THESIS FOR THE DEGREE OF LICENTIATE OF PHILOSOPHY

# Towards Bridging Skill Gaps for the Future Industrial Workforce

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Gothenburg, Sweden 2023

Bridging Skill Gaps
for the Future Industrial Workforce
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IMS-2023-7

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Printed by
Chalmers digitaltryck
Gothenburg, Sweden 2023

# ABSTRACT

Industry faces a multitude of disrupting economic, social, and environmental challenges. To overcome those, a skilled workforce is key. The aim of this thesis is to define, measure, and bridge the skill gaps of industry professionals who primarily have engineering backgrounds. In short, the research carried out and summarized in this thesis contributed to understanding the problem of skill gaps. The "skill gap" was generically defined by synthesizing definitions from the literature. Approaches to measuring skill gaps were compiled. Challenges and success factors when bridging skill gaps were found and potential solutions to bridge those challenges were identified. Those challenges are connected to motivation, managing change, identifying skill gaps, and tailor learning for everyone. The research resulted in a clear definition of skill gaps in an industrial context, a summary of approaches that have been used to measure skill gaps and key topics for employers, employees, and education providers to address when bridging skill gaps. However, the mission isn't completed until the vision of having the right skills with the right person at the right time is fulfilled. So far, an understanding of the problem and potential actions to bridge skill gaps have been achieved. It remains to implement and test solutions to bridge the skill gap to be able to roll out an impactful solution.

**Keywords**: Skill gap, Upskilling, Work, Industry.

# ACKNOWLEDGEMENTS

*Live as if you were to die tomorrow; learn as if you were to live forever.*
Mahatma Gandhi

Throughout my whole life, I have been lucky enough to have people around me whom I could learn from. Whether it was learning how to eat properly, how to ride a bike, how to write and speak in different languages, to do my own laundry, play the piano, dance, or learn how to be a good friend – I needed other people to have the skills I have today. I am deeply thankful for all the people that have prepared me and inspired me.

Today I want to thank the people who have been especially important in writing this thesis. First, I want to thank my supervisor Professor Johan Stahre. Thank you for your unconditional support, well needed in the PhD student journey, and your inspiring ideas. Thank you for being an ally to me and bringing a lot of joy into my life!

I also want to thank Professor Raija Hämäläinen for encouraging me in my work and giving me valuable help to find my way in the educational research field. Thank you to Miitta Järvinen and Pauliina Rikala, you are great writing colleagues. I'm sure we will have many more fruitful collaborations!

This research wouldn't have been possible without the project team of Ingenjör4.0 – a special thank you to Professor Bengt-Göran Rosén and Mattias Bokinge for your support and interesting discussions!

Of course, as in any workplace, colleagues are the most important factor for comfort and happiness. From the first time we met, I knew I wanted to have you in my life, Clarissa. Thank you for making me laugh and always being here for me. Thank you, Omkar and Hao, for being attentive friends that I can joke with. Thank you, Qi, Arpita, Xiaoxia, Huizhong, Henrik, Sven, and Roland, for being kind and helpful colleagues.

Thank you, Professor Björn Johansson, for your ideas and constructive feedback. To Professor Anna Syberfeldt, Associate Professor Mélanie Despeisse, and Professor Anders Skoogh - thank you for enlightening me with your experience.

A special "Thank you" to my friend Anna Höglund for empowering me to apply for the PhD student position, and my aunt Sandra Riomar who besides her mental support recommended interesting references and gave valuable feedback!

Finally, I want to thank my family and friends. Mama & Papa, thank you for your unconditional support. I'm outmost thankful for the best sister in the world, Vera. Thank you to my Swedish family who make Sweden my second home. And I couldn't be happier to have my friends, who make me laugh, who make me travel the world, who let me experience different cultures, who make me feel loved. Thank you, all of you.

*Greta Braun*
Göteborg, July 2023

# FOREWORD

Finding myself in the intersection of the research areas of industry and education reflects my background and interests that have raised during the last years. Growing up in Germany as a daughter of two engineers, I have always heard snippets of what it is like to work in industry. Playing with the question of what I want to become “when I grow up” has always been a huge challenge, filled with curiosity, but also glimpses of concern. When studying, working, and living in a male-dominated field, it became obvious to me that there are many hurdles for women to succeed in industry. Making it my mission, I always felt that creating working environments for everyone is something I want to contribute to. However, I accomplished a bachelor in electrical engineering with an accompanying apprenticeship at a large German industrial company within the division digital industry. Afterwards, my passion for gaining leadership as well as learning and pedagogic skills outgrew my other interests, and I did a master's in Learning and Leadership in Sweden. Coming from this mixed background, I started working for a company where I led a production-related project aiming at demonstrating Industry 4.0 by building learning factories. With excitement, I started the PhD journey to pursue my passion for learning-related questions in production. It’s important to me to see the individual person in this context and find out how they could be supported in finding their way in this changing world of work, and avoid falling behind, or even losing their job without finding a suitable new one. I always want to keep in mind the importance of including people of diverse backgrounds in industry.

# LIST OF APPENDED PAPERS

The five appended papers in this thesis are listed here, along with the contributions and distribution of work among the authors.

**Paper I** **Managing Change towards the Future of Work - Clustering Key Perspectives**

Katrin Singer-Coudoux, Greta Braun, and Johan Stahre (2023)

Article accepted in APMS 2023.

Distribution of work: Second author. Greta supported Katrin in the literature review and in the scoping of the paper. The writing was shared equally and discussed together with Katrin and Johan.

**Paper II** **What does the skill gap really mean, and how can it be measured? – A review on Industry 4.0**

Pauliina Rikala, Greta Braun, Miitta Järvinen, Johan Stahre, Raija Hämäläinen

Submitted to journal *Technological Forecasting & Social Change (June 2023)*

Distribution of work: Second author. The literature review was done by Pauliina, Greta, and Miitta. Greta had a special focus on the methods used to measure skill gaps. Continuous discussions and feedback sessions were held together with the whole authoring team.

**Paper III** **Motivational Challenges of Engineers Participating in an Online Upskilling Program**

Greta Braun, Miitta Järvinen, Johan Stahre, Raija Hämäläinen
(2022)

Presented at the *European Conference on e-Learning*, Brighton, 26-28 October 2022.
Published in *Proccedings of the 21st European Conference on e-Learning*, vol. 21, no. 1.

Distribution of work: Principal author. All authors discussed the scope and the method that was going to be used to conduct the study. Greta and Miitta set up the survey and distributed it to the respondents, answers were analyzed by Greta and Miitta. The writing was done mainly by Greta, and

some parts by Miitta. The whole authoring team gave feedback to improve the article. Greta presented the article at the conference.

**Paper IV** **Ingenjör4.0 – A National Upskilling Programme to Bridge Industry's Skill Gap**

Greta Braun, Johan Stahre, Bengt-Göran Rosén, Mattias Bokinge

Article accepted in CIRP CMS 2023.

Distribution of work: Principal author. The survey was implemented within the Ingenjör 4.0 project and the results were analyzed by Mattias and Greta. Greta wrote the paper. The whole authoring team gave comments to improve the text.

**Paper V** **Skills Matching for a Greener Industry 4.0 – a Literature Review**

Greta Braun, Johan Stahre, and Raija Hämäläinen

Presented at the *Swedish Production Symposium*, Skövde, 26-29 April 2022. Published in *Advances in Transdisciplinary Engineering. vol* 21, p. 677 - 688.

Distribution of work: Principal author. Greta conducted the literature review, and the results were analyzed with the other authors. The paper was written by Greta, and the other authors gave comments and suggestions to improve the text.

# ADDITIONAL PAPER

**Paper A** **Battery production systems: state of the art and future developments**

Mélanie Despeisse, Björn Johansson, Jon Bokrantz, Greta Braun, Arpita Chari, Xiaoxia Chen, Qi Fang, Clarissa A. González Chávez, Anders Skoogh, Johan Stahre, Ninan Theradapuzha Mathew, Ebru Turanoglu Bekar, Hao Wang, Roland Örtengren

Article accepted in APMS 2023.

Distribution of work: Greta and Johan wrote the chapter about skill gaps and competence development for battery manufacturing. Peer-review with the other authors was done and improvements implemented.

# TABLE OF CONTENTS


1 INTRODUCTION ..... 1
1.1 Background ..... 2
1.2 Aim and Research Questions ..... 3
1.3 Scope and Delimitations ..... 4
1.4 Outline of the Thesis ..... 4
2 FRAME OF REFERENCE ..... 7
2.1 Industrial transformations ..... 8
2.2 Future of work ..... 10
2.3 Skills ..... 12
3 METHODOLOGY ..... 19
3.1 Background ..... 20
3.2 Scientific approach ..... 20
3.3 Research design ..... 21
4 RESULTS ..... 27
4.1 RQ1 - The skill gap ..... 29
4.2 RQ2 - Measuring skill gaps ..... 31
4.3 RQ3 - Bridging skill gaps ..... 32
5 DISCUSSION ..... 39
5.1 Vision and mission ..... 40
5.2 Discussing the research questions ..... 40
5.3 Contribution ..... 44
5.4 Discussion of methods ..... 46
5.5 Future research ..... 47
6 CONCLUSION ..... 49
REFERENCES ..... 53

APPENDICES

PAPER I - Managing Change towards the Future of Work - Clustering Key Perspectives

PAPER II - What does the skill gap really mean, and how can it be measured? – A review on Industry 4.0

PAPER III - Motivational Challenges of Engineers Participating in an Online Upskilling Program

PAPER IV - Ingenjör4.0 – A National Upskilling Programme to Bridge Industry's Skill Gap

PAPER V - Skills Matching for a Greener Industry 4.0 – a Literature Review

# LIST OF FIGURES

Figure 1 - The industrial revolutions (adapted from Kagermann et al. (2011), Forschungsunion (2013), and Breque et al. (2021)) ..... 9
Figure 2 - Research approach for this thesis ..... 21
Figure 3 - Design Research Methodology stages (Blessing & Chakrabarti, 2009) ..... 22
Figure 4 - Explaining the skill gap (adapted from paper II) ..... 30
Figure 6 - Approaches to measure skill gaps (adapted from paper II) ..... 31
Figure 7 - One possible approach to measure skill gaps (adapted from paper II) ..... 32
Figure 8 – Key discussion topics regarding Future of Work (adapted from Paper I) ..... 33
Figure 9 – What has been matched in recent studies (adapted from paper V) ..... 35
Figure 10 - Challenges and success factors of an online upskilling programme (adapted from paper IV) ..... 36
Figure 11 - High-potential improvements for online upskilling programmes (adapted from paper IV) ..... 37

# LIST OF TABLES

Table 1 - Focus topics within Future of Work during time periods ..... 11
Table 2 - Research activities and their alignment with the appended papers. ..... 25
Table 3 - Summary of the main contributions from the appended papers ..... 28

# LIST OF ABBREVIATIONS

| | |
|---|---|
| AI | Artificial Intelligence |
| DFKI | Deutsches Forschungszentrum für Künstliche Intelligenz |
| DRM | Design Research Methodology |
| ESCO | European Skills, Competency, and Occupations |
| GPT | General purpose technology |
| HR | Human Resources |
| ML | Machine Learning |
| MOOC | Massive Open Online Courses |
| NER | Named Entity Recognition |
| NLP | Natural Language Processing |
| RQ | Research Question |
| WIL | Work-Integrated Learning |

# 1

# INTRODUCTION

*Work saves [...] from three great evils: boredom, vice, and need.*
*- Voltaire*

This chapter introduces the scientific knowledge relevant to this thesis, bringing light to the background, and states the aim and research questions that were chosen to contribute to the topic. It also presents the scope, delimitations, and outline of the thesis.

## 1.1 BACKGROUND

Today, we live in a complex and fast-changing world, where workplaces transform very quickly (Smil, 2021). The climate crisis, war, and pandemics are reasons why Industry needs more focus on sustainability, resilience, and human-centeredness, namely Industry 5.0 (Breque et al., 2021; Leng et al., 2022). The industry sector stands for almost 30% of the global greenhouse gas emissions (Ritchie et al., 2020), which poses a major challenge if the Paris Agreement should be reached, with governments putting ambitions of reaching climate neutrality (United Nations Framework Convention on Climate Change, 2015) and at the same time maintaining productivity and economic sustainability (Commission, 2022). In Europe, electrification of the automotive industry asks for batteries, and it is estimated that 800 000 workers will need upskilling or reskilling by 2025 to enable battery production (European Commission, 2022a). Hence, there is an urgent need to adopt technologies to meet deep societal challenges by developing skills (European Commission, 2022b; Schuh et al., 2020). To enable technology adoption and changing business models, work design changes and new skills are needed (Grant & Parker, 2009). The European Commission declared 2023 as the European Year of Skills. The necessity to collaborate with companies and find out their skill needs, match people to jobs, upskill the workforce, and make it easy for workers to immigrate to Europe is emphasized (von der Leyen, 2022).

If the technology evolves at the same pace as now, employers estimate that 44% of employees' skills will have to change drastically, whereof the importance of cognitive skills seems to grow most rapidly (World Economic Forum, 2023b). But also lacking technical skills is hindering the adoption of new technologies, such as Additive manufacturing or Smart Maintenance (Bokrantz et al., 2020; Stavropoulos et al., 2023). The United Nations Industrial Development Organization has made green skills a main priority for industrial firms, to support the sustainable development of industry (Auktor, 2020). Green skills are "skills required to adapt products, services or operations to meet adjustments, requirements or regulations designed to stem further climate change or adapt to the impact it is already having" (Jeon et al., 2011).

Given the demographical change, many regions experience a declining trend in the existing workforce (United Nations Department of Economic and Social Affairs, 2022). In Europe and the US, the existing young generations will not be enough to fill the positions that are needed to adopt the goals. Filling the vacancies by recruiting new skilled people may not be enough (Deloitte, 2018). The demographical change urges companies, societies, and governments to find solutions to have the right skilled people (Cedefop, 2015; European Commission, 2020). Professionals working in industry need to relate to the ongoing changes and situate themselves in their work today and tomorrow. This can be described by the term "skill gap", meaning the gap between the skills that are needed to adapt to changing environments and new goals, and the skills that employees possess, and if there are potential employees on the job market (McGuinness et al., 2018). Studies by e.g. the World Economic Forum consistently claim huge skill gaps in industry and other sectors (World Economic Forum, 2016, 2020a, 2023b), and this thesis will help to understand the skill gap, find ways to measure it, and finally be able to bridge it. It is obvious that the need for increased technology adoption leads to an increased need for new skills. In other words, if there is no skill development, there

will be no power for change. Thus, emphasizing the need for research about skill gaps.

### Identified Research Gap

Multiple studies show that there is a skill gap in industry (Brunello & Wruuck, 2021; McGuinness et al., 2018; World Economic Forum, 2023b). However, it seems like there is a lack of consensus on this term and how it is defined, and often used together with other concepts such as skill shortage and skill mismatch (McGuinness et al., 2017). In addition, there is a lack of methods to measure skill gaps for learners, even though there are studies about skill gaps concerning whole industries or companies (Deloitte, 2018; World Economic Forum, 2020a). However, among others, Do et al. (2023) give proposals for measuring skill gaps, but those aren't evaluated. In addition, the challenges of bridging skill gaps and how to address them need to be systematically approached to support stakeholders.

## 1.2 AIM AND RESEARCH QUESTIONS

### Vision

My vision is that people working in industry have the right skills to do their job, given that their job tasks are changing due to social, ecological, and economic challenges and transformations. Industry employees feel supported, have the right resources, and get guidance to get on a successful and motivating learning path to understand and bridge their skill gap. Ultimately, there should be no skill gap.

### Mission

My mission is to define, measure, and bridge the skill gap of multiple selected industry professionals with primarily an engineering background.

### Research Questions

Emerging technologies and other changes in industry create skill gaps among workers who consequently are given new tasks. Policymakers, educators, and employers talk about a skill gap in industry and the concept is used in different ways. That leads to the first research question (RQ):

**RQ1: What is a skill gap in the industrial context?**

After defining what a skill gap in the industrial context is, the next step is to be able to identify and measure skill gaps. Different approaches to measuring skill gaps on a company level and individual level should be considered, and further investigated through the lens of learning providers:

**RQ2: How can skill gaps be measured?**

Finally, when addressing the skill gap, there are challenges regarding the learning itself, finding motivation, supplying the learning in the right way, and creating the right support systems. Hence, the last research question is about overcoming those challenges and enabling learners to learn and bridge their skill gap:

**RQ3: How can skill gaps be bridged?**

## 1.3 SCOPE AND DELIMITATIONS

The research presented in this thesis is about humans in production systems and their role and skills to reach the goals that are set by the environment. The skill gap is a societal challenge and important for many. Due to the data set that was available during my work, this thesis is concerned mainly with engineers and professionals with engineering-related job roles and relevant backgrounds. One reason to focus on this group of high-skilled people is that there is quite high leverage when these people upskill. When balancing what I'm concerned about with what I can influence, I decided to focus mainly on the skill gaps of these high-skilled people.

What am I focusing on:

- Skill gaps of primarily high-skilled professionals, mainly with engineering backgrounds in the manufacturing industry sector, focusing on Sweden and Europe.
- Learners who undergo upskilling are here referred to as employees, even though learners can also be found among people who are not employed.
- Skills within advanced technologies related to industry 4.0, primarily focus on technical skills.
- Skills relevant to the value-based challenges of industry 5.0, i.e., sustainability, resilience, and human-centeredness.

What am I not doing:

- Research about only "blue collar" operators.
- Long-term educational activities.
- Socio-technical systems theory or traditional work science.

## 1.4 OUTLINE OF THE THESIS

This first chapter introduced the topic and emphasized its importance. In the following chapters, the thesis will be structured in the below way.

**Chapter 2, Frame of Reference** introduces key concepts that support the understanding of the problem and the current situation in industry. The chapter starts

with the context in which the research is placed, industry. The changing industry leads to changes in work. Hence, the Future of Work concept is introduced. When work changes, skills need to change, which is described in the skill chapter.

**Chapter 3, Methodology** describes the background of the research, and the ontological and epistemological approaches taken by the researcher, followed by the methodology and methods.

**Chapter 4, Results** summarizes the main findings of the appended papers. These results are structured according to the three research questions.

**Chapter 5, Discussion** combines the vision, the research results, prior knowledge in the research field, and the methodology, to debate the contribution of this thesis and give an outlook on planned future research.

**Chapter 6, Conclusion** offers a clear summary of the key ideas of this thesis and combines the contribution with the vision and mission.

# 2

# FRAME OF REFERENCE

*Work is still designed for family and economic structures from half a century ago. That world no longer exists.*
*- Saadia Zahidi, 2017*

This chapter starts by creating a common understanding of the industrial paradigm and the shifts between paradigms. The industry is the setting for this research and the ongoing, but also past transformations, have a prior impact on the purpose and outcome. After setting the stage, the second part of this chapter introduces concepts and current trends within the Future of Work. The Future of Work is presented from the perspective of current industrial challenges and a focused chapter about skills introduces the main topic of this thesis – skill gaps.

## 2.1 INDUSTRIAL TRANSFORMATIONS

In 2011, during the Hannover fair, the fourth industrial paradigm, known as Industrie 4.0, was coined (Kagermann et al., 2011). This transformation is characterized by increased digitalization, automation, and communication (Oesterreich & Teuteberg, 2016) and key technologies characterizing this revolution in industry are e.g. cyber-physical systems, additive manufacturing, and the Internet of Things (Almada-Lobo, 2016). The industry has gone through revolutions before, i.e., the first, second, and third industrial revolutions. Each of these shifts has mainly been characterized by new technologies. The first industrial revolution was enhanced by the invention of the steam engine. The second industrial revolution introduced electrical engines that powered electrical light, conveyor belts etc., and production became even more efficient (Frey, 2019). The third industrial revolution represents the introduction of robots in industry and enabled the automation of certain tasks. The visualization below is adapted from the description of the industrial revolutions by the German Research Centre for Artificial Intelligence "Deutsches Forschungszentrum für Künstliche Intelligenz" (DFKI).

Additionally, Industry 5.0 is attached as the next paradigm in line, as the European Commission recently coined the term and drives the implementation forward. Industry 5.0 brings sustainability, resilience, and human-centeredness to the core of industry (Breque et al., 2021). Research to enhance sustainability has for example been laid forward through the implications of digital servitization (González Chávez et al., 2023) and the overcoming of risks of the digital, resilient transition to sustainability (Chari et al., 2022). With their paper, Leng et al. (2022) invite researchers to discuss the necessary actions needed to put Industry 5.0 forward, and propose a concept for Society 5.0 driven by "smart people", "smart community", "intelligent decision", and "intelligent technology", always highlighting the focus on the human aspect. Xu et al. (2021) show that while industry 4.0 is technology-driven, Industry 5.0 is based on values, and discuss what happens when those two industrial paradigms, industry 4.0 and 5.0, co-exist. In the fourth industrial revolution, many technologies are involved, such as Artificial Intelligence (AI) and Cyber-physical systems (Kagermann et al., 2011). Moving towards the fifth industrial revolution, the European Commission is even talking about a twin transition – the digital and the green transitions. In her speech, the president of the European Commission, Ursula von der Leyen, highlights the need for new jobs and new skills to support those new goals (von der Leyen, 2022).

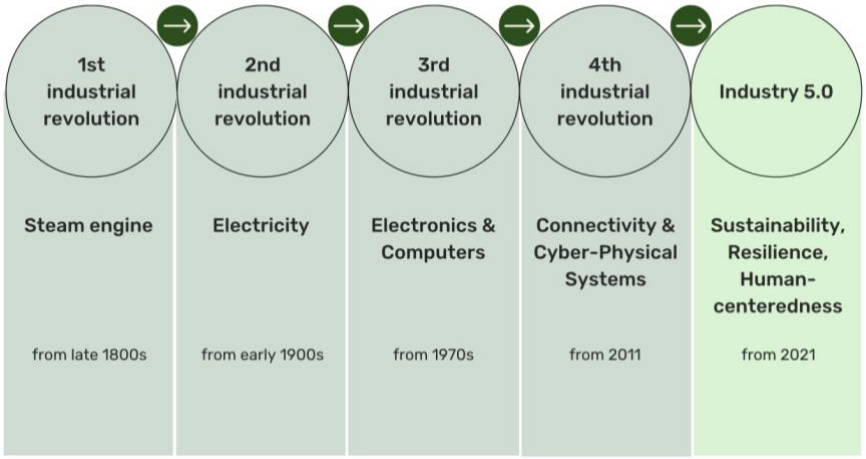



Figure 1 - The industrial revolutions (adapted from Kagermann et al. (2011), Forschungsunion (2013), and Breque et al. (2021))

The goal of innovation in workplaces has been to eliminate labour and make production more productive (Autor, 2015). Still, Erik Brynjolfsson (1993) described a "productivity paradox", where the ambiguity in the introduction of new transformative general purpose technologies (GPT) in industry, like electrification or mass production, resulted in a slowdown of productivity gain. Productivity gain is when the product of one work hour increases, and the paradox comes about because the efforts to implement new technologies would make one assume that this would automatically lead to a growth in productivity, which it not necessarily does. Later, Brynjolfsson et al. (2020) pointed out that the lack of intangibles like the development of new processes, business models, and skilled workers slow down the successful direct achievement of productivity growth when implementing GPTs. Additionally, those intangibles can slow down each other, because the lack of skills could pose a risk to successfully implement new business models that are needed to drive sustainability (González Chávez et al., 2023).

Anticipating how skill requirements are changing and how well employees are meeting those requirements, is critical to achieve the expected productivity. One approach to understanding the changing requirements and even looking into the future are trend radars. A number of trend radars have been set up, visualizing the technologies that are impacting the industry and their maturity (EIT Deep Tech Talent Initiative, 2023; World Economic Forum, 2023a). The famous "Gartner Hype Cycle" is locating technologies according to their maturity in terms of how far the technology has been adopted by industry and society (Fenn & Raskino, 2008). According to their hype cycle, technologies go through five stages: "Technology trigger", "Peak of inflated expectations", "Trough of disillusionment", "Slope of enlightenment", and "Plateau of productivity" (Gartner, 2023). The hype cycle is a dynamic graph that shows the stage of new technologies and therefore it can be used to prepare the workforce for emerging technologies at an early stage.

Lately, the European Commission has put a special focus on Deep tech, to enhance innovation and entrepreneurship, and solve deep societal challenges. In their "New European Innovation Agenda" (European Commission, 2022b) deep tech ought to be

key to solving climate change and other societal challenges. This agenda highlights the need for deep tech talents and accordingly, the required initiatives to support the development of these talents, among those are to upskill 1 million deep tech talents and support the inclusion of women in traditionally male-dominated fields. The transformation is an opportunity to consciously include under-represented groups in industry.

## 2.2 FUTURE OF WORK

The term Future of work relates to the change in organizations caused by trends like digitalization and the resulting shift in work, leading to a need for preparation for the workforce and workplaces (McKinsey and Co, 2023). The European Commission mentions the following key topics for the Future of Work: "quality of jobs and employment; social protection and next-generation manufacturing; the intersection of health and employment as well as the platform economy; inclusive workplaces; reskilling and upskilling; and human-machine collaboration." (European Commission, 2023). There are other governmental initiatives regarding work, e.g., the governmental program "skills future" in Singapore. This program gives citizens opportunities and incentives for upskilling (Government of Singapore, 2023).

Accompanied by an increase in efficiency and well-being of society as such (Lindert & Williamson, 2008), the industrial revolutions have led to a shift in jobs and the skills that are needed by workers, and impacted wage inequality, i.e. widening the gap between low and high-income workers, and the decrease of middle-income workers (Autor et al., 1998). The correlation between firms' adoption of electricity and capital distribution showed that high-skilled workers gained more capital during technology adoption than low-skilled workers (Goldin & Katz, 1998). Braverman (1998) brings ahead the term Deskilling to describe the decrease of value in labour work and discusses the elimination of labour when new technologies are introduced, risking the alienation of workers. On the other hand, Autor (2015) discusses the paradox that automation hasn't taken jobs away, and highlights that even if innovations always aimed at eliminating human labour, there has been a decrease in unemployment rates in Europe and the United States. Instead, those innovations have created other jobs. In addition, he argues for the advantage of machines in taking routine tasks, while humans have more time to use the skills they are good at: "problem-solving skills, adaptability, and creativity" (Autor, 2015). In addition, recent studies show that the green transition and adoption of new technologies will create new tasks and new jobs (World Economic Forum, 2020a). However, technological change leads to a skill gap because certain tasks change and require new skills from humans (Roblek et al., 2016). Autor & Dorn (2013) argue that the change in tasks has impacted low- and high-skilled workers in different ways. They claim that the introduction of computers has "substituted for low-skill workers in performing routine tasks while complementing the abstract, creative, problem-solving, and coordination tasks performed by highly-educated workers" (Autor & Dorn, 2013). Frey and Osborne (2013) suggest that computers not only can replace repetitive tasks but now also non-routine tasks, leading to a change in tasks and occupations. However, they bring up the risk of the disappearance of low-skill jobs in a higher amount than high-skilled jobs. In their study, they also highlight that in previous industrial changes, the opposite has been the case, because technology made the work easier (Frey & Osborne,

2013). Nevertheless, recent studies show that also tasks that traditionally are performed by high-skilled workers could potentially be taken over by machines and artificial intelligence, even if to a smaller amount than those of low-skilled workers (Brynjolfsson et al., 2023). As Generative AI emerges, studies show that work tasks taking around 60-70% of workers' time could be automated by this technology (Chui et al., 2023). The same study also highlights the importance of giving employees the possibility to upskill themselves to be able to use the technology.

In the 1930s, as a probable consequence of the second industrial revolution, there was a rising discussion about the working environment and how it contributes to workers' motivation (Mayo, 1933). As a starting point for work design research, the efficiency in the specialization of workers and the division of labour was investigated (Grant & Parker, 2009). Bainbridge (1983) found that the increase in complexity of a control system leads to an increased contribution of the operator. Further, the interaction between humans and machines is continuously investigated and support systems for operators to act successfully in this environment are proposed (Stahre, 1995). The concepts of Operator 4.0 (Romero et al., 2020) and Operator 5.0 (Romero & Stahre, 2021) have marked new technology-enhanced and augmented ways for operators to work. Here, the authors consider the new operating environment for operators and describe how operators can benefit from the new technologies, what the new tasks will be and what tools they will use.

Not to forget are the demographics showing a declining trend in the working population (Commission;, 2020; Eurostat, 2019). Hence, the challenges of having people with the right skills will be even harder to combat (World Economic Forum, 2016). Jobs and skills are changing due to the implementation of new technologies and critical skills are missing (Deloitte Consulting LLP & Deloitte, 2014). In 2023, the World Economic Forum released a new Future of Jobs report and emphasizes the urgent need for organizations to define their skills gaps. This and the challenge of attracting new talent would be the main barriers to transforming industry (World Economic Forum, 2023b).

### The evolvement of the Future of Work research domain

Santana & Cobo (2020) investigate the publications in the Future of Work field during four time frames and the focus topics researched in these periods, see Table 1.

Table 1 - Focus topics within Future of Work during time periods

| Time | Focus topics researched within Future of Work research field |
|---|---|
| 1959-1997 | Employment |
| 1998-2008 | Telework, wage inequality, new organizational forms |
| 2009-2014 | Telework, talent management, E-Human-resource-management, older workers, wage inequality, innovation, migrant workers, job satisfaction |
| 2015-2019 | Talent management, telework, wage inequality, employment, satisfaction, career, innovation, organizational commitment, corporate social responsibility, older workers, automation, vulnerable workers, leadership |

The highest number of publications in recent years has fallen on talent management. Within this field, the investigated themes are e.g., talent development, talent, human resource management, and talent identification (Santana & Cobo, 2020). Within the topic of career, the investigated themes were e.g., career development, experience, employees, adjustment, diversity, global talent management, behaviour, and expatriation (Santana & Cobo, 2020).

## 2.3 SKILLS

Even if the discussion about skills has gained attention very quickly, the topic is not new. In 1989, Rosenbrock (1989) suggested that in human-centred manufacturing, the skills of workers should be considered, and workers should get the opportunity to learn the necessary skills. Skills are the "ability to apply knowledge and use know-how to complete tasks and solve problems" (European Parliament, 2008). Fitts and Posner (1967) divide skills in motor and cognitive skills. Skills enable one to do something in practice, in comparison to knowledge, where it's only about having the information (Baartman & Bruijn, 2011). Knowledge is the "outcome of the assimilation of information through learning" and competence is defined as the "ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development." (European Parliament, 2008). "Competence" is usually used when speaking about vocational education in which the aim is to be competent for a specific job role (Baartman & Bruijn, 2011).

As mentioned before, the industrial revolutions have led to new tasks and skills for workers. Jeon et al. (2011) identify four kinds of transformations leading to new skill requirements: "physical changes in the environment itself; environmental policy and regulation; technology and innovation; and changes in prices, markets, and consumer habits". The three fastest-growing skills regarding importance are creative thinking, analytical thinking, and technological literacy (World Economic Forum, 2023b). Manpower reports that the five most needed soft skills for the future are "Reliability & Self-Discipline, Creativity & Originality, Critical Thinking & Analysis, Reasoning & Problem-Solving, Resilience & Adaptability" (Manpower, 2023). The World Economic Forum (2023b) estimates, that 44% of people's working skills will change until 2028. In the same report, they also state that more than half of workers will need training before 2027, but that half of all workers have no access to suitable learning opportunities. At the same time, it is highlighted that in companies that focus on developing skills, the workers will have advantages, because they will be able to progress in their careers (Madgavkar et al., 2023).

As one of the fastest emerging skills, a special focus should be given to Green skills. Green skills are seen as one of the domains of emerging skills, and green jobs are growing faster than others (World Economic Forum, 2020b). The European Commission defines green jobs as "all jobs that depend on the environment or are created, substituted, or redefined (in terms of skill sets, work methods, profiles generated, etc.) in the transition process towards a greener economy" (European Commission, 2013). Thus, green skills are skills that are needed to do green jobs. Bowen (2012) claims that green growth is not adopted in the pace that would be needed, because employers often don't support the development of the transferable skills needed for green jobs.

## Skill gaps – Definition

The term skill gap has been used in various ways to describe different phenomena related to the lack of skilled workers. Before presenting the existing definitions, it could help to look at the explanation of Hattie and Timperley (2007) who established three questions to figure out the skill gap of a person. In their paper, the authors established a three-step approach to giving feedback. Those three questions are: 1) "Where am I?", 2) "Where do I want to go?", and 3) "How do I get there?". When talking about skill gaps, we also want to understand what the skill set looks like today, which skill set is the goal to have, and how can those skills be reached. Understanding the skill gap itself could be done by the first two questions – where I am and where do I want to go?

The reasons for skill gaps are of different nature. Technological change is often mentioned as one factor in changing working environments and requirements, leading to new tasks and both new hard and soft skills (Patacsil & Tablatin, 2017). Economical changes or the ageing population are also reasons for a lack of workers with the right skills and Haskel and Martin (1993) found that those continuous skill shortages lead to a decrease in production levels and profitability, an increase in costs, and a risk of not being competitive.

In their report, Manpower reveals that 77% of employers struggle to find the right skilled talents (Manpower, 2023) and other studies show that there is a skill gap in industry that hinders the adoption of technology and the achievement of new goals (Deloitte, 2018; Skevi et al., 2014). The lack of skills has often been discussed with the concepts of skill gaps, skill shortages, skill mismatches, skill surplus, and skill obsolescence (McGuinness et al., 2017; Rikala et al., 2023). Skill gaps are the gap between the type and level of skills that are needed for a job and the skills an employee possesses; skill mismatch refers often to the situation when workers are under- or over-skilled, or if the field of skills doesn't match with the field of skills needed for the job (McGuinness et al., 2017). Skill surplus is often used when there are more potential employees and not enough open positions (Gartner, 2020). With skill shortages, the discussion often goes about open vacant jobs that need to be filled (Deloitte, 2018; McGuinness et al., 2017). Skill obsolescence happens when prior required skills aren't required anymore (McGuinness et al., 2017). In the transforming industrial environment where work is changing, skill gaps arise when employees don't have the required skills to do their current tasks (McGuinness et al., 2018; Rikala et al.). The lack of skilled talents is one of the main challenges for technology adoption, such as additive manufacturing (Stavropoulos et al., 2023). In other words, technological change activates learning and asks for employees' lifelong learning (Shahlaei & Lundh Snis, 2023). Sometimes, skill shortage and mismatch are used to say that employers struggle to find suitable talents for vacant jobs (McGuinness et al., 2018) or describe a regional lack of potential employees with certain skills (Brunello & Wruuck, 2021). There is a challenge to distinguish between closely-related concepts like skill shortage, skill obsolescence and skills mismatch (McGuinness et al., 2018)

## Skill gap – Measurements

Skill gaps have been measured in different ways (McGuinness et al., 2017). A common way of defining learning goals has been by formulating learning objectives according to

Bloom's taxonomy (Adams, 2015). Bloom's taxonomy describes the six cognitive skill levels of humans. The learning objectives can relate to any of these layers. The higher up the layer, the more complex is the task the learner will be able to do. The first level is Knowledge, describing something you learn by heart. The next level is Comprehension in which the learner can formulate the content in their own words, contrasting facts, comparing similar facts, and explaining to others. The third level is Application and here the learner uses new knowledge, skills, and techniques in new situations. The fourth level is Analysis meaning that learners do critical thinking and can differentiate between a fact and an opinion. The fifth level is Synthesis and here learners use their acquired knowledge to by themselves create a new thing. Lastly, level six is Evaluation, in which learners use their critical thinking, and make a connection to evaluate what somebody else has created.(Adams, 2015)

Skill gaps have been measured either in relation to what employers expect and what skills their employees possess (Do et al., 2023), in relation to what education provider offer and what employers expect (Babic et al., 2022), or investigated the lack of people to recruit for open job positions (Chang-Richards et al., 2017).

### Skill gap – Bridging

To bridge the skill gap, companies could address this by either hiring skilled people, training the employees they have, or using augmentation technology to give tasks to machines (Deloitte, 2018; Gartner, 2020; Manpower, 2023). Collaboration between academia and industry is highlighted as another important success factor (Li et al., 2021), considering the gap between what skills employers require and the skills that university students possess. Companies offer talent programmes and other organizations offer opportunities for students to learn the required skills. When bridging skill gaps, a targeted skill set should be reached, meaning the employee possesses the required skills for the job. In a world where the only constant is change, this means that ideally, new goals will be set and there is a continuous learning journey. There are many challenges related to this process. In this thesis, the focus will be on the motivational challenges of learners, the challenges of learning providers, organizational changes needed for building the bridge, and recommendation systems for finding the right learning path. There are many research topics that concern skill gaps, but this thesis focuses on the fields of education and training from the perspective of workers, employers, and learning providers.

As mentioned before, there is a demographic change that leads to a decline in the working population. Hence, training the existing workforce becomes even more important (Deloitte, 2018; DHL, 2021; Gallup/amazon, 2021; World Economic Forum, 2020a). The learning of new skills among workers is often referred to as Work-integrated learning (WIL), as upskilling, or reskilling. **Upskilling** means to learn new skills to stay in the same job role, reskilling means to learn new skills to be able to shift to a new job role (Breque et al., 2021). In the ever-changing industry, it becomes crucial that employees do upskilling continuously, hence life-long learning (Li, 2022). However, upskilling or work-integrated learning comes with several challenges, such as lack of time and financing (DHL, 2021; World Economic Forum, 2020a), and motivational challenges. Work-integrated learning has been investigated broadly, to support

European industry (Moldovan, 2019). Due to the continuous transformations impacting work and leading to new skill needs, lifelong learning has become an important topic (Nygren et al., 2019). Hämäläinen et al. (2019) investigate problem-solving skills among adults and conclude that adults that had enjoyed higher education showed stronger problem-solving skills than adults that hadn't, but they also highlight that non-formal learning was more important for the development of these skills.

One thing that stands out as a positive factor influencing **motivation** is the feeling of purpose (Carton, 2022). In addition, Grant & Parker (2009) found that being autonomous and having the feeling of personal growth support motivation and performance. The ARCS model (Keller, 1987) can be used to systematically design motivating online learning. ARCS stands for Attention, Relevance, Confidence, and Satisfaction – all factors that should be felt by the learner in an online learning environment to create a motivating experience (Keller, 2010).

There are examples of successful upskilling journeys, e.g., a company that upskilled their workers in parallel to the automation of tasks and managed to let their employees do more complex tasks. In this case, the company trained the workers with tasks that were going to be automated, to be able to do tasks that were on the next level of complexity. The employees who did those more complex tasks before also got upskilling and moved up the complexity ladder, and in this way, nobody lost their job and got tasks requiring higher skills (Hilgers, 2023).

The challenges in workplace learning lead to an increased interest in knowledge management in companies. Sørensen and Lundh-Snis (2001) discuss the need for information and communication technology for knowledge management. Boland & Tenkasi (1995) proposed electronic communication for managing knowledge in a company, organizing specialist groups, and bringing the right employees together to work on certain projects. Employees risk feeling left alone with the questions of developing new skills and preparing for new jobs, and in the ever-changing industrial environment it becomes important to integrate continuous reflections about current problems in work situations and resulting learning needs and pathways (Shahlaei & Lundh Snis, 2023). Today, **human resources** (HR) departments must face major changes. Deloitte (2016) claims in a report that there is a need for new ways of working in HR, leadership, and management to support today's workforce. The top 10 trends that they claim are important for HR are organizational design, leadership, culture, engagement, learning, design thinking, changing skills of the HR itself, people analytics, digital HR, and workforce management (Deloitte, 2016). HR can be supportive of the learning of the employees by guiding them in their learning or building systems that guide them. Matching suitable talents with open job positions has been investigated (Bothmer & Schlippe, 2022; Cukier, 2019).

Making a choice of what is a suitable path for a professional working in industry could be a challenge. **Course recommendation systems** would be of use (Guruge et al., 2021). Recommender systems have been used in other use cases, such as video streaming services, where the user gets suggestions of movies that they could potentially like. These content-based recommender systems are defined as "systems that recommend an item to a user based upon a description of the item and a profile of the user's

interests" (Pazzani & Billsus, 2007). There are many ways of doing this, and in the case of learning recommendation systems a range of factors could influence the choice, such as "employment opportunities, [...] interests, academic results, attitudes" (Guruge et al., 2021). However, these recommendation systems are mainly investigated for university students, not for employees that are learning in a workplace. Most commonly, the following data is used to make recommendations: personal data from the user (age, gender, education, and location), textual analysis of content in documents, and ratings of users about former recommendations (Guruge et al., 2021). According to their analysis of the literature, the following approaches have been used to build recommender systems (Guruge et al., 2021):

- Content-based
- Collaborative Filtering
- Knowledge-based
- Data mining
    - Association Rule Mining
    - Fuzzy logic-based
    - Machine-learning approaches
- Hybrid approaches
- Conversational Recommender Systems

Note that this list has no specific focus on course recommender systems, but recommender systems in general. In their review, Guruge et al. (2021) explain examples for each of these approaches. These are summarized in the following part.

**Content-based recommender systems** look at what the user liked in the past and recommend new things accordingly, either by asking explicitly or tracking user choices in a system. The risk with this method is that users could get over-specialized recommendations towards a certain field and no new insights. **Collaborative Filtering Recommender systems** also use data from users' previous choices but make connections to other similar users and predict what else the user could like, based on the user's own data, a common data set, and a user rating matrix. One example that uses this method is amazon.com, where systems handle the demographic data of the user and connect it to other similar people and their choices (Linden et al., 2003). There are different collaborative filtering recommender systems, i.e., memory-based, user-based, item-based, and model-based collaborative filtering. The last mentioned is used by Laghari (2014) in a course-recommender system for students at a university. Both Content-based and collaborative filtering recommender systems don't work well if there is not enough data yet. **Knowledge-based recommender systems** haven't been found in course recommendations but have the advantage of not being dependent on previous data because they use knowledge about the domain to make recommendations. Lastly, **data mining** approaches have been used to make recommendations to users in a system more personal by having a system that learns over time (Portugal et al., 2018). One sub-group of data mining is association rule mining, in which rules are created from recurring patterns between data items. There are different approaches to association rule mining, mainly differing in the performance of course selection for students, as Dol Aher & Lobo (2012) found in their case study. Another approach within data mining is

fuzzy logic, in which the uncertainty in users' choices is considered, and there is not only yes/no but more of a degree of how well the item matches. Using machine learning (ML) or artificial intelligence (AI) for recommender systems could be done with Bayesian, Decision Trees, Neighbor-based, Neural networks, Clustering, or gradient descent-based algorithms (Portugal et al., 2018). There are hybrid approaches that have been used to recommend courses and to improve the outcome and quality of the recommendation. Lastly, there are new studies about conversational recommender systems, asking questions to the user and step by step getting information from them to make personalized recommendations (Kumar & Ganapathy, 2020). Their study shows that approaches that are hybrid and are using data mining are increasing in the number of publications (Guruge et al., 2021). They also propose further investigations in conversational and fuzzy recommender systems to create more personalized help for learners and improve the quality of recommendations. (Guruge et al., 2021)

Another topic to consider when bridging skill gaps in industry is the inclusion of people who traditionally have been underrepresented. Creating environments and cultures that include women and black people would not only bring society closer to equality due to decreased wage inequality and an increase in inclusive products brought to the market, but also help bridge the lack of skilled talents (Brown et al., 2023; Cedefop, 2015).

To sum up, the frame of reference introduced industrial transformations followed by changes in work that result from new innovations. From the change in work, new skill needs arise, leading to a need for upskilling. The skill gap that arises from a changing environment is defined, and ways to measure and bridge this skill gap are presented. Within the bridging of skill gaps, the focus lays on work-integrated learning or upskilling, motivational challenges, and course recommender systems.

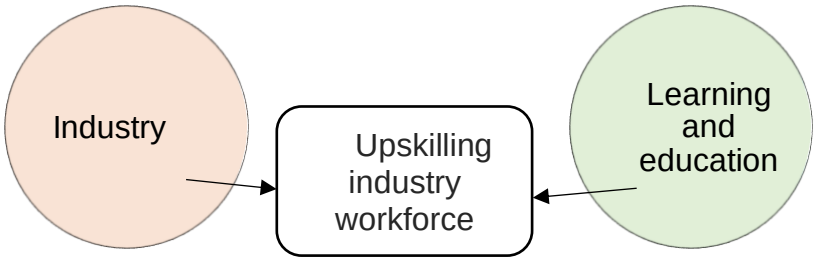
# 3

# METHODOLOGY

In this chapter, the author describes her background and worldview that made her choose the research approach for this thesis. This chapter also puts the thesis into context of research areas that are dealt with. Further, the methods used in the studies are explained and related to the research questions.

## 3.1 BACKGROUND

This research finds itself in the overlap between industry research and learning and education research. The intersection of those two research areas results in the topic of upskilling industry employees. Hence, the knowledge stems from mainly those two research fields. Knowledge is considered as the justified true belief and each research area has its knowledge. (Easterby-Smith et al., 2018)




## 3.2 SCIENTIFIC APPROACH

Industry is going through major transformations leading to discussions about the Future of Work and the increasing skill gap. This is a very critical problem since people are key in driving the sustainable, technology-enhanced transformation forward. Consequently, there is an urgent need to upskill those industry employees. This problem is understood as a practical problem since the current state of the situation leads to a concrete cost that is disadvantageous (Booth et al., 2008).

From an ontological perspective, I take a relativist way of seeing the nature of reality. Relativists often are interested in people's behaviour and mental capabilities and argue that there is not one way how someone behaves or sees the world, because everyone is an individual, coming from different backgrounds and experiences. (Easterby-Smith et al., 2018)

Naturally, the epistemological approach taken is social constructionism, pursuing a holistic understanding of the problem that is socially constructed. In a way, I'm part of the observed situation, finding myself as an engineer and a biased observer. However, it's not a strong constructionist perspective that I'm taking, since I'm still considering established theories describing reality as true. I want to gather data from various people and stakeholders of the problem (learning providers, learners, employers) and use a mix of qualitative and quantitative methods to collect data about the opinions of diverse individuals. One of the advantages of this epistemology is the possibility to generalize the analysis of the data of a sample. (Easterby-Smith et al., 2018)

Coming from an engineering background, I see things in a pragmatic way, having a strong will to identify a problem and wanting to find ways to solve it. The goal is to be able to give practical advice (Booth et al., 2008). Therefore, I take a pragmatic turn of the social constructivist stand, suitable for research done in organizations and using information systems (Kelder et al., 2005). This leads to the methodology that was chosen for this research, namely Design Research Methodology (DRM) (Blessing & Chakrabarti,

2008), in which a problem is identified, understood, and a solution is proposed as well as evaluated.

From the beginning, I took a deductive approach, taking the hypothesis that there is a skill gap and a research area about it, and I want to understand the problem and be able to identify ways to overcome it. In Figure 2, the ontology, epistemology, methodology, and the methods are described. In the following chapter, the research methodology and the methods will be presented in more detail.

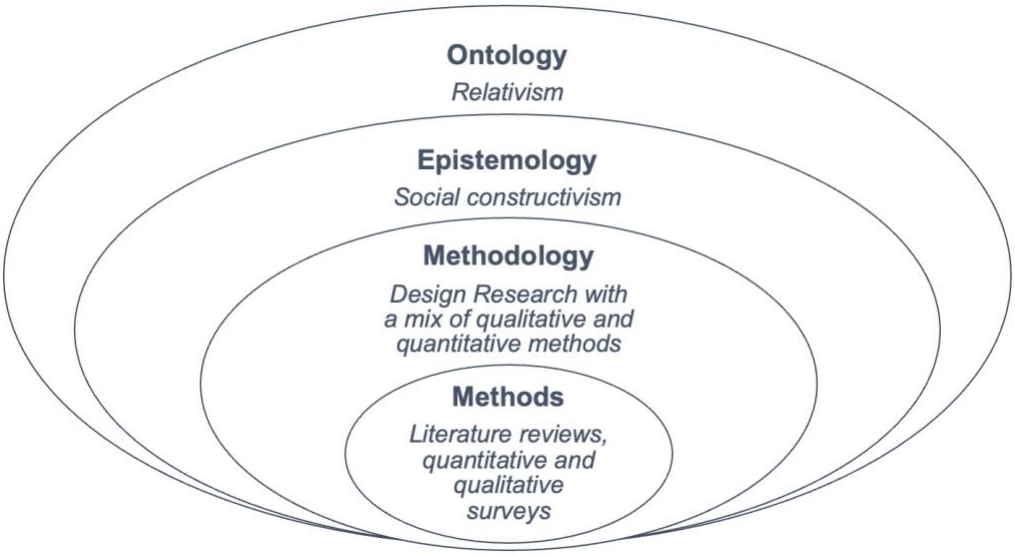



Figure 2 - Research approach for this thesis

## 3.3 RESEARCH DESIGN

The aim of this research is to define, measure and bridge the skill gap in industry. Due to the human-centred problem-solving approach used, I wanted to understand the problem first, and then see how to solve it. Hence, the research questions in this thesis are:

1) What is a skill gap in the industrial context?
2) How can skill gaps be measured?
3) How can skill gaps be bridged?

The three research questions have been set to drive the ambitious mission and are goal-oriented, they help to understand the problem and propose possible requirements for solutions to overcome it. When looking for suitable research methodologies for this work, I found several methodologies where researchers first understand the situation, then propose solutions and evaluate it. The Design Research Methodology (Blessing & Chakrabarti, 2009) was chosen to reach this aim since it addresses a problem by understanding it and then finding a solution and evaluating it. An alternative to this, but with a focus on information systems research, is the Design Science Research methodology (Peffers et al., 2007). Because of the general use of DRM, and the clear

steps, this approach was chosen. This methodology is described in the below section, including the methods used to achieve the outcomes in each step. In this licentiate thesis, the first two steps of the DRM are conducted, leaving steps 2 and 3 and eventual iterations for the planned PhD thesis work.

### 3.3.1 Design Research Methodology (DRM)

As mentioned above, this thesis follows the steps of DRM. DRM is a methodology that is focused on a problem and creates a support tool, that can come in various forms, depending on what the goal is. During the design, a need is recognized, and a solution is created to meet the need. In DRM, researchers go through four stages, and each of them has basic methods and main outcomes. Researchers go through these four stages and often do iterations between the stages (Blessing & Chakrabarti, 2009).

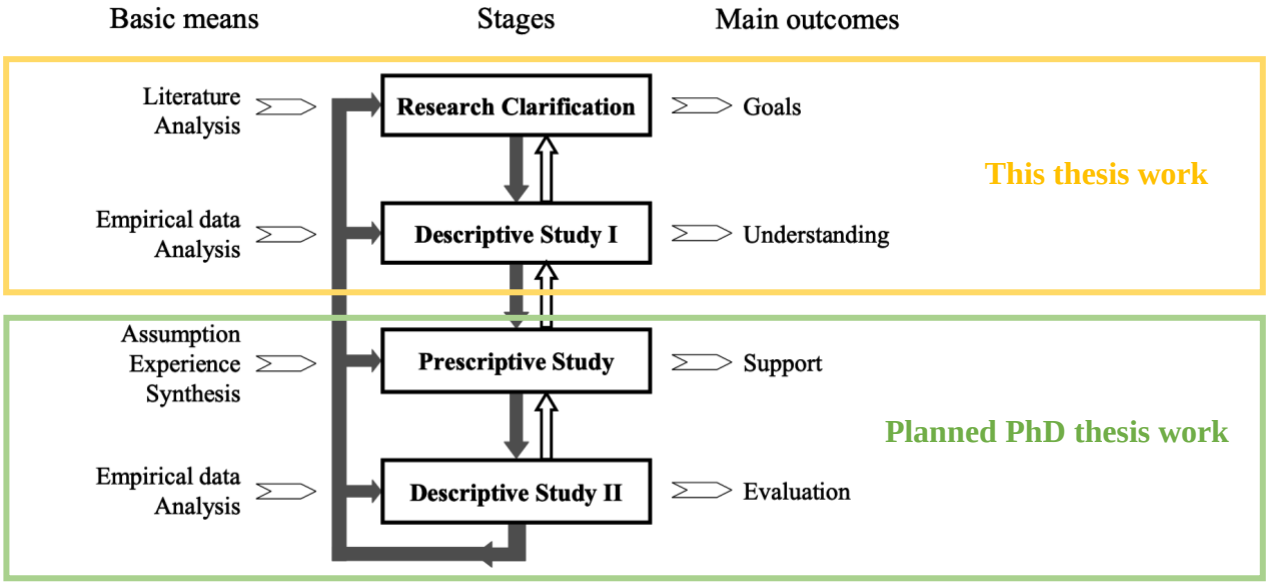



Figure 3 - Design Research Methodology stages (Blessing & Chakrabarti, 2009)

In the work of this thesis, the author went through these first two stages which are meant to be a preparation for the last two stages "Prescriptive Study" and "Descriptive Study II" in which the outcomes are support and lastly, evaluation. Those steps that are done in this thesis work are described in the following two sections. The arrows in between the steps highlight the iterations that the researcher is supposed to do. Sometimes, it will be necessary to go back from a stage to update the stage before, e.g., when Descriptive Study I has been done, one might want to change the goals. Or after the prescriptive study results in some kind of support tool, the researcher might want to go back and do another empirical analysis to understand the problem better and improve the experience. After Descriptive Study II, the researcher might want to go back and improve the support tool or redefine the goals. (Blessing & Chakrabarti, 2009)

### 3.3.2 Stage 1 – Research Clarification

The first stage is "Research Clarification". This stage aims at defining the goals, and finding evidence for the problem, often found by literature review. The result of this

stage is a description of the current situation where the problem exists and a description of the situation that is desired. In addition, the variables to measure the goals are defined in this stage.

In this thesis work, the research clarification stage was realized through a literature review of the changing work of industry employees (Paper I). This paper gave an overview of the topics that need to be addressed by companies to prepare their workforce for the Future of Work, and one of the identified topics was the development of knowledge, skills, and competence – highlighting the skill gap as one of the biggest challenges of organizations.

After the realization that the skill gap topic needs to be addressed, another literature review was conducted (Paper II) to find out how the skill gap in industry is understood, and how it could be measured. The studies found in the literature review were thematically analysed to be able to describe the skill gap and understand the problem even better.

### 3.3.3 Stage 2 – Descriptive Study I

The next stage is "Descriptive Study I", using empirical data analysis to support the understanding of the problem.

In order to understand how skill gaps could be addressed, in the descriptive study stage the different ways to measure skill gaps were identified by the literature review in Paper II. Measuring those skill gaps was decided to be a first step in being able to describe where someone is today regarding their skill set and where they want to go – and in the later stage be able to suggest a way to bridge their skill gap.

In order to address the topic not only from an employer perspective but the other actors that were identified in the literature review of Paper II, those perspectives – employee, employer, and education provider – were included as well.

Thus, the next step was to look at the challenges that employees undergoing upskilling are facing. In Paper III a quantitative survey was conducted with participants of an online upskilling programme for engineering-related skills. This survey was designed by researchers at Helsinki University to investigate students' motivational challenges regarding relevance and support, feedback, organization and structure, study approach, working-life competencies, and study burnout. The study showed that the enrolled learners face challenges within lack of feedback, lack of collaboration and support, and study burnout. However, most of the learners had a deep study approach, think the course is relevant, and can apply their new skills in their working life.

Furthermore, challenges and success factors for learning providers were identified by Paper IV, where a qualitative survey was sent out to learners in the online upskilling platform. In this survey, the learners were asked about what they liked and didn't like, and the free-text answers were replied by thematic analysis. According to the respondents, learning providers should focus on relevance, organization and structure, working life competencies, support from teachers, and collaboration with other learners – to address challenges and use success factors within those dimensions. By identifying

those dimensions, high-potential improvements were suggested. Those are 1) collaboration between universities to ensure relevant content, 2) framework for teachers to create their courses, 3) customized learning to meet personal needs, 4) platform to enable communication, and 5) collaboration between learners.

Lastly, Paper V gives an outlook on challenges to address when addressing the skill gap by matching them to suitable learning paths. This paper is an outlook into the next step of DRM – "Prescriptive Study" where a solution to the problem will be proposed. In this paper V, a literature review was done to understand what approaches different researchers have used to match people to relevant learning items, or jobs, or tasks by understanding how their job is changing due to trends.

### 3.3.4 Research strategy

To address the research questions and follow the steps of DRM, five studies were conducted and presented in paper I-V. The five papers that are included in reaction to the research questions are:

- Paper 1: Singer-Coudoux, K., Braun, G., Stahre, J. (2023) *Managing Change towards the Future of Work - Clustering Key Perspectives.* Article accepted in APMS 2023.

- Paper 2: Rikala, P., Braun, G., Järvinen, M., Stahre, J., Hämäläinen, R., *What does the skill gap really mean and how can it be measured? A review*. Submitted to journal Technological Forecasting & Social Change in June 2023.

- Paper 3: Braun, G., Järvinen, M., Stahre, J., Hämäläinen, R. (2022) *Motivational Challenges of Engineers Participating in an Online Upskilling Program. Proceedings* of the 21st European Conference on e-Learning, vol. 21, no. 1.

- Paper 4: Braun, G., Stahre, J., Rosén, B.-G., Bokinge, M. (2023) *Ingenjör4.0 – A National Upskilling Programme to Bridge Industry's Skill Gap.* Article accepted in CIRP CMS 2023

- Paper 5: Braun, G., Stahre, J., Hämäläinen, R. (2022) *Skills Matching for a Greener Industry 4.0-A Literature Review.* Advances in Transdisciplinary Engineering, vol 21, p.677-688.

RQ1 is about defining the skill gap, and paper II contributes by synthesizing definitions from literature, to be able to understand the problem better. RQ2 is about measuring skill gaps and gets implications mainly from paper II, in which approaches used by researchers in literature are found. RQ3 deals with bridging the skill gap from a managerial perspective (paper I), from employees' perspectives (paper III), from employees' and education providers' perspectives (paper IV), and from a holistic perspective (paper V). See Table 2 for a summary of the conducted research activities and how they are aligned with the RQs and the stages in the DRM. For more details about the methods used in the papers see the appendices.

Table 2 - Research activities and their alignment with the appended papers.

| | Paper I | Paper II | Paper III | Paper IV | Paper V |
|---|---|---|---|---|---|
| RQ1 | | x | | | |
| RQ2 | | x | | | |
| RQ3 | x | | x | x | x |
| Stage in DRM | Research Clarification | Research Clarification | Descriptive Study I | Descriptive Study I | Research Clarification |
| Research activities conducted | Literature review about managerial topics to prepare for Future of Work | Literature review to define skill gap + understanding ways of measuring skill gaps | Quantitative survey to identify challenges and opportunities regarding participants' learning | Qualitative survey to identify dimensions of challenges and success factors from the learners' perception | Literature review to define the necessary parts and actors in a skill matching system |

# 4

# RESULTS

In this chapter, the results of research based on the three research questions are presented. Those results are documented in five appended papers. The three research questions have been a driving force in reaching the aim of this work.

To get an overview, the following table presents the main contributions of each paper for the three research questions. The first research question RQ1 is about defining the concept of skill gap in an industrial context. RQ2 is about the approaches that have been used to measure skill gaps. RQ3 is about challenges and success factors to bridge the skill gap in the industry.

In the following table, the purpose of each paper and the main contributions related to each of the research questions are summarized. The table serves as an overview and the results will be presented in more detail in the sections below the table.

Table 3 - Summary of the main contributions from the appended papers

| Paper | Purpose | Main contribution to RQ1 | Main contribution to RQ2 | Main contribution to RQ3 |
|---|---|---|---|---|
| I | Understand how "Future of work" is evolving and what topics companies need to address. | | | Overview over relevant topics to address regarding knowledge, skill, and competence development in companies. |
| II | Defining the skill gap by synthesizing different understandings. Find approaches to measure skill gaps. | Overview over the vast understandings of the concept skill gap and proposal of a definition. This definition is that a skill gap is the gap between demand and supply of certain skills, resulting from 3 actors' expectations: employers, employees, education providers. | Overview over approaches to measure skill gaps. Most often used: create a skills framework, create survey, and ask employers or employees about importance and performance of those skills. | |
| III | Identify motivational challenges that employees face in their learning, to be able to address those and bridge skill gaps. | | | Challenges in bridging skill gaps lie within motivation and concern study approach, organisation and structure, relevance and support, feedback, mental wellbeing, and working life competencies. |

| | | | | |
|---|---|---|---|---|
| IV | Identify challenges and success factors within online upskilling programmes and supporting learning providers' development. | | | Challenges and success factors in online upskilling are individual. Suggested potential improvements for learning providers of upskilling programmes are collaboration between universities, frameworks for teachers, customized learning, communication with teachers, collaboration with other learners. |
| V | Map research regarding skills matching to tailorize learning pathways | | | Overview over matching as a tool to bridge skill gaps. |

## 4.1 RQ1 - THE SKILL GAP

This section reports the results of RQ1 – "What is a skill gap in the industrial context?". Paper II provides answers to this question.

The term skill gap has been used in various ways, meaning that there are different gaps in relation to skills (paper II). According to the synthesized definitions from the literature review in paper II, the skill gap results in the gap between the demand and supply of skills for industry (Arcelay et al., 2021). Most often these skill gaps are caused by technological development, new requirements on sustainability, and an ageing population (paper II). Either the gap can be about the skills that a company needs in relation to the skills that the existing employees possess or not, or the skills of potential employees (Quintini, 2011). Anyways, the changing environment forces companies to set new goals, and they risk lacking behind and losing competitiveness if they don't adopt those. Due to the quickly changing business environment, some of the employees' skills become outdated, and new skills become in demand (Qiu et al., 2020). Hence, it is not sufficient to fill the skill gap by recruiting new employees - existing employees need to learn new skills (Adepoju & Aigbavboa, 2020). In industry, most commonly, the concept of skill gap is used to describe the missing skills among existing employees that are necessary to do certain tasks or reach certain goals in relation to what their employer requires (Abbasi et al., 2018; Adepoju & Aigbavboa, 2020; McGuinness et al., 2018). Interlinked with skill gaps is the training that education providers offer. Education providers need to adapt to new skill needs and the education they offer (Akdur, 2021; Babic et al., 2022). Figure 4 gives an overview of how to understand the skill gap.

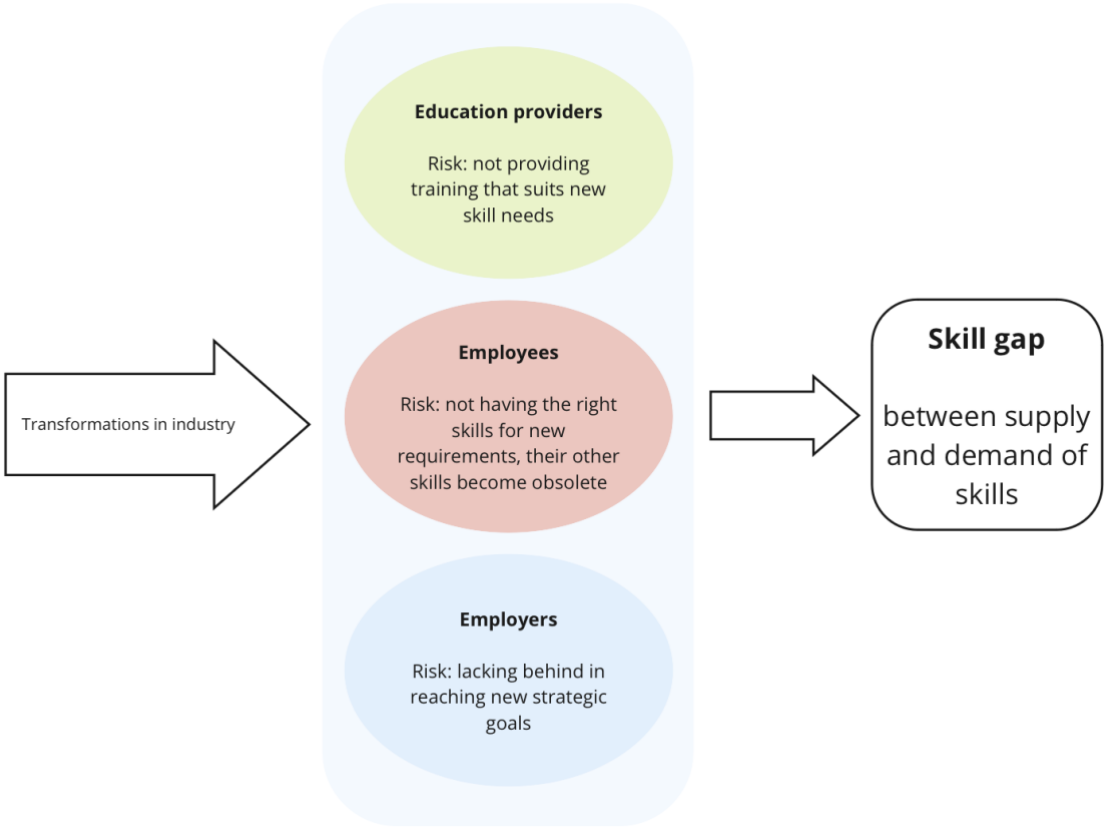



Figure 4 - Explaining the skill gap (adapted from paper II)

As paper II shows, the term "skill gap" has been used in various ways and as a synonym to describe a skill mismatch, surplus, obsolescence, or shortage. The term "skill shortage" is often used when it's hard to fill vacant job posts because there are not enough candidates to fill the job (Chang-Richards et al., 2017). "Skill mismatch" is when the supply and the demand for skills aren't in balance, often concerning certain geographical places (Cohen & Eyal, 2021). In some cases, the gap is described in connection to the training that education providers offer and which skills the industry or certain companies demand, hence could be called education gap (Babic et al., 2022).

This work mainly focuses on the concept of skill gap, as the gap or difference between the skills that a company demands and the skills that the employees possess (Adepoju & Aigbavboa, 2020).

To that end, the skill gap has been investigated from the perspective of employees, employers, and education providers. The changing environment leads to a change in the requirements of employers, a change in what employees need to learn, and what learning providers need to offer for training. To define the skill gap, data from all three perspectives should be considered to come as close to the actual skill gap. All three players – employees, employers, and education providers – play a big role in addressing the skill gap (paper II).

Based on the included studies, the skill gap was defined as the difficulty of having the

right skills to the right people at the right time (paper II). If the skill gap would be bridged it could enhance employee productivity, improve organizational performance, and increase value creation (Ayodele et al., 2020). The fast technological development leads to changes in business models, products, processes, and digitalization of organizations. This leads to a new way of producing, delivering, and using products and services (López Peláez et al., 2021).

## 4.2 RQ2 - MEASURING SKILL GAPS

In this section, the results for RQ2 are described. RQ2 was "How can skill gaps be measured?". The results for this question stem from the appended paper II.

In the study connected to paper II, the authors derived an overview of the approaches used by researchers to measure skill gaps. In the included approaches (references are examples, all references are in the appended paper II), the data was collected by either surveys (Moldovan, 2019), interviews (Morris et al., 2020), focus group workshops (Anshari & Hamdan, 2022), data analysis (Li et al., 2021), or creating skills frameworks (Babic et al., 2022). The sources for the data collection were students, employees, employers, learning providers, literature review, databases with job profiles, or professional social networks (paper II). Some researchers followed several of these mentioned steps.

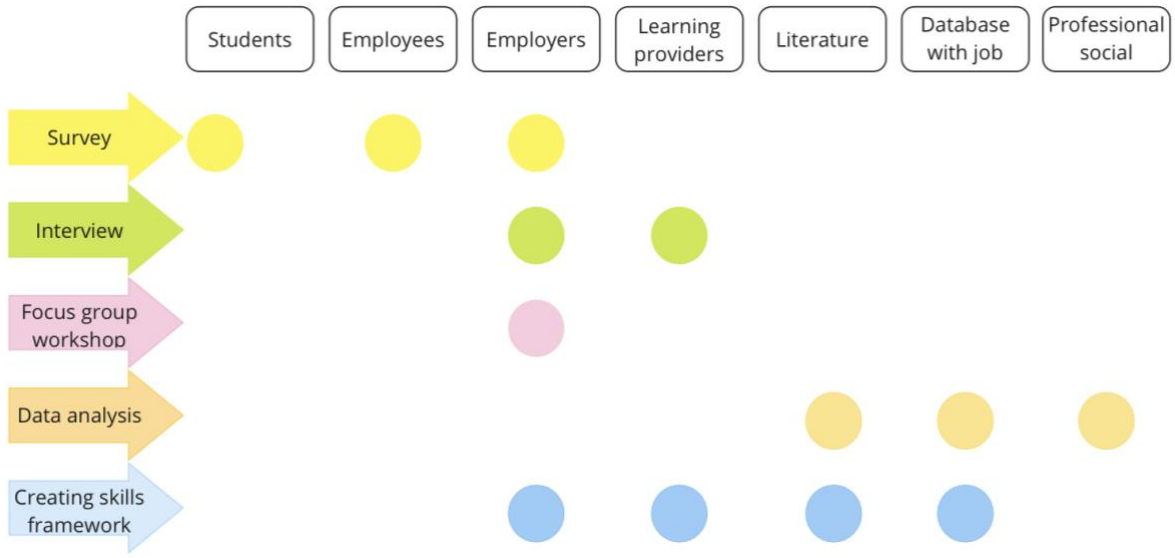



Figure 5 - Approaches to measure skill gaps (adapted from paper II)

Most often, the studies started with the creation of a skills framework, either gained from a literature review or expert interviews, or both, and from using the course curriculum of education providers. In the next step, the researchers used this skill framework that was relevant for a certain job profile or domain to create a survey about these skills and asked about the importance or the performance of these skills (Do et al., 2023). This survey was either sent to employees or employers or to both. If sent to both, the answers could be compared (Zheng & Shi, 2022). The steps following this approach

are presented in Figure 6.

None of the included papers validated their results but Qiu et al. (2020) evaluated the students with knowledge tests and Zheng and Shi (2022) compared results from different sources.

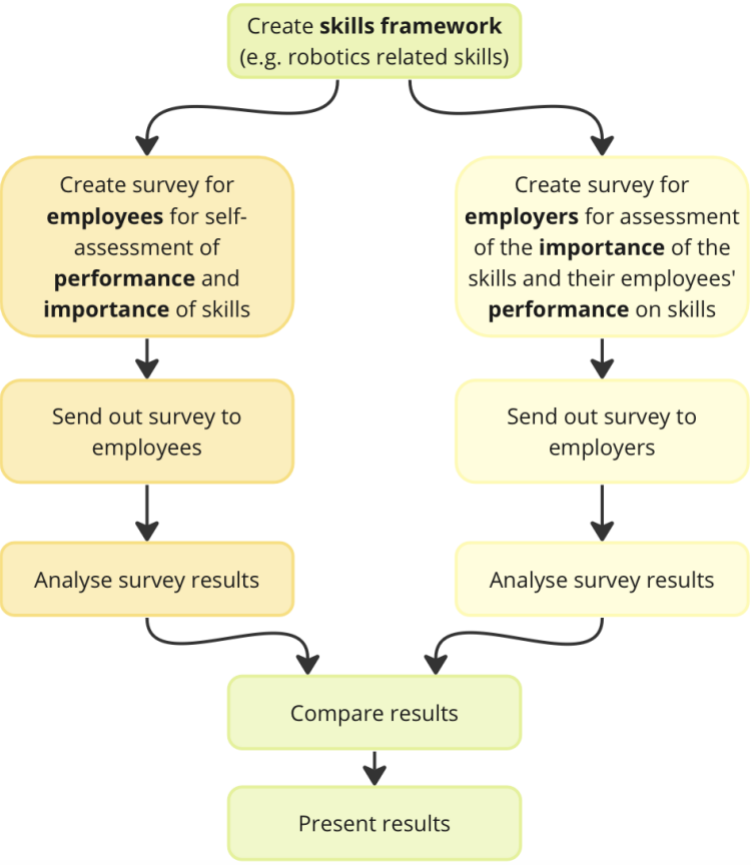



Figure 6 - One possible approach to measure skill gaps (adapted from paper II)

## 4.3 RQ3 - BRIDGING SKILL GAPS

This section summarizes the results for RQ3, which is "How can the skill gap be bridged?". The answers for this RQ come from papers I, III, IV, V. There are many challenges that need to be addressed when bridging skill gaps. As the results from RQ1 show, the skill gap is a gap between the skills that employers require and the skill their employees possess. Connected to the skill gap is the education gap, which describes the gap between employers' skill needs and the offer of education providers. Both the skill gap and the education gap indicate the need to upskill the workforce, which will be the aim of RQ3. Some of the ways to address the skill gap are presented in this chapter, starting with the management perspective, to the learners' perspective, the learning providers' perspective, and finally some supporting technological tools that could support bridging the skill gap.

### 4.3.1 Managing change to bridge skill gaps

The skill gap is part of the broader topic of Future of Work in industry, because when work changes, tasks and skills do, too (Braverman, 1998; Grant & Parker, 2009). Paper I gives an overview of the topics addressed in research regarding Future of Work in industry. To understand the context in which companies and workers are finding themselves in, a literature review was done to understand the changing organization of companies when it comes to work. The literature study focused on Future of work in industry and the identified relevant studies were clustered into nine topics that should be addressed to manage change towards Future of work. Those nine topics are 1) Knowledge, Skills, and Competence Development, 2) Leadership, 3) Collaboration and Communication, 4) Corporate Culture, 5) Work Forms, 6) Workplace and Work environment, 7) Technology Infrastructure and Strategy, 8) Occupational Health and Wellbeing, and 9) Digital Organization and Network. Figure 7 shows those nine topics. All these topics influence people in the workplace and how, when and where they do their work. Concerning skill gaps, all these nine topics influence employees' skill needs, but also the skills leaders need (Greimel et al., 2023).

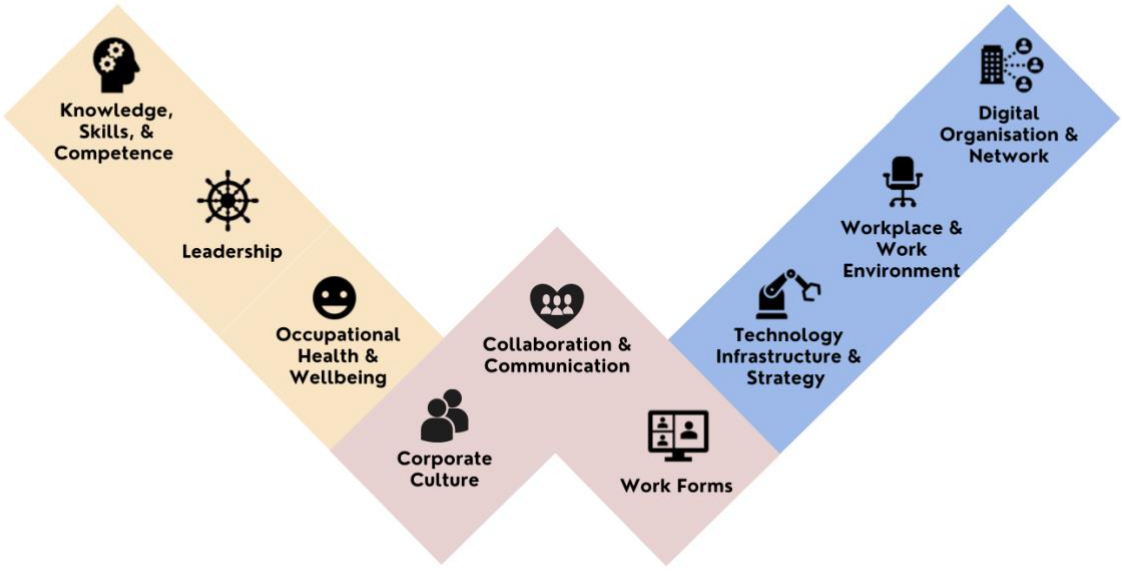



Figure 7 – Key discussion topics regarding Future of Work (adapted from Paper I)

Further, paper I reveals that within the organization, there are many topics that need to be addressed, to be ready for the Future of work, and bridge not only skill gaps, but gaps or lacking behind in leadership, collaboration and communication, corporate culture, work forms, workplace and work environment, technology infrastructure and strategy, occupational health and wellbeing, and digital organization and network. All these things require change to create a place for employees to act within new circumstances (paper I).

The identification of the Knowledge, skill and competence development topic shows there are emerging challenges for companies in bridging the gap between which skills

are demanded from employers and which skills the employees possess. Which skills are needed is highly impacted by Digital organisation and Network, the Workplace and work environment, and Technology infrastructure and Strategy. Upskilling the workforce is also dependent on having the right Leadership, Corporate culture, Collaboration and communication, and work forms in place. It is also crucial to consider Occupational Health and well-being when making upskilling a part of every worker's job (Paper I).

It is important to understand the consequences of the lack of skills, i.e., the insufficient technology adoption or implementation of new business models. This in turn can lead to the shortfall of sustainable business models, such as servitization (González Chávez et al., 2023). In addition, new learning approaches are needed to overcome the challenges of learning in the digital era, such as mixed reality (Pimminger et al., 2022), E-learning (Shahriar et al., 2023), Blended learning (Kelly & McNair, 2022), and Gamification (Keepers et al., 2022; Smith, 2011).

There are many different actors that need to be involved in order to support employees in finding their learning and bridging the skill gap (Paper V). Those are employers, human resources, educators, institutions, policymakers, and individual learners/employees (Paper V).

Paper V dealt with matching skills to individuals, to address their skill gap. In paper V the goal was to understand the bigger picture of what is needed to support employees in understanding their skill gap and mapping actions to address their skill gap.

The overarching goal when measuring skill gaps is to pinpoint goals for an individual employee regarding their skill development, and career development according to the needs of their operating environment, or the needs of their employer specifically. Being able to measure a skill gap of an employee or the skill gap for a company, department, or team is the first step in suggesting a learning path (Paper V).

The studies included in the literature review in paper V deal with matching between 7 different parts: tasks, machines, employees, skills, trends, job profiles, and training. All these aspects can be considered when matching skills to employees. In some studies, tasks were matched to employees or machines. In some cases, trends were matched to job profiles. Some matched skills to training. Some matched employees to job profiles.

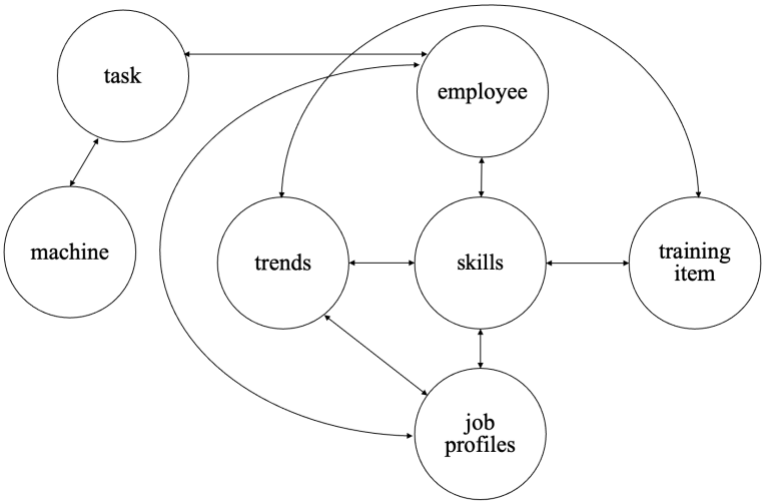



Figure 8 – What has been matched in recent studies (adapted from paper V)

### 4.3.2 Learners' motivational challenges when bridging skill gaps

Paper III used the "HowULearn" (Parpala et al., 2021) questionnaire to identify the challenges of participants taking part in the online upskilling programme Ingenjör4.0, created by 13 Swedish universities. Even if the participants in the survey have decided to enrol in a learning programme, there is still a risk of dropping out. A study about massive open online courses (MOOC) shows that less than 13% of registered learners complete their learning (Onah et al., 2014). The identified challenges in paper III have an impact on the motivation of the learners and can be used to improve the learning experience in online upskilling programmes. Those identified challenges are the lack of satisfying feedback, the lack of collaboration and support among other learners, and some respondents feeling study burnout. However, the results also showed positives, i.e., most respondents have a deep study approach which means they are very interested in learning more, and think what they learn is relevant, and can apply their knowledge from the platform in their work life. From the questionnaire, motivational challenges can be clustered into the topics (Parpala et al., 2021):

- Study approach
- Organization and structure
- Relevance and support
- Feedback
- Mental wellbeing
- Working life competencies

These dimensions were well reflected in paper IV, where qualitative answers were collected and thematically analysed. The study presented in paper IV showed that the respondents (again participants in the Ingenjör4.0 online upskilling programme) see the following areas as challenges and success factors (see Figure 9).

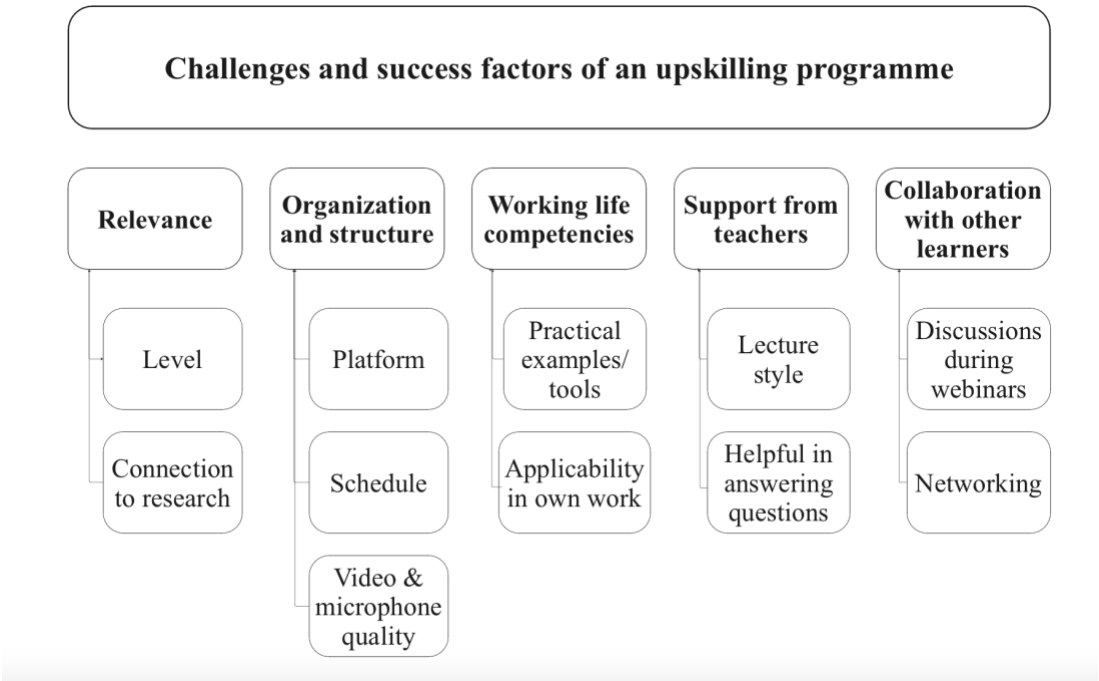



Figure 9 - Challenges and success factors of an online upskilling programme (adapted from paper IV)

These dimensions can be reflected by their challenges, but also success factors since respondents highlighted both positive and negative aspects within these areas. Regarding relevance, some respondents wanted more depth while others felt it was too difficult. Some respondents mentioned the successful connection of the content to research. Regarding organization and structure, respondents highlighted the technical strengths and weaknesses of the platform. They also talked about the strength of having flexible schedules, but sometimes difficulties to make time for the live webinars. Some respondents commented on the possibility to improve the video and microphone quality. Working life competencies were achieved by practical examples and tools, according to many respondents. Many respondents highlight the applicability of the content in their own work. The helpful support from teachers was mentioned as a success, where lecturing style and answering questions were among those important factors. Finally, the collaboration with other learners was talked about by many respondents. Specifically, they mentioned the discussions during webinars and networking opportunities in the platform as something they liked. (Paper IV)

### 4.3.3 Challenges and success factors for learning providers

As the challenges and success factors from the perspective of learners in an online upskilling programme were identified, this chapter presents high-potential improvements of such a platform. These findings stem from paper IV and could be implemented by learning providers to increase the satisfaction of their learners and decrease the dropout rates. The identified dimensions in chapter 4.3.2 were discussed with the Ingenjör4.0 upskilling programme leadership team and some high-potential improvements were identified. The comments from the respondents about relevance

showed that the collaboration between universities is highly appreciated, leading to the dissemination of state-of-the-art knowledge. However, the answers of the respondents regarding relevance, organization, and structure, working life competencies, and support from teachers differed which is why there is a challenge of adapting to each individual. Hence, one high-potential improvement could be to offer customized learning to meet the individuals' needs, by e.g., adapting to the level of the learner, their learning style, their career goal, or their schedule. The comments made about organization and structure make clear that the framework that is used by teachers to build their learning modules in the platform unifies the collaborative efforts. In addition, the platform and the webinars can be used and improved to support the communication between teachers and learners. Lastly, the collaboration between learners can be enabled by having a social network for the learners, to empower them and encourage collaboration. The findings are presented in Figure 10.

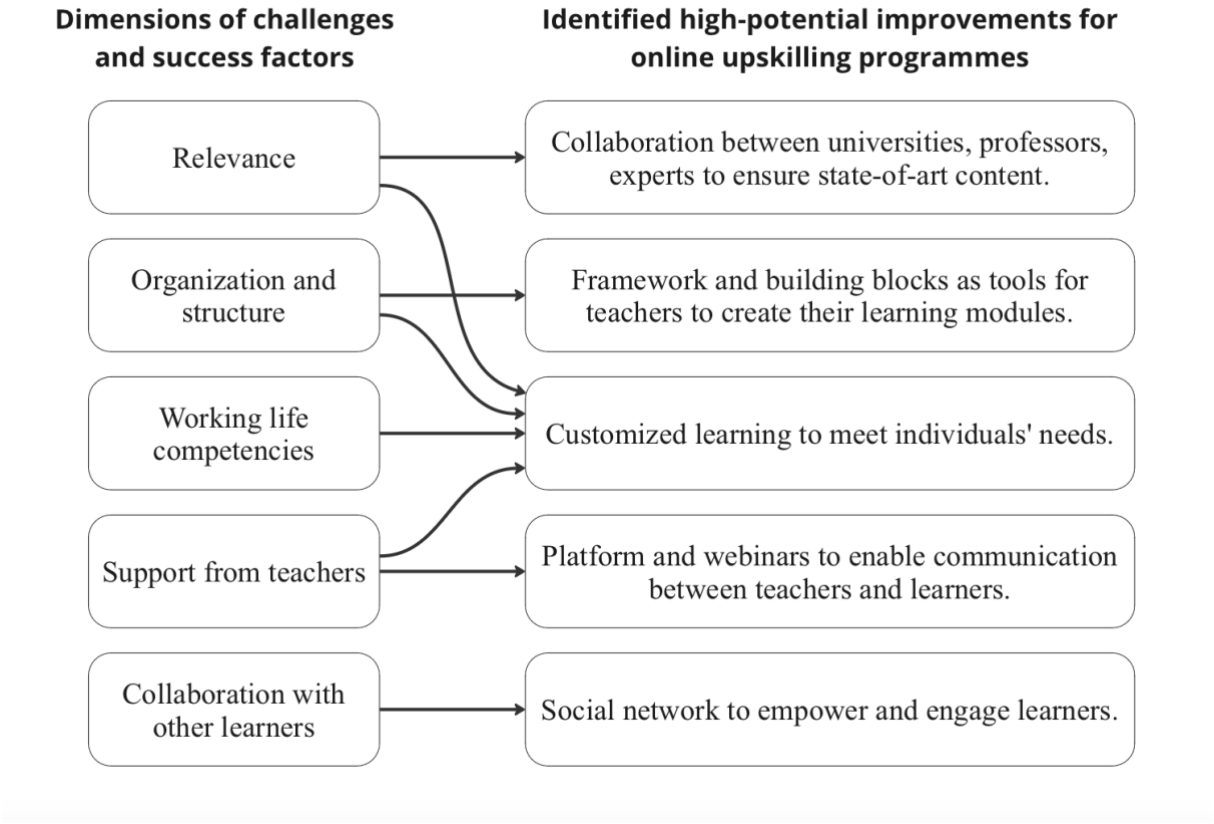



Figure 10 - High-potential improvements for online upskilling programmes (adapted from paper IV)

### 4.3.4 Using matching technology to bridge skill gaps

The studies included in the literature review of paper V highlight the need to support human resources and managers with technology-enabled tools. Generally, technology can help to automize tasks that humans don't have time for. One of the challenges of bridging the skill gap is the amount of people that need upskilling, meaning that managers and human resources would have to help many people.

Pontes et al. (2021) suggest a concept to match trends, job profiles, skills, and training programs for manufacturing skills. One way of using technology is to extract job-, skills-, and task data from databases or professional social networks or to match trends, skills, employees, tasks, tools, job profiles and learning to each other. The study by Solinas et al. (2020) uses the text-mining technology Named Entity Recognition (NER) and a new way of extracting soft skills from text, to decide if a job profile is ready for the Future of work.

Another study presents the Job-Know ontology which is a model with a supply space, a demand space and a matching space (Ansari et al., 2020). This study intends to match tasks to machines and people. These three spaces – demand, supply, and matching – are also used in another study where the authors present a learning assistance system that recommends learning to employees, relevant to their current skills and their productivity curve (Khobreh et al., 2019).

Existing databases of job profiles, tasks, and skills have been used by researchers to work with solutions to measure the skill gap. One example is the database O*NET, created and maintained by the US Department of Labour, used for example in the studies of Solinas et al. (2020), DeMark and Kozyrev (2021), Fareri et al. (2020). Another such database is ESCO, the European Skills, Competency, and Occupations, by the European commission, used as well by (Solinas et al., 2020) and (Fareri et al., 2020). Solinas et al. (2020) investigate how text-mining technologies can be used to extract relevant data from these databases.

Resulting from paper I, there is ongoing research on how to use AI, ML, and NLP in HR Management (Bothmer & Schlippe, 2022). In their paper, Bothmer & Schlippe (2022) suggest an AI-support tool for recruiters and job seekers by using NLP and extracting skills data from job seekers' profiles and job advertisements. Another study by Ifenthaler et al. (2022) summarizes how these technologies can be used to identify, align, and assess employee competencies, but highlight the need for more research to validate how well these tools actually support companies. In addition to the results of papers I and V, there are some recent trends that should be mentioned at this point. With the rise of Generative AI, the way we as humans work is discussed in all kinds of jobs and will impact what tasks we do and what we let AI do (Jesuthasan, 2023).

# 5

# DISCUSSION

As a result of the studies in the five appended papers, this thesis brings light into the concept of skill gaps by first, providing a clear definition that can be used by researchers to focus future studies, and by industrial players to address the topic in their companies. Secondly, this thesis gives a clear overview of the approaches that could be used to measure skill gaps. Thirdly, the thesis supplies directions to overcome the hurdles when bridging skill gaps. The discussion chapter will guide you through a critical reflection of the methods and results and make clear what contribution this thesis makes regarding the set frame of reference. Lastly, future work is proposed.

## 5.1 VISION AND MISSION

This thesis is tangent to a multitude of urgent topics in society. As described in the frame of reference, several researchers and policymakers have emphasized, skilled talents are key to driving innovation forward (European Commission, 2022b; Grant & Parker, 2009) and are needed to create a sustainable and resilient industry (Auktor, 2020) for societal prosperity. Through conducting this work, I have gained more and more confirmation that this topic is urgent, and the skill gap needs to be bridged, by reading about the changing work and a resulting need for upskilling (Brynjolfsson et al., 2023; World Economic Forum, 2016) and the announcement of new regulations, such as the New European Innovation Agenda (European Commission, 2022b)

The mission of this thesis is to define, measure, and bridge the skill gaps of selected industry professionals who primarily have engineering backgrounds. In short, the research carried out and summarized in this thesis, in particular through the appended papers I, II, and V, contributed to this mission by understanding the problem. The "skill gap" was generically defined by synthesizing definitions from literature (Paper II). Approaches to measuring skill gaps were compiled and analyzed (Paper II). Challenges and success factors when bridging skill gaps were found (Paper III) and solutions to bridge those challenges were finally proposed (Paper IV, V). The research resulted in a clear definition of skill gaps in an industrial context, a summary of approaches that have been used to measure skill gaps, and recommendations for employers, employees, and education providers when bridging skill gaps.

However, the mission isn't completed until the vision of having the right skills with the right person at the right time is fulfilled. So far, an understanding for the problem and some underlying factors have been established. It remains to implement and test solutions to bridge the skill gap to be able to roll-out an impactful solution, as described in chapter 5.5 Future work.

## 5.2 DISCUSSING THE RESEARCH QUESTIONS

### RQ1: What is a skill gap in the industrial context?

This research highlights that skill gaps can be defined from three perspectives or interest groups – employee, employer, and education provider, leading to the complexity of defining the skill gap. In literature, the term "skill gap" has been used in mainly this way: a skill gap is a gap between the skills that employers demand and the skills that employees possess (Abbasi et al., 2018; Adepoju & Aigbavboa, 2020). Related terms (Cohen & Eyal, 2021; Quintini, 2011), such as "skill shortage" has been described as the lack of potential employees that employers want to hire (Chang-Richards et al., 2017), and a gap between the skills that educators teach and the skills that employers need has here been called "education gap" (Akdur, 2021). At this point, there is a value in choosing the definition for skill gap but keeping the others and defining connected actions for the three gaps connected to the holistic problem. Since other researchers have struggled before with understanding the term and connected terms (McGuinness et al., 2018), this can help in clarifying the topic. This shows that there are many challenges concerning the skill gap, making it a complex problem. It also shows the importance of

communication between employers, education providers, and employees, and clear communication when doing research about the topic – which gap is described? This is challenging since the skill gap is constantly impacted by changing business environments and an evolving labour market (McGuinness et al., 2018; Rikala et al., 2023). In all three gap definitions, employers' perspectives are considered (Jesuthasan, 2023; World Economic Forum, 2020a, 2023b), but in the end, it's the employee who has to do the learning.

In this thesis, the focus lies on the skill gap describing the gap between the skills that employers require from their employees and the skills that the employees possess (Paper II). The establishment of the definition for this work comes from the strong indications (Paper IV) for a need to upskill the existing workforce as a solution to bridge the skill gap (Deloitte, 2018). In combination with the fact that many countries face demographical changes leading to a decreased workforce (Eurostat, 2019), relying on recruiting suitable talents seems not to be enough, which is why I chose to focus my work on upskilling the existing workforce to bridge the skill gap. Focus on upskilling is also highlighted in the Future of Jobs report (World Economic Forum, 2016) and the New European Innovation Agenda (European Commission, 2022b) as the most urgent action. Hence, as described in Paper II, it is crucial to identify skill gaps of employees in relation to what their employer demands, to know what upskilling is needed. With this in mind, the skill gap can be described for an individual, but also for a group of professionals.

To sum up, in general, the skill gap in industry can be described as the gap between the supply and demand of skills and can be found between three actors: employees, employers, and education providers (see Figure 4). The skill gap can be caused by changing business environments (e.g., digitalization, sustainable transition), but also by insufficient actions from employers, employees, and education providers. Within this work, the definition of the gap between the skills that an employer demands and the skills their employees possess has been the main focus (Rikala et al., 2023), but also the role of education providers and their role in supplying training for skill development has been investigated, hence addressing the "education gap". Defining the skill gap has helped to decide where actions are needed and where to focus this research, and get over the confusion of overlapping concepts (McGuinness et al., 2018). RQ2 and RQ3 are clearly linked to the skill gap, measuring the gap between what skills employees need to learn, and the role of education providers in bridging the gap.

### RQ2: How can skill gaps be measured?

After defining skill gaps in RQ1 and what part to focus on, the next step was to know how to measure the gap between the supply and demand of skills. The literature review (Rikala et al., 2023) gave well-needed insights into how the skill gap can be measured. Even if the main focus was to find out how to measure skill gaps according to the definition "skill gap is the gap between the skills that employers demand and the skills that employees possess", for the review, also skill gaps/shortages and education gaps measurements were investigated, to see what can be learned and how to address the topic in a holistic way (Rikala et al., 2023). However, this opens up a discussion of an appropriate description of both skill supply and demand (Rikala et al., 2023) – and

according to Hattie and Timperley (2007), supply could be found by asking "Where are you?", and demand by asking "Where do you want to go?". The understanding of demand and supply of skills is shared with Ansari et al. (2020) and Khobreh et al. (2019) who defined a "demand space" and a "supply space", and they have a "matching space" in between the two spaces. Hence, RQ2 deals with how skill supply and demand can be measured.

The results indicate there is no straightforward measurement strategy (McGuinness et al., 2018), considering that the skill gap is something intangible and thus hard to measure. Skill gaps are perceived from various perspectives, e.g., employee, employer, and education provider (Adepoju & Aigbavboa, 2020; Do et al., 2023). As said before, skill gaps also have a time dependency. However, only some of the included studies take all perspectives into account, and none is observing change over time (Paper II). In a work context, skill gaps are often measured by comparing the qualifications in open vacancies that a company puts out with the qualifications of the employees or potential employees (Bothmer & Schlippe, 2022; Brunello & Wruuck, 2021). What is missing is the connection to the individual, that in the end, does the learning. Most of the reviewed studies focus on labour markets in general or on companies' skill gaps, and not so many focus on individual employees. As stated in Paper IV, the learning needs to be adapted to everyone, based on their skill gap. To address the skill gap of employees in a company in relation to what their employer needs, the employee needs to know their skill gap and what suitable learning there could be.

Researchers have used different approaches to measure skill gaps (Bothmer & Schlippe, 2022; Chang-Richards et al., 2017; Cohen & Eyal, 2021; Do et al., 2023; Zheng & Shi, 2022), but an evaluation of those approaches is missing (Paper II). Only a few of the included studies evaluated their results by comparing different measurement methods or using knowledge tests (Qiu et al., 2020; Zheng & Shi, 2022). Hence, there is no proof that what was measured is the actual skill gap, but one could still argue that the studies are proof of an existing skill gap.

The approach that was used most to measure skill gaps was to define a skill framework with the relevant skills for a certain job profile or field, and then create a survey to ask about the performance and the importance of those skills. The survey was sent out to employees for self-assessment and employers to assess their employees (Do et al., 2023).

Most of the included papers in the literature review (Paper II) used the perspective of employees, employers, and education providers (see Figure 4) to measure the skill gap, which could be a reason to include all three perspectives in future studies as well, knowing that the collaboration between these three stakeholders helps to bridge the skill gap. In the papers included in the literature review (Paper II), data about the supply and demand of skills was collected from students, professionals, employers, learning providers, databases, and professional social networks. This data was collected through surveys, interviews, focus group workshops, data analysis, and by creating a skills framework (Paper II). Even though none of the studies cited in the literature review (Paper II) measures skill gaps over time, they propose what methods to use to find data about the supply and demand of skills and from where this data can be collected (Paper

II), so there is nothing contradicting the implementation of skill gap measurement at several times.

The main takeaway from this question is that the skill gap can be measured in different ways, depending on the goal of the measurement. As this work focuses on the skill gap of employees in a company, skill frameworks should be set up according to what their industry or their firm needs, and surveys should be sent out to employees and employers, to find out about the importance and performance of the skills. In this way, a skill gap for a certain person can be identified and actions to bridge their individual skill gap could be started. Since this hasn't been tested or evaluated, there is a need to do so in future studies.

### RQ3: How can skill gaps be bridged?

Gartner (2020) claims that skill gaps can be bridged in two ways – either by recruiting skilled people or by upskilling the existing workforce. They also highlight that to date, there aren't enough suitable talents on the market, meaning that it's hard to recruit. According to Deloitte (2018), upskilling and recruiting suitable talents are solutions, and they add that augmenting the workforce also can help bridge skill gaps. Connecting this with the fact that the demographics show a declining trend (Eurostat), there is a need to upskill the workforce in order to bridge the skill gap, since young people are rare. This view is shared with policymakers (European Commission, 2022b), organizations (DHL, 2021; Gallup/amazon, 2021), and academics (Li, 2022). Still, it remains relevant to also investigate how to match talents with suitable jobs, and the other way round (Bothmer & Schlippe, 2022; Cukier, 2019), but this is not the focus of this thesis.

Researchers have been focusing on different perspectives when investigating the Future of Work and skills. The articles included in the literature review in Paper I found topics for managers to work towards the Future of Work, and how they can get prepared, but also showed that there are many changes within the nine topics that impact the work employees do. Even though employees are impacted, those papers don't give clear implications on what employees can do. The topics include skill development, leadership, collaboration and communication, corporate culture, work forms, workplace and work environment, technology infrastructure and strategy, occupational health and wellbeing, and digital organization and network. To support learning and bridging skill gaps, managers should work on understanding the skill gap of their employees and how they can support the learning of their employees (Greimel et al., 2023), resulting in a changed need for skills. However, the literature review didn't give any insights into how employees can support the change, leading to an assumption that employers or leaders play an important role in driving change (Greimel et al., 2023). Still, there are some indications on how to support learning e.g., by gamification (Keepers et al., 2022).

However, papers III and IV showed that there are challenges for employees when facing their skill gap. Motivational challenges were investigated, and what needs to be considered to increase motivation is the study approach of the learner, how the organization and structure of the learning environment support the learner, how relevant the course is for the learner and if they feel support, if they get feedback, if they feel mentally well, and if they learn competencies that can be applied in working life.

Reports show that time and financing can be challenging factors, too, when employees upskill (DHL, 2021; World Economic Forum, 2020a).

However, education providers play a major role in delivering learning that catches the learner and brings them closer to their learning goal. The identified potential success factors (paper IV) of how online upskilling programmes can help to bridge the skill gap are: collaborating between universities; having a standardized way for teachers to build their online learning; tailor learning to individual needs in terms of learning style, level of difficulty, and relevance of the content; having a platform where teachers and learners can communicate; having a social network for learners to connect.

To bring those three perspectives (employer, employee, education provider) together, there is a need for more collaboration to help learners to know what they need to learn and where they can learn those skills and helps learning providers adapt their learning offer, and for employers to express their skill needs and get guidance in how their industry is changing. Pontes et al. (2021) bring up a concept to support the collaboration between education providers, employees, and employers by matching employees to relevant skills and training programmes. Since the idea seems to have the potential in bridging the skill gap, this idea is further tested in this work by investigating different approaches that have been taken to match skills, trends, tasks, and job profiles. Recommendation systems have been studied in the learning context, but also in other contexts before (Guruge et al., 2021). However, studies that are investigating methods to do skills matching successfully are missing (Paper V). Skills matching and course recommender systems are dealing with the same phenomenon but are called differently. However, the studies included in the literature review in Paper V propose solutions for skills matching that could be tested (Pontes et al., 2021; Solinas et al., 2020), highlighting the use of existing databases for jobs, tasks, and skills, like ESCO and O*net.

This discussion shows that there are many topics to consider when bridging skill gaps and researchers and policymakers have chosen to focus on different things. How to bridge the skill gap in industry is a very broad question and with this thesis work, only a part of the challenges could be investigated. For example, the empirical studies only concern professionals that are already enrolled in learning activities, while potential learners are not included in the studies. As the results show, the skill gap must be addressed together with different stakeholders and the learning should be tailored for the individual to create a motivational learning experience (Paper V, Paper III). How this could be done, and in a successful way, couldn't be answered yet.

## 5.3 CONTRIBUTION

Skill needs in industry have always been changing during transformations (Autor et al., 1998; Braverman, 1998; Roblek et al., 2016). Today, we are going through big transformations and the lack of professionals with the relevant skills slows down the achievement of green industry (Auktor, 2020), puts the implementation of new sustainable business models at risk (González Chávez et al., 2023), and hinders the digital, resilient transition to sustainability (Chari et al., 2022). Against this background, this thesis has shown that there is a skill gap in industry today that is caused by new requirements in industry (Paper II).

To set a frame of reference around this thesis, a lot of topics seem to be related. Industrial changes lie at the base of this thesis, leading to a changed working and operating environment for professionals, and new requirements for the workforce regarding their skills (Grant & Parker, 2009). The industrial field has mostly been investigated through technological lenses, mostly with a focus on productivity and economic growth as the end goal (Brynjolfsson, 1993). The start of work design studies began with a focus on economic views of the efficiency of specializing, and division of labour (Grant & Parker, 2009). What is new in the proposed Industry 5.0 is that humans are supposed to be in the centre, and the goal is to achieve sustainability and resilience (Breque et al., 2021). Policymakers, industrial actors, and individuals start to realize that to achieve these goals of saving the world, humans with the right skills are key (European Commission, 2022b; Grant & Parker, 2009; Romero et al., 2020; World Economic Forum, 2023b).

Although many academic papers and publications from policymakers and organizations highlight the importance of upskilling the workforce, a common clear definition of the skill gap was still missing and a clear approach to measure the skill gap for an individual person that must learn something new, too (Paper II). In addition, there is a range of challenges connected to the bridging of skill gaps, namely motivational, providing learning in successful ways, lifelong work-integrated learning, the management of human resources, and the recommendation of relevant learning content to the learner. As Chapter 2 of this thesis shows, there is noteworthy research around these topics, but this thesis has shown that there is a need to combine these topics and put a special focus on professionals with high-skill levels and how they can be supported in their learning. The empirical findings have shown that the professionals enrolled in the investigated online upskilling programme have different perceptions of the learning and would need increased flexibility and learning adapted to their needs. Even if there have been approaches to measure skill gaps, validations of the methods and closer investigations of the measurement itself are missing, as well as a clear method to be used with professionals and employers to measure skill gaps and make recommendations. However, there is a lot of research about motivation, learning, and human resources management, but it seems like often these research areas work in silos.

The literature reviews highlight the existence of a skill gap in industry and the need to bridge the gap (Paper I, II, V), no contradictions to this fact have been found. It also indicated the need for a better understanding of what a skill gap really is. The first search provided an overview. In most cases, skill gaps were described from one perspective, either from a generic holistic perspective or from one singular perspective. To address the skill gap and propose actions, I believe the perspectives of three actors are crucial: employers (World Economic Forum, 2020a), employees (Romero & Stahre, 2021), and education providers (Babic et al., 2022).

This thesis has brought closer an understanding for the term skill gap. The strength of the theoretical contribution of this thesis is the connection between the three areas – industry, future of work, and skills. The impact of a changing environment in industry on the skill gap has been investigated and a definition of what a skill gap is has been synthesized. Further, different approaches to measuring the skill gap have been summarized. In addition, managerial implications for managing change towards the future of work have been summarized. Then, the motivational challenges of learners in

online learning environments were empirically investigated. Further, challenges and success factors that learning providers need to consider have also been empirically presented. Lastly, this thesis presents parts to consider in a matching system that recommends new skills, tasks, and courses to professionals and gives recommendations regarding the involvement of stakeholders and recommender systems based on technologies, such as generative AI.

## 5.4 DISCUSSION OF METHODS

Always with the vision in mind of an industry in which people have the right skills at the right time, it seems natural that I chose a solution-oriented approach to solve a problem. Having a pragmatic worldview and a social constructivist approach, focusing on problems in a context in which humans are involved is a given. In this first step, my approach was to understand the problem of skill gaps in industry, by using DRM (Blessing & Chakrabarti, 2009). The choice of research questions to guide this approach helped to understand the problem and they built up on each other. They have been supporting the systematic approximation of the methodology, by first looking at what is the skill gap that many researchers and policymakers are talking about, then understanding how it could be measured, and acknowledging challenges and requirements to bridge it.

In this methodology, I used literature reviews to understand the underlying definitions and environment of the problem to define goals, and an empirical data analysis to build an understanding of the different stakeholders concerned with the problem: employees, employers, and learning providers. It seems natural to look at what others have done before starting from scratch. This approach has led to an understanding of the situation and the definition of goals for future solutions and research. However, there are steps in the methodology that could have been taken in a different way, because of the delimitations of the methods I used. The studies are discussed in the appended papers, but here I want to highlight the reasons why I chose the methods and what strengths and weaknesses they have in relation to the overall aim.

The literature reviews that were conducted aimed at defining the term skill gap, finding approaches to measure skill gaps, seeing the skill gap in a broader context of the future of work, and finding approaches to do skill matching. Those literature reviews were necessary to find my place in these research fields. However, talking to experienced people who have worked with bridging skill gaps, e.g., people working in HR could have improved the overall understanding of the challenges.

Quantitative research methods have the purpose of giving a wider view of the situation by being quick to implement and easy to analyze. However, they also have the disadvantage of not giving answers to how a problem should be solved, it just gives the view of the current situation, making it hard to find implications of what actions should be taken in the future (Easterby-Smith et al., 2018). Hence, the findings of the quantitative survey could explain the situation, but further qualitative studies should be conducted to gain ideas for improvement. In addition, the quantitative research that was done has a low number of respondents and should be sent to more respondents to find statistical significance in the answers and find out about correlations that might cause

motivational challenges when bridging skill gaps. Still, in this case, there is an advantage in using multiple data sources, because they allow us to make assumptions or generalizations even if the data sample is small (Easterby-Smith et al., 2018).

On the contrary, qualitative methods have the advantage that they can give insights into change processes and also look at how things change over time, and collect people's ideas (Easterby-Smith et al., 2018). The collection of data regarding how employers and human resources departments today work with the challenges of measuring and bridging skill gaps is missing in the methodology. It would be beneficial to know which approaches they are taking to understand the skill needs in different parts of their organization, if and how they know which skills their employees have, and how they set learning goals and find learning providers according to those needs. For these kinds of questions, qualitative research could help to gather information from their experience. Even if qualitative research takes more time and resources, both in the collection and in the analysis of the data, the results could bring key insights (Easterby-Smith et al., 2018).

As can be seen in the appended papers, my aim has constantly been to collaborate with researchers from different fields, to get multiple perspectives from their research and prevent my own bias from taking over. Still, the most important thing for me was to learn from the experience of my supervisors who have been researching in the research fields for many years.

The focus of this research has been impacted by the projects that the author was or is working in. Those were ManuSkills (EIT Manufacturing, 2021)– a project funded by EIT Manufacturing to create a competency framework for the manufacturing workforce, Ingenjör4.0 (Ingenjör4.0, 2023)– a project funded by the Swedish innovation agency Vinnova to upskill engineers in industry, the Deep Tech Talent Initiative (EIT Manufacturing), a project funded by the European Union and EIT Manufacturing to upskill the European workforce within deep tech, and Young Manufacturing Leaders (EIT Manufacturing), a project co-funded by the European Union and EIT manufacturing to engage students and young professionals within manufacturing. This has led to a special focus on high-skilled professionals, even though some of the findings can be used generically for all industry employees.

## 5.5 FUTURE RESEARCH

The insights from this thesis work have led to a desire to propose a method to measure skill gaps and make recommendations based on that skill gap. One or several approaches to measure skill gaps should be implemented in a case study and empirical data could be collected to improve and validate the method. In addition, a matching system could be integrated to make recommendations to professionals about their suitable learning.

The author's plan for the second half of the PhD studies is to continue with the DRM (Blessing & Chakrabarti, 2009), following the third and fourth steps of the research methodology, with eventual iterations in between. Those two steps are a Prescriptive Study and a Descriptive Study II. In the Prescriptive Study, assumptions are made from the gained experience and in this case, a support tool or method would be proposed and implemented in a case study. In the Descriptive Study II, the evaluation of the proposed

tool will be made, by gaining empirical insights if this tool really helped.

The knowledge about recommender systems could be used to design a system to bridge the skill gap by making personalized recommendations in the projects Ingenjör4.0 and the Deep Tech Talent Initiative.

This thesis invites researchers in the fields of recommender systems, managing the change of industrial environments, and work-integrated learning to collaborate in the future.

For my empirical data collection, Ingenjör4.0 will offer a platform to develop and test the ideas, step-by-step. In addition, the Deep Tech Talent initiative by EIT Manufacturing could be a platform to discuss possible solutions and interact with the professionals developing the platform.

# 6

# CONCLUSION

*Enlightenment is when a wave realizes it is the ocean.*
*- Thich Nhat Hanh*

To confront major skill gaps in industry, this thesis has supplied a base to understand what skill gaps are, how they could be measured, and how they can be bridged. As researchers and policymakers emphasize, skilled talents are key to driving innovation forward and are needed to create a sustainable and resilient industry for societal prosperity.

The "skill gap" in industry can generically be **defined** as the gap between the supply and demand of skills. By synthesizing definitions, one skill gap definition emerged: The gap between the skills that employees possess and the skills that their employer requires. Another gap in relation to the skill gap describes the gap between skills that future employers require and skills that students are taught by education providers, hence could be called the education gap. Often used but mostly called a skill shortage is the lack of available and suitably skilled people for open positions of jobs that employers want to fill.

Moreover, individuals' or companies' skill gaps can be **measured** by using the approaches highlighted in this thesis. These approaches use surveys, interviews, focus group workshops, data analysis, and skill frameworks to get data from students, employees, employers, education providers, literature, databases with job profiles, and professional social networks. One approach that stands out and has been used by several researchers is the performance-importance analysis of skills, leading to a clear mapping of a person's or a company's skill gap. However, the chances of measuring the actual skill gap are higher if the employer, employee, and education provider are involved in the assessment.

Finally, skill gaps can be **bridged** by addressing challenges and success factors for individual employees, employers, and learning providers. Specifically, nine key topics for managers to work with are identified. Motivational challenges for learners need to be overcome, by working with study approach, organization and structure, relevance and support, feedback, mental well-being, and working life competencies. For education providers of online learning, there are high-potential improvements by offering customized learning to meet the individuals' needs, collaborating between universities and industry experts, having tools for teachers to build their content online, having a platform to enable communication between teachers and learners, and engaging learners in a social network. To enable customized learning, skills-matching could identify suitable learning paths. This thesis offers an overview of components that are needed to build a skills-matching tool, including course recommender systems, and a summary of approaches that have suggested ideas.

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