør unges karrierevalg*. [Profile subjects in high school determine young people's career choices]. https://deg.dk/aktuelt/nyhedsbreve-de/profilfag-i-gymnasiet-afgoer-unges-uddannelse-og-karriere/profilfag-afgoer-unges-valg/ (accessed 29 January 2021).

Davies, J., de Graff, E., & Kolmos, A. (Eds.) (2011). *PBL across the disciplines: Research into best practice*. Aalborg: Aalborg Universitetsforlag.

de Vries, M.J., Gumaelius, L. and Skogh, I. (2016). Pre- university Engineering Education: An introduction. In M. J. de Vries, L. Gumaelius & I. B. Skogh (Eds.). *Pre-university Engineering Education*. Sense Publishers: Rotterdam.

Duus, G. (2014). ‘Indledning’ [Introduction] In Duus, G., Husted, M., Kildedal, K., Laursen, E. & Tofteng, D. (Eds.) *Aktionsforskning—En grundbog* [Action research—A basic book], 1st edition. Samfundslitteratur.

Edquist, Charles (1977). Teknik, samhälle och energi. [Technique, Society and Energy]. Lund.

Elmeskov, Dorte C. (2015) *Evaluering af bioteknologi A som forsøgsfag i stx og htx* [Evaluation of biotechnology A as an experimental subject in stx and htx] MONA Forskningsrapportserie for matematik- og naturfagsdidaktik nr. 1

Engeström, Y. (1994). *Training for change: New approach to instruction and learning in working life*. Geneva, ILO.

EVA (2018). Den faglige udvikling i gymnasiet—En undersøgelse af udviklingen i dansk, engelsk, matematik og fysik i perioden 1967–2017 belyst gennem læreplaner og eksamenssæt. [The disciplinary development in upper secondary school—A study of the development in Danish, English, mathematics and physics in the period 1967–2017 highlighted through curricula and examination sets]. Danmarks Evalueringsinstitut. [Denmark's Evaluation Institute].

Frandsen, K., Funch, S. & Heide, S. (2017). *Teknologi- En håndbog for HTX.* [Technology- A handbook]. 3. udg., 1. oplag. Praxis – Nyt Teknisk Forlag. Odense SØ.

Freeman, S., Eddy, S.L., McDonough, M., Smith, M.K., Okoroafor, N., Jordt, H. and Wenderroth, M.P. (2016). Active learning increases student performance in science, engineering and mathematics. *Proceedings of the National Academy of sciences of the United States of America*, Vol. 111, No.23, pp.8410–8415.

Gadamer, H. G. (1962/1992). *Truth and Method*. Crossroads.

Garfinkel, H. (2020*). Ethnomethodology's program: Working out Durkheim's aphorism*, In Rawls, A. W. (Ed.). New York & Oxford: Rowman & Littlefield Publishers.

Gil-Pérez, D., Vilches, A., Cachapuz, A., Praia, J., Valdés, P. & Salinas, J. (2005). Technology as 'Applied Science': A Serious Misconception that Reinforces Distorted and Impoverished Views of Science. Science & Education 14, 309–320.

Graaff, E. and Kolmos, A. 2007. History of problem-based and project-based learning. In Graaff, E. and Kolmos, A. (Eds.) Management of change - Implementation of problem-based and project-based learning in engineering. Netherlands: Sense Publishers.

Grant, J., Nelson, G. & Mitchell, T. (2013). 'Negotiating the challenges of participatory Action Research: Relationships, Power, Participation, Change and Credibility'. In P. Reason & H. Bradbury (Eds.) *The SAGE Handbook of Action Research—participative inquiry and practice*. pp. 589. SAGE Publications.

Greenwood, D. J. & Levin, M. (2007). *Introduction to action research—Social research for social change*. 2nd edition. SAGE Publications, Inc.: California.

Guerra, A et al (Eds.) 2017. PBL in Engineering Education. Netherlands: Sense Publishers.

Guerra, A & Kolmos A. 2011. PBL across the disciplines: Research into best practice. Aalborg: Aalborg Universitetsforlag, 3-16.
Hansen, E. J. & Andersen, B. H. (2009). *Et sociologisk værktøj—Introduktion til den kvantitative metode* [A Sociological Tool—Introduction to the Quantitative Method] 2nd edition. Copenhagen: Hans Reitzels Forlag.

Harrits, G.S., Pedersen, C.S. & Halkier, B. (2012). 'Indsamling af interviewdata' [Collection of interview data] In Andersen, L.B, Hansen, K.M. & Klemmesen, R. (Eds.), *Metoder I statskundskab* [Methods in Political Science]. Copenhagen: Hans Reitzels Forlag, pp. 144–172.

Heidegger, M. (1954/1977). *The Question concerning Technology*. Harper & Row.

Henriksen, L.B., O'Donnell, D., Christensen, J.B., Jørgensen, K.M, & Nørreklit, L. (2004). *Dimensions of change—Conceptualising reality in organizational research*. Copenhagen Business School Press.

Henriksen, L.B. (2006). Engineers and Bildung. In Jens Christensen, Lars Bo Henriksen, Anette Kolmos, eds. Engineering Science, Skills, and Bildung. Aalborg University Press.

Henriksen, L.B. (2010). On the Engineering Profession, Reflexivity and Modernity. ScMOI, Virginia.

Henriksen, L.B. & O'Donnell, D. (2013). What did you learn in the real world today: The case of practicum in university. Aalborg University Press.

Henriksen, L.B. & Askehave, J. (2013). 'Engineering students in the real world - on-campus PBL'. In Henriksen, L.B. & O'Donnell, D. (Eds.) *What did you learn in the real world today: The case of practicum in university*. Aalborg University Press.

Henriksen, L.B. (2014) *Studiekompetencer I de erhvervsgymnasiale uddannelser – en undersøgelse af studiekompetencer i HHX og HTX-uddannelserne, med særlig henblik på uddannelsernes profilfag.* [Study competences in the vocational secondary education - a study of study competencies in the HHX and HTX programs, with a special focus on the profile subjects of the programs]. For the Ministry of Children and Education 2014.

Henriksen, L.B. (2016a). 'Are they ready?: The Technical High School as a Preparation for Engineering Studies'. In M. J. de Vries, L. Gumaelius & I. B. Skogh (Eds.). *Pre-university Engineering Education*. Sense Publishers: Rotterdam.

Henriksen, L.B. (2016b). 'Change, concepts and the conceptualising method'. *Proceedings of pragmatic constructivism, Vol. 6* No.2, pp.29–33.

Henriksen, L. B. (2018). 'Language Games, Dialogue and the Other'. Paper presented at the 17th European conference on research methodology for business and management studies. 12–13 July, 2018, Rome, Italy.

Hermansen, M. (2019). 'Videnskabsteori og aktionsforskning' [Science theory and action research] In Sunesen, M.S.K. (Eds.) et al., *Aktionsforskning—Indefra og udefra* [Action research—Inside and out]. Dafolo A/S: Frederikshavn.

Holgaard, J.E., Ryberg, T., Stegeager, N., Stentoft, D. & Thomassen, A.O. (2016). *PBL – Problembaseret læring og projektarbejde ved de videregående uddannelser.* [PBL - Problem-based learning and project work in higher education]. Samfundslitteratur.

Holstein, J. A., & Gubrium, J. F. (2003). *Inside Interviewing.* London, United Kingdom: SAGE Publications, Inc.

Hung, W., Jonassen, D.H., & Liu, R. (2008). Problem-based learning. In J.M. Spector, J.G. van Merrienboer, M.D. Merril, & M. Driscoll (Eds.), *Handbook of research on educational communications and technology* (3rd ed.), pp. 485-506. New York, NY: Erlbaum.

Højrup, T. (2002). *Dannelsens dialektik* [The dialectics of Bildung]. Museum Tusculanum.

Ihde, Don (1990). *Technology and the Lifeworld*. From Garden to Earth. Indiana University Press.

Ingemann, J. H., Kjeldsen, L., Nørup, I. & Rasmussen, S. (2019). Kvalitative undersøgelser i praksis—viden om mennesker og samfund [Qualitative research in practice — knowledge of people and society] 1. udg., 2. oplag. Samfundslitteratur.

International Labour Organisation (2021). Workplace well-being: http://ilo.org/safework/areasofwork/workplace-health-promotion-and-well-being/WCMS_118396/lang--en/index.htm (accessed 9 February, 2021).

Jans, J. (2007). 'Et eksperiment i modvind' [An experiment in headwinds] In Kjærgård, P.M., Bendix, U., Johnsen, V. T. & Andersen P. S. (Eds.). *HTX 25 år med teknisk gymnasium—fra eksperiment til anerkendelse* [HTX 25 years with the technical high school—from experiment to recognition]. Erhvervsskolernes Forlag: Odense, pp. 10–23.

Jarvis, P. (1999). *The Practitioner Researcher*. Jossey-Bass, San Francisco, CA.

Jenkins & Pell (2006) Me and the environmental challenges: A survey of English secondary school students' attitudes towards the environment. *International journal of science education*, 28(7), pp. 765-780.

Jeppesen, M. M. (2020). 'Agree to disagree': Technology teachers' perceptions and practices of problem-based learning (PBL) in the Danish higher technical examination programme (HTX). (In progress).

Jeppesen, M. M. and Henriksen, L.B. (2021). Technology in the technology subject—The Danish Higher Technical Examination programme (HTX), the technology subject and the concept of technology. Learning Tech, Vol 10, pp. ??.

Jeppesen, M. M., Henriksen, L.B. and Routhe, H. W. (2020). Projektarbejdet—Teknologi og Teknikfag [The project work — Technology and Technical Science subject] Systime A/S: Århus.

Jones, A., Buntting, C. & de Vries, M.J. (2011) The developing field of technology education: a review to look forward. *International Journal of technology education,* Vol. 23, pp. 191-212. DOI: 10.1007/s10798-011-9174-4

Kjærgård, P. M., Bendix, U., Johnsen, V.T. & Andersen, P.S. (2007). *HTX 25 år med teknisk gymnasium – fra eksperiment til anerkendelse*. [HTX 25 years with the technical high school - from experiment to recognition]. Erhvervsskolernes Forlag, Odense SØ.

Kjærsdam, F. & Enemark, S. (1994). The Aalborg Experiment Project Innovation in University Education. Aalborg: Aalborg Universitetsforlag.

Knudsen, Herman (Ed.) (1983). Teknik—hverdagsliv. Forskningsresultater og forskningsbehov. [Technique—everyday life. Research results and research needs]. Aalborg University Press.

Kolmos, A., Holgaard, J. E., Clausen, N. R., & Bylov, S. M. (2017). 'Transition from high schools to engineering education'. In Proceedings of the 45th SEFI Annual Conference 2017: Education Excellence for Sustainability. European Society for Engineering Education SEFI, Vol. 45, pp. 998.

Kolmos, A., Graaff, E. and Du, X.Y. (Eds.) 2009. Research on PBL practice in engineering education. Rotterdam: Sense publisher, 9-21.

Kolmos, A. Xiangyun, D., Holgaard, J.E., & Jensen, L.P. 2008. *Facilitation in a PBL environment*. Aalborg University. UNESCO Chair in Problem Based Learning in Engineering Education.

Kolmos, A. 2017. PBL in Engineering Education. Netherlands: Sense publishers, 1-12.

Krogh, L. (2013). 'The Aalborg PBL model and employability'. In Henriksen, L.B. & O'Donnell, D. (Eds.) *What did you learn in the real world today: The case of practicum in university*. Aalborg University Press.

Kvale, S. (1997). Interview: en introduktion til det kvalitative forskningsinterview. [Interview: an introduction to the qualitative research interview]. Hans Reitzels Forlag.

Kvale, S. & Brinkmann, S. (2009). *Interview – Introduktion til et håndværk*. [Interview - Introduction to a craft]. Hans Reitzels Forlag A/S.

Kristeligt Dagblad (2012). Retrieved March 15th, 2019, from www.kristeligt-dagblad.dk

Krogstrup, H.K. & Kristiansen, S. 1999. *Deltagende observation – Introduktion til en forskningsmetodik*. [Participatory observation - Introduction to a research methodology]. København; Hans Reitzels Forlag A/S.

Larsen, P. (2017). *Problemer og teknologi*. [Problems and technology]. 3. udg., 1. oplag. Systime A/S: Århus.

Larsen, Peter (2020) *STEM på htx 25 år med teknologi og engineering i de gymnasiale uddannelser i Danmark*. MONA. Nr. 3.

Larsen, Verner (2013). Faglighed og problembaseret læring—Vidensstrukturer i professions-bacheloruddannelser. [Disciplinarity and problem-based learning—knowledge structures in profession-bachelor educations]. Aalborg University.

Latour, B. (1987). *Science in Action: How to Follow Scientists and Engineers Through Society*. Milton Keynes: Open University Press.

Laursen, E. (2019). 'Etik og aktionsforskning' [Ethics and action research] In Sunesen, M.S.K. (Eds.) *Aktionsforskning—Indefra og udefra* [Action research—Inside and out]. Dafolo A/S: Frederikshavn.

Lehmann, S. (2018). *Aktionsforskning skaber løsninger i praksis* [Action research creates solutions in practice]. Hans Reitzels Forlag: København.

Lorentzen, A. (1988). Technological Capacity—a contribution to a comprehensive understanding of technology and development in an international perspective. Aalborg University Press.

Lorentzen, A. (1994). Teknologi og udvikling i den nordjyske maskinindustri. [Technology and development in the Northern Jutland machine industry]. Aalborg University Press.

Lyotard, J. (1979). *The Postmodern Condition: A Report on knowledge*. Manchester University Press: Manchester.

McNiff, J. & Whitehead, J. (2006). All you need to know about action research. Sage Publications, Inc.: California.

McNiff, J., Lomax, P. & Whitehead, J. (2003). *You and your research project*. 2nd edition. Routhledge Falmer: Abingdon.

Microsoft (2016). *Why Europe's girls aren't studying STEM. Region-wide research of 11.500 women reveals how we can get more young women into science, technology, engineering, and math.* https://news.microsoft.com/uploads/2017/03/ms_stem_whitepaper.pdf (accessed 7 October 2021).

Ministry of Children and Education (2008) High School education in Denmark: HTX https://www.uvm.dk/-/media/filer/uvm/udd/gym/pdf08/fakta/080201-faktaark-HTX.pdf (accessed 16 December 2019).

Ministry of Children and Education (2013) *Evaluering af forsøg med bioteknologi A - delrapport med udgangspunkt i statistisk materiale.*

Ministry of Children and Education (2015). The Ministerial Order: HTX https://www.uvm.dk/gymnasiale-uddannelser/love-og-regler/love-og-bekendtgoerelser (accessed 16 December 2019).

Ministry of Children and Education (2017). Curriculum, Technology subject A and B https://www.uvm.dk/gymnasiale-uddannelser/fag-og-laereplaner/laereplaner-2017/HTX-laereplaner-2017 (accessed 20 March, 2020).

Ministry of Children and Education (2020). High school education: HTX https://www.uvm.dk/gymnasiale-uddannelser/uddannelser/hoejere-teknisk-eksamen-HTX (accessed 31 January, 2020).

Molly-Søholm, T. & Storch, J. (2005). Teambaserede organisationer i praksis: Ledelse og udvikling af teams [Team-based organizations in practice: Leadership and team development]. Dansk Psykologisk Forlag.

Molina- Vasquez, R. (2021). Conceptual Understanding in the Construction of a Technology Concept: A Case Study with Colombian Students. Journal of Technology Education, Vol 32(2), pp. 21-37.

Moltke, H.V. & Graff, H. (2014). *Social kapital i organisationer. Ledelse, kommunikation og samarbejde*. [Social capital in organizations. Leadership, communication and collaboration]. Copenhagen: Dansk Psykologisk Forlag.

Møller, D.B. & Lund, B.M. (2017). HTX Grundforløb. [HTX Basic course]. 1. udg., 1. oplag. Systime A/S: Århus.

Müller, J. (Ed.) (1980). Liquidation or Consolidation of Indigenous Technology. Aalborg University Press.

Müller, J., Remmen, A. & Christensen, P. (1984/1986). Samfundets teknologi – Teknologiens samfund. [Society's technology – Technology's society]. Systime A/S: Herning.

Müller, J. (Ed.) (1990). Infrastruktur og samfundsudvikling. [Infrastructure and society development]. Aalborg University Press.

Neergaard, H. (2010). *Udvælgelse af cases til kvalitative undersøgelser* [Selection of cases for qualitative studies]. Frederiksberg: Samfundslitteratur.

Nepper Larsen, S. (2013). Dannelse—en samtidskritisk og idéhistorisk revitalisering. [Bildung—a contemporary critical and idea-historical revitalization]. Fjordager.

Nielsen, K. A., & Vogelius, P. (red.) (1996). *Aktionsforskning: medarbejderindflydelse på forskning og udvikling i arbejdsmiljøet* [Action research: employee influence on research and development in the work environment]. Arbejdsmiljøfondet.

Nielsen, Allan T. (2007) *HTX: 25 år med teknisk gymnasium - fra eksperiment til anerkendelse* [HTX: 25 years with the technical high school - from experiment to recognition]. *Erhvervsskolernes Forlag*.

Nielsen, H. (2014). 'Borgerdeltagelse' [Citizen participation]. In Duus, G., Husted, M., Kildedal, K., Laursen, E. & Tofteng, D. (Eds.) *Aktionsforskning—En grundbog* [Action research—A basic book], 1st edition. Samfundslitteratur.

Nielsen, K.Aa. & Nielsen, B.S. (2007). Demokrati og naturbeskyttelse. Dannelse af borgerfællesskaber gennem social læring – med Møn som eksempel. [Democracy and nature conservation. Formation of citizens' communities through social learning - with Møn as an example]. København:Frydenlund.

Nørreklit, L. (1973). Concepts: their nature and significance for metaphysics and epistemology. Odense University studies in philosophy. (2).

Nørreklit, L. (1978). *Problemorienteret forskningspraksis og den reale virkeligheds constitution*. [Problem-oriented research practice and the constitution of the real reality]. Aalborg University Press: Aalborg.

Nørreklit, L. (1986). Dialogen som undersøgelsesteknik. In Nørreklit, L. (Ed.). *Virksomhedsanalyse* [Company analysis]. Poseidon: Aarhus, pp. 97–128.
Nørreklit, L. (1986). *Problemorienteret forskningspraksis*. Aalborg University Press

Nørreklit, L. (2004). ***Hvad er virkelighed?*** [What is reality?] In *Vidensgrundlag for handling* [*Knowledge base for action*] edited by J. Christensen.

Nørreklit, L. (2020). A Pragmatic Constructivist Perspective on Language Games. *Proceedings of pragmatic constructivism* (10), 11-28.

O'Leary, M. (2020). *Classroom Observation – A guide to the effective observation of teaching and learning*. Routledge: New York.

Olsson, F. A. (2007). 'En pioner blev uundværlig' [A pioneer became indispensable]. In Kjærgård, P.M., Bendix, U., Johnsen, V. T. & Andersen P. S. (Eds.). *HTX 25 år med teknisk gymnasium—fra eksperiment til anerkendelse* [HTX 25 years with the technical high school—from experiment to recognition]. Erhvervsskolernes Forlag: Odense, pp. 6-7.

Polanyi, Michael (1958). *Personal Knowledge - Towards a Post-Critical Philosophy*, Chicago: The University of Chicago Press.

Putnam, A. R. (2001) *Problem-Based Teaching and Learning in Technology Education.* Paper presented at the Annual Conference of the Association for Career and Technical Education (75th, New Orleans, LA, December 13-16, 2001).

Ulriksen, Lars & Lind Holmegaard, Henriette (2007) *Rigtige piger går ikke på htx, men piger er glade for at gå der – et kvantitativt blik på køn, oplevelser og interesser*. MONA Nr. 2.

Ulriksen, L., Holmegaard, H. T., Simonsen, B., Johnsen, V. T., Eriksen, U. (2008). *Læringsmiljø og naturvidenskab på HTX—kvaliteter og udfordringer*. [Learning environment and science on HTX—qualities and challenges]. Erhvervsskolernes Forlag: Odense.

Ulriksen, L. & Holmegaard, H. T. (2008). Projektarbejde på HTX – erfaringer og udfordringer i projektvejledning. [Project work on HTX – experiences and challenges in project guidance]. ***MONA*** (2), 28-48.

Reason, P., & Bradbury, H. (2013). *The SAGE Handbook of Action Research—Participative inquiry and practice*. SAGE Publications: London.

Ritz, J.M. and Fan, S.C (2014). STEM and technology education: international state-of-the-art. *International journal of technology and design education*, Springer, 25:429-451. DOI: 10.1007/s10798-014-9290-z

Savin-Baden, M. & Howell, C. (2004). Foundations of Problem-based Learning. Open University Press.

Savin-Baden, M. 2007. Management of change. Implementation of problem-based and project-based learning in engineering. In Graaff, E. and Kolmos, A. (Eds.) Management of change - Implementation of problem-based and project-based learning in engineering. Netherlands: Sense Publishers, 9 - 29.

Schumann, K. (2017). 'Aktionsforskeren som forsker og facilitator i innovative samarbejdsprocesser' [The action researcher as a researcher and facilitator in innovative collaboration processes]. In Alrø, H. & Hansen, F.T. (Eds.) *Dialogisk aktionsforskning i et praksisnært perspektiv* [Dialogue action research in a practical perspective]. Aalborg Universitetsforlag: Aalborg Øst.

Shaw, George Bernard (1912/2003). Pygmalion. Penguin Classics.

Shotter, J. (2010). 'Situated dialogical action research: disclosing "beginnings" for innovative change in organizations', *Organisational research methods*, 13, pp. 268-285.

Skjervheim, H. (1957/1971). *Deltaker och Tilskodar* [Participants and spectators]. Oslo: Oslo Universitet.

Sunesen, M. S. K. (2019). 'Forord' [Preface] In Sunesen, M.S.K. (Eds.) et al. *Aktionsforskning—Indefra og udefra* [Action research—Inside and out]. Dafolo A/S: Frederikshavn.

The Right Livelihood Foundation (1981). Acceptance Speech – Mike Cooley. https://www.rightlivelihoodaward.org/speech/acceptance-speech-mike-cooley/ (accessed 13th February, 2021).

Tiller, T. (2000). *Forskende partnerskab—aktionsforskning og aktionslæring I skolen*. [Research partnership—action research and action learning in school]. Kroghs Forlag.

Tilstone, C. (1998). *Observing teaching and learning - Principles and practice*. London: David Fulton

Trist, E. & Bamforth, K. (1951). Some social and psychological consequences of the longwall method of coal-getting. *Human Relations, 4*, pp. 3-38. doi: 10.1177/001872675100400101

Ulriksen, L., Holmegaard, H.T., Simonsen, B., Johnsen, V.T. & Eriksen, U. (2008). Læringsmiljø og naturvidenskab på HTX – kvaliteter og udfordringer. [Learning environment and science in HTX – qualities and challenges] 1. Udg. Erhvervsskolernes Forlag. Odense.

Ulriksen, L. & Holmegaard, H.T. (2008). Projektarbejde på HTX – erfaringer og udfordringer i projektvejledning. [Project work in HTX – experiences and challenges in project guidance]. *MONA* (2), pp. 28-48.

Villesen, Kristian, (2010). Kandidater fra de små universiteter tjener mest. [Graduates from the small universities earn the most]. https://www.information.dk/indland/2010/06/kandidater-smaa-universiteter-tjener-mest (accessed 25 January, 2021).

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*, In Cole, M., Steiner, J. V., Scribner, S. & Souberman, E. (Eds.). Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1979). Consciousness as a problem in the psychology of behaviour. Soviet Psychology, *17*(4), pp. 3–35.

Vygotsky, L. S. (1986). *Thought and Language* (A. Kozulin, Trans.). Cambridge, MA: MIT Press.

Walton, H.J. & Mathews, M.B. (1989). Essentials of problem-based learning. *Medical Education, 23*(6), pp. 542-58.

Wittgenstein, L. (1953). *Philosophical investigations*. Oxford: Blackwell.

Wittgenstein, L. (1965). *The blue and the brown books*. New York: Harper Torch Books.

Xenitidou, M., & Gilbert, N. (2009). *Innovations in social science research methods*. National centre for research methods report. Retrived from http://eprints.ncrm.ac.uk/804/

Zeuner, L., Beck, S., Frederiksen, L. F., Paulsen, M. 2007. *Lærerroller i praksis* [Teacher roles in practice]. Syddansk Universitet. Institut for Filosofi, Pædagogik og Religionsstudier. Gymnasiepædagogik, Nr. 64.

APPENDICES

Appendix A Declaration of consent 220
Appendix B Letter to the students 221
Appendix C Interview guide – Teachers 222
Appendix D Interview guide – Students 223
Appendix E Internet-based survey 224
Appendix F Internet-based survey – Introduction 226
Appendix G First e-mail to the publisher 227
Appendix H First e-mail from publishers 228
Appendix I Confirmation e-mail from publishers 229
Appendix J First e-mail to technology teachers 230
Appendix K Usage statistics by schools 232

Appendix A. Declaration of consent

Declaration of consent

The purpose of this study is to examine what you as a teacher have experienced as the strengths and challenges of the technology subject.

- I am informed that it is voluntary to participate and that I can always withdraw my consent.
- I understand that I am given anonymity in the project, which means that the project does not include personal information.
- I give permission for the interview to be recorded and I am informed that the recordings will be deleted again after the project is completed.

I hereby give my consent to be interviewed and that I agree with the above.

Date__________________

Signature___________________________________

Appendix B. Letter to the students

Hi ’students name’,

I am now ready to conduct the interview I told you about 'place' and I hope you are still interested in participating.

The study I'm doing is about gaining knowledge of what students experience they learn during their study on HTX.
Therefore, when we meet I would also like you to tell me about what you have learned / where you have improved during your study on HTX. For example, you may feel that you have become better at a particular topic, that you have learned to collaborate, or that you have more specifically learned how to write a project, learned a certain formula or something completely different.

The interview will last for 30 minutes. and will take place on HTX (CAO or ØUV).

I have the following days and times available for interviews:
Tuesday May 15th.
12.00 – 12.30
12.30 – 13.00
13.00 – 13.30
13.30 – 14.00

Thursday May 17th.
11.30 – 12.00
12.00 – 12.30

Tuesday May 29th.
08.15 – 08.45

(If none of the days above are suitable, please write to me with a suggestion for another date for when it suits you better).

Please write me what day you have the opportunity to meet with me and whether it should be in CAO or at ØUV and I will confirm as soon as possible.

Best Regards
Mette Møller Jeppesen
Ph.d. student
Aalborg University

Appendix C. Interview guide – Teachers

The purpose of the study is to gain knowledge of what you as teachers see as the strengths of the technology subject and further what challenges you have identified in the subject.

The framework for the interview:

Introduction

1. How many years have you been teaching on HTX?

2. Where did you work before you started working here?

3. What subjects to you teach?

    - Have you taught other subjects during your time here?
    - What are the differences?

4. How many years have you been teaching the technology subject?

The core

5. Can you tell me how you work in the technology subject?

- - If possible, how do you start a new project period?
- What happens? How is it presented? Do you speak to the whole class? Etc.

6. What do you see as the strengths of the technology subject?

7. What challenges have you identified related to the subject?

- Suggest possible changes / improvements

8. If now you could decide for yourself (in the perfect world), is there anything you want to change about the technology subject?

Appendix D. Interview guide – Students

The purpose of the study is to gain knowledge of what you as students on HTX experience that you gain in terms of competencies during your studies.

The framework for the interview:
What I like is for you tell me what you've learned while studying on HTX.

If you can start your story from when you started studying on HTX in Aalborg and end it with the current situation today.

What do you feel you have learned?
Is there anything you've improved at after you started studying on HTX?

For example, you might feel that you have become better at a particular subject, that you have learned to collaborate or that you have more specifically learned how to write a project, use a certain formula etc.

It is essential to say that I am not seeking a specific answer and it is therefore important that you tell me about yourself and your experiences. In this context, there is no right or wrong answer.

Appendix E. Internet-based survey

Which of the following concepts and competencies should be included in the new textbook on project writing?

(14) ❑ Agile methods
(21) ❑ Association technique
(39) ❑ Work drawing
(5) ❑ Belbin
(22) ❑ Brainstorm
(24) ❑ Circle technique
(15) ❑ Documentation
(10) ❑ Self-insight
(8) ❑ External collaboration
(26) ❑ Elevator speech
(40) ❑ Packaging
(18) ❑ Field work
(27) ❑ Focus questions
(41) ❑ Business model
(42) ❑ Business plan
(43) ❑ Manufacturing process
(1) ❑ Group dynamics
(28) ❑ Idea generation
(29) ❑ Idea sorting
(30) ❑ Table of contents
(19) ❑ Interview
(16) ❑ Source indication
(2) ❑ Conflict management
(3) ❑ The conflict ladder
(44) ❑ Requirements
(17) ❑ Logbook
(25) ❑ The traffic light
(6) ❑ Learning styles
(7) ❑ Maslow's pyramid of need
(46) ❑ Material list
(45) ❑ MEKA
(11) ❑ Milestone
(47) ❑ Environmental assessment
(48) ❑ Model
(4) ❑ Motivation
(31) ❑ Target group
(32) ❑ Key problem
(23) ❑ Reverse brainstorm
(33) ❑ Problem description
(34) ❑ Problem statement
(35) ❑ Problem

(36) ❑ Problem tree
(49) ❑ Product
(50) ❑ Product part
(51) ❑ Product requirements
(52) ❑ Product solution
(53) ❑ Product specification
(54) ❑ Product strategy
(37) ❑ Project description
(12) ❑ Project management
(38) ❑ Project proposal
(57) ❑ Prototype
(58) ❑ Risk management
(59) ❑ Assembly method
(60) ❑ Assembly drawing
(61) ❑ Scorecard
(55) ❑ Service
(62) ❑ Scale model
(56) ❑ Sketch
(63) ❑ Exhibition model
(20) ❑ Survey
(64) ❑ Stage gate model
(67) ❑ SWOT-analysis
(65) ❑ Technology assessment
(66) ❑ Test model
(13) ❑ Time schedule
(9) ❑ Knowledge sharing

Are there any of concepts or competencies on the list that are central to include in the new textbook?
(1) ❑ Yes
(2) ❑ No

If yes, which ones?

______

Are there any concepts in the technology subject we need to conceptualise?
(1) ❑ Yes
(2) ❑ No

If yes, which ones?

______

Appendix F. Internet-based survey – Introduction letter

Hi,
My name is Mette Møller Jeppesen and I am employed at Aalborg University and working on a PhD project on HTX and more specifically on the Technology subject on HTX.

In my work on HTX in Aalborg, I have, by the teachers, been made aware of a need to gather knowledge about project writing in i.a. the technology field is based on the three core elements of the technology field: Project competencies, PBL and Integrated Product Development.

Therefore, together with a large number of teachers on HTX in Aalborg, Lars Bo Henriksen, Professor (AAU); Henrik W. Routhe, External Lecturer (AAU) and former Head of TECHCollege Aalborg, and Carsten F. Jørgensen, Head of Education on HTX in Aalborg, I have started a process around the development of a book that can be used for writing projects from the product development course in the first year of study and up to the third year of study. The book should function as a toolbox / reference work. Students must be able to use it as a basis for the development of their projects.
The idea with the book is to create a common language and a common set of concepts in relation to project work on HTX across the HTX-schools in Denmark.

It should be emphasized that it is NOT the idea to create uniformity in the subject, since a large part of the strength of the subject lies in the various disciplines and in what you as teachers each contribute to the subject. Instead, the intention is to create a common base for the academic knowledge students need to write projects in the technology field.

To start the work of the book, we would appreciate that you spend 5 minutes answering this questionnaire which can give us, as authors, an insight into which tools and competencies are central to include in the new book. We would really appreciate it if you fill in the questionnaire no matter if you have chosen to be part of the development of the new textbook for the technology subject or not.

(Info: If you answer no to the last two questions, you should in relation to the additional question: If yes, which ones? Type 0 to move on and exit)

Thank you in advance for your help.
Best regards
Mette Møller Jeppesen
PhD Student
Department of Planning, Aalborg University, Rendsburggade 14, 2. 9000 Aalborg
Telephone office: (+45) 93562398 Email: mmj@plan.aau.dk

Appendix G. First e-mail to the publisher

Hi Lene,
I am writing you as I have an idea for a book that I think may be interesting for you as a publisher and for HTX.

My name is Mette Møller Jeppesen. I am employed at Aalborg University where I am currently writing a PhD at Aalborg University about HTX.
In collaboration with the teachers on HTX, I seek to create a common language and conceptual framework around the technology subject on HTX. Furthermore, I also seek to conceptualize technology formation in an HTX perspective.

After several conversations with the teachers on HTX, I have been made aware that there is a need for a more comprehensive literature for the subject technology which can help to support the creation of a good and solid subject tradition around the subject, among other things through a common language and conceptual device.

I have therefore suggested to the chairman of the Technology Teachers' Association, Dorte Blicher Møller, that we write a book as a kind of reference work for the subject's methods. An idea she supports as it supports the development she and the teachers have sought to ensure for several years. She will therefore also act as co-author of the book.

The book will be based on the three basic elements of the technology subject; project competence, PBL and integrated product development.
The book is composed of material from teachers in the technology subject on HTX in large parts of the country, as it is the teachers who have the best insight into which methods are best used in the subject. In addition, it is intended that a further collaboration will be established with the subject consultant for the technology subject, Pernille Kaltoft, to set the course for the choice of methods in relation to the intention of the curriculum.

As HTX in Aalborg starts a new product development process for the new first year students in November 2018, we want to complete the book before then.

I am very interested to hear if this is a book you want to help develop and publish.

Sincerely
Mette Møller Jeppesen
PhD Student
Department of Planning, Aalborg University, Rendsburggade 14, 2. 9000 Aalborg
Telephone office: (+45) 93562398 Email: mmj@plan.aau.dk

Appendix H. First e-mail from the publisher

Hi Mette,
I am writing to you as a project manager at the publishing house Systime to hear if you could give me a little more information about your thoughts with a new book for the technology subject on HTX.
In general, please feel free to elaborate so that we can take a final position on the release. However, I have a few questions I hope you can answer:
Is the book intended for teachers or students?
If 'students: will it be a new basic book for the subject?
You write that a book should be ready by November 2018. It is generally a short deadline in the eyes of the publisher. In reality (due to the publisher's production processes), this will mean that the book's content should be ready approximately two months before. Is that realistic, do you think?

Best wishes
Klaus Marthinus
Project Manager

--
Systime A/S
Sonnesgade 11
DK-8000 Århus C
Tlf. (+45) 70 12 11 00
www.systime.dk

systime

Adresse | +45 7012 1100 | systime.dk

Appendix I. Confirmation email from the publisher

Hi Mette, Lars Bo, Henrik and Carsten

Systime would like to publish an upcoming textbook for Technology together with you based on pbl oa.

We would therefore like to invite you to a meeting at the publisher, where we will start the process together.

If you have the courage, you are welcome to talk together about a possible meeting date in the near future. I prefer whether it can be a Monday, Tuesday or Wednesday.

One of the initial considerations is whether we should invite technology teachers to the talk? Or whether we should wait until a more detailed plan is laid.

Another general consideration you may want to take is an assessment of whether the PBL angle and the project work can provide a return on other subjects in HTX and possibly other school forms than HTX.

Best wishes

Klaus

Systime A/S
Sonnesgade 11
DK-8000 Århus C
Tlf. (+45) 70 12 11 00
www.systime.dk

systime

Adresse | +45 7012 1100 | systime.dk

Appendix J. First e-mail to the technology teachers regarding interviews

Hi,

My name is Mette Møller Jeppesen and I am employed at Aalborg University and working on a PhD project about HTX and more specifically about the technology subject on HTX.

While I have collaborated with HTX in Aalborg, I have, by the teachers, been made aware of a need to gather knowledge about assignment writing in i.a. the technology subject based on the three core elements in the technology subject: Project competencies, PBL and Integrated Product Development.

I have therefore, together with a large number of teachers on HTX in Aalborg, as well as Lars Bo Henriksen, Professor (AAU); Henrik W. Routhe, External Lecturer (AAU) and former Head of TECHCollege Aalborg, and Carsten F. Jørgensen, Head of Education on HTX in Aalborg, started a process around the development of a book that can be used for assignment writing from the product development course in 1.g. and up to 3.g. The book should function as a toolbox / reference work. Students must be able to use it as a reference work and as a basis for the development of their projects.

The idea with the book is to create a common language and a common conceptual device in relation to project work on HTX across the HTX schools in Denmark.

Furthermore, it is the idea that all the schools and teachers who have an interest in participating and contributing with the development of the book should be able to participate in the project (Aalborg Tekniske Gymnasium and Slotshaven Gymnasium (HTX) have announced that they would like to contribute).

It is you as teachers who are experts and we are therefore also interested in hearing if any of you are interested in participating in the project and thus help determine the content of the book?

- It can be in the form of submitting material
- Or in the form of 1-2 meetings. A meeting with me and the co-authors and possibly a meeting with the publisher and the other interested teachers.
  (Collection of material, meetings, etc. takes place in the autumn of 2018).

Should there be anyone who is interested in participating more / less, it is of course also an option.

There are no special requirements for there to be a certain number of teachers participating from each school. That is, it is perfectly ok to contribute as an individual and that on the other hand, it is also possible that you contribute as a group.

It must be emphasized again that it is NOT the idea to create a unification in the subject, as a large part of the strength of the subject lies in the various disciplines and in it what you teachers each contribute to the subject. Instead, the intention is to create a common base for the academic knowledge the students need to write projects in the field of technology.

You are very welcome to contact me if you have questions or comments about the project or if you need further information.

I look forward to hearing from you.

De bedste hilsner
Mette Møller Jeppesen
PhD Student
Department of Planning, Aalborg University, Rendsburggade 14, 2. 9000 Aalborg
Telephone office: (+45) 93562398 Email: mmj@plan.aau.dk

Appendix K. Usage statistics by schools

The project work - Technology and Technical science subjects						
Number of page views	**2021 (S)**	**2021 (T)**	**2020 (S)**	**2020 (T)**	**2019 (S)**	**2019 (T)**
Total	**101.284**	**18.268**	**86.176**	**18.738**	**12.310**	**7.100**
Schools						
H.C. Ørsted Gymnasiet TEC Lyngby	20,5%	9,4%	6,5%	5,0%	0,6%	6,5%
Aalborg Tekniske Gymnasium	9,1%	5,2%	12,1%	7,8%	21,8%	12,3%
NEXT Uddannelse KBH – Sukkertoppen Gymnasium	8,8%	4,3%	7,2%	3,7%	0,0%	0,0%
EUC Sjælland – HTX/EUX	7,5%	4,8%	2,4%	2,9%	3,4%	7,5%
Aarhus TECH/Aarhus Gymnasium Aarhus C	5,8%	1,6%	8,3%	2,4%	21,9%	5,5%
ZBC Slagelse - HHX/HTX	4,4%	5,2%	4,6%	8,1%	0,6%	0,0%
H.C. Ørsted Gymnasiet	4,3%	1,3%	9,2%	3,6%	1,6%	0,0%
Svendborg Erhvervsskole & Gymnasier - HTX	4,2%	2,1%	3,5%	3,60%	8,1%	2,8%
NEXT Uddannelse KBH – Vibenshus Gymnasium	2,7%	1,2%	3,1%	2,0%	0,0%	0,0%
U/NORD - Erhvervsuddannelser	2,7%	6,4%	0,2%	0,0%	0,0%	0,0%
Aalborg Tekniske Gymnasium	2,3%	1,3%	0,5%	0,0%	1,5%	3,4%
TEC Frederiksberg - EUX	2,0%	11,2%	4,7%	7,3%	0,0%	2,3%
Struer Statsgymnasium – HTX/HHX/EUX	1,5%	5,2%	0,3%	2,9%	0,0%	0,0%

H.C. Ørsted Gymnasiet	1,5%	1,7%	2,3%	2,4%	1,6%	0,0%
Tradium - HTX	1,5%	2,0%	0,7%	2,7%	0,0%	0,0%
Vejle Tekniske Gymnasium	1,4%	1,5%	0,4%	0,8%	0,0%	0,0%
Erhvervsgymaniset Grindsted	1,2%	4,8,0%	0,6%	1,2%	0,0%	0,0%
Niels Brock	1,2%	0,4%	1,30%	0,3%	0,0%	0,0%
HTX Roskilde	1,1%	2,0%	1,1%	1,9%	0,0%	0,0%
College360 - Silkeborg Business College	1,0%	0,5%	0,3%	0,0%	0,0%	0,0%
Teknisk Gymnasium Grenaa – Viden Djurs	1,0%	1,3%	1,5%	1,0%	0,0%	0,0%
NEXT Uddannelse KBH - Vestskoven Gymnasium	0,9%	0,5%	0,3%	0,9%	0,0%	0,0%
EUC Nordvest HTX	0,9%	1,3%	0,40%	0,0%	0,0%	0,0%
Herningsholm Erhvervsskole - HHX/HTX	0,9%	2,0%	1,0%	1,6%	0,5%	4,6%
ZBC Vordingborg - HHX/HTX	0,7%	0,0%	2,5%	0,8%	1,8%	3,0%
Hansenberg	0,6%	0,4%	1,3%	0,5%	0,0%	1,3%
Learnmark Horsens	0,6%	0,7%	0,1%	0,0%	0,5%	0,0%
Aarhus Business College	0,5%	0,0%	0,1%	0,0%	0,0%	0,0%
NEXT Uddannelse KBH - Mediegymnasium og Erh.udd.	0,5%	0,5%	0,70%	0,0%	0,0%	0,0%
Slotshaven Gymnasium - EUC Nordvestsjælland	0,5%	0,7%	0,7%	0,4%	1,3%	1,1%
Struer Statsgymnasium	0,4%	0,5%	0,0%	0,0%	0,0%	0,0%
EUC Nord	0,4%	0,4%	0,3%	2,2%	0,0%	0,0%
Tietgenskolen	0,4%	0,3%	0,2%	0,0%	0,0%	0,0%
Euconline	0,3%	0,0%	0,6%	0,0%	0,0%	0,0%
Gastro Science	0,3%	0,0%	0,0%	0,0%	0,0%	0,0%
Campus Vejle - HHX/EUD/EUX/HF	0,3%	0,0%	0,2%	0,0%	0,0%	0,0%

Køge Handelsskole	0,3%	0,0%	0,2%	0,0%	0,0%	0,0%
NEXT Uddannelse KBH - Sydkysten Gymnasium	0,3%	0,3%	1,0%	2,5%	1,8%	7,0%
CELF- Nykøbing F.	0,3%	0,0%	0,4%	0,0%	0,0%	0,0%
Uddannelsescenter Holstebro HHX/EUD/EUX	0,2%	0,0%	0,3%	0,0%	0,0%	0,0%
EUC Nord, Frederikshavn - HTX	0,2%	0,6%	0,1%	0,5%	0,0%	0,0%
Herningsholm Erhvervsskole EUX/EUD	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%
Skive College - Erhvervsskolen	0,2%	0,0%	0,1%	0,0%	0,0%	0,9%
Roskilde Handelsskole - HHX	0,2%	0,0%	0,1%	0,0%	0,0%	0,0%
Allikelund Gymnasium - EUC Nordvestsjælland	0,2%	0,0%	0,4%	0,0%	0,5%	0,0%
Vestegnen HF & VUC - Albertslund	0,2%	0,0%	0,1%	0,0%	0,0%	0,0%
Midtbyens Gymnasium	0,2%	1,8%	0,20%	0,0%	0,0%	1,3%
IBC Fredericia – Middelfart - hhx/eud/eux	0,2%	0,0%	0,1%	0,0%	0,0%	0,0%
SCU – edu/EUX/HHX/HF	0,2%	0,0%	0,1%	0,0%	0,0%	0,0%
Rybners - HHX	0,2%	0,0%	0,2%	0,0%	0,0%	0,0%
Viden Djurs -HHX	0,1%	1,3%	0,0%	1,0%	0,0%	0,0%
ZBC Næstved - HHX	0,1%	0,4%	1,0%	3,7%	0,0%	0,0%
Aalborg Handelsskole	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%
Aarhus Business College	0,1%	0,0%	0,2%	0,0%	0,0%	0,0%
Tradium	0,1%	0,0%	0,10%	0,9%	0,0%	0,0%
U/NORD - Gymnasierne EUD/EUX	0,1%	0,0%	0,9%	1,2%	0,0%	0,0%
Tietgenskolen	0,1%	0,0%	0,20%	0,0%	0,0%	0,0%
HEG	0,1%	0,0%	0,30%	0,9%	0,0%	0,0%

Det Blå Gymnasium – Business College Syd	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%
EUC Nord	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%
Aarhus Business College	0,1%	0,0%	0,2%	0,0%	0,0%	0,0%
IBC - Aaberaa	0,1%	0,0%	0,1%	0,5%	0,0%	0,0%
EUC Nordvest – HHX	0,1%	0,0%	0,10%	0,3%	0,0%	0,0%
U/NORD -HHX	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%
Aalborg Handelsskole	0,1%	0,0%	0,6%	0,0%	0,0%	0,0%
Svendborg Erhvervsskole & Gymnasier - HTX	0,1%	0,4%	0,0%	0,7%	8,1%	2,8%
Marselisborg Gymnasium	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
U/NORD - Erhvervsuddannelserne	0,1%	0,0%	0,2%	0,0%	0,0%	0,0%
U/Nord - Gymnasierne HHX	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%
Aalborg Handelsskole	0,1%	0,0%	0,2%	0,0%	0,0%	0,0%
Roskilde Handelsskolen - Erhvervsskolen	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
Svendborg Erhvervsskole & Gymnasier - HHX	0,1%	0,0%	0,1%	0,0%	0,8%	1,4%
Tønder Handelsskole	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
Aarhus Maskinmesterskole	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
HF & VUC FYN Odense	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%
CELF - Nakskov	0,1%	0,0%	0,1%	0,0%	0,0%	1,6%
Frederikshavn Handelsskole	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Det Blå Gymnasium – Hadelsev Handelsskole	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
U/Nord - Erhvervsuddannelser	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%
KEA Campus Empire	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
Aalborg Handelsskole	0,1%	0,0%	0,1%	0,0%	0,0%	0,0%
Aarhus HF & VUC	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%

College 360 – EUD/EUX Business	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
NEXT Uddannelse Kbh – Baltorp Gymnasium – Erh.udd.	0,1%	0,0%	0,3%	0,0%	0,0%	0,0%
Marcantec – Viborg Handelsskole	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
NEXT Uddannelse Kbh	0,1%	0,0%	0,0%	0,0%	0,0%	0,0%
Frederikssund Gymnasium	0,0%	3,5%	0,0%	0,4%	0,0%	2,0%
EUC Sjælland	0,0%	2,1%	1,0%	2,5%	4,6%	0,0%
Syddansk Erhvervsskole	0,0%	1,7%	0,1%	0,0%	0,0%	2,2%
Tech College Aalborg	0,0%	1,4%	0,0%	0,0%	0,0%	0,0%
Erhvervsakademi Midtvest	0,0%	1,0%	0,0%	1,5%	0,0%	0,0%
TEC Frederiksberg	0,0%	0,8%	0,1%	2,9%	0,0%	2,3%
Tekniski Skulin i Klaksvik	0,0%	0,6%	0,0%	0,0%	0,0%	0,0%
ZBC Ringsted HHX/HTX	0,0%	0,6%	0,1%	0,0%	0,4%	0,0%
Fredericia Gymnasium	0,0%	0,5%	0,0%	0,0%	0,0%	0,0%
College360	0,0%	0,5%	0,0%	0,0%	0,0%	0,0%
Kold College	0,0%	0,5%	0,4%	0,4%	0,0%	1,5%
GUX Sisimiut	0,0%	0,5%	0,2%	1,5%	0,0%	1,6%
EUC Nordvest	0,0%	0,4%	0,1%	1,0%	0,0%	0,0%
Rybners Tekniske Gymnasium	0,0%	0,4%	0,1%	0,0%	0,0%	1,2%
Hotel - og Restaurantskolen	0,0%	0,3%	0,0%	0,7%	0,0%	0,0%
Aalborg Tekniske Gymnasium	0,0%	0,0%	0,5%	0,0%	0,0%	0,0%
Køge Private Realskole	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
Tradium	0,0%	0,0%	0,0%	0,5%	0,0%	0,0%
U/Nord Gymnasierne eud/eux	0,0%	0,0%	0,3%	0,4%	0,0%	0,0%
ZBC Ringsted - erhvervsskolen	0,0%	0,0%	0,0%	0,6%	0,0%	0,0%
Midtbyens Gymnasium	0,0%	0,0%	0,2%	0,6%	0,0%	0,0%

CELF	0,0%	0,0%	0,1%	0,4%	0,0%	1,6%
Syddansk Erhvervsskole	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
HF og VUC Klar - Slagelse	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
EUC Nordvestsjælland	0,0%	0,0%	0,0%	0,6%	0,0%	0,0%
Tradium - EUD	0,0%	0,0%	0,3%	1,0%	0,0%	2,9%
EUC Nordvestsjælland - Processkolen	0,0%	0,0%	0,0%	0,5%	0,0%	0,0%
College 360 – Silkeborg Tekniske Skole	0,0%	0,0%	0,1%	0,5%	0,0%	0,0%
EUC Syd - Aabenraa	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
Mariagerfjord Gymnasium	0,0%	0,0%	0,2%	0,0%	0,0%	0,0%
EUC Syd - Sønderborg	0,0%	0,0%	0,0%	0,4%	0,0%	0,0%
Campus Bornholm - HTX	0,0%	0,0%	0,0%	0,4%	0,0%	0,0%
Ribe Katedralskole - Handelsgymnasiet	0,0%	0,0%	0,1%	0,3%	0,0%	0,0%
Høje-Taastrup Gymnasium	0,0%	0,0%	0,2%	0,0%	0,0%	0,0%
Uddannelsescenter Holstebro – HHX/EUD/EUX	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%
VUC Storstrøm	0,0%	0,0%	0,1%	0,0%	0,0%	0,0%

ISSN (online): 2446-1628
ISBN (online): 978-87-7210-904-6

AALBORG UNIVERSITY PRESS