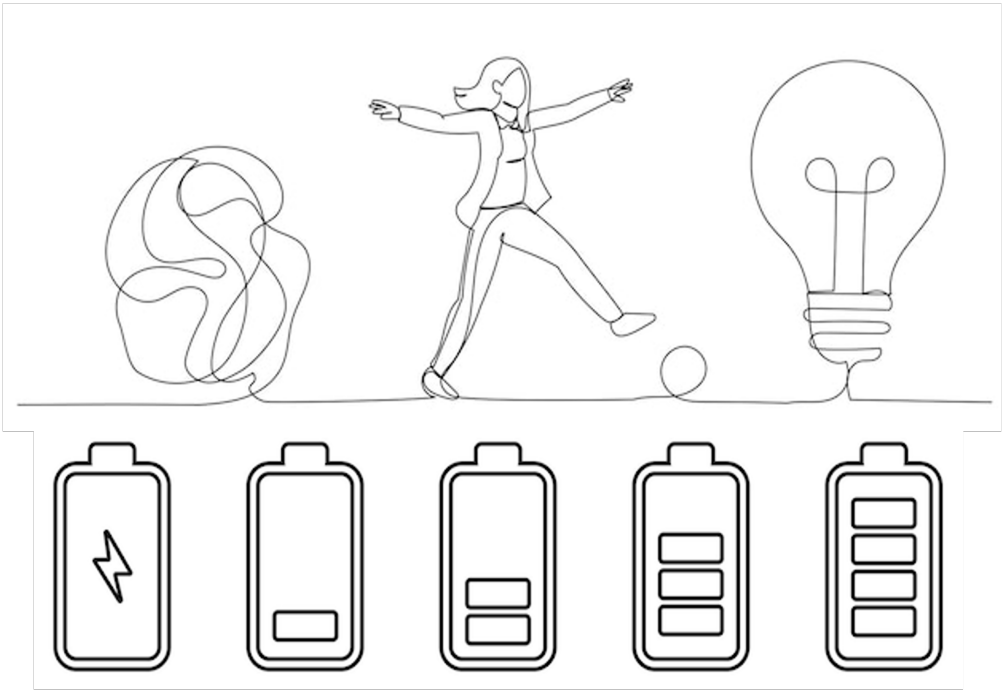

Skills Mapping and Training Facilitation in Battery Cell Production

Identifying Gaps and Addressing Challenges for Workers in Manufacturing

Master's thesis in Learning and Leadership

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2024
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Abstract

As society is transitioning from fossil fuels to electrified systems, the demand for battery technology has surged, driving rapid growth in the battery industry. However, meeting this demand necessitates a skilled and adequate workforce. The aim of this thesis is to identify essential skills for battery cell production workers to standardise conditions for all entrants, regardless of their work experience and background. Additionally, it investigates workforce demands and deficiencies within the industry to develop effective training programs.

The research questions explore the skills required by battery cell production workers, existing skill gaps, workforce challenges, and methods for upskilling. Results indicate that communication, teamwork, standardised working methods, equipment handling, and safety protocols are among the crucial skills, with identified gaps in each area. Challenges include communication barriers, industry interest, and problem-solving abilities.

Insights reveal the importance of battery safety and the challenge of standardising diverse workplace practices. Effective communication, particularly while wearing personal protective equipment, emerges as a critical factor. Training programs integrating cognitive, psycho-motorial, and affective learning targets, alongside pedagogical theories such as pragmatism and andragogy, are proposed to address skill deficiencies and ensure a competent workforce.

This study contributes to establishing a benchmark for the battery industry, contributing to the development of a competitive market, and enhancing workforce capabilities, thereby facilitating the transition to an electrified society.

Keywords: batteries, battery cell production, education, learning, skills, skill gaps, training

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Karin Isaksson, Theres Saad, Gothenburg, May 2024

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

ALBATTS	Alliance for Batteries Technology, Training and Skills
BCP	Battery Cell Production
BVC	Battery Value Chain
CRM	Critical Raw Materials
EBA	European Battery Alliance
EOL	End of Line
HT	High Temperature
LIB	Lithium-Ion Battery
MAL	Material Airlocker
NT	Normal Temperature
PAL	Personnel Airlocker
PPE	Personal Protective Equipment
VET	Vocational Education and Training
SOP	Standard Operating Procedures

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1
Introduction

In recent years, electrified transport has emerged as a key means of future sustainability, driving transformation in the battery industry [1]. With the rapid growth in battery manufacturing, especially within lithium-ion production, electric vehicles offer cleaner and more efficient transportation options. This shift has significant environmental, energy security, and economic implications [2]. Electrified transportation reduces greenhouse gas emissions, decreases the dependency on fossil fuels, and increases the use of renewable energy sources [3], by transferring the energy production to centralised resources and relying on other energy storage and distribution solutions than fossil fuels. However, challenges like meeting the market demand, maintaining a competent workforce and sourcing sustainable raw materials follow [1].

A skilled workforce is vital for the success of this electrification transition [4]. Workers in battery factories ensure the safe and efficient production of high-quality battery cells, requiring expertise in areas such as production processes and quality control. In this thesis, the aim is to identify what essential skills and potential skill gaps battery cell production workers have, along with exploring ways to facilitate the training of future operators. This chapter includes the background, purpose, research questions, limitations, and lastly some ethical and societal aspects of the thesis.

1.1 Background

Given the rapid expansion of the battery industry and the development of electric vehicles, additional manufacturing facilities need to accommodate the increased production. Gigafactories are being built, and with new factories comes the need for well-trained personnel. To meet the demands of the labour market [4], training centres are being built with the purpose of offering companies the possibility to train existing and future personnel, as well as future training for educators who conduct training in other learning environments [5].

In 2017, the European Commission launched the European Battery Alliance, EBA [6]. EBA was established in response to the industrial challenges that society faces, particularly within the battery industry [7]. As the world moves towards a fossil-free and electric future, efficient batteries are essential for transportation, power, and industrial applications. However, the availability of capable batteries remains a major issue. Therefore, research has been progressing at a rapid pace to meet the

growing demand for batteries [7].

With a growing battery industry comes a demand for a sustainable, qualified, well-trained, and skilled workforce along the whole battery value chain [8][9][10]. It is also vital that the workforce is "skilled and well-versed in the nuances of battery safety. They must understand the risks, adapt as necessary to new challenges, and respond when it counts the most" [9]. For the battery industry to become and stay competitive, it is vital to invest in research, development and skills training, otherwise, there is a risk that the industry's development could be negatively affected [10].

1.2 Purpose

The aim of this work is to identify essential skills for battery cell production workers to ensure they acquire basic knowledge before entering the battery industry. This standardises the conditions for all individuals entering the field, regardless of their educational background and work experience. Additionally, the study investigates the demands placed on the workforce by the battery industry and identifies any deficiencies. By understanding these gaps, the development of an effective worker training program is facilitated. Standardising these conditions establishes a benchmark for the battery industry and fosters a strong workforce, contributing to the development of a competitive market.

1.3 Research Questions

Challenges that the battery industry faces are among others meeting demands with adequate and competent personnel. The production of batteries will require skilled workers in a relatively new context. Pre-knowledge in battery production cannot be assumed, and there is a need to understand how best to train new employees and what essential skills they need in battery cell production. Therefore, three questions have been posed to investigate the problem:

RQ1. What skills do battery cell production workers require to fulfil their work assignments?
RQ2. What skill gaps do potential battery cell production workers have?
RQ3. a) What challenges does the workforce in the battery industry face?
b) How can the upskilling of battery production workers be facilitated?

1.4 Limitations

Limitations have been established for the study to fulfil two primary objectives: to ensure the feasibility of the project within the given time frame for a Master's Thesis work and to prevent the scope from becoming excessively broad. The limitations

that have been deemed appropriate for the thesis are:

- Skill composition and skill gaps will be derived solely from data collected within the downstream battery cell production phase, excluding the upstream process and cell-to-pack aspect of battery production.
- The study will concentrate exclusively on the production processes involved in prismatic lithium-ion batteries.
- The research will specifically target one occupational group: operators.

1.5 Ethical and Societal Aspects

Lifelong learning is one of the first principles in the European Pillar of Social Rights [11]. The principle means that all humans have the right to an education of high quality and inclusion, and training to acquire skills. By having the right skill set, current standards of living are sustained, high rates of employment are supported and social cohesion is fostered [11]. The right skill set also helps employees gain personal fulfilment, health, employability and social inclusion, which in turn strengthens Europe's "resilience in a time of rapid and profound change" [11].

By educating and training the workforce in the battery industry, the workforce becomes aware of the safety and sustainability aspects of the battery industry, which is a competitive advantage towards the change to an electrified society [12]. A safe and secure working environment is a right for everyone [13]. In an industry such as the battery industry, it is essential to regard the use of hazardous chemicals and be aware of how they are handled safely since incorrect usage can lead to devastating accidents, long-lasting health issues and sometimes even deaths [14].

2
Theory

This chapter contains the theoretical framework for the thesis and includes descriptions of why batteries are relevant, how they function and how they are produced. Furthermore, learning factories and different pedagogical theories are explained.

2.1 Batteries

Historically speaking, batteries are one of the oldest technological methods of energy storage [15]. They are used in the industry and for personal use, in areas such as traction, aviation, aerospace, electric vehicles and stationary [16]. There are different types of battery cells. Some of them are [17]: cylindrical, the most widely used and common in power tools, medical instruments, laptops and e-bikes; button cells, used in medical implants, watches, hearing aids, car keys and memory backup; prismatic cells, which comes in small and large formats. The small ones are found in mobile phones, tablets and low-profile laptops and the large ones are found in hybrid and electric vehicles; lastly, pouch cells have similar areas of use as prismatic cells but are more space-efficient [17].

2.1.1 Why Batteries?

EBA's goal is to build up the battery technology and production capacity in the EU, to expand battery cell manufacturing in Europe. The aim is to "develop an innovative, competitive and sustainable battery value chain in Europe" [18]. The alliance works aligned with The European Green Deal, meaning that it is striving to become climate neutral and reduce transport emissions by 90% by 2050, and assist businesses in achieving global leadership in clean products and technologies [18]. It also works aligned with the European Industrial Strategy, whose goal is to sustain the EU's position as a global centre for automotive and energy storage innovation and competitiveness, to strengthen Europe's resilience and strategic autonomy in key industrial sectors, and lastly to foster the generation and preservation of skilled jobs within the EU [18].

To secure the transition to a fossil-free and electrified society, it is necessary to find sustainable materials [19]. However, a global issue that is arising, is that it is becoming increasingly difficult to obtain raw materials from reliable sources [20]. Therefore, the European Commission has created a list called *Critical Raw Materials, CRM*, to address the problem. The list includes raw materials that are important to the EU economy, as well as the high risk associated with their supply [20].

Lithium-ion batteries are one of the most advanced rechargeable batteries in the industry [3]. They are used in electronic devices such as cell phones and laptop computers. However, lately, the use of lithium-ion batteries has been expanded in for example the electric and hybrid vehicle industry, which requires high power, capacity, performance, charging rate and long-life battery cells. It is simultaneously important to increase the safety performance and low costs for the battery cells [3].

Challenges that the lithium-ion battery cell industry is facing, are among other [3]:

- electrodes,
- safety concerns,
- low carbon footprint,
- life cycle assessment,
- limitations of raw materials, such as lithium reserves.

It is estimated that one battery gigafactory will have to employ up to 3000 people directly and up to 40,000 indirectly in connection to the industry [21]. To meet the demands of the growing workforce, it is required to invest and implement academic, professional and vocational education, for the workforce to have the "necessary span of competencies and depth of knowledge required to elevate the European Battery Industry". The need for skills and skill gaps in the battery value chain is apparent, and they refer to material design, electrode and cell design and manufacturing, product integration, battery management and process design for large-scale manufacturing factories [21]. However, the "industry needs to be continuously engaged and express identified needs for reskill and upskill of current workforce" [10]. Alistore-ERI, EIT InnoEnergy, ALBATTS 26 and Battery 2030+ are projects that are currently focusing on battery related education [10].

> *Education of the general public and policymakers is of great importance to provide a basic understanding of batteries, the major advantages of transitioning to electric-based transport and energy storage, and the basic knowledge to ensure safe operation and disposal of batteries* [10].

What has been identified, is that there is a skill gap between what skills the workforce in the battery industry offers and what the high technology industry requires [21], making it hard for the industry to hire people with the right qualifications. This implies that the problem lies with vocational and professional education. The skill gap also implies a need for up- and re-skilling of the existing workforce, education on

cross-cutting skills and creating knowledge in large-scale battery cell production [21].

Challenges that the battery industry faces with filling the skill gap are among other [21]:

- sector attractiveness,
- lack of equipment and training labs,
- mobility possibilities,
- the existence of separation between industry, academia, and training schools/centres and
- building up competencies in large-scale cell manufacturing.

Proposed solutions for the challenges are [21]:

- implementation of coordinated training, reskilling, and upskilling programmes,
- the industry should provide necessary training to academic personnel,
- hands-on training related to cell manufacturing,
- training on battery behaviour, safety, tooling, equipment and following standards,
- teach emergency steps and logistics for handling, storing, packaging, and transporting batteries,
- reskilling and upskilling of professionals and for vocational education already in a profession and
- setting up industrial education centres across Europe.

2.1.2 How Batteries Work

Batteries are a collection of galvanic cells connected in series [22]. Galvanic cells are electrochemical cells, which are devices in which electric currents, or a flow of electrons through a circuit, in this case, are produced by spontaneous chemical reactions. The chemical reaction in the galvanic cell is used to generate electric current, and the voltage that a battery produces is the total sum of the voltage of each galvanic cell [22].

Galvanic cells consist of two electrodes, which are metallic conductors. These electrodes are separated by an electrolyte, which is an ionically conducting medium. An electric current is created by the movement of ions between the conductors. The electrodes are called anode and cathode. At the anode side, a chemical process called oxidation occurs, while a chemical process called reduction, occurs at the cathode side. Oxidation is when atoms release electrons and become positively charged ions, while reduction is when atoms absorb electrons and become negatively charged ions. In a galvanic cell, these electrons travel from the anode side to the cathode side through an external circuit. When electrons are released into the external circuit, the positively charged ions from the anode are released simultaneously into the electrolyte solution, to the negatively charged ions on the cathode side, creating a flow of electrons, hence an electric current [22].

2.1.2.1 Lithium-Ion Batteries

A lithium-ion battery, LIB, is one among several types of batteries. Like other galvanic cells, it consists of anode, cathode and electrolyte [23]. The cathode material in LIB is metal oxide and the anode consists of porous carbon. LIB also consist of a separator, a thin porous membrane that physically separates the anode from the cathode for safety reasons [24] and is used to allow only ions to pass through [25]. The battery also consists of current collectors, which support the electrode material, and work as an electrical conductor between the electrode and external circuit [26]. The cathode material in LIB is usually coated onto an aluminium current collector, while the anode material is generally coated on a copper current collector. The electrolyte is made of lithium salt in an organic solvent [23]. Electrolytes used in electrochemical systems require strict control of contamination and composition since contamination is harmful to the long-term stability of the battery [27].

When the battery is discharged, the positive ions flow from the anode to the cathode side through the electrolyte and separator. When the battery is charged, the ions shift direction and flow from the cathode to anode [23].

2.1.3 Battery Value Chain

Raw materials and processing, components and cell manufacturing, battery packs and systems, application and integration, operation, repair and maintenance and recycling/second life, are the elements that cover the battery value chain, BVC [28][29]. Raw materials and processing is the first step of the BVC. Raw materials need to be mined and refined afterwards. and this is the upstream process in the BVC. The second step, components and cell manufacturing, the downstream process of the BVC, is when the components that make a battery cell are mixed and built. Battery packs and systems are the third step in the BVC, and they refer to ”the aggregation of various battery cells in a module. A pack is usually referred to as a group of modules powering an electric vehicle for example” [29]. The fourth step, application and integration, is when a battery cell is integrated into a functioning battery system. Operation, repair and maintenance is the fifth step where the battery is used in devices and needs reparation and maintenance when and if a problem arises. The last step in the BVC is recycling/second life, which closes the BVC. This step strives to recover the materials used in the batteries and reuse them, making the BVC sustainable [29].

2.1.4 Battery Cell Production

Downstream battery cell manufacturing, or the operating principle of a lithium-ion prismatic battery cell, is divided into three main process steps: electrode manufacturing, cell assembly and cell finishing. The main process consists of a total of fourteen steps, shown in Figure 2.1 [27]. These steps differ slightly from factory to factory [30].

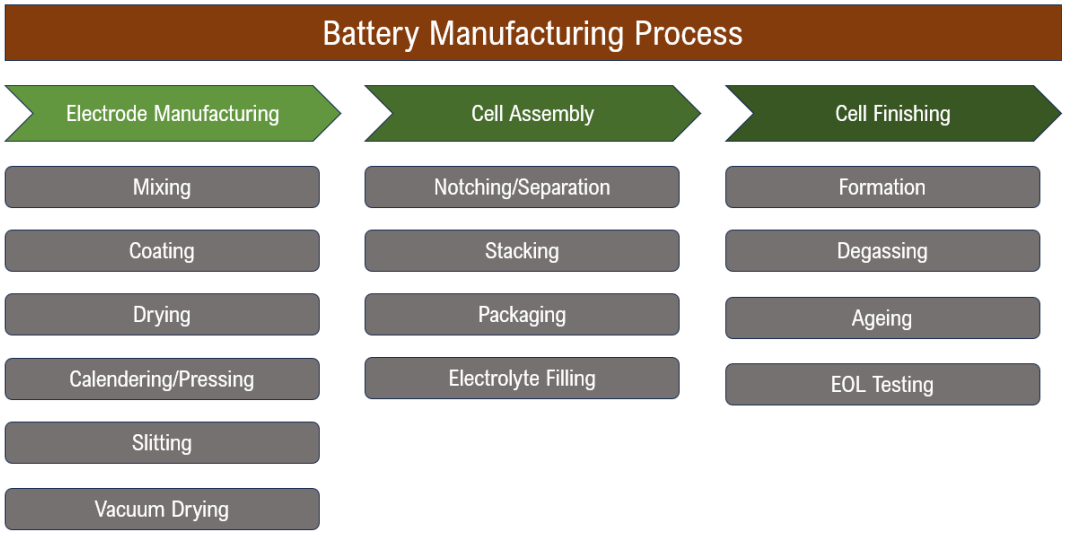


Figure 2.1: A step-by-step illustration of downstream battery cell production.

Electrode manufacturing and cell finishing are independent of the cell type, while the cell assembly depends on it. However, regardless of the cell type, a lithium-ion battery cell consists of two electrodes with a separator, and an ion-conductive electrolyte [27].

Electrode Manufacturing

Electrode manufacturing consists of the steps mixing, coating, drying, calendering/-pressing, slitting and vacuum drying, all of which will be explained in Table 2.1 [27][31].

Table 2.1: A step-by-step explanation of the battery manufacturing process in electrode manufacturing.

Electrode Manufacturing	
Process Step	**Explanation**
Mixing	A so-called slurry, a black mass, is mixed for the anode and cathode in the battery cell. The slurry contains active materials, conductive additives, solvents and polymer binders. For homogeneous dispersion and consistent processing, the electrode slurries must be free from clumps or agglomerates from solid components. They are therefore mixed in planetary mixers with high shear dispersing capability for several hours.
Coating	Slurry is applied to the current carrying foil of the anode and cathode. The anode is coated on copper foil and the cathode on aluminium.
Drying	The coating is dried in a continuous process in a heating chamber, which allows the solvent in the slurry to evaporate.
Calendering/Pressing	The coated anode and cathode material is compressed between rollers to evenly disperse the active material.
Slitting	A separation method where rolling knives are used to cut wider electrode coils into smaller electrode coils, called daughter rolls.
Vacuum Drying	The smaller electrode coils are put in a vacuum oven for 12-30 hours, to remove residual moisture and solvents. When the drying is done, the cells are transferred to a dry room or dry packed under a vacuum.

Cell Assembly

Cell assembly generally consists of the steps notching/separation, stacking, packaging and electrolyte filling, all of which will be explained in Table 2.2. However, the cell assembly differs depending on the battery cell type. The assembly described in the table is for the type prismatic battery cell [27].

Table 2.2: A step-by-step explanation of the battery manufacturing process in cell assembly.

Cell Assembly	
Process Step	**Explanation**
Notching/Separation	The daughter rolls are separated by a punching tool to anode, cathode and separator sheets.
Stacking	The separated electrodes are stacked in a repeating cycle of anode, separator, cathode and separator.
Packaging	First, the collector foils are welded together by ultrasonics or laser. Then, the cell stack is positioned in the foil.
Electrolyte Filling	The cell is filled with electrolytes. This process step is divided into two sub-process steps called filling and wetting. Filling is when the electrolytes are filled into the cell under a vacuum, and wetting is when a pressure profile is applied to the cell so the capillary effect is activated.

Cell Finishing

Cell finishing consists of the steps formation, degassing, ageing and end of line, EOL, testing all of which will be explained in Table 2.3 [27].

Table 2.3: A step-by-step explanation of the battery manufacturing process in cell finishing.

Cell Finishing	
Process Step	**Explanation**
Formation	The cell is first charged and discharged with voltage through spring-loaded contact pins. Through this process, an interface layer is created between the electrolyte and electrode.
Degassing	During the former step, there is a certain gasification which needs emptying. After emptying, it is sealed under a vacuum.
Ageing	This step is divided into two steps, high temperature, HT, ageing and normal temperature, NT, ageing. HT ageing is the first step in the ageing process of a battery, which is done for quality assurance. The cell characteristics and performance are during the ageing, monitored by measuring the open circuit voltage of the cell for up to three weeks. The process is repeated under normal temperatures.
EOL testing	The batteries are tested in an EOL test rig, where they are discharged to the shipping state of charge, involving a capacity measurement. After the successful testing, the cells are sorted according to their performance data, packed and shipped.

2.2 Skills and Skill Gaps

In 2017, the European Parliament, Commission and Council took on the European Pillar of Social Rights, a pillar that consists of 20 key principles. The principles are supposed to promote equality, fairness and inclusiveness in the labour market and welfare systems, as well as create opportunities for all Europeans [32]. The first key principle, *Education, training and life-long learning*, implies that ”Everyone has the right to good education and training throughout their whole life” [33]. In 2018, the European Council presented a recommendation on key competencies for lifelong learning, which implies that ”People need the right set of skills and competencies to sustain current standards of living, support high rates of employment and fos-

ter social cohesion in the light of tomorrow's society and world of work" and that "in a rapidly changing and highly interconnected world, each person will need a wide range of skills and competencies and to develop them continually throughout life" [11]. However, there is a difference between skills and competencies. Competencies are defined as a combination of knowledge, skills and attitudes, while skills are defined as "the ability and capacity to carry out processes and use the existing knowledge to achieve results" [11]. In other words, "a skill is only one of the elements that make up a competence" [34]. Skills are also described as "individual attributes, related to work, which have value and can usually be learned" [35].

Skills contribute to success in the labour market [36] and are essential for the performance of companies when it comes to innovation and the economy [37]. There are mainly two kinds of skills, *soft* and *hard* skills [36] and they are developed through training [37], education and life-long learning [11], also seen as experience [34]. Hard skills are mainly related to knowledge [36] and "technical aspects to do some tasks in the job" [37] and can be easily trained and measured, while soft skills are more related to attitudes, a person's way of responding. These skills are more rooted in an individual's psychological traits, preferences, experience and background, which makes them harder to measure and develop [36].

There are various definitions of skill gaps [38], however, studies have shown that there is a missing distinct definition [39]. One definition is that a skill gap is a "situation where an individual does not have the level of skills required to perform his or her job adequately" [40]. Another definition is that the skill gap is "the difference between the market's need (demand) and the current skills supplied by local education institutes (supply)" [41]. A third definition is "a skill gap is a gap between the skills that employers demand and the skills that employees possess" [38]. To be able to know how to reach desired skills, one must understand what the skill set looks like today and what skill set one wants to reach [38]. Bridging of skill gaps can be done through companies hiring skilled people, training their employees, using augmentation technology to give tasks to machines, or collaborating with academia [38].

Changes in demography and the green and digital transition are factors that contribute to a need for the development of skills in society. It is therefore important to keep up with the changes by providing relevant, learner-centred, inclusive and efficient vocational education and training, VET [42]. Industry 4.0, the fourth industrial revolution, is revolutionising manufacturing and engineering all over the world. Due to this, it is predicted that half of the employees all over the world, are going to be needing reskilling by 2025 [43]. Reskilling is a term used in the labour market to describe employees who need to learn new skills to change their work roles. Upskilling is also a common term used in the labour market for bridging skill gaps. Upskilling means "to learn new skills to stay in the same job role" [38].

2.2.1 Measuring Skill Gaps

Skill gaps are as previously mentioned, ”a gap between the skills that employers demand and the skills that employees possess” [38]. There are many ways to measure skill gaps [39]. A common approach however is to [39]:

1. *create a skill framework for the field in which the study was to be conducted;*
2. *use the framework to design one or two different surveys to*
    - *ask employers about employees' performance regarding each skill, their importance for the company, and/or the need for specific skills, and/or*
    - *ask employees about their alignment with the skill framework, and, finally,*
3. *analyze the collected data, identify skill development, recruitment, or education curriculum gaps, and formulate the needs.*

When the skill set is done, surveys should be sent to employers and employees, or students or student employees. Employers should be asked about the importance of the summarised skills and the employees' performance regarding them. Employees should do a self-assessment regarding these skills. Students or student employees should be asked about the importance of the skills and their performance of them [39].

2.3 Pedagogical Theories

Humans have different ways of learning, previous learning experiences and learning preferences. The learning process is affected by different factors, such as background, study techniques and life experiences [44]. Since there are such various learning conditions, training and education need to be adaptable and differentiated [44].

There are different pedagogical approaches to adult learning. They are often motivated by adults' specific needs and objectives since adults seek education and knowledge that align with their professional lives, personal interests, and career goals [44]. Adult education is suggested to be ”predominantly informed by four different epistemologies” [45]. Epistemology is ”referred to as the theory of knowledge” [46]. The four types of epistemologies are: disciplinary, which ”understands knowledge as truth and suggests that learning is a process of enlightenment which can occur as a result of following certain rules”; constructivist, which ”understands knowledge as an active process through which learning is achieved through participation in authentic experiences”; emancipatory, which ”understands knowledge as power and sees education as a political process”; and lastly, instrumental, which ”understands knowledge as action. It is focused on the learning which is responsive to and valued by the wider culture at the time” [45]. The latter epistemology is also referred to as pragmatism [47].

Pragmatism

Pragmatism, also known as ”learning by doing” [48], ”maintains that a worldview arises out of actions, situations and consequences” and that ”learning enriches experience and vice versa” [47]. One of the founders of the philosophy of pragmatism is the psychologist John Dewey [49]. Dewey believed that learning is socially constructed [45] and that ”traditional education was too concerned with the delivery of pre-ordained knowledge and not focused enough on the learner's actual learning experiences” [49]. The psychologist emphasises that learners' experiences should be used as a teaching tool, instead of teachers communicating skills and knowledge to them [49].

Critique that pragmatism faces, is that pragmatists tend to neglect insights given by literature since they are attached to science and social science, which leads to a narrow worldview [50]. Another criticism that has been pointed to pragmatism, is Dewey's view on theory and practice. Since Dewey has the view that education should focus on being practical and contextual, knowledge becomes relative rather than objective. This implies that the gap between knowledge goals and everyday life could become too large [51].

Andragogy

Andragogy is an adult learning theory, developed by Malcolm Knowles. Knowles was an educator whose job involved evaluating what skills and knowledge employers wanted their employees to possess [52]. He implied that adults want to be in control of their learning [49]. Knowles argued that adults are self-directed and problem-solving learners whose life experience constitutes a significant learning resource and that adult learners have a need to be valued and respected [49]. In the learning theory, Knowles made five assumptions about the characteristics of adult learners: self-concept, the learning experience, readiness to learn, learning orientation, and motivation to learn [52]. Self-concept implies that as individuals grow, so does their independence, hence, adults are more self-directed and thus prefer a more self-directed approach to learning. As a result of becoming independent, adults also carry ”skills and knowledge needed to learn and understand independently” [52]. The learning experience implies that adults have past experiences, such as education, training, jobs and life events that they can use in the learning process since past experience can contribute to knowledge and context. Readiness to learn signifies that adults become more enthusiastic to learn ”things that help us achieve our goals or accomplish relevant tasks” [52]. Learning orientation means that adults want what they learn to be applicable in everyday life. Lastly, motivation to learn suggests that as humans grow and mature, the motivation to learn becomes internal [52].

A critique that andragogy has faced, is among others if its view on adults being self-directed is accurate, since there are also adults that do not take initiative in their learning, but rather prefer to be lead in their learning process. Since the theory only represents one worldview, it does not allow other learning preferences to be

seen [53]. Cultural difference is a factor that affects whether adults are self-directed learners or not [52] which the learning theory does not take into consideration since it idealises individualism, which is not necessarily valued by all cultures [53]. Andragogy is also criticised for separating the relationship between self and society, which results in the description of psychological traits in an adult being separated from social, political, economic and historical views. The theory does not consider politics in an education perspective, making itself politically neutral, which is not realistic in a world where education is "inherently value laden and serves to socialise and shape behaviour" [52].

2.4 Learning Factories

Learning factories have been built up in industry and academia, for training, education and research purposes [54]. "By using a learning factory for teaching, theoretical knowledge can be more effectively communicated and tested for practical applications, and learning results can be transferred to industry" [55]. When learning factories were first implemented, the purpose of them was to give "hands-on experience gained by applying knowledge learned at the culmination of engineering education to solve real problems in industry and design/redesign products to satisfy identified needs" [54]. Today, they are used with the aim of enhancing the learning experience for trainees within different areas of knowledge. The term *learning* in this case, stresses the "importance of experiential learning where research has shown that learning by doing leads to greater retention and application possibilities than traditional methods such as lectures" [54].

Processes and technologies within learning factories are based on real industrial sites, and didactic concepts are a must to specify what and how should be learned by whom. To achieve the development of competencies, "the core of the learning factory concept is a high degree of contextualization [...] and a hands-on experience of the trainees" [54]. "Learning in the learning factory can take place in the planning, realization, and ramp-up phase (greenfield) but also in the improvement of existing processes and factory environments (brownfield)" [54]. Urban development was what caused the terms greenfield and brownfield to emerge [56]. Greenfield sites are "undeveloped land that can be used for commercial or residential development" [57]. Brownfield sites are developed sites that have potential building development [56].

Didactics is one of the seven dimensions in the morphology of learning factories [54][58]. The educational goal of learning factories is to develop technical and methodological competencies, however, activity and implementation-oriented competencies are taught to improve cognitive and psycho-motoric skills. "Didactics are founded on training use cases with an emphasis on demonstration, yet they primarily focus on actual do-it-yourself experience" [58]. Cognitive, affective and psycho-motorial approaches, or learning targets, are used in learning factories to develop technical, methodological, social, communication, personal, activity and

implementation-oriented competencies, through instruction, demonstration, open and closed scenarios, and experience/do-it-yourself training [54][58]. Findings indicate that the three learning targets are significantly interrelated and a strong correlation exists between affective achievement and cognitive and psycho-motorial achievement [59].

Cognitivism

Cognitivism is a learning theory that is based on the principle that information is processed inside the mind of a person, and the way that people process and store information is key to understanding how they learn [49][60]. Learning happens when pieces of information are puzzled and gathered until they form a complete picture [49].

Several learning models or influences go under cognitivism and one of the more famous ones is Jean Piaget's theory about constructivism [61]. Constructivism implies that knowledge is constructed and that emotional, biological and mental stages of development are factors that affect the construction of knowledge [49]. Piaget argues that there are four stages of development: sensorimotor; preoperational; concrete operations; and formal operations [49][61]. The sensorimotor stage implies that learning happens through feeling and touching. At the preoperational stage, logical thinking occurs and the ability to arrange objects logically develops. At the concrete operational stage, the ability to think logically about objects and events becomes structured. Lastly, the formal operational stage is when abstract thinking and verbal reasoning, develop [49]. Lev Vygotsky's theory, the zone of proximal development is also a common model in cognitivism. Vygotsky believed that "knowledge and thought are constructed through social interaction".

Weaknesses with cognitivism are among other that the theory is of an abstract nature, not directly observable and there are difficulties with defining thoughts. The theory itself is not "agreed upon definition or application" [61] and it ignores "other factors towards behaviour that have been shown to affect behaviour" [61]. A critique that has been directed towards Piaget's theory is that he did not evaluate the development of children from diverse cultural backgrounds, but only in the Western world [61]. The strengths of the cognitive theory are that it has various applications, in the way that it helps with understanding how learning works, which can be used in teaching and work situations. It also relies on experimental methods, which allows for cause and effect to be determined, but more importantly for high control over confounding variables [61].

Affective Learning

Affective learning, or emotional intelligence by Daniel Goleman [49] is ”the process of acquiring knowledge, skills and attitudes through emotional engagement” [62]. Affective learning ”recognises that emotions play a pivotal role in shaping cognitive processes, memory retention and decision-making. In the context of higher education, affective learning involves creating an environment that fosters positive emotions, such as curiosity and enthusiasm, to enhance learning outcomes” [62]. It argues that people must develop their emotional intelligence, not just high IQ [49]. Critiques that the theory faces are among others how it works in workplace settings since it may prioritize the suppression of emotions that don't align with organizational expectations which could lead to a culture where individuals feel pressured to mask their real emotions to fit in. The theory also overlooks broader issues such as power dynamics, structural inequalities and oppressive workplace cultures [63]. The theory's strengths are that it emphasises recognising and managing emotions, which can be beneficial for individuals in navigating interpersonal interactions and handling stressful situations effectively. The theory also provides valuable skills for enhancing communication, empathy, and conflict resolution in both personal and professional contexts [63].

Psycho-motorial Learning

Psycho-motorial learning is the development of ”organized patterns of muscular activities guided by signals from the environment” [64]. Memories are retained, and similar to that, learning is acquisition [64]. Psycho-motorial learning involves acquiring and perfecting skills that require physical movement and coordination. This process is essential for a wide range of daily tasks, from basic actions to complex manoeuvres, where precise motor skills are crucial. The term ”psycho-motorial” is derived from ”psycho”, relating to the mind, and ”motor”, about physical movement. This connection underscores the complex relationship between cognitive functions and physical actions in the development and execution of skills [65]. Factors that affect psycho-motorial skills are the amount of practice, psychological feedback, task complexity, work distribution, and motive-incentive and environmental conditions [64].

Bloom's Taxonomy

Bloom's taxonomy is a hierarchical framework that categorises learning objectives into cognitive, affective and psycho-motorial domains [65]. The cognitive domain addresses intellectual skills, affective, emotional and social, and psycho-motorial, physical abilities and coordination [65]. The cognitive domain is a six-level structure, which can be summarised as [49]:

- Level 1: Knowledge, information is recalled and recognised.
- Level 2: Comprehension, the meaning of information is understood.
- Level 3: Application, the ideas that come with the information are put into practice.
- Level 4: Analysis, the practice is interpreted and assessed.
- Level 5: Synthesis, new approaches are developed to practice.
- Level 6: Evaluation, assessment of how well the new approaches are working.

The affective domain is similarly divided into five models, which can be summarised as [49]:

- Level 1: Recieve, being willing and openminded to a change in values.
- Level 2: Respond, participating in exercises that may change values.
- Level 3: Value, examining, how are the new values in conflict with previous ones?
- Level 4: Conceptualise, harmonising internal conflicts with established values.
- Level 5: Internalise, adopting a new belief system.

Lastly, the psycho-motorial, which is "most prominent related to adult learning" [49], is divided into five levels which can be summarised as [49]:

- Level 1: Imitation, the actions of others are observed and replicated.
- Level 2: Manipulation, the action is reproduced from memory.
- Level 3: Precision, the action is accurately executed without help.
- Level 4: Articulation, skills are integrated.
- Level 5: Neutralisation, skills are automatically mastered.

Criticism that Bloom's taxonomy has faced, is that the concept of the hierarchal taxonomy does not necessarily apply in reality, since it implies "that each higher skill is composed of the skills beneath it; comprehension requires knowledge; application requires comprehension and knowledge, and so on" [66], which is not the truth [66]. A strength of the model, however, is that it has placed a usable structure for practitioners [66].

2.4.1 Education in Battery Industry

In Section 2.1.1, it was mentioned that there are several projects concerning up- and reskilling of the workforce, where ALBATTS and EIT InnoEnergy were two of those [10].

EIT InnoEnergy Skills Institute was launched in 2023 as a response to the skills shortage in Europe. The institute is working towards a sustainable future and specialises in skills intelligence, modular training, and industry-recognised qualifications and certifications that are aimed to provide businesses with essential knowledge and skills [67]. Their training programs are within battery safety, since it is crucial to

know how to handle batteries safely and about the battery value chain [68].

The Alliance for Batteries Technology, Training and Skills, ALBATTS [69], was started in 2019, also as a response to the development of the battery value chain in Europe. They, together with VET providers and universities work alongside to identify and develop the relevant competencies, learning, education and training materials to meet the demands in the battery market [69].

Skill cards have become one of the results of the ALBATTS project [70]. The skill cards describe occupations with corresponding skills and one of the aims is for training providers and companies to create or improve training material [70]. There is a skill card for the machine operators in the battery industry and mentioned skills that the operator should possess, are: equipment and tools handling, inspecting the quality of products, operating material handling equipment, working safely with machines, ensuring equipment maintenance, problem-solving and troubleshooting, follow reporting procedures and lastly written skills [71].

In Section 2.1.1, it is mentioned that there are several challenges with filling the skill gaps that the battery industry faces [21]. Skill gaps in the battery industry have been divided into five elements that battery education should cover, for bridging the skill gaps [21]. The elements are: Science and Technology, Integrations and Applications, Environment and Economics, Processing and Safety, and Social Impact [21]. The skills within those elements are divided into technical and transferable and are of high importance. The transferable skills, which are often neglected, are skills such as teamwork, collaboration and negotiation skills, interdisciplinary working, multicultural sensitivity, decision-making, communication, leadership, critical thinking, curiosity, strategic thinking and commercial awareness [21]. Other identified skill gaps are [72]:

- understanding the task context or the bigger picture, how a task is performed and why and how it affects different parts of the process
- coordinating and prioritising requirements, such as quality and customer requirements or risk assessment and internal demands,
- quality standards, to understand them,
- educational background and relevant coursework, lack of competence and knowledge,
- battery manufacturing process and serial manufacturing, to understand them and how they relate to each other,
- electrochemistry and LIB knowledge,
- data analytics and automation,
- structured problem solving, applying methods such as 5 Why's and 8D,
- continuous improvement, such as 5S, lean and six sigma,
- commissioning, to understand the process of machine design, installation, and testing before operational use and maintenance; machine and equipment knowledge,
- shop floor experience

- autonomy and self-directed learning, being eager to learn and autonomous,
- communication and networking skills and; attitude and personality, having the right attitude, outside of the box-thinking and knowing who to contact and when to contact them [72].

3
Methodology

In this chapter, the chosen methodological approach for the study is explained. It consists of the different data collection methods: field research, interviews, survey and literature review, followed by a description of the data analysis and the importance of maintaining the study's authenticity. A visual representation of the methodological framework is provided in Figure 3.1.

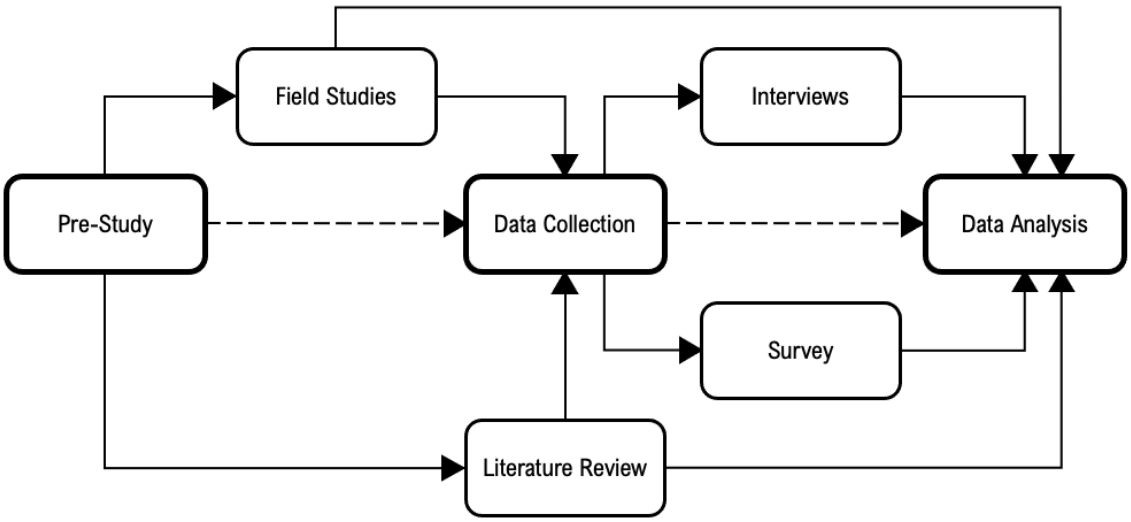


Figure 3.1: Outline of the methodology used for the study.

3.1 Data Collection

The research for the study was mainly based on qualitative data collection. Qualitative data collection concentrates on the participants' experiences and perspectives to get a nuanced understanding of the area in question, which in this thesis has been carried out through field studies, interviews and literature review [73]. Research question two had a quantitative data collection method. Quantitative data collection, unlike qualitative, relies more on quantification and the comprehension of the area comes more from external and impartial perspectives, which in this case has been accomplished through a survey [73].

3.1.1 Field Research

Two field studies were conducted in the initial phase of the research, to get a deeper understanding of the concept of training operators and how the BCP works. Field research is a qualitative research method where data is collected directly in the field. It is a combination of observations and interviews made on-site [74]. The main purposes for conducting these field studies were to gain a general understanding and prepare for the upcoming interviews.

3.1.1.1 Field Study One

The first field study was at an established factory equipped with an established academy dedicated to the necessary skills training of new hires. The primary purpose of this field study was to gain insights into how necessary skills could be defined and why the training was designed the way it was. The visit also served a secondary purpose of contributing to building a knowledge base for the interview study.

During the visit, one of the trainers responsible for overseeing the training gave a tour of the facilities while explaining the structure of the training and answering both prepared and supplementary questions about the program. This gave a deeper understanding regarding the used methodologies, thought processes and lessons learned from the design of the training.

3.1.1.2 Field Study Two

The second field study was conducted at a battery manufacturing company's facilities. The purpose of this visit was mainly to get a perception of key tasks executed for each step in the battery cell manufacturing process. This was done through a guided tour of the factory during production, allowing observations of operators in action. During the tour, plenty of questions were asked about the procedures conducted at each step. This gave an initial insight into what necessary skills are required for operators in the battery cell manufacturing industry.

3.1.2 Interviews

To gain a deeper understanding of each step of the battery cell process, a series of semi-structured interviews were conducted. A semi-structured interview is when the interviewer has a prepared questionnaire in varied order with the possibility of supplementary questions if deemed necessary [73]. The interviews aimed to identify the necessary skills required for each production step (RQ1), and also discover what the participants perceived as most challenging within their work role (RQ3). The interviewees were all currently employed in the battery industry, or related to the industry, either working within the BCP or as trainers, see Table 3.1. Each interviewee had different experience in the battery industry and worked within different production steps, see Table 3.2.

Table 3.1: Distribution of the interviewees' different work roles.

Interviewees	
Group	**Quantity**
Operator	5
Engineer	5
Manager	2
Trainers	1
Total	**13**

Table 3.2: What group does each interviewee belong to, and what production steps and experience in the battery industry do they have.

Interviewees			
Interviewee	**Group**	**Production Step**	**Experience**
1	Engineer	All	9 years
2	Engineer	Notching	7 months
3	Engineer	Mixing, Calendering, Notching	8 months
4	Engineer	Mixing, Coating, Calendering	6 weeks
5	Engineer	Raw Materials	9 months
6	Operator	Mixing	7 months
7	Operator	Mixing	1,5 years
8	Operator	Coating, Calendering	9 months
9	Operator	Mixing	9 months
10	Operator	Cell Assembly	7 months
11	Manager	Formation, Aging	1 month
12	Manager	Stacking	8 months
13	Trainers	Battery Safety & ESD	1 year & 24 years

Most of the interviewees worked at the same company except for one, and all of the interviews were performed over an online video call meeting, except for one that was held on-site. The separate interview was with two trainers at a research company that also holds courses connected to the battery industry. The video call meetings lasted for 30-45 minutes, while the on-site meeting lasted for two hours and was composed of an interview and a workshop. The online interviews had the same fundamental questions laid out, see Appendix A.1. The interviews were conducted by the two authors, where one interviewed while the other took notes. The interviews

were recorded by the interviewers' mobile devices and transcribed with the help of the Microsoft Office Word transcription tool. Lastly, the transcription files were proofread, corrected and in some cases, translated, see Appendix A.

3.1.3 Survey

A survey was conducted to identify skill gaps for operators in vocational education to help answer the second research question (RQ2). The survey was designed so that the operator students could do a self-assessment of their skills. The self-assessment was done by allowing the students to place the identified and listed skills in a chart, see Figure 3.2, where the fourth quadrant represents the skill gap [39]. The x-axis represents Relevance on a scale from unimportant to important (0-5) and the y-axis represents Performance from not at all to very good (0-5). The survey was conducted online and was completely anonymous. The survey was constructed according to how skill gaps are measured, as mentioned in Section 2.2.1 [39] and can be found in Appendix C.1.

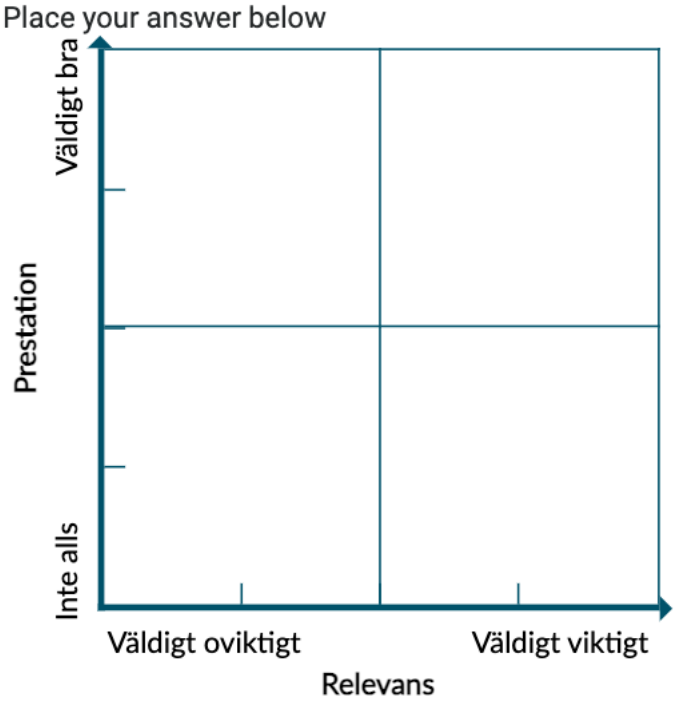


Figure 3.2: Visualisation of the self-assessment chart.

3.1.4 Literature Review

The scope of the literature review was divided into two areas. The first area was to broaden the understanding of how the battery industry works in general, gather intel for the theory and set a foundation for the approach of the study. The second area was to research relevant pedagogical theories and learning models to help answer the third research question (RQ3). The literature review of the first area was mainly conducted during the initial stages of the study while the second area transpired

during the later stages. This was conducted by searching for articles and reports in different databases, such as Google Scholar, Science Direct and libraries. Keywords used were for example: batteries, cell production, adult learning, learning factories, VET, learning theories and pedagogical theories.

3.2 Data Analysis

The data was analysed in different ways, mainly depending on the nature of the data collection. To make the analysis easier, notes were taken during the observations and all interviews were both recorded and noted down. The notes and recordings were conducted to be able to re-visit what had been said or observed to get a better understanding of the information.

3.2.1 RQ1 - Skills

The result for the first research question emerged primarily from the data collected during the field studies and interviews but also from the literature research. Initially, a brief empirical analysis was conducted using data collected from field studies. Empirical analysis relies on real-world observations or experiences to draw conclusions and support findings [75]. The composed data from the analysis was then compiled and categorised in themes together with the data from the interviews through a thematic analysis. A thematic analysis is a method used to recognise, examine and present patterns, or themes, within collected data [76]. A thematic analysis generally consists of six steps [76].

1. Familiarising yourself with your data
    - Transcribing the data
    - Analysing the data
    - Document preliminary ideas
2. Generating initial codes
    - Deduct what is interesting about the data
    - Find common denominators within the data set
3. Searching for themes
    - Combine the denominators into larger groups, making the potential themes
    - Make correlations in the data to initial theme ideas
4. Reviewing for themes
    - Check the relevance between the denominators and themes, and how it correlates with the entire data set
    - Review the phrasing of the themes
5. Defining and naming themes
    - Finalise the data analysis
    - Ensure that the themes represent the data in a correct manner
6. Producing the report
    - Extract examples to present which represent the themes

- Make connections between the result of the analysis and previous parts of the report

The thought process of this study's thematic analysis when finalising the skills and their associated category involved questions such as:

1. Are there connections between what has been told in interviews, and the workshop, and collected in the research?
2. How many times are the skills mentioned?
3. Are there correlations within the mentioned skills?
   (a) Is there a way to summarize them? How?
   (b) How are the skills connected and how can they be categorised?

3.2.2 RQ2 - Skill Gap

The second research question mainly used data gathered from the survey sent out to individuals studying to become operators. The arrangement of the survey was that the respondents made a self-assessment, see Figure 3.2. The fourth quadrant represents skills respondents consider important to know but do not yet possess, which leads to it representing the skills gap for the composed skills. Each respondent's answers were compiled in a Microsoft Excel sheet. The answers from the self-assessment were presented in charts for analysis.

3.2.3 RQ3 - Challenges

In the interviews, the participants were asked what they saw as challenging, or most challenging, in their work role. This was done to establish what different challenges could be encountered within battery cell production. The interviewees' answers were compiled and a thematic analysis was conducted following the steps mentioned in 3.2.1. However, the thought process was different:

1. What did they perceive as a challenge?
2. How many times are the challenges mentioned?
3. Is there a way to summarize them? How?
4. Are there any similarities to the established skill gaps?

Additionally, a literature review of learning factories and pedagogical theories that exist on the market was made. Furthermore, the challenges were divided into learning targets according to the founded theories mentioned in Section 2.4.

3.3 Authenticity

To deem a research study trustworthy, it must meet specific criteria, including credibility, transferability, dependability, and confirmability [77]. Some agree that those criteria are important, but instead, refer the criteria to the importance within quantitative research [73]. In qualitative research, researchers are divided on the significance of the terms ”reliability” and ”validity”. They debate over different outlooks on what defines a study's authenticity, where one points out that validity is about if you ”observes, identifies or *measures* what one claims to measure”. Other researchers argue that the terms can be divided into four: *External reliability, Internal reliability, Internal validity* and *External validity* which can be compared with some of the initially mentioned criteria [73]:

- Credibility - Internal Validity,
  - can be ensured by incorporating multiple perspectives during data collection, thereby confirming the relevance of the data.
- Transferability - External Validity,
  - ensures that the study findings can be applied to comparable settings or individuals.
- Dependability - Reliability,
  - is established by ensuring that the findings remain consistent despite any changes within the research setting or participants during data collection.
- Confirmability - Objectivity
  - is ensured by thoroughly verifying and re-verifying the data throughout the process of collection and analysis, thus increasing the likelihood that others could replicate the results [77][73].

Some of the arguments regarding the disputes of interpretation of ”reliability” and ”validity” in qualitative studies are that they presuppose the possibility of coming to one single portrayal of reality. Some researchers try to explain it as a possibility of the existence of multiple ways to portray the same reality [73].

4
Results

This chapter presents the outcome of the study. What the essential skills are for an operator in battery cell manufacturing, skill gaps for potential future operators, challenges that the workforce faces in a BCP and how the training of operators can be facilitated.

4.1 Skills

Figure 4.1 shows an overview of the identified skills that are needed in downstream battery cell production. The skills were determined after a compilation of interviews, workshops and a literature review. For an overview of the compilation, see Appendix B.1. The colours in the upper left corner represent what category(ies) the skill is assigned to. The skills are divided into cognitive, safety, quality control, and/or work process skills as a result of the thematic analysis, where the categories emerged based on the similarities and correlations among the skills. These categories indicate the areas in which the skills are needed and are of importance. The initial result and composition from the thematic analysis can be found in Appendix B. Table 4.2 shows a more detailed overview of how each skill is divided into different categories.

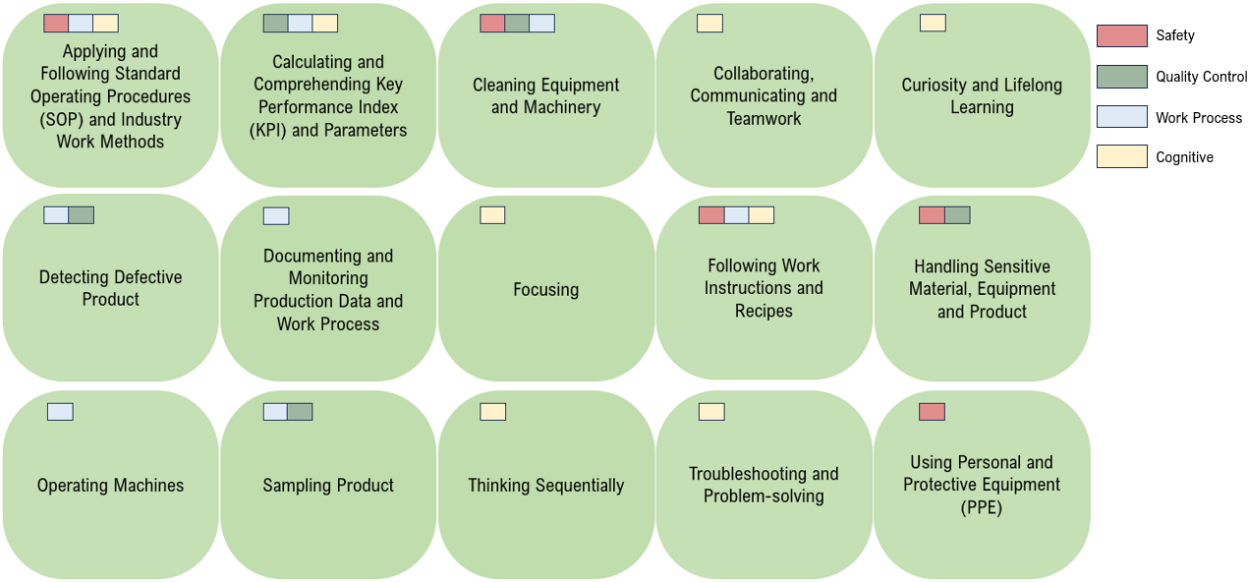


Figure 4.1: Identified skills in the downstream battery cell production.

Figure 4.2 presents each skill, with vital takeaways. In Table 4.1, there is a detailed description of what each skill entails.

Figure 4.2: Identified skills in the downstream battery cell production, summarised with key takeaways.

Table 4.1: A table conveying each skill, skill explanation and examples of each.

No.	Skill	Explanation	Examples
S1	Applying and Following Standard Operating Procedures[1] and Industry Work Methods	To establish workplace standards, it is important for the operator to apply and follow the company's SOP's and common industry work methods.	Lean, 5S, 5 Whys, 8D, Six Sigma
S2	Calculating and Comprehending Key Performance Index (KPI) and Parameters	To maintain high product quality and ensure correct production processes, it is important for the operator to possess the knowledge to calculate KPIs and understand various parameters that might affect the outcome of the product.	Agglomeration, Capacity, Compression, Current, Density, Humidity, Loading Level, Particle fineness, Porosity, Pressure, Resistance, Solid Content, Temperature, Thermal and Mechanical Stress, Thickness, Tolerance, Velocity, Viscosity, Voltage
S3	Cleaning Equipment and Machinery	To avoid contamination and ensure safety and product quality, it is important for the operator to know how to clean the equipment and machinery properly.	Cleaning of tanks, pipes, knives, microscopes, machines, tools
S4	Collaborating, Communicating and Teamwork	To avoid process errors, ensure smooth and continuous production and understand different work cultures, it is important for the operator to know how to collaborate, communicate and work in a team.	In and between process steps. With full gear. Different work and cultural backgrounds.

Continued on next page

[1]Standard Operating Procedure, or SOP for short, is a documented set of step-by-step instructions that outline the routine procedures, protocols, or processes to be followed in specific situations or tasks within an organization [78].

Table 4.1 – continued from previous page

No.	Skill	Explanation	Examples
S5	Curiosity and Lifelong Learning	To streamline workflow, enhance self-development and reduce the risk of process errors, it is beneficial for the operator to be curious and eager to learn.	Ask questions, Engage in training, Have an open mind
S6	Detecting Defective Products	To ensure product quality, continuous production and waste reduction, it is important for the operator to know how to detect deviations in products or machines and quickly correct errors. It is also important to know how and when to remove defective products.	Stripes, bubbles, burrs, holes, spikes, delamination, microcracks, dross, telescopic effect, irregularities
S7	Documenting and Monitoring Production Data and Work Process	To avoid process and production errors, it is important for the operator to document deviations and their work processes so that other personnel know what happened during a previous shift or process step. To ensure product quality and continuous process, the operator needs to monitor the machines and screens at all times to detect deviations.	Parameter values
S8	Focusing	To avoid process errors and ensure product quality, it is important for the operator to know how to maintain focus over a longer period, as some tasks could become monotonous due to a lack of deviations.	Monitoring screens
S9	Following Work Instructions and Recipes	To ensure standardised work routines and equal performance at each task, it is important for the operator to know how to read and follow given work instructions and recipes.	Mixing slurry, sampling

Continued on next page

Table 4.1 – continued from previous page

No.	Skill	Explanation	Examples
S10	Handling Sensitive Material, Equipment and Product	To avoid damage and contamination of the sensitive, and sometimes hazardous, materials and products, it is important for the operator to know how to handle them. To ensure equipment reliability, the operator needs to know how to use tools correctly.	Calibration, Measurement, Transportation, Tools; viscometer, grind gauge, density cup, scissors, tape, ruler, rear meter, material airlock (MAL)
S11	Operating Machines	To ensure continuous process flow and product quality, it is important for the operator to know how to operate the machines.	Change parameter values, solve simple errors.
S12	Sampling Product	To ensure high product quality, it is important for the operator to know how to do various product sample tests for each process step.	Parameter and deviation checks
S13	Thinking Sequentially	To ensure continuous process flow, it is important for the operator to know how their work affects the process and how small changes can have a significant sequential impact on it.	Reflect, ask questions
S14	Troubleshooting and Problem-solving	To ensure continuous production and avoid recurring errors, it is important for the operator to know how to troubleshoot and when to solve issues within their work role, or when to seek assistance from a technician or engineer.	Machine errors
S15	Using Personal Protective Equipment (PPE)	To ensure material and personal safety, it is important for the operator to know how, why, and when to use PPE, as well as the amount of gear necessary for different tasks.	PPE could be gloves, coveralls, face masks, goggles, safety shoes, and personnel airlock (PAL).

Table 4.2: Display of the categories to which each skill is affiliated.

Skill	Safety	Quality Control	Work Process	Cognitive
Applying and Following Standard Operating Procedures and Industry Work Methods	x		x	x
Calculating and Comprehending Key Performance Index and Parameters		x	x	x
Cleaning Equipment and Machinery	x	x	x	
Collaborating, Communicating and Teamwork				x
Curiosity and Lifelong Learning				x
Detecting Defective Products		x	x	
Documenting and Monitoring Production Data and Work Process			x	
Focusing				x
Following Work Instructions and Recipes	x		x	x
Handling Sensitive Material, Equipment and Product	x	x		
Operating Machines			x	
Sampling Product		x	x	
Thinking Sequentially				x
Troubleshooting and Problem-solving				x
Using Personal Protective Equipment	x			

4.2 Skill Gaps

The identification of skill gaps was generated from the answers given in a survey sent out to operator students in vocational education. The respondents' previous fields of work experience are presented in Figure 4.3 which shows that they come from different backgrounds but neither have experience in the battery industry. The chart shows that the majority of participants do not have previous work experience in a technical industry field.

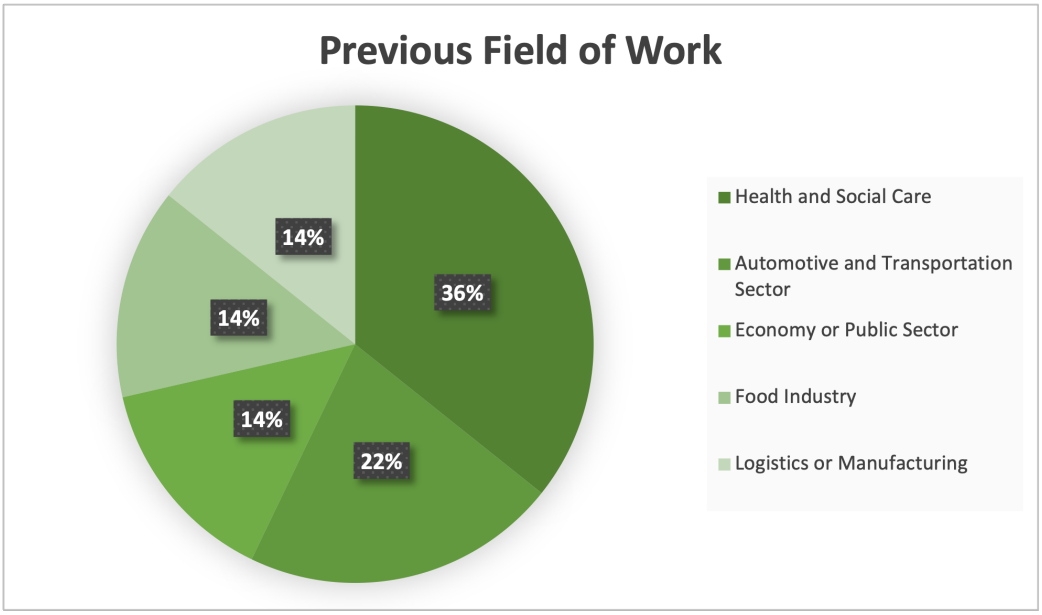
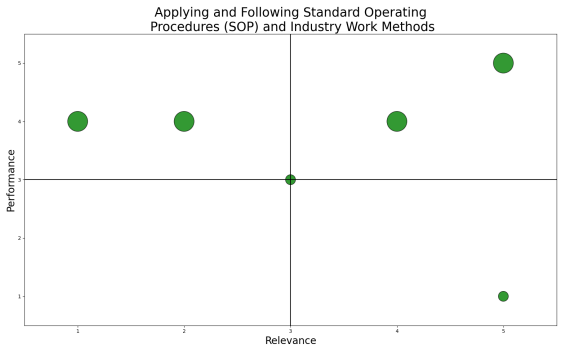


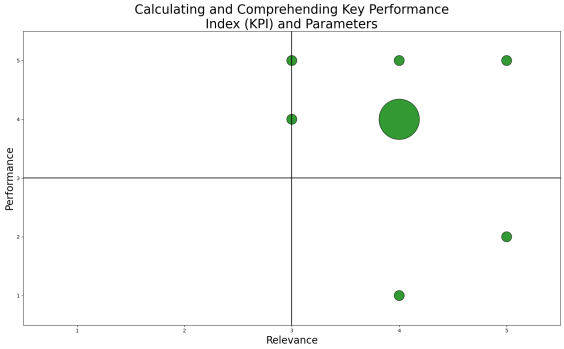
Figure 4.3: A pie chart showing the distribution of the survey respondents' previous field of work experience.

The charts in Figures 4.4 – 4.7 display the distribution of respondents' answers for each skill, ranging from its perceived relevance to their perceived performance. The size of the dots represents the answer frequency, where the largest dot represents the highest frequency (4) and the smallest the lowest frequency (1). The skill gap emerges from each chart's fourth quadrant, where the skill is considered as being of high relevance but the respondent does not possess it well enough, hence a skill gap.

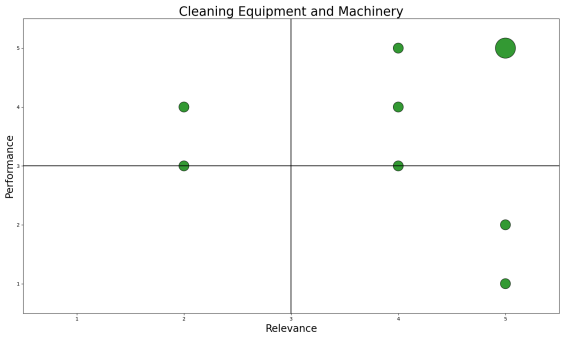
In Figure 4.4 different tendencies in the responses of the relevance and performance are observed for the first four skills. The x-axis represents the relevance scale from unimportant (1) to important (5) and the y-axis represents the performance scale from not at all (1) to very good (5). As shown in 4.4*(a)*, S1 has a broad dispersal of the perceived relevance of the skill with answers. Similar tendencies are found in 4.4*(c)*, S3, but with a narrower distribution of the answers. What can be apprehended regarding the performance is that the majority of the respondents consider themselves to possess the skills in question, with only a few exceptions for each skill.



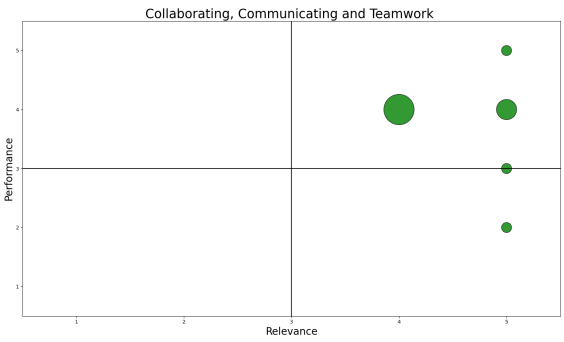
(a) Skill 1 - Applying and Following Standard Operating Procedures (SOP) and Industry Work Methods



(b) Skill 2 - Calculating and Comprehending Key Performance Index (KPI) and Parameters



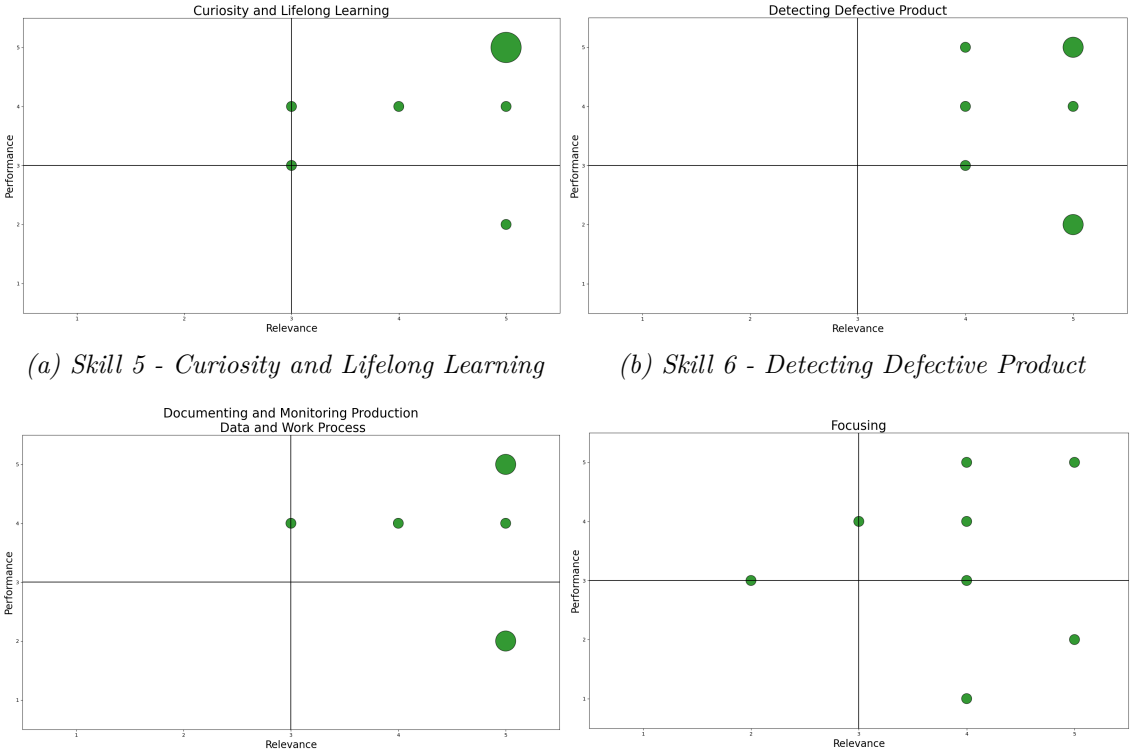
(c) Skill 3 - Cleaning Equipment and Machinery



(d) Skill 4 - Collaborating, Communicating and Teamwork

Figure 4.4: Dot charts displaying the respondents' answers on the first (1) to fourth (4) skill.

The charts of skills 5–8 in Figure 4.5 display a more collected tendency of higher relevance of the skills in comparison to skills 1–4 in Figure 4.4. The majority of the answers are also in the first quadrant which implies the skills to be of both high relevance *and* performance level. S8 has a wide distribution along the performance scale. All skills have a perceived skill gap.



(a) Skill 5 - Curiosity and Lifelong Learning

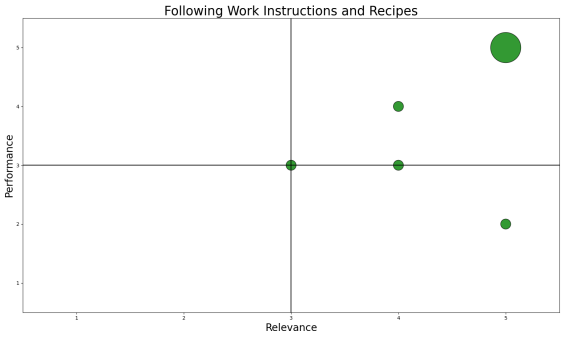
(b) Skill 6 - Detecting Defective Product

(c) Skill 7 - Documenting and Monitoring Production Data and Work Process

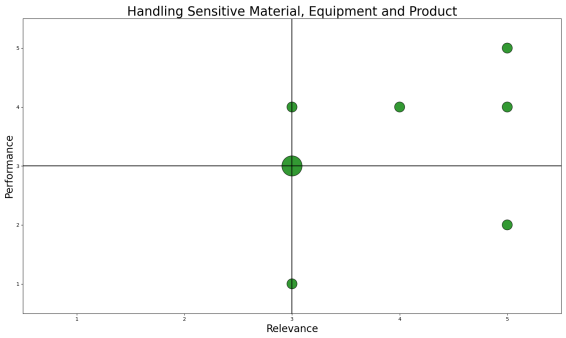
(d) Skill 8 - Focusing

Figure 4.5: Dot charts displaying the respondents' answers on the fifth (5) to eighth (8) skill.

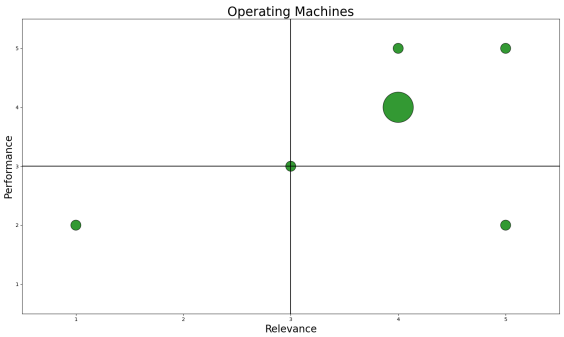
The distribution of the answers for skills 9 – 12 is shown in Figure 4.6. It is a relatively wide distribution of the answers along the performance axis in all four charts *(a)-(d)* but S10 has the most spacious distribution without a strong tendency towards high or low performance. All of the skills are of high relevance.



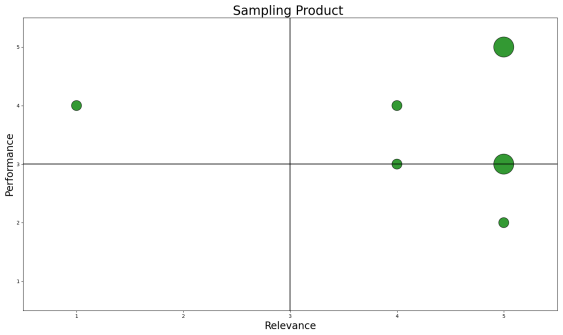
(a) Skill 9 - Following Work Instructions and Recipes



(b) Skill 10 - Handling Sensitive Material, Equipment and Product



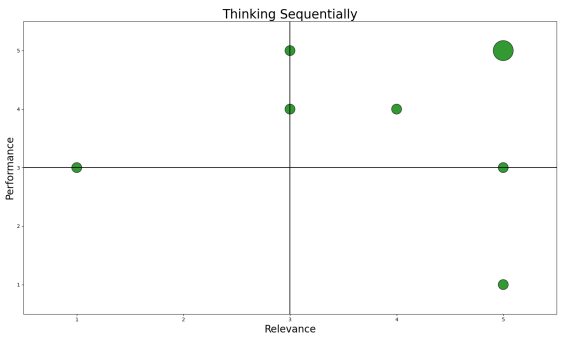
(c) Skill 11 - Operating Machines



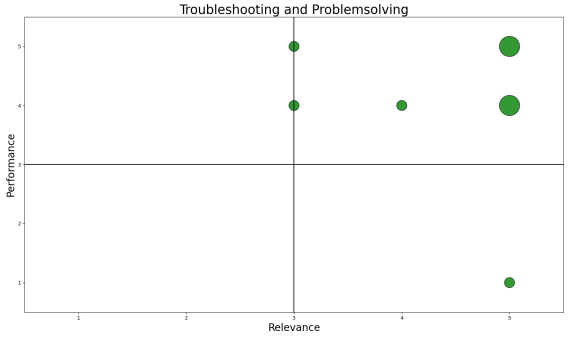
(d) Skill 12 - Sampling Product

Figure 4.6: Dot charts displaying the respondents' answer combinations on the ninth (9) to twelfth (12) skill.

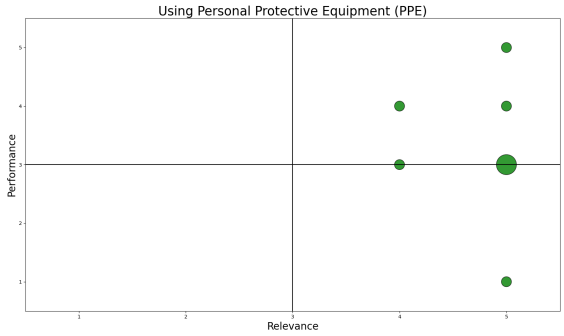
Figure 4.7 show the answer distribution of the three last skills, skills 13–15. S14 and S15 in Figure 4.7*(b)* and *(c)* show a strong tendency to have a high relevance value as all of the answers are on the right side of the chart. S13 shows the same tendency, with only one deviant answer with a low relevance value. All skills show values of high performance, with S14 having the highest frequency.



(a) Skill 13 - Thinking Sequentially



(b) Skill 14 - Troubleshooting and Problem-solving



(c) Skill 15 - Using Personal Protective Equipment (PPE)

Figure 4.7: Dot charts displaying the respondents' answers on the thirteenth (13) to fifteenth (15) skill.

Figure 4.8 shows how many of the respondents deem the skill as a skill gap. The skill gaps with the highest frequency of four (4) is *S10 - Handling Sensitive Material, Equipment and Product*, *S12 - Sampling Product* and *S15 - Using Personal Protective Equipment*. The skill is perceived as a skill gap if the answer is above three (3) on the relevance scale and below three (3) on the performance scale, thus appearing in the fourth quadrant of the dot charts. *S14 - Troubleshooting and Problem-solving* is the one with the lowest frequency regarding its perception of being a skill gap or not with only one answer in the fourth quadrant.

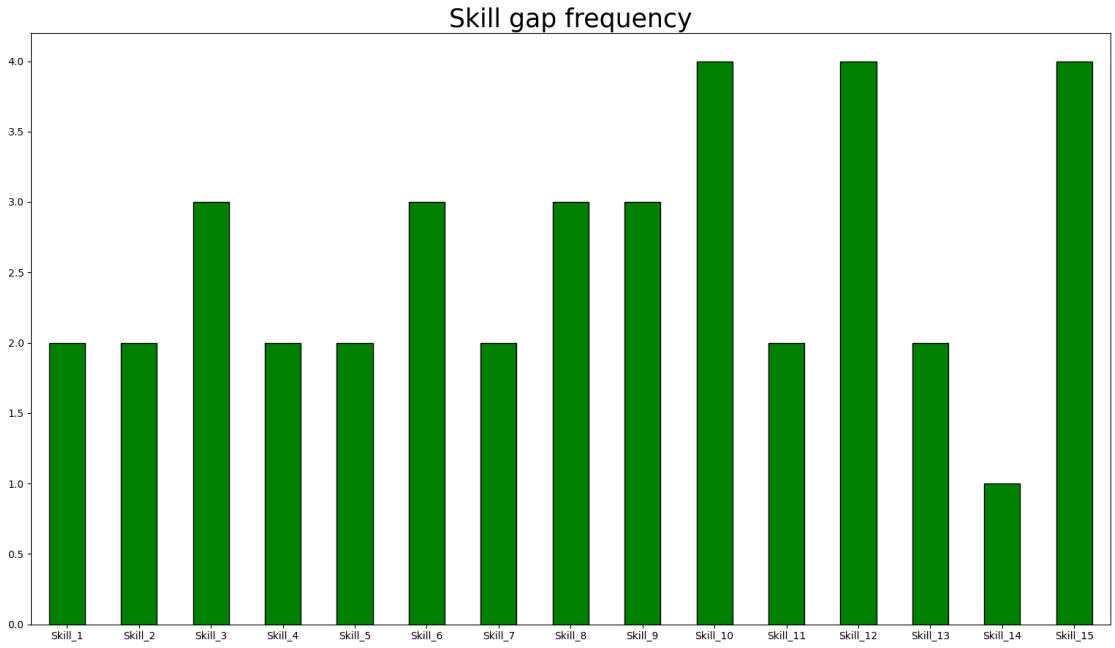


Figure 4.8: A bar chart representing the frequency of which skills are perceived as a skill gap.

4.3 Challenges

Figure 4.9 presents a pie chart of challenges that battery industry personnel face with their work tasks. The challenges were developed through an analysis of the interviews where the question ”What do you find most challenging about your work/-tasks?”, was asked. The chart shows that the majority of interview respondents found communication and teamwork as the most challenging parts of their work. Furthermore, problem-solving, monitoring and managing machines, having standardised ways of working, high precision and accuracy, and lastly, general interest in the area, are challenging parts of work.

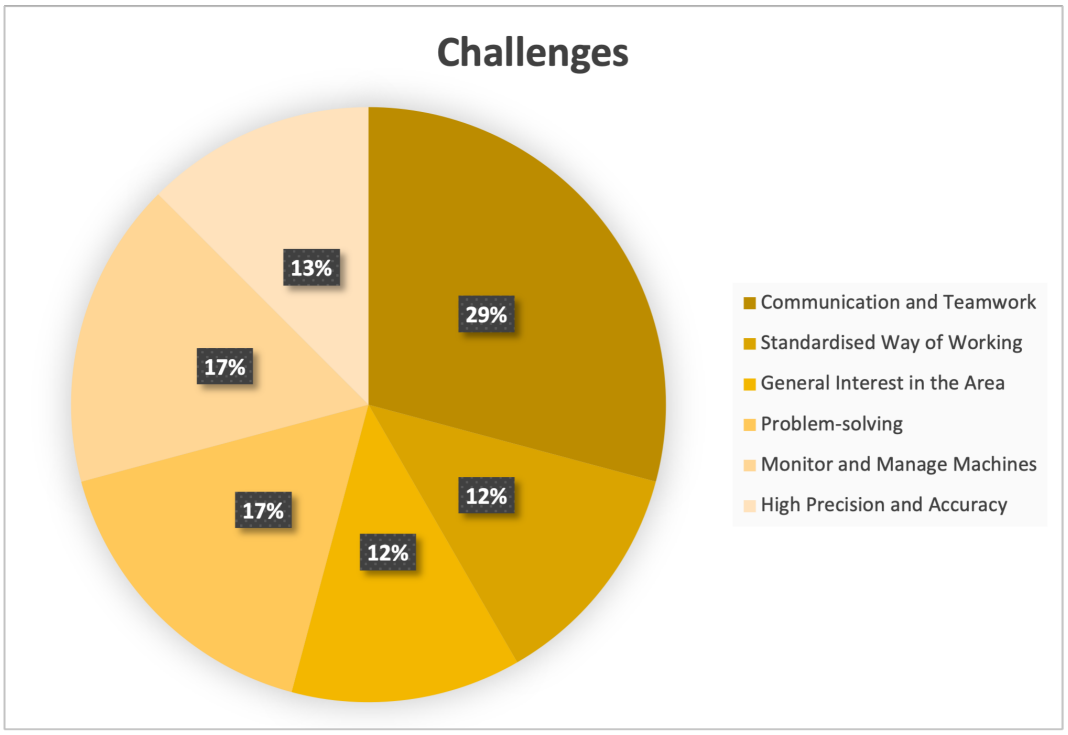


Figure 4.9: Pie chart that represents identified challenges in work tasks for battery cell production personnel.

Below are selected quotes from the interviewees regarding the challenges they face in their work roles.

> *At* [redacted]*, it's about keeping up with everything. I come from a place where I've been able to deliver and had the necessary conditions. Here, you have to make the best of the situation every time, and that presents challenges for me.*
>
> *– Interviewee 3*

> *I would say it's really like convincing the team, because normally a manufacturing engineer is not boss of anyone, but you have several people that you work with and convince them to follow the same way as you are doing to make it work. So I would say that part is especially challenging, I mean bringing everyone together in one direction with one goal and making it, let's say, fit into the team. And I mean, we have different people you communicate with as well, so that is a bit like I would say that's the challenging part of the job.*
>
> *– Interviewee 2*

> *Yeah, challenging part basically is communication. Because, one team might have an issue with the machine and the next team coming up, because we have like let's say four teams like A-D and then I think a lack of communication a lot for people not letting us know that, OK, maybe they changed some parameters here, or they had an issue here. So basically, that's the most challenging part. Communication between, like, even from stacking before or like from e-filling, I think if we are better with communication, we'll be able to produce better quality machine, because right now I'm feeling like there's so much waste.*
>
> – *Interviewee 10*

> *When things go wrong. Problem-solving in the beginning, that was it really. There's a lot to learn in the beginning, but once you've learned it, it's mostly just the problem-solving that's complicated.*
>
> – *Interviewee 8*

> *It's all about the needs of people with an eye for detail.*
>
> – *Interviewee 1*

> *I think I find it quite easy because I'm quite interested in technology and such things, while many colleagues are not interested in it at all it seems. So they have a bit more difficulty learning everything.*
>
> – *Interviewee 6*

> *I'll try to describe the process, how we need to do the process, but that is in that way sounds really easy, but actually it's not because we need to manage the machines and we need to manage issues inside the machines or related to them. We need to solve all these issues and sometimes we cannot explain like "OK, I cannot continue doing the process because of this". Now we need to manage all those things and inside we have a lot of things to manage.*
>
> – *Interviewee 9*

Figure 4.10 shows the division of challenges in affective, cognitive and psycho-motorial learning targets, as described in Section 2.4. The challenges are named C1 for the first challenge, C2 for the second challenge and so on. *C1 - Communication and Teamwork* and *C2 - Standardised Ways of Working*, are divided into affective and cognitive learning targets. *C3 - General interest* is divided into affective learning targets. *C4 - Problem-solving* and *C6 - High Precision and Accuracy* are divided into cognitive and psycho-motorial learning targets. Lastly, *C5 - Monitor*

and Manage Machines is divided into psycho-motorial learning targets.

Learning Target	Affective	Cognitive	Psycho-Mototrial
C1	Communication and Teamwork		
C2	Standardised Ways of Working		
C3	General Interest in the Area		
C4		Problem-Solving	
C5			Monitor and Manage Machines
C6		High Precision and Accuracy	

Figure 4.10: Challenges C1–C6 divided into affective, cognitive and/or psycho-motorial learning targets.

Figure 4.11 presents a Venn diagram of how learning factory, learning theories and skill gaps correlate. The middle part of the diagram, where all classes meet, represents the bridging of skill gaps with help from learning factories and learning theories. If learning factories have learning theories integrated with them, learning is enhanced. Skill gaps can be bridged with the help of training in a learning factory. Skill gaps can be bridged with help from learning theories. The combination of all three is the optimal choice for facilitation of bridging the skill gaps. The Venn diagram is developed based on insights gathered from the literature review and interviews. The learning factory is structured around specific learning targets encompassing affective (emotional), cognitive (thinking), and psycho-motorial (physical skills) domains, see Section 2.4. Supporting these targets are various learning theories: andragogy and pragmatism, that guide the process of skill development and ultimately aid in overcoming the challenges associated with bridging skill gaps.

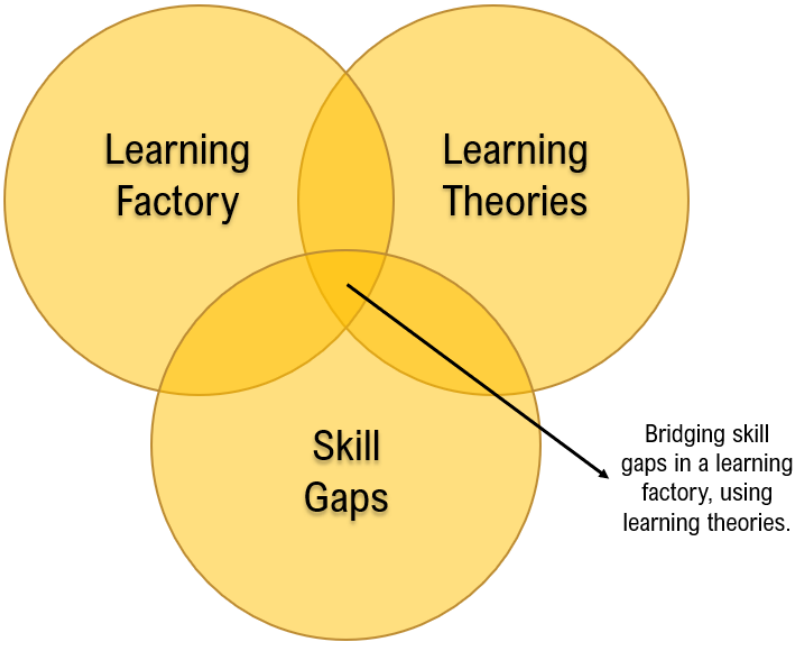


Figure 4.11: Venn diagram representing how learning factories and learning theories correlate with skill gaps to help facilitate them.

Learning Targets and Theories

As mentioned in Section 2.4, the learning targets of learning factories are usually cognitivism, affective and psycho-motorial learning. In Section 2.3, pragmatism and andragogy are learning theories that support the education of adults. By combining what the theory says about adult learning, with the knowledge of learning targets, the upskilling of battery production workers can be facilitated. By knowing the skill gaps and challenges for the workforce, they can be divided into the correct learning targets, similar to what has been made in Figure 4.10. Furthermore, it becomes more straightforward to find a correlating learning model for each learning target. Hence, the bridging of the skill gap becomes facilitated.

5
Discussion

In the following chapter, the outcome from this study will be discussed, divided into each research question, followed by a review of the study's strengths and weaknesses, and lastly, a discussion regarding possible future work.

5.1 Research Question 1 - Skills

Skills are, as mentioned in Section 2.2, "the ability and capacity to carry out processes and use the existing knowledge to achieve results" [11] and it is one of the elements that make up competence [34]. Figure 4.1 and Table 4.1 show the identified skills needed for battery cell production personnel, specifically operators.

For the skills to be established, it was vital to first understand what skills and skills training looked like, and what the industry required. Secondly, it was important to understand what each process step in the BCP looked like. Research into what skills and skill gaps are, and what the predictions are for the future was made, followed by how a battery works and what the BCP looks like, to find basic knowledge. The research, in turn, facilitated the field studies that were made.

The established skills developed firstly through observations in field studies, where numerous questions about how the battery cell production works, and what is important to think about as an operator in each production step, were asked. With the literature study in mind, a broader understanding was formed of what the downstream BCP looks like, and a clearer picture was established of what necessary skills were needed. The field study facilitated the formulation of interview questions, since the understanding of how BCP worked, was deepened.

When the interviews were performed, a thematic analysis was made. During the analysis, it was discussed what categories the skills should be divided into, and the outcome was safety, quality control, work process and cognitive, as shown in Table 4.2. Safety overall is fundamental in BCP, as mentioned in Section 2.1.1, therefore it was made as a category instead of a skill. The thought was to define and clarify what skills that contribute to safety. They are in turn used in each process step somehow. An example of this is *S15 - Using PPE* and *S10 - Handling Sensitive Material, Equipment and Product.* S15 is used in each process step somehow, whether it is full gear or only gloves. Wearing PPE, protects the individual and the material, and contributes to safety. S10 contributes to safety by handling the sensitive material

correctly, to also protect the product and the individual.

The same thought process was used with the rest of the categories and skills. The category work process implies that the skill is a part of keeping a continuous process flow. Quality control implies that the skill is needed to ensure high product quality. Lastly, cognitive skills are those that are not hands-on, technical skills that can be measured, but rather are soft or transferable skills.

During field study two and interviews, several new insights were made, which literature had not made as apparent before. First, there was this realisation that it was going to be more difficult to gather data than first thought. Research had shown that the battery industry was a new field in Europe [7], which there was an awareness of, however, reality made that even clearer. Since the battery industry is such a new field, people are busy and not as open to participating in surveys and interviews. Besides that, the industry is very secretive. Even though the study was not after secret cooperation information, it became an additional obstacle in the data collection.

Second, it was emphasised that there was a deficiency in competent personnel at the site. The workload and work pace were growing more rapidly than the workforce, making it hard for the already established personnel to train new hires. Hence, the need for skilled personnel is a must.

Third, it was explicitly stated that there are difficulties with communication and standardising work due to personnel having different cultural backgrounds and ways of working. This was mentioned in several interviews and the communication was lacking not only because people do not understand each other due to language barriers, but also because of the need of having to communicate wearing safety gear, not being able to hear each other clearly, read lips or see face expressions. Besides that, it seems hard to convince people to perform work tasks a certain way if they are not used to the way of working. This is why S1 and S4 are vital since a standardised way of working also contributes to safety, reduction of waste, and high product quality, since the task is performed the same way each time, ensuring that the product outcome stays the same.

Fourth, safety was a major topic. Not only does it influence all process steps, but it has also become a type of mindset at the factory and something that should be of second nature for everyone entering and working in the battery industry. It is therefore a vital keystone that all workers should carry with them through the whole BVC.

Fifth, there was a realisation that the biggest part of the BCP is automated, which made it harder to understand what it is that operators actually need to practice and what technical skills they need to possess. However, the content of it was that the important part of working in the process steps that are automated is the sequential thinking and the sequential understanding. To know what is happening during this exact process step, and how the outcome of the product affects the next part of the process.

5.2 Research Question 2 - Skill Gap

The compilation of the skill gaps is based on a survey study of ten respondents who are vocational operator students. They were asked to self-assess the relevance and own performance on the 15 skills composed previously in this study. The skills were formed from three different information sources, literature, field studies and the assessment of individuals employed in the battery industry. This gave a varied perception of the demands existing on the market which aligns with one of the definitions of skill gaps mentioned in Section 2.2: ”the difference between the market's need (demand) and the current skills supplied by local education institutes (supply)” [41]. This definition together with the basis of how the skills were produced indicates that the skill gaps presented in this study are a representative image of how the gap appears in reality.

However, one of the other definitions of skill gap is ”a skill gap is a gap between the skills that employers demand and the skills that employees possess” [38]. With this definition, the skill gaps concluded in this study lack the input from what skills the employers deem necessary for their employees to possess. Data from employers' opinions has not been collected, since that was not feasible during this project, due to the difficulties finding employers who have time to participate in the study. Nevertheless, the interviewees were a mix of different work roles: operators, engineers, shift managers and trainers. This gave a diverse point of view of what is expected of the operators, rather than if the input had come from the operators alone. One of the interviewed engineers, Interviewee 1, was previously a hiring manager within quality control, who was also a part of the workshop. That interview and workshop gave inputs regarding what hiring managers typically look for when hiring new personnel, see Appendix A, which gave insights into what employers have in consideration when hiring. This gave a small perspective of what employers demand.

Furthermore, one of the parts in one approach to measuring skill gaps, mentioned in Section 2.2.1, is to ask students to self-assess their thoughts on the relevance and their performance regarding each skill in the compiled skill set. This approach is what has been used in this study to determine what the skill gaps are since the respondents were all at the end of their studies to become operators in the future.

Something that is worth considering with the established skill gaps is the possibility of misinterpretations from the respondents regarding the meaning of each skill since they only received the names of the skills and not the full explanation. This could have resulted in a misplacement of their answers while grading the skills against their relevance and performance, thereby giving a misleading result. However, the tendency that can be found in the respondents' answers is that there are at least two participants who view each skill as a skill gap, except for one: *S14 - Troubleshooting and Problem-solving*, where only one respondent perceived that as a skill gap. This lowers the risk of the answers being a result of a misinterpretation and instead be-

comes a more reliable result. At the same time, it could be argued that skills gaps with a low answer frequency, such as S14, are something the respondents consider to possess and thereby place it higher on the performance scale. It could be that troubleshooting and problem-solving are a rather general skill to possess within multiple work fields, and that it is seen as something the respondents can do, no matter the difficulties in different work fields. All of the respondents have previous work experience but are from different areas and industries, perhaps problem-solving and troubleshooting is something they already have encountered and do possess.

The skills with the highest skill gap frequency are *S10 - Handling Sensitive Material, Equipment and Products, S12 - Sampling Product* and *S15 - Using Personal Protective Equipment*. These skills can be perceived as more industry-specific and therefore more participants view them as something they have yet to possess. They can also be seen as challenging, because of a lack of experience or because they are difficult to perform.

What is interesting is that the tendencies in the answers indicate that each skill has high relevance and importance since the majority of the answers are on the right side of the charts in Figures 4.4 – 4.7. This confirms that the skills are reasonable and therefore can be considered skills that an operator should possess within the battery industry.

The skill which shows a deviated answer regarding the respondents' view of the relevance is *S1 - Applying and Following Standard Operating Procedures and Industry Work Methods*, see Figure 4.4*(a)*, having a larger share of answers on the lower side of the relevance scale. This contradicts the result of it being a skill. As mentioned in the previous section, it is vital to have a similar and standardised way of working within and between the teams, to achieve streamlined production, minimize waste, and ensure both personal and material safety. That the skill is not seen as relevant, stresses even more how important it is to have, for it to become seen as relevant to all entering and working in the battery industry.

5.3 Research Question 3 - Challenges

When the interviewees were asked what they believe is most challenging with their work tasks, they stated that they found communication and teamwork, standardised ways of working, general interest in the area, problem-solving, monitoring and managing machines and high precision and accuracy, to be difficult, as seen in Figure 4.9. The answers are interesting for several reasons: 1. the challenges are based on the interviewees' perceptions, however, the interviewees had similar answers; 2. the challenges correlate with the findings of skill gaps in Section 4.2; 3. one skill that workers in battery cell production find relevant and experience as challenging, vocational students do not.

Even though the challenges are based on the interviewees' perceptions of what they find hard about their work tasks, the interviewees had similar answers. The per-

ception of difficulties can be explained from various perspectives. First, the battery market is quickly expanding, which requires new competent workers [4]. Interviewee 3 expresses that it is important to keep up because the pace is high, see Appendix A. If the workforce is not growing at the same pace that the market is, then there will be an insufficient and inadequate workforce, which makes the training of new workforce difficult. This leads to the second perspective, that the workforce does not have adequate experience in the battery industry. With the growing battery comes a demand for an adequate and skilled workforce [8][9][10]. If the workers are not experienced enough, more time will have to be added to learning, to be able to perform the task. If there are not enough experienced workers who can teach, then it will become more challenging to learn and perform the task. The third perspective is simply that the execution moments are hard, or that the work culture/workplace is experienced similarly, especially in this case where most interviewees work at the same company.

To address the second point, the challenges correlate with the skill gaps. Each challenge is mentioned as a skill gap, which Figure 4.8 shows. General interest in the area goes under *S5 - Curiosity and Lifelong Learning*. *S14 - Troubleshooting and Problem-solving*, seems to be the skill with the smallest skill gap according to the figure. However, problem-solving according to the interviewees, is one of the most challenging skills. This could be explained by the same reasons mentioned in the previous section, that the interviewees have more experience in the battery industry, which might have given them an insight that it is a bigger challenge than it seems. This leads to the third point, that one skill that workers in battery cell production find relevant and experience as challenging, vocational students do not.

Most of the challenges are seen as relevant according to the results in Section 4.2. However, as previously mentioned *S1 - Applying and Following Standard Operating Procedures (SOP) and Industry Work Methods*, differs and is not seen as relevant. Interviewees 2 and 10, mention that there are various cultural backgrounds in the battery industry. Although it brings diversity to the workplace, people also have different ways of working and bring different work cultures to the workplace. For everyone to work similarly, it is therefore important that everyone can follow SOP and common work methods. This might be unknown for vocational students who have not yet entered the battery industry, therefore, the skill does not seem as relevant.

As mentioned in Section 2.4, learning factories have been built up in industry and academia, for training, education and research purposes [54]. One way to bridge skill gaps, as mentioned in Section 2.2, is for companies to train their employees [38]. Didactics is one of the dimensions of the morphology of a learning factory and the learning targets that are deemed to be appropriate for the development of skills, are cognitive, affective and psycho-motorial. For the operators to develop their skills, their training must contain these learning targets. However, since the operators are adults working in the battery industry, the learning factories must have a suitable pedagogical approach, which andragogy and pragmatism are. By

combining the knowledge of how to teach adults, and allowing them to develop their skills in learning factories, the training can be facilitated and the workforce becomes upskilled.

The established skills are both of technical and transferable nature, and they are a combination of soft and hard skills. Since the learning targets in learning factories are to develop such skills, the cognitive, affective and psycho-motorial domains were deemed to be appropriate, especially after weighing the pros and cons. The same reasoning goes for the chosen pedagogical theories, andragogy and pragmatism. One can always argue that other learning models or theories are more appropriate, however, this study sets an example of what it could look like. Negative aspects of the learning models and pedagogical theories have been that they rarely consider other cultures or parts of the world when developing, which makes their perspective narrow to how adults learn, for example. This is a flaw, especially since the workforce in the battery industry is diverse. However, what learning factories can do, is to use feedback to adjust to these gaps.

5.4 Strengths and Weaknesses

As mentioned in Section 3.3, four criteria should be met to establish the trustworthiness of research: Credibility, Transferability, Dependability and Confirmability [73]. Each of these has been continuously considered throughout the course of this study. The credibility has been achieved through the inclusion of diverse perspectives in the data collection, with various work roles interviewed and the use of different data collection methods. The transferability is supported when the survey results indicate a high relevance of the composed skills. The study's dependability and confirmability is achieved through a thorough thematic analysis which re-visits the definitions repeatedly while being further validated through the course of the data collection. By attaining these criteria, the study's process and result can be viewed as trustworthy.

With the restrictions of obtaining information from the battery industry, worldwide, Europe and Sweden may have influenced the findings, potentially biasing them towards the companies involved in this study. It is difficult to be certain whether the results apply to the entire battery industry or only reflect the researched corporations.

The response rate on the survey is rather low, making each of the ten respondents' answers considerably significant. Even though the survey was only meant to define the skill gaps, the results support that the established skills are of high relevance, which concludes a reliable composed skill set.

5.5 Future Work

If given the opportunity, an additional approach that can give further insights into skills in BCP is to expand the research to incorporate perspectives from other companies or industries. A supplementary industry that could have been interesting to observe is the pharmaceutical industry which also has a lot of similar regulations regarding cleanliness in production and therefore a sensitive industry much like the battery industry. Since the battery industry is a rather young industry with its latest transformation and growth [1], it could be a valuable input to include insights from similar production industries.

Moreover, to better determine factors that could enhance operator training, it would be beneficial to incorporate feedback and evaluations from operational training centres when more of those exist. An observational study within a battery training centre could also be beneficial for determining what learning models apply to the different types of skills.

What can be deducted from the explanation of each process step in the battery cell production explained in Section 2.1.4 and Tables 2.1 – 2.3 is that the steps differ a lot from each other. A further area of relevance to study would be categorising and determining skills to which process step it is connected.

6
Conclusion

This study aimed to investigate what is essential to know when working as an operator within battery cell production, what skill gaps they may have, what challenges they face and how the training of the operators can be facilitated. This was conducted via field studies, interviews, a survey and a literature review.

Necessary skills that operators in downstream battery cell production are shown in Figure 6.1 (identical to Figure 4.1). The areas which were perceived as most important are safety, communication and following standard operating procedures.

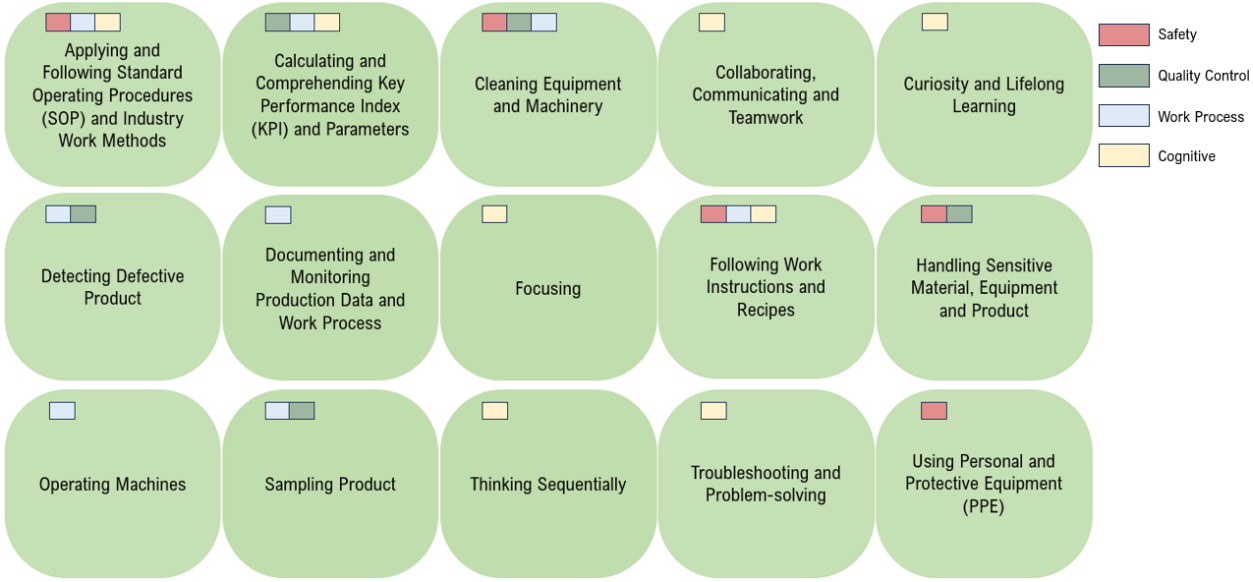


Figure 6.1: Identified skills in the downstream battery cell production.

All of the skills were perceived as skill gaps to an extent by the vocational students studying to become operators. The ones who had the largest gap were skills *Handling Sensitive Material, Equipment and Product*, *Sampling Product* and *Using personal and Protective Equipment (PPE)*, however, they were not seen as challenges by operators working in the downstream battery cell production. Challenges for the workforce were instead: *Communication and Teamwork*, *Standardised Way of Working*, *General Interest in the Area*, *Problem-Solving*, *Monitor and Manage Machines* and lastly *High Precision and Accuracy*.

Learning factories could be a solution for training operators in battery cell production. The learning factory should have learning targets within the cognitive, affective and psycho-motorial domains, and be developed on pedagogical theories such as pragmatism and andragogy, which are adult learning theories.

Bibliography

[1] D. V. Pelegov and J. Pontes, "Main drivers of battery industry changes: Electric vehicles—a market overview," *Batteries*, vol. 4, no. 65, 2018. DOI: https://doi.org/10.3390/batteries4040065.

[2] T. P. Narins, "The battery business: Lithium availability and the growth of the global electric car industry," *The Extractive Industries and Society*, vol. 4, no. 2, pp. 321–328, 2017-04. DOI: https://doi.org/10.1016/j.exis.2017.01.013.

[3] D. Deng, "Li-ion batteries: Basics, progress, and challenges," *Energy Science and Engineering*, vol. 3, no. 5, pp. 385–418, 2015. DOI: https://doi.org/10.1002/ese3.95.

[4] A. Lökholm. "Utbildningscenter för batterier tar form – driftansvarig på plats." (2024), [Online]. Available: https://www.mynewsdesk.com/se/goteborgsstad/pressreleases/utbildningscenter-foer-batterier-tar-form-driftansvarig-paa-plats-3296137 (visited on 01/26/2024).

[5] C. Samuelsson, *Genomförandeplan utbildningscentrum batteri*, Aug. 15, 2023. [Online]. Available: https://www4.goteborg.se/prod/Intraservice/Namndhandlingar/SamrumPortal.nsf/6B8DB4B8CA67FCFFC1258A0C004358B0/$File/8%20Genomforandeplan%20utbildningscentrum%20batteri.pdf?OpenElement.

[6] European Battery Alliance. "About eba250." (n.d.), [Online]. Available: https://www.eba250.com/about-eba250/ (visited on 01/26/2024).

[7] European Battery Alliance. "Building a european battery industry." (n.d.), [Online]. Available: https://www.eba250.com/ (visited on 01/26/2024).

[8] Albatts. "Background." (n.d.), [Online]. Available: https://www.project-albatts.eu/en/background (visited on 04/25/2024).

[9] InnoEnergy. "Empowering the energy workforce: Innoenergy's new course sets the standard for battery safety." (2024), [Online]. Available: https://www.innoenergy.com/skillsinstitute/insights/empowering-the-energy-workforce-innoenergys-new-course-sets-the-standard-for-battery-safety/ (visited on 04/25/2024).

[10] European Commission. "Strategic research agenda for batteries." (2020), [Online]. Available: https://energy.ec.europa.eu/document/download/ff94310e-2830-449e-9654-5e9e9f091441_en (visited on 04/25/2024).

[11] E. Council, "On key competencies for lifelong learning," *Official Journal of the European Union Society Interface*, vol. C, no. 189, 2018. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01) (visited on 04/17/2024).

[12] V. Jonasson. "Battery training and courses in batteries." (n.d.), [Online]. Available: https://www.ri.se/en/what-we-do/educations/battery-training-and-courses-in-batteries (visited on 06/06/2024).

[13] Regerinskansliet. "Ett tryggt arbetsliv." (Feb. 2021), [Online]. Available: https://www.regeringen.se/regeringens-politik/arbetsmiljostrategin-2021-2025/ett-tryggt-arbetsliv/ (visited on 06/06/2024).

[14] Y. Chen, Y. Kang, Y. Zhao, *et al.*, "A review of lithium-ion battery safety concerns: The issues, strategies, and testing standards," *Journal of Energy Chemistry*, vol. 59, Aug. 2021. DOI: https://doi.org/10.1016/j.jechem.2020.10.017.

[15] E.B. Tetteh. "Understanding battery types, components and the role of battery material testing in development and manufacture." (Aug. 2023), [Online]. Available: https://www.technologynetworks.com/applied-sciences/articles/understanding-battery-types-components-and-the-role-of-battery-material-testing-in-development-and-376993 (visited on 05/07/2024).

[16] Batteries in Industries. "Bu-1001: Batteries in industries." (Nov. 2021), [Online]. Available: https://batteryuniversity.com/article/bu-1001-batteries-in-industries (visited on 05/07/2024).

[17] Batteries in Industries. "Bu-301a: Types of battery cells." (Apr. 2019), [Online]. Available: https://batteryuniversity.com/article/bu-301a-types-of-battery-cells (visited on 05/07/2024).

[18] European Commission. "European battery alliance." (n.d.), [Online]. Available: https://single-market-economy.ec.europa.eu/industry/strategy/industrial-alliances/european-battery-alliance_en (visited on 01/30/2024).

[19] RISE. "Battery materials." (n.d.), [Online]. Available: https://www.ri.se/en/what-we-do/expertises/battery-materials (visited on 01/30/2024).

[20] European Commission. "Critical raw materials." (n.d.), [Online]. Available: https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en (visited on 01/30/2024).

[21] Dominko, R., Maleka, D., Thielmann, A. "Deliverable: Tf education and skills position paper." (2020), [Online]. Available: https://energy.ec.europa.eu/document/download/89d1f065-e480-4474-8763-4264a4941055_en?filename=education_and_skills_task_force_position_paper.pdf (visited on 04/25/2024).

[22] P. Atkins, L. Jones. and L. Laverman, *Chemical Principles: The Quest for Insight*, 7th ed. New York, United States of America: W. H. Freeman and Company, 2016.

[23] Battery University. "Bu-204: How do lithium batteries work?" (2022), [Online]. Available: https://batteryuniversity.com/article/bu-204-how-do-lithium-batteries-work (visited on 02/02/2024).

[24] C. J. Orendorff, "The role of separators in lithium-ion cell safety," *The Electrochemical Society Interface*, vol. 21, no. 2, 2012. [Online]. Available: https://iopscience.iop.org/article/10.1149/2.F07122if (visited on 05/07/2024).

[25] Samsung SDI. "The four components of a li-ion battery." (n.d.), [Online]. Available: https://www.samsungsdi.com/column/technology/detail/55272.html# (visited on 05/07/2024).

[26] C. Chen. "Current collectors for lithium-ion batteries." (Oct. 2022), [Online]. Available: https://www.msesupplies.com/blogs/news/current-collectors-for-lithium-ion-batteries (visited on 05/07/2024).

[27] Heimes, H.H., Kampker, A., Lienemann, C., Locke, M., Michaelis, S., Offermanns, C., Rahimzei, E. "Lithium-ion battery cell production process." (2018), [Online]. Available: https://www.pem.rwth-aachen.de/global/show_document.asp?id=aaaaaaaaabdqbtk (visited on 01/31/2024).

[28] EIT InnoEnergy. "Value chain." (n.d.), [Online]. Available: https://www.eba250.com/about-eba250/value-chain/ (visited on 05/07/2024).

[29] ALBATTS. "Albatts - introduction to the battery sector." (n.d.), [Online]. Available: https://learn.skills-framework.eu/course/view.php?id=56 (visited on 05/07/2024).

[30] L. Dahllöf and E. Emilsson, "Lithium-ion vehicle battery production," IVL Swedish Environmental Research Institute, Stockholm, Sweden, Tech. Rep. C 444, 2019. [Online]. Available: https://www.ivl.se/download/18.694ca0617a1de98f473464/1628416191286/FULLTEXT01.pdf (visited on 05/12/2024).

[31] K. W. Beard, *Linden's Handbook of Batteries, 5th Edition*, 5th ed. McGraw-Hill Education, 2019.

[32] European Commission. "European pillar of social rights - building a fairer and more inclusive european union." (n.d.), [Online]. Available: https://ec.europa.eu/social/main.jsp?catId=1226&langId=en (visited on 04/17/2024).

[33] European Commission. "What are the 20 principles of the european pillar of social rights? (easy-to-read version)." (n.d.), [Online]. Available: https://ec.europa.eu/social/main.jsp?catId=1567&langId=en (visited on 04/17/2024).

[34] R. van Echtelt. "What are skills? explanations examples." (Feb. 2024), [Online]. Available: https://www.ag5.com/what-are-skills/ (visited on 04/19/2024).

[35] European Commission. "Defining 'skill' and 'competence'." (n.d.), [Online]. Available: https://joint-research-centre.ec.europa.eu/scientific-activities-z/skills-and-competences/defining-skill-and-competence_en (visited on 04/17/2024).

[36] J. Balcar, "Is it better to invest in hard or soft skills?" *UNSW Business School*, vol. 27, no. 4, 2016. [Online]. Available: https://journals.sagepub.com/doi/abs/10.1177/1035304616674613?casa_token=0I_ZOTs_gE4AAAAA%3AyvQ9Bu96MPBVnZtF06h8OYpx2snsauOIBIIpeAtAMtYSr_C2drsBusMVmvFVHMG2lBsXbj5b83tT&journalCode=elra (visited on 04/19/2024).

[37] U. Cantner and A. F. Hendarman, "Soft skills, hard skills, and individual innovativeness," *Eurasian Business Review*, vol. 8, no. 1, pp. 139–169, May 2017. [Online]. Available: https://link.springer.com/article/10.1007/s40821-017-0076-6 (visited on 04/19/2024).

[38] G. Braun, "Towards bridging skill gaps for the future industrial workforce," Ph.D. dissertation, Department of Industrial and Materials Science, Gothenburg, Sweden, 2023. [Online]. Available: https://research.chalmers.se/publication/537006/file/537006_Fulltext.pdf (visited on 04/21/2024).

[39] G. Braun, R. Hämäläinen, M. Järvinen, P. Rikala, and J. Stahre, "Understanding and measuring skill gaps in industry 4.0 — a review," *Technological Forecasting and Social Change*, vol. 201, no. 123206, Apr. 2024. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0040162524000027?via%3Dihub (visited on 05/09/2024).

[40] Cedefop, *Terminology of european education and training policy a selection of 130 key terms*, 2014. DOI: https://data.europa.eu/doi/10.2801/15877. [Online]. Available: https://www.cedefop.europa.eu/files/4117_en.pdf (visited on 04/21/2024).

[41] F. F. Patacsil and C. L. S. Tablatin, "Exploring the importance of soft and hard skills as perceived by it internship students and industry: A gap analysis," *Journal of Technology and Science Education*, vol. 7, no. 3, Sep. 2017. [Online]. Available: https://www.researchgate.net/publication/319893490_Exploring_the_importance_of_soft_and_hard_skills_as_perceived_by_IT_internship_students_and_industry_A_gap_analysis (visited on 04/22/2024).

[42] J. V. Loo and S. Chatzychristou, 2023. [Online]. Available: https://www.cedefop.europa.eu/files/9190_en.pdf (visited on 04/22/2024).

[43] L. Li, "Reskilling and upskilling the future-ready workforce for industry 4.0 and beyond," *Information Systems Frontiers*, Jul. 13, 2022. [Online]. Available: https://link.springer.com/article/10.1007/s10796-022-10308-y (visited on 04/22/2024).

[44] Albatts. "Handbook for training in the battery industry." (2024), [Online]. Available: https://www.project-albatts.eu/Media/Publications/97/Publications_97_20240328_95033.pdf (visited on 05/01/2024).

[45] S. Briggs, K. Forrester, E. Garrett, K. McArdle, *Community Work Theory into Practice*, 1st ed. Bristol, United Kingdom: Policy Press, 2024.

[46] A.P. Martinich and A. Stroll. "Epistemology." (Apr. 2024), [Online]. Available: https://www.britannica.com/topic/epistemology/The-other-minds-problem (visited on 05/01/2024).

[47] G. T.-S. E. Reinsfield and V. Wang, "Transformative learning, epistemology and technology in adult education," *Journal of Adult and Continuing Education*, vol. 27, no. 2, May 2020. DOI: https://doi.org/10.1177/1477971420918602. [Online]. Available: https://journals.sagepub.com/doi/abs/10.1177/1477971420918602?journalCode=adua&journalCode=adua (visited on 05/02/2024).

[48] Learning by Doing. "John dewey." (n.d.), [Online]. Available: https://learning-by-doing.se/john-dewey/ (visited on 05/02/2024).

[49] B. Bates, *Learning Theories Simplified*, 2nd ed. London, United Kingdom: SAGE Publications Ltd, 2019.

[50] D. Brooks, "The problem with pragmatism," *The New York Times*, Oct. 2014. [Online]. Available: https://www.nytimes.com/2014/10/03/opinion/david-brooks-the-problem-with-pragmatism.html (visited on 05/02/2024).

[51] V. Forss, *Lärandeteorier i undervisning och examination. en studie av samhällskunskapslärares kunskapssyn i gymnasieskolan*, Umeå, Sweden, 2017. [Online]. Available: http://www.diva-portal.se/smash/get/diva2:1114028/FULLTEXT01.pdf (visited on 05/02/2024).

[52] H. Cloke. "What is malcolm knowles' adult learning theory?" (Feb. 2023), [Online]. Available: https://www.growthengineering.co.uk/adult-learning-theory/ (visited on 05/02/2024).

[53] J. Sandlin, "Andragogy and its discontents: An analysis of andragogy from three critical perspectives," *Journal of Lifelong Learning*, vol. 14, 2005. [Online]. Available: https://www.iup.edu/pse/files/programs/graduate_programs_r/instructional_design_and_technology_ma/paace_journal_of_lifelong_learning/volume_14,_2005/sandlin2005.pdf (visited on 05/02/2024).

[54] E. Abele, J Metternich, M. Tisch et al., "Learning factories for research, education, and training," *Procedia CIRP*, vol. 32, pp. 1–6, 2015. DOI: https://doi.org/10.1016/j.procir.2015.02.187. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S221282711500503X?ref=pdf_download&fr=RR-7&rr=882443e74f479980 (visited on 05/04/2024).

[55] A. AlGeddawy, H. ElMaraghy, E. Myller and U. Wagner, "The state-of-the-art and prospects of learning factories," *Procedia CIRP*, vol. 3, pp. 109–114, 2012. DOI: https://doi.org/10.1016/j.procir.2012.07.020.

[56] D. Nåfors, *On brownfield factory layout planning*, Gothenburg, Sweden, 2019. [Online]. Available: https://research.chalmers.se/publication/514487/file/514487_Fulltext.pdf (visited on 05/05/2024).

[57] S. Johnson. "What is a greenfield site: Everything you need to know." (Sep. 2022), [Online]. Available: https://hy-tek.com/resources/what-is-a-greenfield-site-everything-you-need-to-know/ (visited on 05/06/2024).

[58] S. Cremer, S. Dany, M. Molitor, J. Prote and G. Schuh, "Classification of a hybrid production infrastructure in a learning factory morphology," *Procedia Manufacturing*, vol. 9, pp. 17–24, 2017. DOI: https://doi.org/10.1016/j.promfg.2017.04.007.

[59] S. Batool, S. Devi, Y. Kuo, T. Tahir and J. Yu, "Exploring the impact of emotionalized learning experiences on the affective domain: A comprehensive analysis," *Heliyon*, vol. 9, Jan. 2024. DOI: https://doi.org/10.1016/j.heliyon.2023.e23263.

[60] S. Lakha. "Understanding cognitivism: A learning theory." (Jun. 2023), [Online]. Available: https://www.educasciences.org/learning-theories-cognitivism (visited on 05/08/2024).

[61] M. Alahmad, "Strengths and weaknesses of cognitive theory," *Budapest International Research and Critics Institute (BIRCI-Journal) Humanities and Social Sciences*, vol. 3, no. 3, pp. 1584–1593, Jul. 2020. DOI: 10.33258/birci.v3i3.1088.

[62] J.D. Mahadeo and R. Nepal. "Using affective learning to foster engagement and critical thinking." (Sep. 2023), [Online]. Available: https://www.timeshighereducation.com/campus/using-affective-learning-foster-engagement-and-critical-thinking (visited on 05/08/2024).

[63] M. Emre. "The repressive politics of emotional intelligence." (Apr. 2021), [Online]. Available: https://www.newyorker.com/magazine/2021/04/19/the-repressive-politics-of-emotional-intelligence (visited on 05/08/2024).

[64] C.E. Noble and B.J Cratty, "Psychomotor learning," *Encyclopedia Britannica*, Sep. 2022. [Online]. Available: https://www.britannica.com/science/psychomotor-learning (visited on 05/09/2024).

[65] A. Olya, J. Levitas and A. Olya. "Psychomotor learning | definition, objectives examples." (Nov. 2023), [Online]. Available: https://study.com/academy/lesson/psychomotor-learning-objectives-examples.html (visited on 05/09/2024).

[66] S. M. A. Soozandehfar and M. R. Adeli, "A critical appraisal of bloom's taxonomy," *American Research Journal of English and Literature(ARJEL)*, vol. 2, pp. 1–9, 2016. DOI: 10.21694/2378-9026.16014.

[67] InnoEnergy. "Let's shape a brighter, more sustainable future together." (n.d.), [Online]. Available: https://www.innoenergy.com/skillsinstitute/ (visited on 04/30/2024).

[68] InnoEnergy. "Battery training portfolio overview." (2023), [Online]. Available: https://3416096.fs1.hubspotusercontent-na1.net/hubfs/3416096/Skills%20Institute/InnoEnergy%20Skills%20Institute%20Brochure%202024.pdf (visited on 04/30/2024).

[69] Albatts. "About albatts." (n.d.), [Online]. Available: https://www.project-albatts.eu/en/aboutus (visited on 04/30/2024).

[70] Albatts. "Skill cards." (n.d.), [Online]. Available: https://www.project-albatts.eu/en/skillscards (visited on 05/01/2024).

[71] Albatts. "Machine operator in battery industry." (2023), [Online]. Available: https://www.project-albatts.eu/Media/SkillCard/21/SkillCard_21_SKILLCARD_20230623_7420.pdf (visited on 05/01/2024).

[72] N. Zahiraldinni, *Towards a competency framework for bridging skill gaps in the european li-ion battery industry: A case study on a leading european battery player*, Stockholm, Sweden, 2022. [Online]. Available: https://www.diva-portal.org/smash/get/diva2:1668698/FULLTEXT01.pdf (visited on 05/09/2024).

[73] A. Bryman, *Samhällsvetenskapliga metoder*, trans. by B. Nilsson. Liber, 2011, ISBN: 9789147090686.

[74] J. West. "Field research." (2019-03), [Online]. Available: https://researchconnections.org/research-tools/data-collection/field-research (visited on 04/26/2024).

[75] I. Akushevich and A. I. Yashin, "Empirical analysis," *International Encyclopedia of Public Health (Second Edition)*, 2017. [Online]. Available: https://www.sciencedirect.com/topics/earth-and-planetary-sciences/empirical-analysis (visited on 05/10/2024).

[76] V. B. V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77–101, 2006. DOI: 10.1191/1478088706qp063oa.

[77] Dissertation Center. "Trustworthiness of qualitative data." (2024-04-19), [Online]. Available: https://resources.nu.edu/c.php?g=1007180&p=7392379 (visited on 04/29/2024).

[78] D. Oragui. "How to create a standard operating procedure (sop)?" (2024-04-19), [Online]. Available: https://helpjuice.com/blog/standard-operating-procedure (visited on 04/30/2024).

A

Interviews

A.1 Interview template

For the interviews to be feasible, and somewhat structured, an interview template was constructed for the interviewers to start from:

1. Tell us about your background, how did you end up at XX, for how long have you been at *[company]*?
2. Tell us more about your work role, what do you do as a *[company]*?
3. What are typical work tasks that you perform on a daily basis?
4. What do you think is most challenging with your work tasks?
5. What did the training/learning process look like for your current role?
6. How long did it take for you to be comfortable with your work tasks?
   (a) Is there anything you would've liked to be different?
7. How was your previous knowledge before you took up your work role?
   (a) Was it enough? What would've been good to know before?

Since the interviews were semi-structured, follow-up questions could among others be:

1. Could you explain XX more?
2. How does the outcome of XX affect the process later on?
3. How do you perform XX?
4. How does XX work?
5. How could XX be done differently?
6. Is there anything else you would like to add?

A.2 Transcriptions

A.2.1 Interviewee 1

Interviewer So first of all, we'd like to, like, get to know a little bit more about you. Could you tell us a little bit about yourself like your work tasks, your current title, what you've done to come here basically.

Interviewee Yes. So I'm Austrian originally. I grew up in Belgium and then went to the UK and ended up being there nearly 8-9 years. Doing first a chemistry

undergraduates I'm a chemist originally and then doing my master thesis. I got into batteries and started. Yeah, that was my first introduction to batteries back. And from there, yes. So I really love the topic of batteries and I did a my PhD in battery materials as well. More working on solid-state batteries, so it's actually a battery where everything is solid in size right now there's liquid components. Like electrolytes. Yeah. So I was working sort of with those kind of batteries, the PhD. Then also a short little post doc just to finish up some papers. But I was always really into industry, so I did a couple of internships in the industry already. And yeah, really. Once again to the battery industry. So. So [redacted] was definitely one of the possible routes. And so that's how I ended up in the end. In 2020, I joined [redacted] in Västerås. And joined there first as an engineer, weirdly enough, which was quite interesting for me because you know I'm a chemist. So it's like, OK, now I'm an engineer, it's everybody's called engineer here, so it seems funny, yeah. But you don't need to have a degree in engineering to be an engineer. That's also the learning that I've done, yeah. I started there and the quality control team, which was also interesting because I'm more of a R&D-person and but they were looking for somebody with battery experience to actually join and the quality control organisation there. And of course I was back in 2020. I started there a little bit before covid and of course [redacted] was still sort of, you know building up right, that there was nothing. They were trying to build their pilot line that. So a lot of implementation and so on and and the great thing about being in the quality control team is that it enabled me really to, and this was one of the the sort of aim in my first job to actually have the full overview of the of the battery industry. Yeah. And the manufacturing process because as quality department you are sort of a support function. So you're supporting production there. Where you were, you know, like analytical instruments and skills, try to, you know, help and make sure that the product that you're producing is actually how the customer wants it and not, you know different shape and size on so exactly. Safety hazards. So I saw that as an engineer, but then throughout the year they were looking for a manager. And sort of they then asked me to take the lead of the team and then yeah, manager of the team. So I went from like 0 direct report to like 13 within a day, yeah, well overnight. So suddenly my colleagues were suddenly my employees, which was very interesting. Yeah, and, yeah. And then I did that for, you know, 3-4 years until in November, where I was like, yeah, maybe maybe time that my team gets somebody else to continue leading it. But yeah, back in [redacted], I sort of built up the entire, that quality control department. Yeah. And that was really, you know, hiring quality control technicians that are really doing the same kind of inspections and tests over and over and over again. So really there, trying to find the by profile of people that you know are suitable for that job. Hiring analytical chemists, hiring quality control engineers. Hiring a like senior metallurgist because we really needed to understand, OK, how do we weld metals together and nobody had a clue about anything. So, you know, hiring people with 20-30 years of experience, so yeah, I think I've done. I don't know, probably 300 interviews or, yeah, and yeah, probably hired, I don't know, 60-70 people in the last four years and learned a lot through the, you know, interview process, I had a really good guy that taught me how to interview and how to recognise. Yeah, who you actually need in the team and who

is good. So that was super interesting. But but yeah, also understanding sort of the Swedish workforce and and you know understanding, OK how, like what can I get, like how I don't know. How can I attract actually local people. Yeah. And who do I take from all these other people that apply? That's that, you know, maybe are just want just to get the job, but then actually long term they don't want to stay in that position. So technician, we had such a turnover because we could just not get sort of the people that actually want to do this as a job for a long time. They they don't exist yet and this is when you guys come in. So that's been a little bit tricky because especially when you have a production that's basically. There's no training programme, there's no learning. You need people, they come, they need to be sort of smart enough to get, you know, if you have one person showing you wants the test, you want them to be able to to be independent as soon as possible. There's no time to train people over and over and. Or or watch, you know, like babysit people. People that are very fast and can learn fast. So already have those basic skills. But it's then usually what has happened. It's people that have a masters that have a masters in. I don't know, like chemical engineering or chemistry or something, right, that have actually had lab experience and that have been stirring something or, you know, worked with the equipment and so on. But they of course especially well. I would say Swedish people don't even apply because they're like, hey, I'm a chemist. I don't want to start after my masters as you know, a quality control technician. Which I think is something in this, It's this generation, I think of people who I think, in Europe. I think we struggled a little bit as people don't. I mean people think that, you know, maybe after masters, I'm gonna be, you know, straight away sort of a junior engineer and have a lot of responsibility and you know, but I think we are as a continent, we're not very good in just you know. Starting somewhere low and actually doing doing the work. I think we're all living a little bit on like Cloud 9 and everybody thinks that, you know. Oh, yeah, I've, you know, I don't know now how you guys feel. I hope I'm not. I'm not, you know. When I think back after my masters and for me it was very clear that I was always going to do a PhD and so on, yeah. But I think, yeah, it's very tricky. It's very tricky to attract people to apply for a technician position, if you have done a masters, I think maybe previously there was more at it because people were more you know, OK for you know 2-3 or 4 years to actually do a technician work and because then they have a really good foundation. But nowadays I feel like people want to go straight into it but be an engineer and that's, you know, becoming a director at the age of 38, the kind of. So. So that was super tricky because of course, you could not guess anything. Yeah, who you could get, was people desperate, who needed the work permits. Who it's. You know, it's, you know, Indian Iranians, all sorts of people. And they're, you know, and they're happy just for the work permits they say, OK, yes, I take this position, but they of course. Don't stay long in that and if and you know, especially the battery industry, as soon as you have a little bit of experience, you're super valuable because there's so many jobs out there, right. So these people are gone. They move either internally or something and it's super sad because you've trained them and and they've been really good and and then you lose them right. So we've had the turnarounds and I mean, some people did stay for two years, but it was very, very tricky to just keep on the technician level, keep

even for two years. That was extremely difficult. Because of course they were all looking for engineering positions. The other thing that we then did a little bit and I was involved is that actually I just realised that technician, the word technician was just not attractive anymore. Well, this is that was my feeling that. That if you have a job ad that sais technician with this and this and this. If you change it to associate or what was the word? Analyst. Yeah, I changed so so I worked with HR then to completely change the growth path of sort of you know. Like the growth path, if you start after your, I don't know either after your bachelors or nothing. How you how you grow from technician to engineers and chemists and so on. Yeah. And then we sort of changed a little bit that there is the associate entry level, like super people that don't have any kind of lab experience and so on. Then there's the technician level that we sort of still kept, but then from technician, you don't get to see a technician because nobody wants that. Nobody is interested in that. You then change it to analyst. And you know I can call it quality control analyst thing next. That was basically a senior technician. But but it just sounds much better. Right. And and and so yeah, so that's also something that I've looked a lot into, how to make it. Yeah, actually, even if it's just the title in the end, it's the same job, but it makes a big difference. And that's important that we actually, yeah, get the vibe of the workforce nowadays and so on, of course, they probably need sort of a like reality check and so on. And we, I think we need to get the society more into hey, you know, you have no experience, you come fresh out of school, work four years, right? Get like, get the basics and then only pretend that you're an expert. But this is I think something that's gonna take it a little more longer, but what can we do to actually attract the right people? Because there's some people that's that's actually enjoy doing routine work. And so they would be ideal for it. And if you just call the analysis the technician, you might actually get those people. Yeah. So there's there was a lot of that involved. Yeah, because they are in Sweden. No laboratory, sort of. It's not like. I don't think it exists that sort of at the age of 14-15. You decide. Hey, I want to work in a laboratory. And I do this, you know. Yeah, I don't know. We don't get to this. What do you call the the? High school diploma, or something.

Interviewer High school diploma?

Interviewee Like when you finish high school, it's you have the same kind of like. Does everybody get to their points?

Interviewer Yeah, I think. Yeah, depending on. No. So basically high school is not mandatory. You choose if you want to go high school, although most of the Swedish like population do go through high school. Yeah, exactly. And then some of them go, it's called like. It's more work oriented, so when you're finished, you're like an under. Uh, what's it called? Like an under nurse? Yeah, exactly. Exactly like some become under nurses, depending on their programme. Some some become like mechanics.

Interviewee There I think what doesn't exist is like sort of a lab technician.

Interviewer No, definitely we don't. We don't have that, no.

Interviewee In Germany. For example, yeah, you have that. You have people that are really, really well trained to actually want to be in there, but they don't think they don't have a chemistry degree. But they're they're practically like excellent and they love to work in this environments and you know, and these are the people, so, so, so all the battery companies in Germany, this is where they hire people from. Because what you need people is. It's just, you know, people that like to be in the lab. That have, of course over the time, they probably know more than the chemists, right? But they don't, are not officially a chemist because they haven't gone through the academic career, but they've just been practically trained. And that of course doesn't exist. And so so, you know, here in Sweden this is the question, right, how like. How do you then get that work force, even for the battery industry?

Interviewer Exactly. So you. Basically. I was thinking about the skills that people bring with them, like if they are educated and like for example lab as you are speaking now, what skills would you say like are? Because if you get in more to the technicians like what they do, what are their tasks exactly? If you were to describe them?

Interviewee Yeah, so they usually. They will get trained on certain types of equipment and instruments, so it's analytical instruments. It depends, sort of. It could be so they're very good. They will get trained on many types of equipment, maybe at the start they would only start with one. What is interesting in the quality control lab is that you basically have mechanical tests, so they need more mechanical.

Interviewer Knowledge?

Interviewee Well, not knowledge, but it's a willingness, right? It's like tensile testing for example, it's, yeah, it's, you know, like foil inspections where you pull a like aluminium foil, a cup of foil, you just pull apart.

Interviewer Yeah. So like stress?

Interviewee Yeah, exactly. Tensile strength, for example the material. So it's, you know, incoming inspections of all the battery materials. Yeah, but more from the mechanical sides. So it's like that dimension testing, it's looking at how the cutting process has been done. It's looking at pulling things apart with the tensile machine, it's doing some polishing, cutting, grinding, that kind of works of preparing cross sections. For example, if you you know if you're interested in, you know this phone and you want to cut it in two, there's a specific machine where you then cut it and then where you polish it nicely. That's that burr. And then on the microscopes, a lot of optical microscopes work and so on. And so that is sort of the mechanical, let's say, area that you would then hire people that's of course. Do that kind of background. Often you then get like material scientists and Mechanical Engineers and so

on in there. But but ideally you would want somebody that's, yeah, has maximum bachelors, maybe even less theoretically, right. But somebody that's that's. Yeah, in the quality control department. It's all about the needs of people with an eye for detail. Yeah, that's sort of really perfected. Yeah. So that's that's the mechanical testing part, but then we'll also need sort of chemical testing, people that you know can play around with liquids and solutions. And use all the more chemical analytical instruments, right. So doing some like titrations. Yeah, moisture checks, all sorts of all sorts of more chemical where you know, yeah, you're playing around with liquids and so on and and actual chemicals. So. And what I realised is that actually I need to hire a different type of person for each. You see, that was all together, but I realise it's very, very hard to find a person that's is happy to do both, and can do both. So in the end, sort of, we had to really sort of separate those two areas out and really find sort of the right, the right person for the mechanical side more and the right person for the chemical side more because, yeah finding person that can do both is very rare and.

Interviewer Do you think that is because of the also like because of the time management that you don't have the time to actually educate them in both areas as well?

Interviewee Yeah, yes, yes, yes. And one of the. Yeah, so one of the requirements for me was always that people actually had worked in the lab environment before. Because you didn't have time to explain to them that, hey, an acid, it looks like a transparent liquid, it's ******* dangerous if it's falls on the floor. One of the questions in my interviews is always right. And if you get into lab, what is for you the most important thing? Like, what would you want to know if the person doesn't mention safety? I don't hire them. If I tell them, hey, you know, you see that your neighbour working in the same lab bench, there's been a chemical spill. What do you do? How do you help? If that person says Ohh, you know I'm gonna, you know, I'm just gonna scream for help or something or. Right. I need people that actually know what to do and that have worked with the chemicals before that have the safety awareness, OK, I need to look at the risk because that's what I need to make a risk assessment before I even start. I need to look at the safety data sheet of the chemicals that I work with. Know that you know this chemical and this chemical should not be in the same place in the chemical cabinet. Yeah, I need to wear the right PPE, right? All of that. You know. Being at least a little bit familiar with that environment exactly because otherwise if you get people that have no clue, accidents happen and then that goes really fast. Because you don't have that perfect training programmes. Eventually now at [redacted]. I mean they they are, you know, getting sort of an Academy and so on and and you start as you know super associate and then slurry associate and you get to do more. But at the start you want to get going straight away. You know, on on the actual technician level, and skip the understanding. So some kind of lab experience was important. Yeah. And then really analytical mindsets and and people that for sort of now and and and quality control lab. The people that love equipments like and and you know the setting the equipment up and running their samples and. Uh. Yeah, people wanted to take care of that. I don't know if I'm going completely, I don't really follow your

questions.

Interviewer No, no. It's definitely you're answering like several of our questions at the same time. So no, no, so we're going to have to puzzle everything, but it's fine. It's fine.

Interviewee OK.

Interviewer Yeah. No, that's perfect. Actually, we have. Yeah, summarized it pretty much like a lot of what we are wondering.

Interviewee This this other thing. I mean, now I'm talking a lot just about sort of quality control, right, that technicians and so on. Now we've not really come to what I'm doing right now here but for. Like, what's also been very well. It's it's actually understanding also more about the the specific role, right, quality control technician he is or she is getting something from production to do a test. And you have very clear you know in specification on specification so so. So when you do for example dimension test on this microscope right you know the product should be in between this range. Now imagine you do the tests you measure something and it's out of out. I mean, it's out of that range, right? Theoretically you were then the one saying, hey, stop production. Yeah, we have an issue here, right. But you need to make sure that what you've measured out. Your equipment was calibrated. Everything is set because the first thing that's you know if if the quality control department is very new, they're gonna be like, oh, but Are you sure your microscope has worked or Are you sure that you have done? You know you're trained enough to do this and to do that. Right. So there's a lot of what I had to train people is is to make sure that hey, they, they're actually fully in control of the instruments that they use, that they know, hey, yes, this instrument is completely calibrated. Yeah, I have. I have a reference that I checked before. Right. Let's let's make sure that OK. If I use a balance and any type of balance, right? This is my reference. I put it on it. If it doesn't say 100 grams, yeah, plus or minus something, something is wrong with the equipment. I should not go and take my sample and put it on. And 104 grams trust us. Right. So there's a lot of that training, I think that's you don't specifically get taught at university. You don't. You don't get taught anywhere. This, I don't know. Quality control, quality assurance. It's not a topic that you get that you expose to much.

Interviewer No, not that much. No.

Interviewee Maybe it's one lecture. If you study production engineering or something, or in industrial engineering and you have a little bit of that, you know.

Interviewer Yeah. Because I know from my experience I'm educated as a chemical engineer. So. So to have like chemistry as a background but. Uh, we did like in the laboratory, of course we needed to have that in mind, like calibrating the pH like measurement equipment or or the. I just need to think about the terms in English

that we're trying to translate at the same time. Like HPLC equipment as well like the. Scale the scale like this mindset is still.

Interviewee You take this for granted. You think that this is?

Interviewer Definitely. I think so, yeah.

Interviewee For granted, you think that the last person you know has not messed up on this. You think you know you play something and we stupidly think that this is 100 grams.

Interviewer Yeah, yeah. We can't take that for granted no, definitely.

Interviewee How do we like? How do we trust this right? And so what you need people is that you know they. They they actually verify this and of course, and you know, a big established company. You there have, you know, made sense which. You have preventive stuff. You have reference, but at the start you need to set this up and you need to set us. Up with the technicians that you hire, right? Yeah, yeah. And nobody is well trained and you know, sometimes we then say, OK, you are just doing this test because at least if you do it, we have the systematic error, just you, right? But that that kind of awareness depending on, you know where they're actually going to take their role that's that's that awareness needs to be in there. And that this is done automatically. Yeah, little nitty gritty details. Another question I usually ask my interviewees like what is the difference between accuracy and precision. There's a big difference with that. And if you work in a quality control department, you need to make sure that you understand the difference been accuracy and precision. You know it's my result now. Here accurate is the precise enough. The equipment will also have only like a set of precision, right? If if my tolerance and production is much larger or narrower. Is the equipment I'm using suitable? There are many ways to, for example, measure the length of this phone, right? You can go with the ruler, yeah? But is this enough, right? You could use a micrometer. There are different types of micrometers, or if the micrometer falls on the floor, it might be broken, right? You need to be like, hey, actually, is this still calibrated now? It fell on the floor. Maybe you got, like you know, that kind of. Like really have like a feeling for equipment and instruments and and.

Interviewer This critical thinking, kind of and just, yeah.

Interviewee Exactly. Which as if you're very good technician. You owned us? Yeah, probably owned us. And and your, you know, you enjoy working with the equipment you enjoy in, in your lab that you worked at each equipment is, you know, fully ready for whatever comes from production. You can measure that and you know that your equipment is sharp and it is sharp using it. So so that's that's sort of. Sort of. The skills that I would ideally you know, want somebody to have.

Interviewer Yeah, exactly. Yeah. Perfect. I was going to ask as well, like let's say

that the technician is taken out of the battery cell chain production. How would that affect the battery chain? If the technician yeah weren't working, like how? Or maybe if I rephrase it like, how do? How does their role affect the battery chain process overall? Like what would happen? Yeah, what would happen if they were removed? The technicians, they quality technicians, like the quality controls or would happen in the battery chain or in the battery cell production.

Interviewee If if he would not have anything. . . ?

Interviewer Yeah. But. But I mean. So, so, I mean the work that my team back then. So at the start we were the ones also implementing a sort of all the quality control inspections for the entire production. So it was both. It was both setting up at line inspections. Yeah. So it's inspections that you usually do inside the production that we set up the microscope, we trained then the operators that we're actually producing and we were like, hey, you know, every single new roll that you produce, you do that check and you do it like that and you know, try to put them into a box which is super difficult because they love to do shortcuts because they are. They're being sort of measured on how much they produce. And but having that quality mindset, yeah, has has been a struggle. The people in the quality Department have the quality mindsets, but it should be throughout the entire company, right? You should not as an operator. If you for example are responsible for the stacking process, you should not continue. If you see something bad, you should stop and you should fix it and you should, yeah. But it really depends on what kind of production managers you have. If they're just, you know, output numbers and they don't care about quality or if they actually care, but but people need to also, and I think maybe this is something really good to to sort of add in a training Academy programme, right is. What is a good sub product in the process? Yeah. What is the bad? How do I recognise at each process, what is good and what is bad and actually having photos on things like that. So that's something that we try to sort of train the operators in production. You know this electric sheet is is you know there's a corner lap like this, it's all good, but then also explain why yeah, right. It's really going from all the possible defects that you could have, but are you going into this order? Why? And that's, yeah, but of course you need also the people that are interested in this. Yeah. Or at least that they know, right. That they stop the process. So yeah, it was a lot of sort of implementing these at-line things, but then also our main job was we were in a lab with all sorts of cool equipments like cutting edge equipments I would say, equipment that it's not just pressing a button where you actually to do a lot of sample preparation. To have your sample in the right thing to then do these tests and need people that actually really sort of live in that lab. And basically then for these kind of tests, they could not be done at line. So it was more. It took you know. Sometimes I mean a couple of hours and sometimes days. So these were tests, really, where the production was fine, either to wait or that the results came later on. So that samples were samples from different parts of the production process sent to the lab, and you then have a lot of samples every day coming in, and then you just allocated people and equipment sort of that. They would then do that. So as a technician, you were, for example, on the like chemical side. You then had, you know, your samples coming in. You knew your responsibility for this equipment and then with of course planning and so on you

then you know it was you just took the sample from there. You analysed it, report the results next one. But what you always have to make sure that your equipment is super reliable. Whatever sample comes in, you can be 150% sure if you say it's in specification under specification, that actually pretty true. Which was tricky. It's not easy because then you also need to have the proof, right say that your equipment is fine, right? You need to have your calibration, certificates, you need to have your reference check and everything and so yeah.

Interviewer Do people tend to be like sloppy with those?

Interviewee No, but they have to be implemented because I mean, when I started in the team like we just about installed equipment, nobody knew how to use it, right, you know, but the samples came in at the same time. So you know, you have to, you don't know, there's a lot of little things that you just. And of course, the people, they, they, they did not. It's not like these people that were technicians who worked 5-10 years with with scales or with, you know, actually had to repair something. It also needs to be people that like you know, sort of doing little maintenance, right or, you know, just like cleaning analytical balance. Yeah, they need to be cleaned. They need to be otherwise. Yeah, the doors aren't work anymore. And then you say, oh, the door doesn't work. Yeah. You need to take care of it. So it's like, yeah, it's like having a horse, right or or or a boat. Yeah. If you don't clean your boats. You. I mean, you're gonna sail nicely, right? So it's the same thing and it needs.It needs these people that really love analytical instruments I would say, and enjoy that.

Interviewer Yeah. That's definitely like a pro, like an advantage to have that quality, definitely. Let me just check the questionnaire here. Yeah, with. OK, so basically we talked, we spoke a little bit about the basic skills in the that you are looking for and the kind of like require while hiring, but like what basic skills would you say developed during the process of being a technician like what comes with learning by doing so to say.

Interviewee Well, all of those things came by learning by doing. But learning by doing is that's, I mean, these people spend a lot of time, of course, because it's, I mean, in that setup it's, I mean it is eventually quite a routine job, right. You have different types of samples. You need to make sure that. You have a method and your equipment to do that. But in the end, it gets a little itchy, but then things happen right suddenly breaks down, or you don't know? And here ideally you would slowly learn how to fix the equipment. What's important and it starts. I mean we we started to then just. We needed to actually do internal trainings on just how to use analytical scale, just an analytical scale. You can do an entire workshop on instruments. Right. You can actually. And this is this is always a really good, it's something super easy where everyone are like Oh yeah I can use a scale. But can you actually? Do you understand the difference between the tare button and the 0 button and do you understand how it actually mechanically works inside. So I think I mean if you do. Just so that you can teach people a lot of things that are then applicable to to any kind of instruments, right? You don't have your reference

weights, for example. Yeah, you know, this is 1 kilogram and you still need to get this. I'm like certified every year. But a lot of money to just get a stamp on this. There's this really one kilogram. Right. But then you put it on the scale you can check and you can then. You know do do verifications and and they just set up a plan. Hey you verify this once a day, once a week. Every sample what you did right? This is so. This is something that we established in the team. Slowly, slowly, per equipment. What is a preventive routine? And on the scale, that was always a really good sort of start. Because or or like the thickness gage as well, that's that's a super easy, easy one as well. You know, if you over tighten, it's.

Interviewer Yeah, how does it affect?

Interviewee If you have this thing right where you go and ask if you know if a man has made more force than a sound thing, that like this might be 4 centimeters of somebody else, it might be 4.2. What is the true thing? Nobody knows, right? But you start to think like very basic stuff you start to think a lot. Well I start to think a lot.

Interviewer Exactly. Well, that's where we come in to identify like specifically these parts like.

Interviewee So yeah, and you would want. Yeah. I mean people would would in that role, I mean of course they, they know already the basic and so on they would just of course a lot just happens, yeah, they would learn lots of different materials how to then you know they have the samples suddenly that's much much longer and they're like hey we have not had that before but OK I have this equipment. How do I then change it like, how do I make sure you know this equipment is invalidated for that sample? Yeah. And of course, a lot of troubleshooting as well. These these instruments, analytical instruments, they are sensitive. And sometimes you just don't know what's happening. With some of these chemical equipments, it's. One day it works and one day it doesn't and you need to be patient and have a troubleshooting mindset and try things out and be. Yeah, know how to troubleshoot on an instrument as well.

Interviewer Yeah. So you would say that's like part of being a technician to be able to troubleshoot as well?

Interviewee Yeah, the basic things before you then need to call a supplier because you're really, but there needs to be sort of a checklist of things. You know, you check. OK. Is the power in properly? Right. It's like, you know this, the system breaks down.

Interviewer Yeah, yeah, what do you check? Yeah. Interviewee Basic things, but without and sometimes people need to know their limit as well, right? Need to need to have enough training that they feel comfortable in doing what they can do. Yeah. But then of course not overdoing it so that they don't break it even more right?

Interviewer Exactly. Knowing when to ask for help? Basically, yeah.

Interviewee Yeah. Basic things I think. We have a sort of an instruments engineer, or like maintenance engineer and a team as well eventually, and I mean he could be called up for things that he should have not been called up for because people are just they're like ohh. Doesn't like uh, you know, help. Right, that's you would want the technicians to be more than a user. Right. Because that makes you a really, I think, thorough technician. Yeah, because anybody can be an operator. You just follow the work instruction and so on, but you actually need to know what you are doing. And also, how you're contributing to the rest of the company, right? This is a super important job. Yeah, it's routine but it's super important. If you've done bad, then bad project is going to be sent to the customer. If you don't, if you don't say something. Hey, this doesn't look right. And even if people question how you do things, I mean it's better to say something, right? And this is really like I I always try to deliver the message to my team that we are the goalkeeper. Like we are the last you know, a line of defense sort of right, if if you know. Yeah. If there's no goalkeeper then it's much easier to get through.

Interviewer You don't know what you end up with basically, yeah. Perfect.

Interviewee Is your programme mainly for, I mean is it for operators, technicians or is it for everything or what's?

Interviewer It's mostly for operators and technicians, I suppose, yeah.

Interviewee But I would say everything that's sort of why I've talked about now, right, it was very focusing on analytical lab, but it's equally applicable to an operator in a machine, operating machinery and so on. When in my first year at [redacted]. I had to, I was actually working in production really. I was in there a lot trying to explain to them. Hey, you know, you need to actually look at. They were cutting something. Yeah, they were notching out or cutting something and you had to check the quality of the cuts at the notching machine right there was like an actual mechanical knife. And that knife was doing like, whatever. There was no cleaning routine yet for that knife, or how many nice cuts could it do before you know, it gets to to unsharp and yeah, to sharping it up and so on. Right. But then there was this annoying quality check that I, you know, that I pushed them to do is to go under the microscope, waste some time and you know, look how the edge look like, but then eventually. The idea was really to teach them, hey, you know, I'm looking at this edge and then if there's a bit of metals or something, if the edge is not nice here, I know that this part here. I've done that quality check now and it's related to this part of the knife and you can fix this straight away. Yeah, right. So actually have that connection of if there's a problem there, yeah, we'll see it like this and. And over the years, they become really good at it when you were like, hey, you know, if I see it here, I know I need to clean here on this. So that was super good, it's like it's. But it's people there spend a lot of time infront of their

equipment trying to you know connect the dots, yeah.

Interviewer That's very interesting, yeah.

Interviewee That's where you want a person get to.

Interviewer To get to that point, basically, yeah.

Interviewee Yeah, and. And then to to to also you know, get to the point where, hey, these quality inspections, I mean they need to be useful, they need to, you know, they should not be a waste of time. At the start people just thought this is a waste of time. Yeah.

Interviewer Yeah. I think there's a lack of understanding like in the bigger picture like how it does affect like as you are saying, yeah.

Interviewee Yeah. And how you can become a better operator if you're using better quality products, that's like.

Interviewer Definitely, yeah. Very interesting. Do we have any more questions about the skill part of this. I feel like we got our answers too. Thank you very much.

A.2.2 Interviewee 2

Interviewer 1 And so our first question for you is if you could tell us a little bit about your background, how did you end up at your workplace?

Interviewee OK. So I mean my background is mainly from the automotive industry. I started working there in Brazil, my home country and I started working for a German company there, worked for 5-6 years plus internship from college. Then I got invited to move to Sweden, during the factory they have in Wattenberg. Then I worked there for another 5, almost five years, 4 1/2. Then I got this proposal from [redacted] moving to Skellefteå to spend 1 1/2 year or two years there and then return to Gothenburg afterwards. Then I decided it was time to take another, let's say challenge. So then I have been working during those 10 years, mainly with manufacturing engineering. So developing specifications, trying auto supplier conditioning machines ramp up of production, training of operators. That kind of stuff.

Interviewer 1 Perfect. Thank you. Our next question was actually if you wouldn't mind telling us a little bit more about what you do like your daily work tasks and more about your role.

Interviewee Currently we have it on meeting production and manufacturing engineering cause more or less everything is like in commissioning phase and during

commissioning we're also in series. It's a bit of a mix there, so, basically my daily tasks, I mean I'm mainly responsible to ensure production's running smoothly from production side when we have machines that are in series. And I'm also responsible for the, let's say, ensure the commissioning of the new machines, that the new equipment that we install at the factory, are capable of producing with quality, safety and the output we need to give to our customer. Basically satisfying the entire organization and making it run. If we go like into daily tests, I mean, It changes from time to time depending on the time of the project we are on, so sometimes it's more planning and more office work, delivering suppliers, following up schedule, budget or whatever, and sometimes it's more like action on field, like going to the machine and doing nsa:s, doing run tests to make sure that we have the correct output going out. Looking for improvements to get into suppliers because normally when we start running a machine, we find several stuff that we see that we could have planned that better, so we need to change it somehow. So yeah, those are the different tasks. So a lot of meetings with production to align like on downtimes on the machines and what we can't destroy so we can produce. So yeah, I would say those are the, let's say two sides of the job. A lot of planning some stages and a lot of action like real action in the phase where machines are installed. And there are phases today that the supplier trying machines and releasing them to be shipped.

Interviewer 1 Awesome. Thank you. What would you say is most challenging with your work?

Interviewee Most challenging, I would say it's the, I mean, the technical part is OK, so I would say it's really like convincing the team, because normally as a manufacturing engineer is not boss of anyone, but you have several people that you work with and convince them to follow the same way as you are doing to make it work. So I would say that part is especially challenging, I mean bringing everyone together in one direction with one goal and making it, let's say, fit into the team. And I mean, we have different people you communicate with as well, so that is a bit like I would say that's the challenging part of the job.

Interviewer 1 Yeah. Thank you. Yeah, well, yeah, people, I can imagine people having different views on work tasks and how things should be performed and whatever.

Interviewee Yeah, when people ask me that question, I guess I feel that people expect, like something very technical but normally my answer is like people, I mean, you need to be really good in dealing with people because when you reach a certain technical level in the career, it gets easier to learn new things and to keep yourself updated. But people, it's like everyone is different from each other, so you need to keep learning every day and try to read people and how to communicate to them the best way.

Interviewer 1 OK. Perfect. Thank you. So what I experienced is that you from what you explained, is that you feel pretty comfortable in your work role, the techni-

cal part of it. But when you arrived to [redacted], did you have, like, a training process or learning process for your current role, or did you have onboarding? What did it look like? et cetera.

Interviewee Yeah, we we had like a one week on boarding at our vote. Mainly it was like 3 days of let's say online trainings via teams that you basically sit in your, at their home and attend to the trainings and so on. Really basic stuff, basics about batteries and so on. And also basics about safety and organizational stuff. A lot of stuff wasn't new for me coming from the industry already, but I mean as it's a group, I mean they do it like for 70 people, I guess per week. So they need to go read into the basics. Hmm. So those are the three days we have. Then we have one day off like local safety training on site, that is pretty much like safety training about fire and save time and work. And the last day is more or less like when they hand you over to your department to your manager, and when your manager is taking you around and doing introductions to the people, you must know to your team. So there was a training but, but it was a general training from [redacted], general for everyone. Specifically to the role I have, my manager gave me a list of trainings that we have like. More specifically for the job. As well, most of them online. So I did them. I went through them, but it wasn't anything like super deep. I would say [redacted], especially for younger people, less experienced, more like they are adopting more, like the learning on the job. Which is good on some points bad in other points. But that's how they are doing it that's I guess the way they can do it. That's how it's going on there.

Interviewer 1 OK, so keep building on that track. How would you like things to have been different, because you said that it could look otherwise?

Interviewee I think it could be a bit more like tailored to the different, let's say functions or level of experiences. There's one example that I like given that I mean we had a 50 minutes long training of 5S and I mean 5S for people who are new is quite important, but for someone who came already from the automotive industry, you have all the knowledge. It would be enough to have like a 15 minutes short presentation, just to remind you the importance or like the specific rules for the company itself or going to work with and maybe focus more like in other stuff and use the time for other kind of types of training. So it's a bit more tailor made for the level of experience or function, maybe it would be a bit better. I know it's not easy to do, especially when they are hiring massive amount of people every week, but I guess that would help in the onboarding process there it would feel a bit more efficient and I guess the use of time would be better.

Interviewer 1 Perfect. Thank you. The role that is your work role currently, how does it differ from your previous experience as an engineer?

Interviewee Yeah, my previous experience I was like, I would say I worked in a smaller team. It's also a big company. It is globally present in all of countries, and so on. So it's a big organization, but I worked in like a smaller project team who

focused like in projects for [redacted] specifically. So it was basically, I mean the manufacturing engineer was me, so I was leading the guys with procuring machines. The people who were developing technology for that for that specific project and controlling timeline, budget and everything. So I was really like I've been a manufacturing engineer/technical project manager. Now, we have a big, big team. I mean and we are really focusing like on one part of the process. Before I was really focused on the entire production chain and for the specific project in the battery world. I mean we need to be really focused in one part of the process. The process is too long, it's too many machines so you need to be specifically like attached to one part of it. So that's, I would say the main difference that I feel right now.

Interviewer 1 Thank you. I was going to ask you because you said that you, was it the notching area that you are specified in? Could you perhaps tell us a little bit more about the challenges just in the like notching part of the battery cell production?

Interviewee Yes. I mean, first general, if you guys heard, but no, we have no notching. So I'm kind of misplaced. But so far I'm watching. And I would say challenges that we have right now, I mean our equipment is equipment that was purchased in a rush and I understand why it was, (I wasn't there), so it's easy for me to say now, but I understand why it was done in a rush. I mean, the company has a way of operating and need to be pioneered and to be first, and sometimes it comes with the cost of not being really perfect, as I was used to have my project in the automotive industry. So we have equipment that were procured like from China, not with the ideal process of validation and testing. So they were installed and now we are facing situations where we need to install, we need to investigate. Need to dig deeper into root causes and so on. Then we don't have the time for that because the machines are in production, so you need to deliver to the customers. But that's a big, big challenge we have right now. So that's, I would say the biggest one in the notching area so far. So the equipment is not let's say fully prepared for production even though it is producing in series and delivering to customers. So we have quite some troubles there to make it work.

Interviewer 1 If the notching part of the process is taken away, let's say for now, is there like another process that's kind of more time efficient than, or just something that works as notching, like something similar to it or how does it work?

Interviewee Basically I mean and you know have extra so much into the [redacted] product in detail. I mean I have asked some questions to ask her and to the guys. And what I know that I mean now we we cut the steps in the battery. That's how the battery industry works. But [redacted] chose to follow path where they have no tabs, I mean the foil will be fully exposed so and somehow they will be welded together and there will be no tabs actually. So when we coat the foil it will be like that and then we cut the electrodes with the foil completely present on the side of the active material and that is how it's going to work. So basically the notching process will just not exist, not be replaced by anything. It will just be excluded

from the equation.

Interviewer 1 Doesn't that affect the prestanda/standard or the like of the efficiency of the battery somehow?

Interviewee I wonder the same, and I know that there are some challenges on making it work. I know that there are discussions about if that's the right path to follow or not. But I know that's, I mean looking at, but looking at it as a, let's say looking as owner, that's something I would pursue because you're just eliminating a process. And that's basically, I mean the cutouts, I mean you're just wasting investment, people do that if you have a way to don't do it. It's just. getting you more money in the end so the profit is increasing. So that's something I would really pursue. But I know there are challenges. I don't have all the technical details. To be honest, I'm really trying to chase that and that's one thing we need to improve. Yeah, that's something that you guys want to hear a lot. We're not deeply involved yet in the development. Now it's getting better with all the meetings we are having, but still we are a bit like trying to take some information. So what I know is there is a way, that people believe it works, they are having challenges, but that's something that is being pushed into the market. So we need to try to make it work.

Interviewer 1 Yeah, definitely. No. Do you have anymore questions? Have we missed anything?

Interviewer 2 I don't think so, but I just perhaps, at the beginning you mentioned that you might be involved with the training of the operators. Or you have or you are now.

Interviewee Right now I'm a little bit less because they are, I mean, we have a training team. So basically what we do is we train the first operators and the production team is kind of responsible for replicating that to the others unless something very specific from engineering, then we provide the trainings like in regular basis for new people. But let's say operational training. We do it when we stall the machine, so we have the main operators, the key ones, the most experienced ones trained, and they are the ones who will be training, let's say the other people on the process itself.

A.2.3 Interviewee 3

Interviewer Our first question to you is about your background and how you ended up at [redacted]/[redacted]?

Interviewee It's been 10 years since I started in the industry. I actually studied to be an X-ray nurse at the University of Gothenburg. [redacted] offered good pay and the flexibility to work night shifts while studying. So I thought, why not give it a try? I started working there part-time, initially just to earn some extra money. I had friends who were doing the same. But I found the work incredibly

interesting, and I got hooked. I ended up completing my studies while working. However, when it was time to consider a job in the X-ray field, I didn't want to leave [redacted]. So, I continued, and then I thought about taking the next step. I'm someone who loves developing things and sees potential for improvement. Being an operator at that level wasn't quite adequate for me. So, to take the next step, I enrolled in a two-year program in production development at Göteborgs Tekniska College, which I had heard very good things about. Looking back, I'm very grateful that I took that program because I was considering studying mechanical engineering at Chalmers or something similar. I came from the university world, so I had my preconceptions about vocational education, but I'm really glad I chose that program and nothing else. It turned out incredibly well for me. After that, during my thesis work at GTC, I got in touch with a company that builds trucks. They are now relocating to Finland, which is partly why I'm here in the battery industry, taking the opportunity to jump into this exciting field temporarily. Over there, I work as a quality engineer in production, focusing on production quality. Yes, and [redacted] had an event at Science Park last year in March, I believe, where they presented the whole concept, and there were about fifteen hundred people attending. I just thought, "This is something I want to be a part of," so I sent in my CV, and here I am now. Yes, and I both love and hate being here, but I love it because I'm learning so much. It's incredibly exciting, and there's nothing that can compensate for the knowledge I can gain here, really.

Interviewer Could you describe a bit more about your role and what you do? What does your typical day look like?

Interviewee As a quality engineer in production, it's about addressing errors when production needs support. We, together with other functions like maintenance, production, and process engineering, work cross-functionally to identify root causes and implement corrective actions to prevent recurring issues. Containment actions and corrective actions are two different things. The first is about stopping the bleeding, so to speak. But it's equally important to address errors properly to prevent them from happening again; otherwise, we'll just end up in a loop with the same problems. Additionally, we conduct risk analyses, develop various documents, and take ownership, such as developing control plans that outline our specifications and what we need to deliver. It's about what the customer has purchased from us, under what conditions it should be produced, and what specifications it needs to meet before moving to the next process. If we don't adhere to our standards and specifications, it can hinder other processes and lead to the product not becoming a final product. So, we also perform PFMEA on those, conducting risk analyses to anticipate potential errors in a process and try to avoid them. We work very systematically with these things and are also involved in new development projects and similar activities.

Interviewer What do you find most challenging about your tasks?

Interviewee At [redacted], it's about keeping up with everything. I come from a place where I've been able to deliver and had the necessary conditions. Here, you

have to make the best of the situation every time, and that presents challenges for me. It's not fun to feel like you might have done something mediocre because you have to go and do something else. Then there's the challenge of being a quality engineer. It suits me very well, but generally, it requires a certain type of person, in my opinion. It's about being analytical, thinking outside the box, and having a burning interest. Otherwise, you won't delve deep enough into these issues to excel in the role. So, to excel, you have to ask yourself, "Is this something that would suit me?" If it does, it usually turns out to be a very good match, and I love quality, so if any other department had tried to catch my interest, I would have said stop and no.

Interviewer How long have you been working at [redacted] initially?

Interviewee I started in August last year, and the contract runs until the end of the year.

Interviewer What was the training process like when you started at [redacted]?

Interviewee At [redacted], it perhaps hasn't been the best experience. There wasn't much of an introduction. I didn't have any introduction. I was put directly on shift. Now, looking back, it's something I've talked about a lot with [redacted] because I notice that they haven't been able to utilize me and my full capacity because I didn't quickly adapt to the work and didn't interact well with what I was supposed to do. And I can be objective about that because I know what I've done before. I know what I'm capable of, so it's not something I take personally. It's actually about looking at it objectively when I reflect on myself and the situation. So, it's about the introduction you receive. It's very important, and it's definitely something I want to do differently for those we will receive at [redacted]. So, it's something I'll take with me. It's not just about having a lot of theory and a lot of compendiums to go through in the first week and then jumping into your situation without any support, especially when you work as a quality engineer or perhaps a processing engineer or maintenance engineer or technician. You need this constant support to be like: hey, I encountered this problem. This is how it looked, and these are the things I found. Because when you ask that question to someone who really knows and has been here for a long time, then that person can say, yes, you know what? I'm thinking about this too. Have you looked into it? No, I actually haven't. Good idea. I'll go and do that. And you know, that's how you learn, and you can't learn that through a compendium you go through in a week. It requires experience, and it also requires exactly what I said, support to be able to bounce ideas off someone. It's a very special group of people who work when you also work as a technician or engineer. And in my case, I was put in a team where I didn't have an engineer; instead, I had a team of a technician and very inexperienced other individuals, so unfortunately, I haven't been able to learn much from them. And if you work during the day, it's much easier to do that because then you have people around you in the office whom you can ask, like sitting next to you. But my office is completely empty during the night and evening and weekend when I work, so I have no one to call, and that's a huge challenge with this. And I hope we can do it differ-

ently. We're in a new industry, and there are completely new problems. I've never heard of these deviations. When I went from [redacted] to [redacted], I didn't need an introduction for more than 3-4 weeks, and then I was in and running like 100% and became a project manager directly after 2 months for a special project. Here, it hasn't been able to go that way because everything is so new, so you have so much to ask about. And that's what I think we're facing a bit, that it's a strong challenge because it's a new industry. And what does a new industry mean? Well, it's like, we haven't encountered these before. No one can come and say, yes, but we did it like this for 10 years. We had these problems. We don't know about this and that product. That's also a difference because in a car, if you screw something in wrong, you can go and get another component and screw the correct one in. Here, there's no rework. You can't come and say, you know what, did that one turn out wrong? Okay, we'll polish it a bit. You can't touch the material; it has to be perfect or nearly perfect every time to pass. And you have many processes to go through, so you have to act perfectly, almost perfect, in every situation, and the tolerances are very narrow. So, this is a very difficult product to produce. Yes, that's almost the biggest challenge of working here. That we don't have the opportunity to redo and get it right; it has to be good and more than good every time directly.

Interviewer Why do you think you didn't receive this practical training?

Interviewee Yes, I know the answer to that. That's why I'm not even irritated because I understand that at [redacted], they have recruited from all over the world; they have cleaned out the entire market, and that's what all the other companies building batteries are doing too. All other battery plants in the world are recruiting, and people are asked, do you want to move to China or Norway? These people don't really exist today, and we also have difficulty recruiting everyone, like how many 1000 people do we need? We are 5400, and we only have 2 factories, and we're going to open at least 3 more here, so we have DS1, DS2, DS3, DS4, DS5 is planned. We don't cover that. And then, on top of that, it's not just us acting in Europe; there are many other countries in Europe right now with the same plans as [redacted] to build a battery plant, and the people here, my colleagues, are not only from Sweden, they're from all over the world, so they don't exist. You can't walk two people next to each other and say, now you just jump in and do the best you can in the situation. And in my shift, there are no engineers; there are some who don't even have an engineer on their shift, so if I were to go and say, hey, can I shadow an engineer, no, it doesn't work like that.

Interviewer How long did it take before you felt comfortable with your tasks? Or do you feel comfortable with them yet?

Interviewee Yes and no, I can say after 6 months, I'm starting to feel comfortable, and that's a very long time for me, as I said, I learn very easily, and I take a lot of responsibility for it, so for me, it was almost, it became a conflict within me that I felt, God, this is taking too long. I won't say that I feel completely comfortable yet, but I don't think my colleagues do either if you ask them. Because we're in

a new battery industry, and everything we encounter is new, so I don't actually expect that. I think I might feel a bit more comfortable when I come down to [redacted] and feel that, you know, now I know a bit more than the people here because I've had a prelude, so to speak, that will be very valuable. So, I think, to be fair, you should ask my colleagues who have been here for 2 years, and I don't think they feel comfortable. They face questions they can't answer every day. And you have to come to terms with that because it can be tough for some, for example, like me, not to have answers to things or not being able to figure out the answers.

Interviewer Which part of the production were you working in?

Interviewee Yes, there's slurry, and then there's something called coating, and in coating, you paint on this foil, so you add active material, and that's not my process either. I work in something called dry electrodes, so I have nothing to do with wet or moist materials. Instead, we receive a dry product, and then we need to press this product to the correct thickness, and that's a very significant specification, like a crucial specification to press it to the right thickness. That's what the process is about, and furthermore, I'm involved in two processes in dry electrode, and then you also have something called notching, which we won't really have at [redacted], but we will have slitting, which is when you have a very large PJR, a press jumbo roll, for example, then you want to slit it in the middle and get pancakes out of it, and that process will be available at [redacted], so I work in calendering/slitting equivalent at [redacted]. And then comes stacking and cell assembly.

Interviewer What would you say are the most fundamental competencies one needs to have to perform the tasks in the calendering step?

Interviewee Are you referring to what level and in what role?

Interviewer Yes, but like to stand there and work. What do I need to keep in mind? What do I need to think about when performing my tasks, and you can speak from your own role.

Interviewee OK, I think it's important for the person standing there, perhaps as a machine operator, to have an understanding of the very fine tolerances we work with. To have a high level of awareness and focus in their work. You can't really talk about "hey, what are you doing this weekend" and press the HMI buttons because those parameters are very specific, and you need to know what you're doing. It's not a coincidence that this fine product is produced; it requires a lot of focus and attention from the people doing it. It would be good to have some kind of industrial background, so you could have been an operator somewhere else so that it's not completely new for them. Then I think you have to interact a bit more, well, higher, what should I say, part or you have to get involved a bit in the quality aspects; that's very important because we can't do rework. So if you're in production and see a mistake but don't know what to do about it or don't call us, then it becomes material that has to be discarded, and in the middle process where I am, a

small pancake can cost hundreds of thousands of kronor, so it immediately becomes that you have to throw things away. Then you need to be a bit technical, but you don't really need that because you need to know your HMI, you need to know the parameters for your process, and I think you can learn that even if you're not very technical. But as long as you have the ability to focus and understand the seriousness of what you're doing, then it's very good conditions. And then working in a clean/dry room, maybe you shouldn't, it might not be so fun if you have asthma or serious skin problems or eczema because it's a very special environment, or if you're sensitive to, like. Yeah, but what should I say if you're prone to fainting and things like that, because it's a dry environment. You have a mask on, you have a suit on, you can feel a bit claustrophobic, and being in that room might give you a headache, and so if you have migraines, it's not the best to be in a cleanroom. As a parallel, if I were pregnant or had a cold, I wouldn't have been able to wear that mask and work in there. It just wouldn't be good.

Interviewer How long do you spend in the dry/clean room?

Interviewee I'm not so much in the dry room. I run between the office and the dry room, but those who work there, they have to be there for 2 to 2.5 hours. Then they have to take a shorter break. They can't be there longer than that. The company has also announced that so manufacturing has regular breaks, and production has regular breaks, and we in quality have been a bit fluid when it suits us, but I recommend having fixed times because it doesn't always work out, and others are affected, and not everyone can take the responsibility to have freedom with accountability.

A.2.4 Interviewee 4

Interviewer Tell us a bit about your background, how did you end up at [redacted]?

Interviewee I've worked in the factory located in Skövde, which previously belonged to [redacted] and is now called [redacted]. The company changed its name two years ago when it was divested. They manufacture internal combustion engines, and I've been with the company for 29 years. However, I've held various roles within the factory over the years, not consistently in the same position. I've worked in logistics, manual assembly, automated assembly, and machining areas, across several departments. I've also served as a supervisor in all the areas I've worked in. Additionally, I underwent production technology training 2-3 years ago.

Interviewer Could you tell us more about your current or intended role, what do you do as a production technician?

Interviewee It's been quite challenging for me because when I came here, there's a role called production engineer in Gothenburg within the [redacted] world, so to speak. There's no difference between the two titles. We call it a production technician in Swedish. Up here, everyone speaks English, which is a challenge in

itself. They didn't really know what I was supposed to do or what role I had, and what was expected of me. Initially, it was somewhat amusing, but after a while, it became a bit taxing because you still have to figure out what you're supposed to do and get on track, what am I supposed to do, and so on. The issues probably originated more from this end rather than from [redacted]'s side; there haven't been any problems from [redacted]'s side. But the challenges have been more about finding the right direction and assistance here. Eventually, I found my own way to some extent, partly with the help of certain individuals and partly because maybe they didn't have, because initially, I thought they would have very specific requirements and so on. But there was nothing like that initially, and that's not always easy either. But now I've settled; I actually had a meeting with [redacted] this week and outlined a plan, or well, I already had one earlier, but I've extended it for my time here, and it feels much better to have something to work towards. I still have quite a bit of freedom, though. I can't entirely set my agenda; I check in with them a bit, but still quite freely. I want to learn as much as possible during this time. You might think that half a year, which is how long I'm supposed to be here today, is quite a long time. But it's necessary because now I've taken on the challenge of learning six departments. If you're an operator, you typically learn one department in one and a half years, and then you come to Gothenburg. And I'm supposed to learn six departments, which makes it a bit tougher, but I like challenges.

Interviewer And it's six because you're working with both anode and cathode?

Interviewee Yes, it's somewhat self-selected as well, but I think it will work out fine. Plus, I have the opportunity to focus a lot on training during my time here, and maybe I don't have the pressure to perform certain tasks, which might not have been possible otherwise. It's really about learning as much as possible, but I believe it will be highly beneficial in the future, especially for [redacted], so that they have someone who has absorbed a lot of knowledge since there aren't many people up here. So, the more one can grasp, the better.

Interviewer And what would you say if you could summarize it briefly? What do you roughly do on a daily basis or what is intended for you to do?

Interviewee Well, that's a good question. Ultimately, if you break down the role of a production technician, as you probably know, it involves creating work instructions, implementing improvement measures, and so on. So, that's the goal. But to get there, I feel like I'm more in the initial phase of learning the process, which is also [redacted]'s focus, to learn it really, really well. Right now, I'm not actively involved in production in terms of technical aspects. Currently, I'm mostly reading through all the work instructions to form an understanding. So, I'm not actively involved in production technically right now. The opportunity I saw here is that I can take advantage of this time to learn many departments since I don't have the pressure. They have plenty of production engineers up here who can handle that, so they're not short on staff at the moment.

Interviewer Yes, and do you have any spontaneous feelings about what you would say is the biggest difference in processes between the anode and cathode sides?

Interviewee Well, you have to consider that the chemicals handled on the cathode side are very dangerous, while on the anode side, they're not dangerous at all. That's a big difference. Last week, there was an instance where dealing with the air in those workrooms, called clean and dry rooms, could be challenging. Everything should be very controlled, but sometimes there are lapses. It can be taxing with strong fumes, so you end up on the cathode side, which doesn't pose any problems regarding hazardous chemicals. So, there's a big difference. Additionally, the materials themselves behave a bit differently, so the processes are somewhat different too, despite similar machines. Although they might look very similar from a distance, handling them is quite different. Also, there's very little collaboration between the cathode and anode sides here. There's minimal cooperation between the personnel and technicians on both sides, unlike what I'm doing. It could be desirable to have a bit more collaboration and a broader view so that people can see the whole picture.

Interviewer Moving on to your learning process, what do you get to do, and what's the setup for your training?

Interviewee That's a good question. I've created that myself, to some extent. Initially, it was a bit like I followed an engineer around, and he probably thought, "We'll walk around for 2 hours, and then you'll know this." But that's not really how it works, especially in coating, which is quite a complicated process with living materials and many steps. So, I didn't find that part to be effective. In consultation with others, I decided to take a different approach, which is why I'm heavily involved in production as an operator for now and will gradually transition into the technician role.

Interviewer Are you shadowing those working in production, or are you hands-on with the machines yourself?

Interviewee It's both. It depends on where I am. I think it's a good way to learn the whole process thoroughly, not just sitting in the office reading about it. I've been in the actual environment, and it's a good opportunity that I've been given. I haven't decided this on my own; I've discussed it with others, and they approved the setup. I started in the slurry department, spending a week on each side with practical training, then I'll attend a two-week slurry camp, which is essentially a basic training for operators. These camps are meant to train people to be immediately useful in production and be of assistance.

Interviewer Staying on the topic of the learning process, you mentioned you've structured it yourself. How would you have preferred it to be when you arrived, or what would you have liked to be different?

Interviewee For my role, this setup seems somewhat optimal, as I've tried to tailor

it to fit. We all might have different opinions, but what I'm optimizing is that I won't be an operator for long after the training; I'll gradually transition to what is now called a technician or engineer role. I haven't explored many parts yet, though.

Interviewer Yes, but there are still training programs for you to attend, it's just that your role is a bit customized.

Interviewee Well, it's not entirely straightforward, I must say, to get into these training programs. But I've established a good connection with the training coordinator, let's call her that, and she managed to squeeze me into that course. It was pretty much the same with the coating camp; I got to be an extra person there, which was a bit special because they're under a lot of pressure to accommodate so many people, and they struggle with these trainings. Mainly, it's a week of theory and two weeks of practical training. But they find it challenging to organize the practical part. For the course I attended, they had difficulties coordinating it because maybe they had a plan for the next day and had talked to the production staff and got the green light, but then the next day, everything had changed, and the trainers didn't have a plan B for that. So, it resulted in a lot of downtime, not for me personally, as I had other things to do during that time. There are plenty of courses available on the computer here, called LMS courses, and there's a lot for each department.

Interviewer Yes, but what would you say are the most fundamental skills an operator needs in the processes/steps you're involved in?

Interviewee It's quite comprehensive, especially in the coating department. There are easy tasks and much harder ones that require time and practice, so to speak.

Interviewer If you think about the easier ones that don't require much time and practice.

Interviewee Yes, exactly, and they cover that very well in this coating camp. You get to try it out practically in real-life situations. Each participant gets to do that. And there's a lot with the computer system up here. Practically everything is digital; there's no paper. All employees have their own iPhone; some have their own computers, and there are shared computers as well. So, it's very digitalized.

Interviewer So, do you carry your phone with you to your stations, so you can know what needs to be done at each place, or how does it work?

Interviewee Absolutely, and you also log what you've done, so instead of checking off on paper or something, you do it in the computer world, so to speak. Everything is digitized.

Interviewer What's the mix between theory and practice?

Interviewee You could say it's one-third theory and two-thirds practical, particularly in coating. Now, I'm speaking only from the perspective of someone who has completed it. They teach the easier parts, and there are a few stations that are easier, and then there are some stations that are harder. We learn and do a lot of work because we have the basic knowledge, but some things will take time, and they'll have to sit with those tasks under the supervision of the available staff and be there to ask questions and so forth because it's not something you can just do. Monitoring is what it's called, where you control the flow or where the machine spreads this slurry onto the foil in a very, very thin layer. It has to go smoothly and well and be very precise in measurements because it's a very meticulous process.

A.2.5 Interviewee 5

Interviewer So our first question is that would you mind telling us about your background, how did you end up at [redacted] and for how long have you been there?

Interviewee Thank you for asking this question. Yeah, I have started my bachelors with the chemical engineering background in my native place in India and now I am, I have completed my masters in material engineering, especially specializing on nanomaterials for energy storage, so my thesis is also based on that so next generation materials,batteries and capacitor. And as I studied my masters in Chalmers, So why I got to know about that for more than. It would be lost. When, when? When the deal was signed with the [redacted] I I was following, you know. From that time. And fortunately, I got an opportunity to work at [redacted] in the exchange program, so now I have been here for the last 9 months. In the company. And especially taking care of the incoming quality control in chemical laboratory.

Interviewer So you receive quality control material, is it tests or could you tell us more about your work role? Like, what do you do and what does it mean?

Interviewee Certainly, I am working here as a quality control technician inside a chemical laboratory in incoming materials, so we will be dealing with the, all kind of incoming materials from outside the company. So we'll be understanding that material in the chemical aspect. So we have some sort of moisture analysis and some sort of tap density analysis. Some are more regarding about the surface area. So we mainly deal with the material in the chemical aspect. How it looks.

Interviewer How does like a typical work day look like for you? What are your typical work task?

Interviewee What task would be the main integrated part was testing the materials inside the laboratory, with the various instrument because we have different parameters for our different materials, we'll be taking that from some other incoming quality control protocol they're developing over there and we will. This is one part testing, and discarding the materials. Or getting the right materials from the

production to the lab. So this would be the secondary work and testing work would be maintained in the lab. That would be the 3rd level of work on a daily routine basis monthly basis we have something called regular check over the work construction risk assessment as well as some sort of new technology, new method will be arrived from labs or from from our colleagues. So we will be adopting that to our lab. And this is would be a monthly on monthly basis would be, yeah. And maybe in 3 months or 4 or 6 months, once we'll be having a deep cleaning all.

Interviewer OK. Yeah, thank you. I was gonna ask. So the chemicals that you are like taking the quality control of or how to say, does it come directly from like which step in the battery cell production is it, does it come from the slurry, the mixing or which part is it, the coating?

Interviewee That's a great question. So as I am part of incoming material that means, we will be handling materials before mixing before slurry mixing. That means from supplier we will be getting some powders or solvent that we'll be inspecting in the laboratory, and we'lll be reporting a deviation, if you got the deviation you will be reporting that. So that the production starts with the slurry mixing, so it is the first step of the entire batch production.

Interviewer Yeah. So you basically approve or disapprove the chemicals?

Interviewee Yes. So we will be be cross checking with the second kickoff analysis from the supplier, whether it was the right one, we will will not go in there because we will be doing the selective test on random sample basis.

Interviewer So next next question is what do you think is most or least challenging with your work tasks?

Interviewee The most challenging, one particular to me was, As I have some technical background as a chemical and material engineering and I was being in the lab for last 4 years. Especially in the Academy as well as some sort of research about this. I know the protocol of most of the Protocol on safety as well as chemical handling. A dangerous thing which hazardous and dangerous thing inside the instrument especially. The learning thing, even though I was there, I need some more time here to learn about that. Now my learning about it at the same time. The most challenging one was. Conveying this whatever I or whatever the people know. To the new users to what's the most challenging one, because their background was so different. So their liability was more important, you know? So communicating to them was was a bit challenging process. Because so we have work instruction but that, we have a very good work in but still we need to standardize stuff at the same time, we don't know how the new users would be because they have a very different technical background. So can main the transformation of that data from the file to today practice. That was a challenging goal.

Interviewer Well, that's great because it actually takes us into the next question

where we ask, what did the training or learning process look like for your current role? Like how did you become a quality technician?

Interviewee I was in India, I was working in the quality control department in the paint industry, so it does not completely new to me. I was familiar with some of it. So. The thing was, the training is it's more important because on everyday basis the chemical, the chemistry inside the material or exploring by the people or any people or any other aspect so. If you will closely watch everything. Once we will be. Changing the discussion will be changing the safety protocol for a particular material, so the learning is the kind of a continuous. Process. Inside the lab, if it is a continuous process. But if you're asking a new users perspective what we are following here is the first 4, first week we will be. Having onboarding week. That gives you the overall picture of the company as well as the what materials will be handling, what are the risk we are going to face. Yeah, the next week what we used to do will be just going around the lab or just maybe some expertise or manager who know about the you are working. Then, more than a month, what we but this will be shadowing the expert resource. How they do, how what kind of? How do they handle the material, how they they go, the safety protocols, how they do the checklist, how they do everything, they will be following and we have skill matrix. Drawing to take the skill matrix, we have a 3 different level of training for the new user given by the expert users. One would be the introductory. Theoretical experience over the. particular instrumental part of material for specialized material and the secondary level there will be showing on hands on how you want to do experiment. And 3rd level will be classified into 2 types, one under the supervision you will be going. Another one the supervisor would be inside the home, but they will not take they have not looked into directly into the instrument or the user. If the user have account they can supervisor that kind of follow it. And at any point of time, we have a policy that no one should work inside the lab alone. So that means if you have any doubt over here, you should have a colleague to consult about that at the same time. You are the instrument order the product owners. They will be available in teams if you have a quick question. We have 23 export users and the remaining. 10 Plus should be as an intermediate user.So we are we are planning that we are we we need a one export user for one instrument using 10 instruments 10 different export will be available.

Interviewer OK. Thank you. And is there anything that you would like have to have been different in the learning process at [redacted] or was the onboarding and the like the following process enough for you?

Interviewee No, I will be stick with this onboarding because this is like where whatever the onboarding provider but not. It's mandatory we we as as users we have some more suggestions what the goal like can we integrate the artificial intelligence training programs because here we are more independent over the work instruction first. Second, we are more and more independent of the expert users because they are suggestions and they are comments are more important here. In addition to that, we are recommending kind of lab metal works or some kind of real

technology to help other thing which is commonly available in the market but not adopted by the company and still we are pushing. Everybody for the database is not workinstruction. Just these 2 things we are. Still pushing along the border.

Interviewer And so how long would you say that it took for you to become comfortable with your work tasks?

Interviewee As I said earlier, I was inside the lab for last 4-5 years, so the first day I was comfortable. As I said, during the onboarding, you will get clarity over what are the materials. And that gives you a clarity over that dangerous thing, what you're going to handle, but once you come to lab, I feel that everybody should be confident because lab has, especially the lab work has most of the ambiguity. You cannot predict what would be coming next. So I prefer everybody should be confident, even though, you know, I don't know, at least what you know. To whom you want to reach? That's. That's the only thing everybody needs to know in first week. Capacity issue means who I want to reach. If there is a best discard means who I want to. Every, every everything. They should go and there should be more and more. I feel like learning but nobody gave you have a learning thing.

A.2.6 Interviewee 6

Interviewer So, first question then, tell us a little about your background, how did you end up at [redacted] and how long have you been there and what have you done before?

Interviewee I'm only 19 years old and I don't really know how I ended up here, everyone else seems a bit more qualified in the industry than I am. But I went to a technical high school with a focus - IT. I've worked summers in a factory and that's about it.

Interviewer Well, that's very good for being 19! But how long have you been at [redacted] and the [redacted] program?

Interviewee I was hired in mid-September 2023, so I've been working here for almost 6 months.

Interviewer Okay, exciting. Tell us more about your role, what do you do in your role as a manufacturing associate in anode slurry?

Interviewee Yes, I'm an operator in the slurry. I work with the shifts that for a few hours make the slurry - the active material that will be put on the copper foil. So, we manufacture the slurry as I said.

Interviewer Exciting. What would you say are typical tasks that you perform on a daily basis?

Interviewee There's a lot of sampling, as it's called. We have to test everything very often, at least the slurry we've made and also the binder that binds it together, additive binder it's called - CMC. So, we have to test that very often, at least once a day, depending on where everything is located. We often have to clean the tanks, maybe not every day but very often too. Then you always have to keep good track of what's in all the tanks, we write down a lot what's exactly where - document. It's a lot of cleaning actually. We're not allowed to leave slurry in a pipe or in a tank, we're not allowed to leave an empty tank that has had slurry in it for over 24 hours. And that's the biggest problem when we're in production because we need to continue making batches and slurry all the time. The problem arises if the coating on the anode side has a lot of problems, it means we can't produce as much as I said, and we often have to stop production and then we have to clean a lot. And that's when, as I said, all the pipes, all the different tanks. We also have a lot of filters that we have to clean. So yes, cleaning is a big part of our work.

Interviewer How do you go about the cleaning process then? Is it mostly done by hand or does it happen automatically or in what way do the cleaning processes take place?

Interviewee We can start from the beginning where we make the slurry mixers. There we usually just pour in some water and then let it stand and rotate or mix for 20 minutes. Usually after that time, there are still larger pieces of semi-dried slurry left at the top of the tank. So we have to push that down. We do that by hand and then we also sometimes have to wipe off the blades. And then we just pour it out and often we have to add more water. And then repeat it a few times. This depends on how far apart the tanks are, but usually if we're going to clean a pipe we need about 200 liters of water. But then, from the mixers, we usually send water to a storage tank. Let it mix for a while. Then depending on how clean that water is, you can either send it on to the next storage tank and clean that pipe and the pump. Or we pour it out and pour in more water and then send it on. And then finally we send it to the coating side, to their tanks, and then we've basically cleaned everything. It's a full-on cleaning, as it's called.

Interviewer Okay, and do you only work with water?

Interviewee Yes, on the anode side, it's just deionized water and on the cathode side, I think it's NMC. But we can only use water. Something else we have to do once a week more or less is something called pigging. Then you send a small plastic plug, from our last storage tank to the coating, to really clean the pipe. It's not very easy to explain but you just put the plug in the pipe and then you increase the air on our side of the plug so it moves on to the coating side and it removes the dirt.

Interviewer OK, and is the idea that it scrapes along the sides somehow so that it removes everything so water doesn't get stuck or?

Interviewee Yes, exactly, our slurry dissolves very well in water, but it never really

gets clean in the pipes with just plain water so we send one of those too. Yes, and then all the filters. We have a mesh filter and a magnetic filter. That we have to clean by hand. It's right at the beginning of the tank, so right when the slurry leaves the tank, it goes through both of these filters before it goes to the pump. So it's just a matter of opening a clamp and cleaning over it with wipes. We also have another filter which is a cross filter that is inside the tank that we usually clean when we clean the tank itself. I don't really know exactly how we should clean those filters because when I started we did it with one vacuum pump. But now the vacuum pump doesn't work anymore so we do it by hand now by just sticking a brush type thing in the pipe.

Interviewer Okay. And if we go back to the sampling part? How do you perform those moments if you want to explain it a little more concretely?

Interviewee We have 4 tests that we do at-line, and then we have 2 more that we do offline, which we don't do ourselves but are done by a QC team, so I don't know much about those. But the at-line tests, anyway, there we test solid content. We check viscosity, and we check density, and we check particle fineness. We measure solid content by taking a small metal plate, type, measuring how much it weighs in grams, and then we write it down. Then we zero the value and add exactly (plus/minus 0.05 grams), but in any case about 5 g of slurry. Then we put it in an oven and wait 20 minutes until it has solidified. Then we measure again, and I think we subtract the earlier value from the later one. No, the other way around, the later value minus the earlier value, so we get the percentage of how much has solidified during that time. Then we do 3 different tests and take the average between the tests and do it at the same time. I've done it quite a lot now so I'm quite good at it. I know we have quite a lot of problems with it. With new ones coming in and doing it because I actually don't know exactly why they can't do it. But it has happened sometimes that it has to be done several times because it goes wrong when it shouldn't. Like I said, I don't really know what goes wrong, but it's probably a mixture of different things, and if you accidentally touch the slurry a little, then it removes a little of the slurry, and then you will get incorrect values in the end. You might accidentally leave it in the oven for too long. Yes, it could be various things, a little difficult to say exactly what it could be. Then we have viscosity. Then we have a small metal tube or metal pipe into which we pour about 18.8 g of slurry. Then we put it in a measuring tool type that tests its viscosity by lowering a metal peg type that spins and I don't really know exactly how it works, but, it tests the viscosity anyway. The viscosity of a new slurry usually ranges between 8 and 15. I don't know what unit we use for them, by the way. Something with cubic meters per kilogram or something like that, doesn't matter. Anyway, it should be between 8 and 15. A new batch usually is around 11 or so. Finally, when it reaches coating after a day, it may have gone down to 8, and below 8, we cannot use it. Those are the main tests, those are the ones that mean the most, usually. Yes, if any of them are not approved, it usually means that the slurry is bad, and we should not use it. And then we also have density, which we test by using a cup type that we measure the weight of just before we use it. We zero the value on the scale. Then we fill

it with as much slurry as we can, and then we have a lid with 1 small hole in the middle which is then placed on and pressed on, and then the slurry will come out of the small hole, and so it usually becomes full of slurry. Wipe it off and then measure again, and then you get the value of how much the slurry weighs per, I think it's 100 milliliters in that jar. I think it should be around 1.4... It's a very simple test, it's very difficult to go wrong. The only problem is that sometimes people can lose the lid, which can create holes or defects in the jar. It has happened that we had to change the jar sometimes because the measurements were incorrect. And then the last test is the particle fineness test or grind gauge as we call it. Then you have a metal plate type that you have values on the right side of the small metal plate. From the bottom up, zero to 60, I think. You also have a kind of sharp plate, type that you will then spread the slurry on in a way. But you have the plate, and then you pour the slurry absolutely at the top, draw a line across, and then you take this and draw with you the slurry all the way down to the end of the plate, so it comes off the plate. Then you will see a line from the bottom up. And that's how big the particles are, approximately. Then you should measure approximately halfway between the 2 highest lines and then you should take the highest value, and then you often take the jar weight where most lines start, and then you have the average of the 2 which should be under 30. Then it's a good average. And then note it down. We also have a QC sheet, as it's called, where we write down all the values. It works like that. It's not very automated, a lot of writing, but it works.

Interviewer Do you write it by hand on paper, or do you have some system for it so it's digital?

Interviewee No, we have an Excel document where we write everything.

Interviewer Great, then we can move on to the next area. Just a few more questions, more about your perceptions of it then? What have you thought or what do you think is the most or least challenging about your tasks? Just a little more general.

Interviewee I haven't felt that it's very challenging myself, but I have colleagues who seem to think it's more challenging.

Interviewer What do you perceive to be challenging for them then?

Interviewee Well, I'm not really sure what is challenging for them. There are quite a lot of things. It's difficult to say because I think I find it quite easy because I'm quite interested in technology and such things, while many colleagues are not interested in it at all it seems. So they have a bit more difficulty learning everything. But we deal a lot with HMIs - Human Interface Screens, for example. And they are quite different depending on which tank you are working with, so just remembering everything is usually quite difficult, there is a lot you have to remember. Then you have to be in different settings depending on what you want to do. People don't really remember it. Like I said, you have to be in completely different settings de-

pending on which tank you are in, you can't do the same things in certain tanks. But yes, sampling, what is very good when doing sampling is that you have to be very careful. Otherwise, it can easily go wrong. So, whatever you do in there, you have to be very careful and always think before you do things. We deal with quite dangerous substances, at least on the cathode side. On the anode side, it's not as dangerous, but it's still dangerous, so it's important to think about what you're doing.

Interviewer Yes, I think that was very good, thank you. You don't need to delve deeper than that. Okay, but what did your training process look like then? How did you learn what you were supposed to do?

Interviewee Well, I haven't really had the same as everyone else it seems. I went to something called Adult Education, because it was for people like young students who come up here to start working up here. We had 13 weeks, I think. Every fourth week, we were at VUX, which is an adult school here in Skellefteå. And between the 4 weeks, we were at [redacted] for 3 weeks and just worked basically. Like I said, I had no industry experience before this job. But at VUX, there were 5 teachers, I think, who had previously worked at [redacted] and had basically worked in the industry all their lives, so they had some small factory machines, type. They had robots and some other things, and so you get to learn about how it works in an industry then. They emphasized very much that safety was absolutely the most important thing when you came in there. Anyway, I was in the pilot group. I was the first group to do it. I thought it was very good anyway because I got to learn, not specifically about what happened in the factory itself, but more just like an overview of how the factory works. I think it was great. It has helped me a lot anyway, I would say. Then I think in the program itself, those weeks we were at that school were very good, but technically, the learning process was supposed to happen at [redacted] when we were working. It was just a regular training. We sat and did courses voluntarily when we felt like it, so it wasn't very structured. I think it could have been more structured, that there could have been some goal during the first few weeks, even when working at [redacted] then. Yes, I think that was very good. I haven't really had any other kind of training, I would say. My team leader may have gone through something when there was an opportunity.

Interviewer Okay, but you didn't have any supervisor or anything on site during the time between the weeks then?

Interviewee No, like I said. We had nothing, it was like a regular job. But, yes, I don't know, I thought it was strange because these are college courses we have done now, and we did them during those 13 weeks, and like I said, the majority of the weeks were then onsite, and we later received grades in those courses after a while, and no one knew what we were doing at the actual job. The teachers who were supposed to grade us only knew what we did at school. So in the end, we had to evaluate what we thought we had learned well on the job itself. Then we received grades for that. So the VUX things were very good, but what happened at the job

wasn't as good, I would say.

Interviewer And there was no connection between the actual job and VUX then, more like 2 separate parts?

Interviewee Yes, it was work and school like that, there was no thought of training someone specifically there.

Interviewer No. What do you actively think is missing then or how could it be improved?

Interviewee Well, I had onboarding too. It's a week, or well, 5 days where you sit and listen to team meetings for 8 hours every day. It was quite terrible, but we have talked internally about how bad it was. I think you should have a longer period to be introduced, especially if you haven't worked in a factory before. A couple of weeks at least, I would say, where you could have the onboarding, you could have it in-person too, I would say.

Interviewer Yes, because I was going to ask you, what did you do then on teams for a whole week?

Interviewee It was a girl from Västerås who sat and went through a lot of things. It was everything from safety to which apps we should use. It was extremely much information actually.

Interviewer Yes, how many were you in the same group then too? How many were you being onboarded at the same time?

Interviewee I, I remember that we were about 70 people in my group, but then I know someone in the [redacted] thing had 20 people so I know it can vary quite a bit. But yes, there were also. There were so many technical issues that there were many who had just received their work computer, we got our work phone just. There weren't many who had them up and running then and actually it took up a huge part of the time too like that. A longer introduction process where after you have learned a lot about what [redacted] stands for and how it is to work overall at [redacted], you should also have some kind of specialized focus on where you should work. I would also say that is a pretty big thing that we should also do. That each person should have at least a week with a mix of practical and theoretical exercises, type. It also helps just to see, I mean before you have learned everything theoretically so that you have just seen the place, and can get a picture of what you are reading, so to speak.

Interviewer So how long if you were to estimate did it take before you became comfortable with your tasks as you do them today?

Interviewee 2-3 months maybe. We have had some problems as I said, we haven't

produced a lot. We have basically started producing quite a lot in the last month. But we didn't do much in the beginning so well, but I still think I had a better learning process than many others. There are people who have worked as long as me now who don't know much at all. And they haven't done that VUX thing I'm pretty sure of.

Interviewer Did you think it helped a lot to have the VUX thing anyway to get into it even if it wasn't so well coordinated between them? Did you find that it facilitated having the theoretical parallel with the practical?

Interviewee Yes, it helped a lot I would say. We were dealing with roughly the same things but it was not literally exactly the same things we did. It was a bit overall what we did. It helped a lot anyway. We dealt with pneumatics, electropneumatics, and so on. They have like a small production line, like a little production. They have a lot of sensors and HMIs and yes, it helped a lot anyway.

Interviewer Great, but those were basically all the questions we had from our side. Do you have any other thoughts or anything else you think I would like to add or any questions for us?

Interviewee Maybe that fundamentally is that you should teach people to think about what you are doing as I said and to think about safety because many team leaders have made a lot of mistakes. Solely because they didn't think before they did something but rushed through it because they had to produce, you know. My team leader, I think he's very good because he thinks a lot about safety and such things, so if you would like to have a culture at [redacted], you would gladly have some kind of safety culture to think before you do things, I think that's important.

Interviewer Yes, thank you very much for participating in the interview.

A.2.7 Interviewee 7

Interviewer So would you mind telling us a little bit about your background? How did you end up at [redacted]?

Interviewee I ended up at [redacted] just because they had started up and they were looking for a lot of new hires so I applied and then I got the job and it was just nothing more than that.

Interviewer OK, great. And what did you do before?

Interviewee I've been on maternity leave and also like I've had, like small jobs in customer service and in stores and stuff like that.

Interviewer Yeah. Awesome. And could you tell us a little about a little bit more about your work role, what do you do today and how does a normal work day look

like for you?

Interviewee Yes. So I work in anode slurry auxiliary in DS1 in Skellefteå. I'm just a normal operator over there. So my work day consists mostly of starting slurry batches, making the slurry, sampling the slurry, you know, cleaning all the tanks and making sure we have enough material in our hoppers and stuff like that.

Interviewer Awesome. Thank you. And what did your learning journey look like? Like, how did you learn everything as an operator?

Interviewee Well, I got trained by my colleagues. The ones that had already worked there for a while, so in the beginning cause I started like a year and a half ago. So back then all the training we got were like from each other. So we're just learned from each other basically, but now we have just started up with the slurry camp to get more extensive training before actually starting in production.

Interviewer And you yourself haven't gone through this training. It was just by the colleagues?

Interviewee No, I haven't. I am actually the one building it right now and it's starting starting that one up. So I'm gonna be a trainer for everyone that starts here.

Interviewer Well, great. Could you tell us a little bit more about that? How is the training going to look like and why did you feel like you needed to insert this training?

Interviewee Yeah, well, I got the question. Basically, if I wanted to take the lead on it and you know build the material for it. And I said, yeah, sure, cause it sounds like fun. So first I had to like, spend a few weeks building the material, making a PowerPoint of all the things that we actually do in slurry. You know, step by step instructions and photos and everything. And then we got. We had our first group almost a month ago now. And so the plan is they're gonna be in this slurry camp. We are calling it for two weeks. So we're going to do like some theoretical training and we're going to also do some practical training. So what we have done is we have gone over the PowerPoint looking at like different segments of the training and then we have gone into production and actually had them like show them and like, you know train them. Practically as well.

Interviewer OK, that's awesome. So what would you say the percentage is of the practical training and the theoretical?

Interviewee It's a little bit more practical than theoretical because a lot of the things you have to do them, like a few times before you know them, you can't learn everything just by looking at the screen. You have to do it. So I would say maybe 65% practical training, yeah.

Interviewer And is the training on each and every step of the battery cell production. Or have you chosen like part of it?

Interviewee I think it's going to be in every department. Right now, I know it exists now for slurry as we've built it in slurry just now and it has existed in coating for quite a while. And then I'm not sure about the rest of the departments, but if it doesn't exist, it's gonna exist in the future because it is a good program and it does help with having more experienced operators from the moment they actually start in production. So it takes away time from the normal operators so that they don't have to like train and focus on like making sure everyone is supervised in the same way that they used to.

Interviewer Thank you. And what would you say is most challenging about your work tasks as an operator?

Interviewee Most challenging, I would say when we are loading the powders for the hoppers because that one is quite a physical task so it puts a strain on the body and also all the gear you have to have because you have to have like the gas mask with the air supply. And so it's kind of hard, like making sure you can read properly in it and move properly and also like. Sometimes it's in quite uncomfortable positions. So it's quite physical that part, but we divide it so that you don't have to do it every time you have like maybe once every shift you do it. So the next time it needs loading, then the next person does it goes and does it so.

Interviewer How long would you say it took for you to get comfortable doing your work tasks? Since you have your own or like the training was with colleagues and stuff?

Interviewee Yeah, I learned everything quite quickly, but I am a fast learner, so for me, I started like feeling really comfortable within, like the first three weeks maybe. But then, like I've had colleagues that have started after me that have taken like 3 months before they have started. So it's very individual like if you are a fast learner, you're going to learn it quicker, of course, but for me it was like 3 weeks and then I knew pretty much everything I needed to.

Interviewer Great. And what do you think that can depend on? Like what other factors than being a quick learner, do you think it can depend?

Interviewee Yeah, I think like some people are a bit more stressed and worried about like pushing the wrong buttons and something in the HMI's suggest that like they don't have like the guts to, like actually try. But they always have someone with them who will stop them if they try to press something wrong. So like if people were just like have the courage to actually just try. They would probably learn a lot quicker, but a lot of them are like hesitant and like oh, I wanna try. But I also don't wanna try, you know, little bit like that, yeah.

Interviewer Yeah. Yeah, I understand. What would you say are the most necessary competencies or how to say when beginning to work within the slurry or the mixing or part like what do you need to take with you before you start working with the tasks?

Interviewee Yeah, I don't think you need like any, like, special competencies like that, but you just need to have like you just need to have some sort of interest for what the work is like. If you find that that the machinery is like cool. Then you're gonna learn it better also because it's you're gonna get interested in it. And if you're totally not interested, then yeah, you're not going to learn this quick.

Interviewer OK, but which parts of the process are most necessary for operators to learn, so to say before or when entering the battery production or factory. So what would you say is basic skills? Or like necessary skills needed in your production.

Interviewee Yeah, anode slurry is not like a difficult job. It's just like, I think most people can learn it. It's not that difficult. It's not that straining on the body. We don't have that many harmful chemicals because if you work in the cathode side, then obviously you need to be more wary of all the different chemicals that can affect you, but in anode slurry, most people can learn it because it's not that difficult. You just need to spend the time to actually learn the machines. And like the HMI's because they are. They look very intimidating when you first see them, but then after you've seen the same thing like over and over a few times, you're going to get the hang of it and learn which page does what.

Interviewer How did you come up with the kind of training that you have at the slurry camp?

Interviewee Well, I kind of started like from the basics like because the end goal is to have like slurry that's good enough to send over to coding. So I kind of just started like what are the basic steps, what's the first thing you need before you can even make a slurry? And that's to make a binder. And what do we need to make a binder? We need these materials. We need to learn this machine first so that we can make this step 1st and then I just went from there and took it like one step at a time. And then I ended with all the different cleaning segments that we also have to do. So I kind of just went like step by step, what's the first step in making a slurry? What's the second step? Yeah. And just went from there and from experience So I also went and took like some photographs of all the different machines and the HMI's and all of the different steps. I had some of my colleagues like post with the photos so that I could show like this is what we are doing. This is what we are taking apart. This is what we are putting together. This is how you wear your PPE. You know everything step by step, very, very simple, you know.

Interviewer Did you prioritize somehow within the skills needed if you? Choose to not include anything?

Interviewee I tried to include as many points as possible from each task just so that because we are, even if the chemicals in anode side aren't as harmful as the one in in cathode side, we still want our operators to be mindful and vary of all of the different things they are handling and wear the proper PPE so that they don't get hurt. And do the proper procedures. So it's like, but I kind of cause a lot of things because I've been working for a while. I do them without think thinking. So then I had to like really remember like I need to also include this part because I do it subconsciously, but they won't because they have just like remember every single step.

Interviewer Thank you very much for that and thank you for signing up for this interview with us. It's very helpful and we are very grateful for every information we get.

A.2.8 Interviewee 8

Interviewer
Firstly, you're welcome to share a bit about your background. How did you end up at [redacted] and how long have you been there?

Interviewee
I've been at [redacted] since July. I don't know, I like cars and stuff. I thought about trying to work on the assembly line, but then I applied to [redacted] instead because if you look at the car industry, it's moving more and more towards electric cars. So I thought that could be a bit fun. The plan is later when I'm going to study, maybe something related to that.

Interviewer
What did you do before [redacted]? What is your previous background?

Interviewee
I'm studying logistics at university and I've basically been through elementary and high school.

Interviewer
Great, and could you tell us a bit more about your role, what do you do in the cathode part of coating and pressing?

Interviewee
We actually have 3 stations, all 3 are essentially monitoring to ensure everything is running smoothly. So you're looking at different screens to see the various values that come up when the machines are running, and those values should match a target value, and then there's like a 5 micronewton or something up and down difference that's allowed. If it's more than that, the material becomes easily damaged. OK, so that's basically what we do, sit and monitor. We have 4 different screens and make sure everything matches up and identify any deviations and errors.

Interviewer
What are typical tasks performed on a daily basis? Could you give a brief overview of what a shift usually looks like?

Interviewee
Well, during a good shift, you're basically just monitoring the screens to make sure everything works. If you're working on sampling, then you'll take some samples to verify that they match what the screens are saying. But otherwise, not much happens; it tends to be quite boring if everything goes as it should.

Interviewer
Do you have any responsibility over the machines that you need to adjust, or is it just observing the material?

Interviewee
We need to ensure that we have a few things to check. Usually, when you enter a production line, it's not recommended to immediately shut down production, so you continue, relying on the previous shift to have done their job properly. But otherwise, we usually check this to ensure everything looks OK just before we start.

Interviewer
OK, and what would you say is the most challenging aspect of your job?

Interviewee
When things go wrong. Problem-solving in the beginning, that was it really. There's a lot to learn in the beginning, but once you've learned it, it's mostly just the problem-solving that's complicated.

Interviewer
What does the training process look like in that case or overall?

Interviewee
They've changed the training process now. When I started, it was just observing. You would shadow one of the workers. The first week, they shadowed and supervised you, but now they have what they call a coating camp, where I think they go through more of what is expected of them. And now they're away for 3 weeks, after which they should be able to handle basic things.

Interviewer
OK, so that was how it was for you when you just followed someone who worked or had worked there before. How long did it take for you to feel comfortable with your tasks?

Interviewee
One to two months. Until I felt I didn't need to ask anyone, so to speak. Until I felt

confident about what I was supposed to do, it was one to two months. But I know some take much longer, some are still learning even after 6 months or something. But generally, it's like this, exceptions aside. It usually takes one to two months before you get the hang of it. Now, when they run, they work regular hours at the coating camp, from 7 to 4 approximately. And the trainers show exactly how it's done.

Interviewer
Was there anything you felt was different about how you were trained? Did you feel like something was missing?

Interviewee
No, I like the practical aspect, you just go in and try things out. I know many found it quite tough. But it's a bit of your own responsibility when it's practical, and you learn depending on how interested you are in learning. Whereas now, it's a bit more like you learn even if you're not super interested in learning.

Interviewer
What would you say, looking at operators in your process step, what would you say is important or what are the most important or basic skills they need to know either at the beginning or even before they go into production?

Interviewee
Attention to detail, I mean if you're attentive, not much is required. The problem is when you've been here for a long time, you often get tired. And that's where it sometimes fails. But generally, just being a bit attentive usually gets you quite far. It's not rocket science we're dealing with. Yeah. Just be attentive and you'll learn. Since everything is about looking at screens, so if, oh it's gone 5 minutes, it was wrong, well, it's not optimal, but it's better than it going on for an hour.

Interviewer
Great, thank you very much and thanks so much for your time. Thank you very much. We appreciate it a lot. Have a good one then, yes, have a continued nice day.

A.2.9 Interviewee 9

Interviewer So our first question for you is if you could tell us a little bit about your background, how did you end up at [redacted] and what do you do there?

Interviewee I am working in [redacted]. I need to work with [redacted] for two years before to go to Gothenburg to work at [redacted]. Well, my background is, I'm from Venezuela. I'm a mechanical engineer. The mechanical engineering in Venezuela and there I worked like mechanical engineer for I think 11 or 12 years. I always work with teams. Sometimes big teams and sometimes smaller teams, as a supervisor and electromechanical supervisor. And also like a team lead there or shift lead in that moment. And in my water company or the company that managed

the water in Venezuela. Yes, I managed one part of that company. The part of the manage the water in one city. I was the manager, responsible for that and part of the company for actually two years 2-3 years, that was. And yes, my competency was leadership. All the placement that we did in that area or manage all the things about the water in my company I had in my charge like a team forming 30-35 people in that moment in different areas with different specialities. And just I needed to manage that for some years. Basically that was my main background for staying away. My work is all time has been with machines in fabrication or manufacturing or preparing of machines in different things of machines like engines, valves, big valves and those kind of things related with water, and huge size. Here is a little bit different actually. My work here is nothing related with my background and has been a huge joy, because everything for me since the beginning was completely new. My chemistry background was only in my primary school, all my background chemistry and here everything is about not chemistry but yes, Chemistry things. Something like that.

Interviewer Great. Thank you. And how did you end up at [redacted] or here? When did you move to Sweden?

Interviewee I move here in December 2022 actually, but I started working in [redacted] in July 2023.

Interviewer OK, so almost a year then. Great. Thank you. And today you do work as a manufacturing associate right? With anode.

Interviewee Yes, exactly.

Interviewer Could you describe your mainly daily tasks or weekly tasks? How does your day look like?

Interviewee Yeah. OK, my daily routine is like, go inside the room and look what the previous shift did during that shift. I need to evaluate that and know what are the tasks for the day. That's the main important thing. If we are in production, we need to know how many batches that is made, a main batch of slurry we need to do during the shift. According to the next step, that is the coating. We need to work with them and manage to avoid producing more than necessary, but also we need to provide them with all the slurry that they need, so we need to work with that. Basically, we need to start producing and the production is load the materials that we need to use during the batch and that start in the second floor we call it. And 1st floor, but in the real things we. Seven floors between us, between where we are and the place when we have the to this second floor and charge all the material, all the powders that we need to use for making the batch. So the team split in two. And one part of the team need to go there to load the material and the other part taken loading and the perceivement. So basically is that everything starts there upstairs and actually the main important thing to do that perceivement in a good way and fast as the most fast and in a better way that we can. So after that we need to start

when we have enough material in our system we need to start, we need to start the batch, we need to start the produce and we need to use a computer and we need to load all the parameters that we need to use according to the recipe the engineers made for us. So we need to start to produce that batch and we need to control all the parameters in that batch according to the recipe that we have. We need to control it during all the proceeds. The proceeding that during around four hours and one person or two need to stay there, controlling all the proceedings should be, according to the to the spec. After that we need to transfer this material to other parts and cans and the next step, our neighbors, in the next step, can request this material when it's made and when it's transferred to this time. So basically that is the main process, the graphic process. The team need to control everything inside this process. Basically, it's that and we need to know if we need to produce more or not. We need to stop for something or need to continue. Yeah, all that thing. Yes, it's basically done.

Interviewer Yeah. Awesome. And what would you say is most challenging with your work tasks? Or do you work overall?

Interviewee I'll try to describe the process, how we need to do the process, but that is in that way sounds really easy, but actually it's not because we need to manage the machines and we need to manage issues inside the machines or related to them. We need to solve all these issues and sometimes we cannot explain like "OK, I cannot continue doing the process because of this". Now we need to manage all those things and inside we have a lot of things to manage. So when you explain the process it looks really really easy, but it actually is not easy at all. So I think the most difficult thing is to manage that thing to give a good result or to gain the task. But without the express, "OK, we cannot do that because we have some this all these dishes", we need to manage all that. You know? Yes, that and sometimes it's not so easy to manage the team because it's a very difficult process. Also in this area, in this powder room, when I tell you and everything begins, it's a really hard precision. And sometimes the teams are tired and we need to manage that because it's very hard. So you need to try to figure it out how to manage this in order to continue producing. So the relation with the team needs to be very strong because you need to be able to talk with the team and explain the situation and not only that, you need to receive their information and understand them, so it's like a very close family that you need to have in in during the war and you need to have the ability to communicate and also to understand their situation. Yeah. So it's a complex thing because in all these relations you need to work with several people and we need to gain an important result because it's the production. If we don't make the batch, the next step cannot continue and we are the 1th step. So all the processes stop if we don't produce so and we are only five or six people sometimes and sometimes you are only three people and you need to do the same with the three people as the six people, so it's a little bit complicated.

Interviewer Yeah, thank you for that answer. And you were talking about like how hard it is to manage the machines and stuff. And I was going to ask you, how

was the, how was your learning experience like when you arrived at [redacted]? How did you learn all of the machines or the whole process?

Interviewee Asking, basically. Asking why I need to do this? What happens if I don't do this? What do these machines have? Asking, basically it's not so like you have a teacher at the beginning. No, that is not at all. And I've tried to do that with my team when a new member arrived, I tried to teach him without wait for he or she ask me what I need to do or why I need to do this. You know, I try to teach. We are doing this right now. And I take the guy and I turn. We are doing this right now and we need to do this. This is the second step. And for do this we need to go to the computer and we need to do this and press this and press this. And if you press this you go to do that and if you press this you can. You do that, and if you cannot do this, never because you can die, in a joke obviously it's joke. But I need to and like to teach people that way that person can learn as fast as he or she can, and we can have a more functional team because that is the thing you need to have a functional team in order to. You don't need to stay inside during the process all time. If you can do that, the team is a good team, a team that doesn't need a leader for make, his process, made his work. It's a good team actually, and I tried to do that so for me was different because, for me was nobody told me. No one told me. No one nobody told me nothing in the from the beginning, and I needed to ask everything. And yes, I don't like that. No, that was with me. I don't know. I don't know how was with other people, but my experience was that I worked in the beginning. I was in other team in other parts than right now, I'm in anode, but in the beginning I was in cathode. It's basically the same, but the opposite. Yes, you know what is the two-part of the process obviously, right. So OK, I work in that in the beginning I learned for 2-3 weeks, one month more or less and the basic things, asking when I arrived to this team to anode, I knew some things in the beginning I was easier, obviously for me. But I don't know how it is for other teams, but that was my experience.

Interviewer Yeah, thank you. And did you have like an onboarding?

Interviewee Yeah. Yes, we had an onboarding. I have been talking with my bosses about the onboarding because my onboarding wasn't so good. I had a lot of information about the general process and the company. But not for my specific role, so that is a thing that I talked a lot with one of my bosses and I know in [redacted] it is going to be different. We will have specific information for the specific task. In Center for manufacturing associate, you need to have this information, you need to have this kind of onboarding after the general onboarding. You'll have a specific onboarding your work. You have actually LMS spots and they are really good courses, but courses that you need to manage during your work and sometimes you don't have enough time for maybe this learning. At the same time, to work. So if you have this learning process or beginning before, to start working, you're going to have a more general and basic information about your work, but these are very good stuff and I know we have in [redacted] that kind of onboarding. So I'm quite cool in that area because I know that. For me it was different and I don't want other

people to have that experience that I had and I'm sure other people have a better experience than me, but that was for me.

Interviewer It looks different for everyone, so they take your opinions and probably improve their experience for others as well. So others have you to thank probably for giving that feedback.

Interviewee Yes, yes, it's my pleasure.

Interviewer Yeah. OK. So our next question. So in your work tasks like in the things that you do, what do you believe is something that operators need to know? Like what are the main or most basic process steps or knowledge overall that they need to know before entering the manufacturing industry?

Interviewee I think, everyone that started working in [redacted] has a very good background in the studies. I know that they are very intelligent people and with the studies and all that things. But I think the operators and manufacturers to say we need to have some skills. In order to work appropriately, or the best way for their job, and I think the most important thing or skill soft skill I'm talking about soft skill should be like the the ability to pay attention to the details and that is that is an ability that I have and for me has been really, really good to use this ability. I I can see details and I can pay attention to detail when I'm working with a lot of things, I can focus in detail and that has been good for my work, and I think a person with that capacity is necessary to be a good, in this case manufacturing, because the process is so complex, but the process all time is telling you what happened, but you need to have the capacity to understand this small detail in order to know what happened. Because sometimes you can see a pressure and a normal pressure is between 0.44 and 0.65. But sometimes you have. a pressure close to 0.6 and other people can say it's OK, it's normal. It's between these two values. But if you have some time looking at pressure, a little bit close to the higher value, you need to say OK - Something happened right now is not critical, but something is happening. OK, you know, that ability is important to manage this small things. In that way, you can avoid a lot of problems, not only in the with the machines but also with you and with your life with your wrist, because a high pressure can produce a leak and a leak in cathode by example is not good. It's really really bad. In anode it's not so good but it's not as important. At least it's something you can manage it, but cathode by example. A leak in your body should be really, really bad for you, so that is the things that are really, really important for a manufacturer to say, the ability to have that capacity to pay attention and to the small details. Another thing is the capacity to learn things fast because, I think we are not trained for being a manufacturer or work in that position, but if you have the ability or they decide to learn things. You can be good with your work. Sometimes you can find a person, and this person has a lot of information, knows a lot of things, and for that reason they know they don't like to learn other things because they think that they know everything. You know, I don't know if I explain it with myself, but if you can say. OK, I study in mechanical engineer. I don't know nothing about how to do a

batch so I need to learn as much as I can so that I can gain information but can help you a lot with to be a very good worker or operator or whatever. It's more about the soft skills that one person can ask than the other skills that the knowledge or the background that the person that that person gets.

Interviewer I think actually that was the end of our questions. Thank you very much for all of your answers. They have been great and very valuable to us.

A.2.10 Interviewee 10

Interviewer Would you like to tell us a little bit more about your background and how you ended up at [redacted] and what you do there?

Interviewee OK. Yeah. You'll be surprised I went to Chalmers also. But many, many years ago, maybe about 10 years ago. I studied supply chain engineering and manufacturing. and then after that, well, first of all, I am African American as you might hear, I grew up in Washington, DC and and then I have been living with my family, who is Swedish in Sweden.. And so after school I started working at [redacted] and then our [redacted]. And then after that during pandemic we all got fired. So I became a cook I wanted to be a cook. Like they say, just when I thought I was out with the auto industry, they pulled me back in. Yeah. And so now I've been here for about like seven months now. Yes, and I'm part of the cell, I work in cell assembly, basically, yeah.

Interviewer Would you mind telling us more about what you do at cell assembly? Like what is your work role, what are your work tasks?

Interviewee Yeah, like my mission at [redacted] here is to basically learn all the machine they used in cell assembly. Basically I don't know if you're aware of how battery system works? It goes from slurry, coating and then it goes to stacking. That's when they cut it up into Jelly rolls and after stacking comes cell assembly, and cell assembly is about maybe 8 or 9 machines that it goes to something called top pre welding. it's when the anode and cathode side like meets, basically with a separator, and that's when we start doing a pre welding of the of the things and so it first goes into a machine that's called hard press. Yeah, like really pressed with electricity right there and then they cut the extra like anode and cathode, which is aluminum and copper, and they cut the extras on the side on the side of the Jelly roll. And then from then on, it goes to. And then it's a sheet, there's like, I think, 42 anode sides and 42 cathode side. From each cells, and then after that it goes to a conveyor and it goes to an X-ray and I started working as an X-ray operator. Basically that's where they put me and after that it goes to an X-ray which, X-rays to make sure that, because all cathode anode have a separator. So the X-ray, basically X-rays to make sure that there is like enough space between the cathode and anode and there's a separated in it and it counts it. And then if it approves it, it goes forward to a conveyor if it doesn't approve it, it goes to a conveyor that calls a no good side, which A&B side, which is the cathode and anode side which the X-ray

will disapprove, which is no good. And then we basically have to check with quality to see if we could maybe just some anomaly. Maybe they could approve it and we'll let it go. Or if they tell it no, it's no good or there's some other issues that make it clear to see that it's no good, then we we scrapped And then as an operator, my goal is to know the machines and to be able to fix all the errors on the machines because a lot of things go down in the machine. There's like so many different problems that the machine might occur. Maybe like the sensor aren't working. And if you're lucky, 99% of the time the machine will tell you what's wrong with it, and then you're trying to either change something in a machine, or open the machine and check it out and see if you could fix the machine, basically as an operator and my goal is to know every machine. So I'll just maybe tell you, OK, so it goes to top pre welding, X-ray and then it goes to top final welding. That's when the two jelly rolls comes to the machine together and it's welding on a lid, and then after a lid it goes through something called a IFW. It's like insulating, it's like a plastic tape that goes around the Jelly rolls. It's kind of a green plastic tapes. And then after that it goes to a conveyor and then from a conveyor it goes to something called CCI. It's a can insertion. That's when it goes into the can. And then after that it goes to CCL, which is like a can laser welding this when a laser will weld on the top of the lids to make sure it goes and then it goes to another X-ray, which is called XRC, which will make sure that the X-ray will see if all the lasering is good and then it goes to another section called helium where they will they will fill it with helium for like 13 seconds to to check if there is leakage. And then from there on it goes to something called efil, which is electrolytes filling. So that's basically cell assembly, so quite of a long process. And so my job is to know basically all of those machines and then maybe to teach that to the future operators and then when I get back to Gothenburg, I guess. Like my mission right now, like everyone is like, oh, you could be in a leadership role, shift manager or team leader, but I say no, my mission is to learn every machine. So I could basically know so I could teach it to the people the right way with following the work instructions and following the safety rules. Following all the 5S. Because it's very important, there's like machines that are quite dangerous sometimes, especially when you're in it. You might get people trying to, might take chances and make sure that they work like the right way. And then safety is a paramount.So yeah, it's my mission just to learn every machine. So the machine is divided between something called frontline and end line, and frontline starts at hard press all the way to EFW where it's insulating. And then from insulating to X-rays helium it's endline. So. So right now I'm in in my final frontline machine between the top final welding and with something called EFW which is insulating something I can't remember the other other stuff. So yeah, so I was one of the guys, the original guys from first six people that came with the [redacted] program here.

Interviewer So how how do you learn about the machines? Like, do you have someone you walk with or do you just, yeah tell tell us more about that?

Interviewee Well, you learn by doing basically these machines we have by doing, actually we have still the Chinese there, the people that build the machine from China. So they're over there basically. And we have maintenance and then we have

a lot of new people maintenance, so we know basically, the machine more than the maintenance guys. Since I have a background in supply chain logistics, I kind of can think logically to see OK, what where? Everything is gone because there's a schematic reading of the machines, how it is set up the screen. So if you have a background in supply chain logistic you will know, OK, how is it structured? And then and then you will start to understand. So you have a bit more background in, let me say working in an assembly line, then you could think logically. OK, this is going to go from here to this and then from that to that. So you basically learn, learn it by watching other people do it.. So when I started, no one had worked there for more than 4 months, everyone were brand new and we started like 6 on each machine. So we're like a lot of people fighting to get to learn something. And then once we starting getting spread out, then you starting to get more in the machine, and then I learned a lot I think from the people from labs in Västerås also when they come in to calibrate the machine and fix the machine. So I think I got to learn a lot by them doing testing on the machines so testing the machine, that means they're going to repeat a lot of what they're doing. Repeat, repeat, repeat, repeat, repeat. Run an X-ray, run one tray maybe 44 times, and then the 44 times it will have an alarm and then for 3-4 times you will see OK how to remember because basically it's a lot of you have to remember exactly how to do because we we don't really have work instructions. And so work instructions is a very important for the future so you understand exactly. So I just learn by watching other operators and I learn hopefully from the engineers also when they come in and so they know exactly what to do.

Interviewer And these worksheets, are you or instructions, is there like a plan of implementing those nearby in the future?

Interviewee When I started labs, or in Skellefteå maybe once a month to implement it. But somehow because when some of the engineers comes. They do the work in section, they take a picture. OK, this is the start button. This is the reset button. OK. This is where you need to go. If you have this error number and basically they come and take picture and they write the work instruction how they work, but it still has to be approved by the project engineers. Because for them they have to go make it further to see, OK, it's all the safety switch are there because sometimes, like we say, we have two machines that are connected like we have a machine called hard press and top pre welding. There are basically two machines but they are connected together so to be able to go to one machine if there's an issue, alarm issue in hard press, you have to be able to go into it, both machine has to be on manual side, yeah. So if you start on manual side, you might go to one machine and then someone will start the other machine and that thing could act it and that could be so a safety issue because it has happened before. So I guess that's the issue right now they're having both the the, I guess the production engineers and then some other type of engineer has to work together to and someone has to approve it so that it is that's why it is a delay. But for us at [redacted], that's what we strive for to have work instructions as fast as possible.

Interviewer So besides the things that you already mentioned, what do you feel

like is the most challenging parts with your job or your work?

Interviewee Yeah, challenging part basically is communication. Because, one team might have an issue with the machine and the next team coming up, because we have like let's say four teams like A-D and then I think a lack of communication a lot for people not letting us know that, OK, maybe they changed some parameters here, or they had an issue here. So basically, that's the most challenging part. Communication between, like, even from stacking before or like from e-filling, I think if we are better with communication, we'll be able to produce better quality machine, because right now I'm feeling like there's so much waste. Because of lack of communication between quality people and cell assembly people and stacking people to really find the root cause of a problem, be able to to avoid cost because, from my experience at [redacted], we had a meeting every week about how to cut cost and here it seems like how to make more waste. They want to have, they have a have a program, they're going to build a factory called [redacted] which is basically recycling of all the first thing like lithium, cobalt and aluminum or all the copper, even though. But that's like five years ahead. So I'm thinking all of these ways they have to send it to a company and pay for it. So because I've heard that a number where there's, like maybe a million waste cell per month that cost them like a million for just one section. So for me it drives me nuts that. Yeah, we are wasting so much because we could do so much, so much better.

Interviewer How do you think that the communication can be improved then? What tools?

Interviewee Basically by having enough time each start of a meeting. Because, OK, let's say we have, Every morning shift has like a meeting. I see that, everyone has a meeting between the production managers, the engineers. And some of the team leaders have a meeting and they feel like the meeting does not come once they have the meeting, it doesn't get really implemented into once we start running the machines. Basically, it's just like as soon as an alarm goes, one section, all of the meeting just seems to go away because. We are getting pressure off to produce to to hit the target. You know, because the pressure of, like, uh producing for like for the bosses to keep PI to see, OK, we produce so much this. Oh, blah blah blah. We produce in one section in cell assembly. Maybe it was OK, but once it hits forming and aging, it will be no good. Because the forming an aging will have an issue with the lid and it will scrap it in the end. Because that's the problem sometimes, that all the stacking will come will receive material in stacking, but once it goes to cell assembly somehow it will be like a no good material and all that stuff. So I think basically between the departments really have a good understanding between the engineers, the team leaders and some of the more experienced operators to know exactly, OK. Because what I found out in the beginning, we had a lot of people that were like changing parameters, which will maybe be OK for one machine, but the next machine or two machine before there will be an issue with that because they changed the parameters and then there will be like the material might be good, but somehow the sensor is reading it wrong, you know. But even though maybe

the material is really good. But since those machines are set up in one way, then they will not approve the material. So there we just having waste, basically. So it's basically to have a standardized system which I see that [redacted] is trying to implement because they like realizing they're having so much waste, so they need to have a standardized system where each machine before you start it we have a parameter checks. So we check that OK, no one has changed the parameters, so if we had a change in the parameters, we'll write it in, and then we'll go to teams and say, OK, we had a deviation in the parameters and and maybe hopefully the engineers or some of the maintenance will or the team leaders will realize it and then changes back to the to that standard size. So we'll like avoid waste.

Interviewer So my next question is (you have touched these bits a little bit already from what I feel that I interpreted at least, but) So what would you say that the most like? Basic or necessary competencies that operators need to have to in order to be working with this stuff in or in cell assembly overall.

Interviewee It's basically because I see a lot of people when I started basically, I didn't have no background in making battery. You know, making I had a background and like I said, I had a background in automating car making or like car parts, chassis and stuff, but it's still basically the same logic, but it was never. It's the same logic because you have something that has to go from point A to point B, and it has to go to a different section, so I guess. Maybe in the beginning they need to, I think it's hard to find people with the same kind of background that have you might find the the technical people. You might find the administrative people and maybe in this type of people don't have. So I guess training is paramount. Yeah. Maybe they a machine that you could just go to test, work in a machine. Kind of a like a lab or something, which is like, almost like a prototype. Where they could really on hand, cause, once you start at the [redacted], there's a week of something called onboarding that's basically introductions to all the safety, all the way to work and all that stuff. But it has once you get into the cell assembly, hold on the reality over there and so I think, training with prototypes. Really understanding like so where you could physically like work and see the product like maybe kind of a makeup of prototype product. So where you could get trained. So when you go into the real machine real cell assembly, you won't be, like, totally surprised or shocked for all that stuff. So. So I've heard. Maybe [redacted] will start working on that where they could just really have like a prototype where you could just go and get get trained. I've heard something. They have something called or maybe even maybe have a line already at the at the factory where it's just basically for testing. Yes, I guess that's that's another way also to to have a line which is just dedicated for for testing and training and then it is parallel to the real thing that we're doing. And then we basically those new people get to work there and then slowly getting implemented to the real line. Yeah, basically.

Interviewer So you were talking about this prototype and what would be necessary to have in it? Like how would an ideal prototype look like for you?

Interviewee I guess an ideal prototype. Well. It's where it basically can mirror exactly the real machine. Maybe there are like a few section where it will skip, but it will basically get mirror like the same functions to the other machines. Because like I said, all of these machines are like the Chinese have the biggest advantage right now is that the one being building it. So we're like the rest of the world, is running really late. Maybe Tesla has a great advantage, but Tesla? Their their batteries is made by the Japanese, which is called Panasonic, and then and then the Chinese that we have here. It's a company called lead. They're like the biggest in the world. So so, so I guess to be more effective and and less cost cutting is basically to build a machine that basically mirrors the machines that we're working on, but maybe it's made in a miniature way.

Interviewer Should it consist like a screen/ buttons?

Interviewee Yeah, like a screen where basically touch it because I I'm feeling I've never been to Västerås, but it seem like they have something kind of called a prototype there in their labs over there where they could test the Jelly rolls in a maybe miniature way and then they can actually see like a products and and then once you it's just like building kind of a Lego, like building cars and Lego, a car, Lego. And then once you actually start building car [redacted], then you say, OK, this is this is I guess you can't really it'll be hard but, you just have to try and teach people logic. I think whoever, when they come with a different background. You just have to. That's what I'm because I trained a lot of people. But the new operators are from far away countries and I'm just trying to time and think of their mindset because they're just working as an operator. To build understanding, OK, what you do here will affect the next machine merge far away, so I guess you really have to have, like really good trainers, like, could really understand. OK, these guys understand this guys background and his his limitations for now and then to really make them understand logically how everything works, because it's it's not rocket science really, but it's basically to work to learn how to be and how to anticipate. And then how to work preventively, you know, so you can. OK you have how much material is coming out right now? OK, this conveyors loading material is gonna come out. OK. Do we have enough tape? Do we have enough like parts? That's that we need to fit on this machine, so we'll have to run everything smooth where we don't have to stop the machine a lot, because that's basically what I've seen some of the operators not really thinking to be more preventive, more anticipating what's coming or or maybe being more communicative to the next machine or to the previous machine, to to really make, not just. OK. You press stop. You press reset. Because sometimes some people just know that, OK. If the machine *makes alarm sound*. OK stop. You don't really know. OK. If you go into the, then you. You want to learn anything with that you you have to train. OK, you have to start looking at the trays. Our case is the wear and tear. OK. Is it like, OK, we have a we have an A section called in between Topre welding and X before it goes to X-ray, we have a a section where where you basically we have an operator is job is basically to visualize with a mirror if all the welding. Is is OK? There's no cracks. Yeah. And then you have to teach them what to look for. And then. I feel like

we had training with the visual relation of the cracks, but I'm saying we're doing it in such a hard setting where we're wearing masks. We're in control environment and we're not really hearing the quality people. I think that was my issue because I had. I couldn't really hear because they're talking about a mask. I say if we need to do that, we really need to be in an open setting. Not just be in that. Or maybe speak with a microphone. Where we could really hear and then have a huge camera to really understand. But if you are like 10 people and one guy is talking there and everyone's pretending to understand what it means, that's basically just a waste of time. And and that has happened many times at [redacted], where we're getting quality training but can barely hear the guy talking because we're in the control setting, he has a mask on and I think they need to change that where we need to maybe in that prototype section, or maybe in a quality section. Where we could. Touch the product and see the product and then really, really hear the guy openly and more clearly not just under some control settings, which I understand some of the material will work are like we call it dangerous and some of them are active materials. So also, yeah, there's that issue also where they need to come up with a in a room where you can have those the mask on, but do it in a clear setting. Use like really high definition camera and then maybe have a headset or maybe have like a high speakers to really understand that and then we could go do the test ourselves because. I think 2 weeks ago we had a training. They taught us how to train, how to look for deviation and quality. And but. We have to like. On an app, see OK which is A&B and then you can see half of the class failed and we'll have to retake it again.

Interviewer I was going to ask you when you train the operators or whatever, how do you train them into this mindset that you are talking about? This thinking ahead.

Interviewee I I think you have to have empathy. Empathy is very important and then always make sure to tell them and hopefully like I said, I learned the best when I had as much repetition. Might be boring, but as much repetition as as possible. And then just make them aware and make them like care, basically because everyone is different. Everyone like takes information in a in a way. So I think basically it's to have enough time, maybe because I've learned at [redacted] I think, I really felt comfortable on like basically one machine after four months. That's like trial and error. Trial and error trial and that so, time, giving time. Some people take them, I think [redacted]'s hoping everyone will understand the machine after 8 weeks. But I think. It needs maybe double that because you need the trial and error because right now I'm working in a machine which is has maybe 32 different moments and there's like a and there's an error in every minute, and then you have to like, it's crazy. It's a it's a crazy design machine. So you basically, but I I feel like I need at least four months to really to be able to understand and to be able to speak the language of the machine. And then, if I really can fix it, to tell maintenance, OK, this is the issue. You have the tools. You could fix it or or maybe I might have the tools, I could fix it really fast and I'll be able to communicate it. It's basically the machines, it's there's a language in a way also to to it's a. There's a language to speak to, better communicate to, to your leader or to the engineers, that OK, this is what I've seen. And this is what I've noticed. And this is what happened. Yeah,

not just. OK. This is what happened on the screen, come and fix it, and then the engineers come in and he's trying to look into his log book, blah blah blah, which will take a long time. But if you tell him, OK, this is what happened. This is why it happened. Maybe it happened from the previous setting. That's what I've noticed. So basically you need time to really understand machines, so yeah.

Interviewer You said the logbook, How do you document your deviations and stuff?

Interviewee Yeah, yeah, I think there there there's a log book, but I don't think it's they. Right, sometimes you don't even have the time to do that because yeah, because you are. Everyone is telling, OK, it's the machine running you. You have the you have the team leaders coming running. Oh, is the machine running? And then and there's another alarm coming and then you don't have time to really basically so I think it's for, I think there's a way for them to see how many. have they had in one machine. So maybe in a in a long run, for each shift they need to come in and there's like a go back to the machine where they could check the history of machine and it and then see OK, what was how much alarm did we have because some of these Chinese machines, they don't really give you. There's, like, there's a logbook of every alarm, but it's a very complicated sometimes to really understand, yeah.

Interviewer How often do these errors occur? Is it different from machine to machine or?

Interviewee Yeah, different from X-ray, once you are comfortable with it. So you know, OK, this will be less alarm machines once you know what to look for and what you know what to avoid and what you know how to how to communicate with the maintenance not to happen, but some other machines like. We like toughen. There's so many different moments of the machines, then it's impossible. There's always something's going to go wrong. It is just the nature of the beast for these machines, so you cannot. It's going to happen. Yeah. It's just the design. Yeah.

Interviewer And are there lamps that tells you that something is wrong, or is it like the screen monitoring? Or do you have a sound alarm going off or?

Interviewee Yeah, it's a screen monitor monitoring, called HMI or something, yeah. And then here there's a red light sounding off. Yeah, there's a there's an alarm you could see, and it will tell you exactly which section has an alarm. Yeah.

Interviewer Is there an operator monitoring the screen at all times, or do you just check it sometimes now and then basically?

Interviewee Normally, that's how it's supposed to work but, let's say if you are lack of people and then lack of experienced people were like, let's say I'm experienced with the frontline, so, I'm running on one machine, but two machine before someone is calling me up. Hey, [redacted], I need help here. Blah, blah, blah. So I have to go

running and stuff, but normally, some machine you might need, you need really two people, some machine, you just need one person and some machine can be run. If everything works well by one person can run two machines and all that. If everything runs so it it depends. Yeah.

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Interviewer So the first question then, tell us a bit about your background, how did you end up at [redacted], and how long have you been there and what have you done before?

Interviewee Absolutely, well, it's my, what is it? My third or fourth week, so I'm very new here.

Interviewer I see, okay.

Interviewee Because I thought about it before, but I thought that I still want to be nice and book myself in. So I talked to some colleagues, they just said no, but it's too early. But I thought like this. That I can participate in this interview because if you feel that you want to get more information, then we can book another interview in 4, 5, 6 months so that I am a little more settled in by then.

Interviewer Yes, I mean, that would have been wonderful, but our thesis project needs to be completed in 2 months. That's the thing, otherwise it would have been fantastic. But couldn't you tell us about your time during these 3 weeks? What have you been up to? What have you done?

Interviewee Yes, well, the first week was very intense via Teams. We had an onboarding week where we had training via Teams. It was closer, I think there were 96 people participating in this training. The first day was very hectic as everyone had to log into their [redacted] accounts and so on. There was a lot of trouble for many. There was a lot of anxiety about logging in, and many people hadn't received their devices, that is, mobile phones or computers, and the information was perhaps not up to par if I may say so, but then I understand with the number of people being onboarded, that is, almost 100 people. It becomes very difficult to reach everyone in the correct way. So the first hour was a lot of IT issues where we tried to log into [redacted]'s Microsoft login, and eventually, I managed to solve it and join the training. Then we had training in various things. The first day was a lot of training on applications and software that the company uses, and then the remaining days were very much related to safety considering that we handle very dangerous substances here.

Interviewer Yes, exactly. How interesting.

Interviewee So on the fourth day, that is, Thursday, we had, we had a safety training with a firefighter and it was on-site, at a place called the [redacted]. It

was a large conference hall, where we had safety training in various things, including fire safety, chemicals, and other topics.

Interviewer Yes, that sounds great. So you're going to start working as, or maybe you've already started, as a shift manager in Formation and Ageing if we understand correctly?

Interviewee That's correct.

Interviewer Have you had the opportunity to work on anything within that role or is it still just training?

Interviewee No, I haven't. Yes, I've been with my supervisor, that is, the shift manager who works in Formation and Ageing, and we've gone through the processes. We've toured the factory and discussed tasks, but I haven't practically worked on anything myself yet.

Interviewer But it's exciting to have someone to shadow at least?

Interviewee Yes, I've had that. For 2 weeks at least. The first week, I was with my boss, that is, the production manager, and I didn't get much out of it, we mostly just sat in a room and watched. I barely learned anything there, but it was still rewarding in a way. But yes, the best weeks were probably the last 2 weeks now with my shift manager.

Interviewer Yes, how nice. How did you end up at [redacted] then, or [redacted]? What's your background?

Interviewee Well, I come from the retail industry, a completely different industry. I worked as a group leader at a central warehouse and had personnel responsibility. I did that for 9 years. And I felt that my job satisfaction was a bit limited. I didn't feel stimulated enough. I applied for some warehouse manager positions and a few other things, but I didn't get that role. I got pretty far in those recruitments, but not all the way, so I looked at LinkedIn, just scrolled a bit, and then I saw an ad for a shift manager program, [redacted]/[redacted], Skellefteå, and Gothenburg, and then I started reading. It sounded very exciting so I thought why not. So I updated my CV and cover letter and sent it in, so we'll see where it leads. It's really just a coincidence, and yes, that's how I ended up here.

Interviewer Okay, our next question. Now you haven't been out in the work role very much, but what do you think will be the most challenging aspect of your tasks overall?

Interviewee For me, it's not the leadership level. That's probably not a difficulty for me, considering my leadership experience. So I think I can handle that pretty well. It's probably the technical aspects then. I come from retail and switch to the

industry. It's those parts that I will find challenging, and of course, a bit of English. But you get into it.

Interviewer Yes, you will. But wonderful. We've already talked about the training process since that's what we've gone through. What have you noticed during the time you've been able to follow around the factory and the process that you've discovered? Oh, this might be a bit challenging or this was a particularly interesting moment that you noticed? It could be something extra interesting or something that stood out during the time you've been able to walk around and observe.

Interviewee Well, yes, I've seen a few things that I'm not used to. You could say it's an incredibly production-oriented company right now. But maybe one buries one's head in the sand a bit and doesn't look up much, but focuses a lot on production. I feel that one could have a broader perspective and perhaps work a bit with soft values? What I'm used to is that alongside soft values, you work with hard values, that is, production and so on, but right now, there are too few soft values. Also, we have limited spaces where we can have discussions with staff, yes, it can be larger contexts. It can even be face-to-face, but there are very few rooms. It's still a construction site, it's not really finished yet. I think about 1/3 of the factory is built so it's not quite finished yet, but it still feels like you have to go to the cafeteria to have a conversation with a coworker or have a meeting over Teams. It's not really sustainable in my opinion, there should be rooms for that so it can be a challenge in production, but otherwise, it's very much about working a lot with production and forgetting about soft values.

Interviewer Yes, that's true, you really need to have that in order for the workplace to be good in the long run. So, how do you think, will you assume your leadership role as soon as you finish this training, or how will it look?

Interviewee I think that I will get my own team and work as a shift manager at [redacted] for a year, and a few months after that, I will take that knowledge to Gothenburg when we start up [redacted].

Interviewer Yes, exactly, and how does it feel, is there any uncertainty in that you don't know the process steps or do you think it won't affect your role?

Interviewee No, I'm not worried. I'll learn, I feel. I've already learned a lot in these 2 weeks with my shift manager so I'm not worried. I'll learn. There's a lot to take in, a lot to learn, a lot of technical terms, a bit of their own language, you could say, but it's like that in every company, it was difficult to learn, but once you get into it, give me 2 months and I'll get it.
Interviewer Yes, exactly, everyone learns at their own pace and so on, so yes, definitely. What do you think will be, when you have your team then, what do you think they will find most challenging in your part of production?

Interviewee Well, if I look at my shift manager for example, he has a very broad

knowledge. He works with the systems, that is, the production systems at [redacted], with apps and so on. And he monitors the systems very well. He has 5 team leaders under him who work for each section in production and they turn to him quite a bit, that is, when things get a bit troublesome, and he has quite a lot of answers to questions because he has been working with it for three years, I think it is, and knows a lot. I won't work exactly like that, but it will be more about delegating more to the team leader. I try to lead and create conditions for them to be the experts, not me. That's a bit of my leadership role. I've worked as a team leader before too, and I want the ones on the floor to be the experts and I'm more of a support, so I think we'll have different leadership styles. So the contrast between me and the shift manager today will be quite large because I'm not the type of leader he is.

So I think it will be quite a challenge because they probably want answers quite quickly and they won't get that from me because I'm not quite there yet and I don't work that way either, I try to build competence in the groups.

Interviewer Exciting. Yes, I can imagine that it's also needed, two different types depending on what phase the company is in, like it probably needed someone like your shift manager in that situation as there's someone who's an expert since everyone is so new. But the more knowledge they start acquiring, the more it will be on them, and it will be time for someone like you to come in and delegate more in that way. So it also sounds like a quite natural transition. So yes, how will a typical workday look for you then? Do you have any idea about that?

Interviewee Well, it depends, we work in shifts, so we work five shifts. It's actually three shifts, but it becomes five shifts since we work at different times. So we work day, evening, and night, rolling. So it depends on when you start your day, but often you start with a handover from the previous shift with the previous shift manager and discuss any production bottlenecks and so on, and then you have a meeting with your team leaders. And then you start the day and do your daily tasks in the various systems and take a round of the factory, you do that a couple of times a day. You walk around the factory and make sure everyone is doing well and there are no problems. And then you sit in a room and work a bit on the computer, then you go out again and that's how you work, very operationally. And I'm not used to that, working so operationally. It was very much office work for me before.

Interviewer Yes, I see. Reasonable.

Interviewer Yes, okay, is it nice with a bit of change then?

Interviewee Yes, this setup suits me well.

Interviewer Yes, wonderful, we've usually asked a question like, what types of basic skills would you say are required of the operators who are then out in your production steps or those you will have some oversight of if you've managed to get

a picture of it? Is there anything that stands out there? But this is something that you need to have a more thorough understanding of.

Interviewee Well, they don't work physically so much, but it's mostly about monitoring machines and robots and conveyors, that is, these belts that roll. The most important thing is to have knowledge of these technical aspects so that production is always running. That's the priority, and that you're always alert and aware of what's happening in production. Then they sit quite a bit. I see a challenge there with that knowledge, and what I notice is that it's a bit limited today considering that we have Chinese tools that we've received and we're not fully knowledgeable about how they work. So we have quite a few Chinese engineers on-site who solve the problems that arise with these machines. In the future, I hope that we won't be dependent on the engineers from China who are here and helping out.

Interviewer That was exactly my follow-up question and you managed to answer it before I asked the question, but is the idea that the operators or you on-site will take over then?

Interviewee Yes, the idea is that maintenance will solve many of these problems. So we actually have a group called maintenance who will solve many of these problems.

Interviewer Okay, those were about our questions. Is there anything else you think could be useful for us that we haven't really asked about?

Interviewee Based on what I've understood your thesis is about. Then it's actually my pitch. That is, we had, as I said, an onboarding with safety. What is it called digitally, and safety is a priority considering that we handle flammable substances. We handle chemicals that are life-threatening for the body, we handle explosion risks, so the prerequisite knowledge you get to hammer and hammer and hammer there with safety because it must not happen, and therefore, it's not like driving a bit too fast on the road, but if something were to happen in the factory if you stretch the safety risks a bit? Yes, then you can end up really badly, so just in our department on F&A, it's so, we are quite spared with chemicals and so on. Without, we might not handle so many chemicals, but it's more of an explosion risk that can occur. But in the other areas, for example, on cell assembly and so on, there is. Well, if you get electrolyte on the skin, for example, you need to urgently rinse it off with other substances because otherwise, you will be corroded from the inside, so safety, I say, is paramount.

Interviewer Exactly. It's about standardization, like everyone should have this mindset that you're trying to create at this training center too.

Interviewee Visually, you might see a lot in text form, but also a bit with slideshows to capture it with video and slideshows perhaps so that you can see how bad it can actually go.

Interviewer Yes, it's a very good tool to visualize. It may make people think a step further and actually understand that there are risks in this.
Well, a big, big thank you for participating in this today. We really appreciate it, and it's very valuable for our work.

A.2.12 Interviewee 12

Interviewer Let's just dive straight in and tell us a bit about your background and your path to [redacted] and how long you've been there?

Interviewee Absolutely, so we can begin. In August 2023, I started here and then I began as a shift manager in a department called stacking. I worked there for a couple of months before I got the opportunity to come here to the Academy, and I did that solely to broaden my competence development regarding the entire factory, whether it's practical in production or a bit more administrative like role descriptions and other tasks. So, yes, I enjoy the town, Skellefteå, as far north as you can go. But other than that, unfortunately, that's my little brief presentation of myself.

Interviewer Alright, but you can continue on that, tell us a bit more about what you do within the academy?

Interviewee The Academy, OK, so since I moved to the Academy and there is no defined role for me, so I'm involved in a bit of everything. I'm involved in onboarding people, working on role descriptions for different production sections, whether it's operators, team leads, shift managers, or production managers. I spend a lot of time on leadership training, standardized work, work instructions. Yes, we're working on educating about LEAN, for example, we have a little game we're working on here. Yes, I have a vague role, so I don't have exact knowledge of everything I've done. But I'm involved in most things. Let me briefly mention before, as a stacking shift manager, then what the stacking department is, stacking is where we make stacks of the material we receive from the previous department, which is notching, and in the end, it becomes a jelly roll and the jelly roll is then transported to cell assembly. Yes, as a shift manager, you just have a bit more personnel responsibility. Make sure that your production is running smoothly according to your HPIs, which is how efficiently a machine runs, so it's just that.

Interviewer Exciting, very broad.

Interviewee Was it? Is that enough or do I need to elaborate more?

Interviewer No, that was absolutely sufficient for now at least, and we'll see if we come back to more specifics later. But now we can move on to what you know about the Academy in general, like when was it started, why, and how long has it been in operation?

Interviewee So the Academy was launched, I would say at the end of November. The plan with the Academy then, if I may explain it nicely. It is to provide production with the right conditions. So whether it's standardized work methods, work instructions, how to behave in production, how to act on different occasions. General competence development for everyone. That's what the Academy does, so it's fairly newly established and there was pressure from upper management that we need such a department because when you focus too much on production, production, production, you lose that human focus. So that's why the Academy came about.

Interviewer Yes, you've already partly answered this, but to what purpose was it started and why? But is the focus on new hires or is there also a focus on further competence development within the company?

Interviewee Both, both. So we have a few different roles within the Academy. We have training specialists who specialize in their own sections, departments then, they work to ensure that there are the right work instructions. There should be material. There should be, yes, everything should work so that the operators down there can perform their work. Then we have training coordinators, and they are a bit more support to training specialists and it can be everything from train-the-trainer. It can be 5S training, it can be leadership training. What else do we have? ATEX training. Fire safety, CPR, so some general things that are important to know in production. Then we have someone who works as a leadership specialist and that is well incorporated with everything. Work culture, how do you act as a boss? How should you treat your employees? Are you an empathetic boss? Are you systematic? And it's just because that role is important to keep the culture on the right track so that one does not act in one way and the other acts in another way in a scenario, and it's just to introduce more standardization in the factory.

Interviewer It sounds very broad anyway, that is to say, it's everywhere in a completely different way.

Interviewee Yes, and as for my role, I'm involved in everything. So that's why I can't specify exactly what I do, but it's a bit of everything. Just that, then we also have the onboarding team. The onboarding team is the ones who receive the new hires. They have a Teams training the first 3 days they start here, then they have an on-site training, and then we talk more about safety, fire safety. How to put on your PPEs for example. There we also work with IT to help them with their programs on the phone. Or computer and they have the opportunity to ask us some questions. If something bugs out. Then on Friday, the last day, they get to meet their manager so they get a tour of production. And in addition to that, the training team in the Academy here is responsible for online courses. We have something called LMS Course and it can be about anything just so it concerns 5S, fire safety. It's more for us to have statistics on who learns what and when they learn it, have they completed the training. So there's data on that.

Interviewer What does LMS stand for?

Interviewee Good question, and I'll check. LMS - Learning Management System.

Interviewer Sounds reasonable when you say it. OK, but how do you work then, since it's so young and new? How do you work with development, I mean further development of it, for example with evaluations and with new approaches?

Interviewee That's where LMS comes into the picture because if there's a new course, a new training, a new work standard we're going to use, then we send them out here, either online courses or on-site courses. Where either we have someone presenting and so, we log their names and then we know that they have completed the training or it's an online course where you answer questions with a little quiz and there we see that this person has completed it. So there's a way to track both new hires and people who have already been working here for a while. Usually, when a new course comes out, it only goes to relevant people, so if someone from HSC should always know how to load material onto a machine. But if we've been working here for a long time, these LMS courses go out to relevant departments and then we can track if you're old, have you done the training or not.

Interviewer And the existing material you have? How do you work on the development of that? I mean when you have a course and consider it finished, does it just continue or do you also develop what has already been produced?

Interviewee I would say there is quite a bit of collaboration with external companies as well, such as an example, Scania. We not only deliver the battery to them but they are also involved in helping to develop various courses regarding, for example, fire safety or something because they have more experience in it than we do because we started in 2018 and Scania has been around for about forty years or whatever it may be? So they are involved in helping to develop some course material. Yes, so that. I hope that answers the question anyway.

Interviewer Yes, I don't know if I was looking for something specific either. It's very good and when we might be a bit into collaborations and that part. This may also be a bit of a side note, but how does the ETT and Academy and the [redacted] collaboration fit into that? You don't need to go into too much detail, we just want to get a brief overview of it.

Interviewee That's why I'm not doing a specific thing but I'm doing a bit of everything. It's because the Academy here should roughly resemble what will be at [redacted]. But right now, we don't have defined roles in [redacted], that's why I'm doing a bit of everything. But most of what I do here will also need to be implemented in [redacted] as well. So yes, that's why we have no specific role and therefore no specific tasks but do a bit of everything. Take in as much information as possible and share it with [redacted].

Interviewer OK. And, yes, that has also touched on. You say it's a bit vague, but what is a typical workday like? What are typical tasks that you do on a daily or weekly basis?

Interviewee OK, my day-to-day is quite different, but starting with coming to work. Check a few Teams messages, check some emails. Then we're usually booked for meetings, strategy meetings or competence meetings or safety meetings. Where we try to plan, is there something we're missing? Is there something we need to do? And it goes like this, it's a lot of administrative work. Then for my part, I'm also out in production a lot because I also try to learn the steps in the factory. And then I can also have a dialogue with shift managers and operators. Hi, do you have this? Do you have that? Do you need help with this? Do you need help with that? And try to support them as much as possible. So that's my everyday work. It's a bit different from day to day, yes, no day is the same here. But I can imagine that for people who have slightly more defined roles, maybe they do more or less the same thing every day.

Interviewer But it's also a bit like when everything is new, so it's not so strange that it's very varied either.

Interviewee Exactly, exactly, and it's a little challenge in itself, but we persevere, we're persistent.

Interviewer That's exactly our next question as well, what do you feel is the most challenging aspect of your role and your tasks?

Interviewee It's convincing people to follow the same path or to maintain the standard that should be maintained. Not everyone always agrees on that and sometimes you have to convince them of different things because we have a multicultural workforce here. There are many international hires, many people from different backgrounds with their different work cultures and trying to establish a standard in that way is a real challenge. But with pressure and a little escalation, it works.

Interviewer How can resistance look in such cases? Why is it difficult to follow a standard or get them to follow a standard? Or how does it show that they find it difficult?

Interviewee It's a bit difficult to describe in a nice way, but say you've been working in an industry for a certain number of years, for example, 10 years. You're used to your way of working and you don't want to change that way of working, but this doesn't only apply to newly started companies. It applies to any industry. If something new is implemented, it's always difficult to convince people who have been working with it for quite some time. So that's where the persuasion is a bit difficult and because we have different work cultures here, it's a bit difficult if it doesn't come from your direct manager that a change should be made, then it's

not done. As a little explanation, for example. We have Chinese suppliers for the machines and in their work culture, if you don't tell the workers what to do, then they don't. They don't work on their own will. If a problem arises, they do nothing until they are told. So a little bit of those kinds of different cultures you work with, so yes, that's where the challenge comes.

Interviewer But if you think like this, what is by far the most important or what needs to be highlighted the most or prioritized the highest if you have to narrow down priorities a bit?

Interviewee Safety. It's safety. A lot of pressure on safety. We've had accidents here. If you've probably read about it in the news and hence there was more and more pressure on us to focus on safety. Yes, and that's why it's important with standardized work methods or having the right work instructions, work instructions, so that everything is invested in the right way to mitigate or avoid safety risks. And usually, there are no problems with introducing safety changes in production because, yes, everyone knows that it's for human safety so there we have no problems, but most of the focus from our side is on safety.

Interviewer And how does the training itself look like? How is it structured? Is it mostly online? Mostly on-site, quite varied?

Interviewee It's quite varied, quite varied depending on what is being trained. If something can be done online? Then it's done online. Are there things that are better done on-site where you can have active dialogues with people? Then it happens on-site and like for example we have "Swedish labor laws and environment". That's done on-site so that you can discuss why it is so, why the rules are laid out as they are and bounce around a bit in that and why it's important to follow the labor laws that exist here. So it's a bit good to mix depending on which training you take. Those that are a bit more serious are probably mostly on-site.

Interviewer But if we go back to the development of it. What's the difference in how it looks today and what's the vision for how it will look in the future considering it's so new?

Interviewee Yes, the setup at [redacted] is in 5 buildings that work called downstream. They built the first building, DS1, learned from it, built DS2 learned from it so it's always improvement, improvement, improvement with each building that is built and hopefully then DS5 which will be the final building that produces batteries. It will then try to reflect back to the previous sections so that the improvements made in DS5 are cascaded back to DS1 again so that everything as I said has a standard. And it's important that we follow up on the problems, so if we have a problem with DS1 and have found a solution, it's always important to follow up. Is it solved? Have there been any other problems? Encountered any other problems? So that's also what the Academy works with. We shouldn't just solve a problem and let it go, but follow up on it. So yes, the plan and vision are

that all factories, all buildings, should work in the same way with the same work methods, the same standards, the same work instructions.

Interviewer And if we think about the training in the same question, do you feel that you're still in the startup phase? Do you have a vision that it will look different or?

Interviewee Yes. It's not that the startup phase is the problem in itself. It's the heavy hires we're doing right now. We have 100 people starting every week or so. So every week we have an onboarding with 100 people and we're supposed to introduce them and they have to complete all the training that has been done and then there are new trainings that they may also have to do and then there are existing trainings that must be done. It's this pressure we have. There's a lot of focus on ramping up, ramping up, ramping up. Then it's a challenge to make sure everyone has done what they're supposed to do. Everyone has learned what they're supposed to do. But yes, the visions for the training are the same as for the factories, learning lessons about something that doesn't work, implementing something better and making sure everyone gets it.

Interviewer Do you do evaluations at the end of the training or how do you work with that?

Interviewee Definitely, we have an evaluation after each training where you can leave your feedback on the training. Now it's often like, hey, please leave your feedback, it's rare that anyone responds to it. But for example, if we have someone responsible for that training or related to it, say we have some safety training and the HSE director is supposed to conduct that training. He will definitely provide feedback if he has any deficiencies. And then it's just updating, implementing, and sending it out again. Yes, and there are follow-ups towards the HSE director who is responsible for his section, if he notices any difference, perfect then the training works. If he doesn't notice it, then we have to rethink and think right.

Interviewer Yes, the ones who train are they experienced trainers or are they people who volunteer? Is it internal or outsourced?

Interviewee Mixed bag yes, so for example, external trainings, a-text training is external. We hire people from either Scania or Nersia or whatever they're called. They are more seasoned. They know their stuff so they come here and handle the trainings. If it's production-related trainings, of course, we take someone who is already experienced in the factory to handle that training and who has been trained on how to train.

Interviewer So there are pedagogical elements to it.

Interviewee Exactly, it's a bit of a mix of who handles the training. For example, recently we introduced some new leadership methods and leadership ideologies, you

could say, and then we got a lot of interest from existing production directors who are willing to train. And rightfully so, like it's their section. It's their responsibility and they're curious and willing to train and that's great.

Interviewer Great. Those were the questions we were thinking of asking you right now. Fantastic, we really appreciate your help and your answers to the questions.

A.2.13 Interviewees 13

Interviewer Tell us a little more about your background.

Interviewee A Yes. Yes, but I have a background when I studied chemistry at GU and then I did a doctorate at Chalmers with storage of solar energy in small molecules and then about 1.5 years ago I started at [redacted] and then changed my focus a bit to yes, but batteries then with a focus on safety, so I work in the department, fire and safety and there we have in our group, you can say that it is divided into test engineers and researchers and the test engineers only carry out customer tests according to standards and do yes, but so-called then abuse tests so they do needle penetration and yes, but destructive tests so that there are these worst possible scenarios that can occur and we have a fire lab for that so we do it in a safe way, and we researchers then make a little bit of everything possible , but a lot of the time we are also doing tests, although everything is then connected to research projects, so we also sit and write a lot. Now it's a period that we? Forced to write a lot on applications. And we are everything from we also do literature studies, summarizing statistics. So very much and then we have a part that I am mainly employed for now who have little to keep up with these educations. So much, different things.

Interviewee B No, but I don't work on the research side that much, but I'm more against the testing side, the certification side of it and of course it's not development testing, but it's more certification of products, finished products and I've worked at [redacted] for a long time, 24 years and I have had a lot of training for quite a few years in various different areas including. My main subject has been ESD electrostatic discharges, so I have worked a lot towards production. Electronics production not battery production but also electronics production. Eriksson, the Norwegian armed forces, the Swedish armed forces, all electronics producing companies are in Sweden plus the Baltics and also some in China and the USA then. Since then, I have worked a lot with battery safety, also battery tests, and then it becomes a natural thing that I come into contact with Maria on the fire side as well. I have, I work with these electrical properties, but when we come to abuse tests, destructive tests, our skills coincide because my tests usually lead to fire and such phenomena. So I have been involved a lot in the educational planning within within rise. For quite a few years.

Interviewer Yes, lovely. OK, so our first question is actually yes, but when did you realize that there was a need for battery courses and why?

Interviewee B Yes, I can say that we started about ten years ago, that it is a new technology with lithium-ion batteries. The technology there is quite young and we saw that there were many companies that started looking at this mostly with assembly of batteries, you buy battery cells from Asia and build their battery packs and so on and so on. There are beginning to be some incidents and there is beginning to be an awareness that there are risks associated with this. We have identified that there are fire risks. Yes, there are thermal runaway effects in the lithium ion batteries that we have not been used to with other batteries with chemistries that have additional risks, you could say. And we have still built batteries for fairly high battery voltages too. Before, it was mostly hand machines, maybe not even the ones we use then, there were laptops and so on with fairly low battery voltages. And now we build vehicle batteries of 400 volts, 800 volts, even up to 1000 volts, and more for new dangers. Partly in terms of electrical safety purely in terms of handling that it is, you can actually die from the electric shock when you get into these high voltages, then the handling of it is a danger that we have identified and also then with the fire side the part that we have looked at Tesla, tesla cars and and electric cars that the incidents are few, but they become quite serious because there are such large volumes, such large amounts of energy and so on that are released when something goes crazy.

Interviewee A And then, if I'm not now, I haven't been with the battery industry as long, but a large part of what we researchers do is also contact, like, different companies that should be part of reference groups and that I notice. There is a great deal of ignorance about batteries, and not just among the general public. But also people in the industry that you kind of don't know. What if you don't have this kind of thinking about it at all, i.e. you are constantly asked, like, how can you load, what can you do and what is happening here? And it's like that general education on how to handle it doesn't exist, because it's like that and we usually compare it to traditional fuel. Maybe a little because I don't put 3 cans of petrol in and store them in my daughter's bedroom, so maybe that's not where 3 electric scooters should be charged either. Or that there is a lack of how to deal with it, and we have it in our training courses. Companies that have been there and summer workers have literally thrown the batteries into boxes and that has led to different, such an ignorance everywhere.

Interviewee B But we also see that this is spreading, as I say this is about that. We first identify the manufacturer where you have an assembly of battery packs and so on, but now the interest is starting to grow as we get more batteries. We get bigger batteries. You have lawnmowers today, you have ride-on lawnmowers, you have regular robotic lawnmowers, you have clearing saws, you have chainsaws, so now also park administrations are starting, those that use a lot of such machines and store them in the same place and so on in warehouses and. where that, the questions or the security issue grows. All the time, and we have identified that, and there is great interest in this particular security part of it.

Interviewee A And what is also identified is that there are many people who draw

"better safe than sorry", conclusions and take, for example, that the police have introduced a distance of 100 m from a burning electric car, which, yes, in our opinion is unreasonable to do, but it's about if the knowledge isn't there and then you don't dare to take a chance and there will be more and more bans on charging inside workplaces and that has a big negative effect on the entire electrification of society. So yes, there are needs everywhere simply.

Interviewee B So, this spreads to emergency services and so on as well. But that today there is a big yes. There aren't such large battery warehouses, but storage of batteries in the true sense of the word with storage rooms and so on, right? And what, what happens if we have a large-scale fire or what risks can we face in a large-scale fire and so on? And so the rescue service is also an actor who seeks knowledge then arises.

Interviewer Yes, but so they also come to your courses?

Interviewee A Yes, and then it is very much involved in our research projects and provides input in the reference group and, for us, it is very important, because it is actually those who are there and do not sit in front of the computer and read without and on their input that you usually don't have. Yes, but as a background from Chalmers I have no idea at all, so to speak, very important.

Interviewer Our next question is really about how your courses are designed and what was the preparation for this design like as well?

Interviewee B When the preparations have been, it's pretty solid. No, but the preparations have actually been quite solid in that we have a research activity and we get a lot of results from that, a lot of new knowledge and, of course, an enormous amount of film material. We can show all these worst case, scenarios and so on because we we we have the opportunity to do those tests and so on so we can show the thermal runway for example what it leads to. We can show thermal propagation and things like that in a pretty educational way. And then the training part came afterwards, you can say that now we have so much knowledge that we should share with industry and users then.

Interviewee A Yes, but really, and then we have the courses that Ingvar and I hold together, so we generally run a very basic course twice a year, one on site and one online. But then we also sometimes get requests and then we sit and work on the material a bit. For example, we will have Volvo in a few weeks and then they will have a higher level, so now we are sitting a bit with our material here to adapt it to them so that there will be a little more with just these general courses and our general material basic because they are also yes to fit a wider target group, so we still work on it a little based on each target group we get, so to speak, as time permits. We also have, after all, 1000 ideas that we could also improve, but that might take some time, you can't do that before every training opportunity, so to speak.

Interviewee B It's as you say that we always look at which participants we have and where we want to steer or where we should steer the training as well then so, there is a good competence in the company and we see that we have a specific customer group or a specific company, then we can actually bring in additional experts and so on who can take certain pieces then huh.

Interviewee A Yes, but exactly and it is before the next course is exactly what we have done. We have then replaced one lecturer with another in order to sort of adapt to the customer.

Interviewee B And we have a pretty good base, we have 3,000 employees within the company and we probably have 100 people who work in some way with batteries, yes, probably 100 people, so you can find these special skills quite easily here at the company. Then where it comes from also now I see that, we have, we also saw 10 years ago when yes something like that a need for internal training as well. It's growing and so it's catching up with lithium-ion batteries and we're getting more and more staff who handle batteries and so on. So, even there, we saw a need that is also the basis for external courses, that we have trained our own staff as well.

Interviewer Let's say you are training a company now and have adapted this training to them, does the course then run over one day or at some point or do they come so often that you have it once a year or what does it look like? So sort of.

Interviewee A It's very different then it's also, yes, we also need to pay for the course and we sit before we always first have a small meeting and see what we want, how much will it cost like this? And then we have to take that into account too, so very different, but we prefer to have them, because we have here, online and on site. But from our side, we think it's better to have live in place because you get a completely different one. Yes, but you can talk at lunch, you get some coffee and they can also connect with each other, so we get to choose, we have it in place. And think it is better for the course participants.

Interviewee B And we run trainings both physical trainings on site at rise. We can go out to companies, but we also run via team training courses, also digital. Then it's a bit different which target groups we have, as well as the fact that we don't have that many mass trainings for production personnel and so we get requests for such trainings as well. But that's not really what we're doing. I have worked a lot with ESD in the past, electrostatic discharges in electronics production and there is more training for production personnel, so I agree in those areas, I agree with mass training as well. But not within the battery side, we haven't worked so much to that extent then.

Interviewer But do you stand and lecture then or do they sort of get to do practical parts like this or, because you talked a little about you also demonstrating videos?

Interviewee B Yes of course. That, there are more views of our tests because we can, we can't run real tests for groups or educational groups then, but, but so it is, the more examples we have.

Interviewee A Then they usually get a small tour if we are on site in our labs anyway to stretch our legs a bit anyway, see what it looks like for real and everything, so you get a completely different picture of what it looks like. But then we've talked a little about the latest evaluation, then maybe we would have to add a little more to the online versions so that you can get a yes, but maybe a little quiz or something a little to activate them in a slightly different way that you then maybe not need in the same way when you're on site and have these little mingling moments, so it's something we've thought we'll do for future online occasions anyway.

Interviewee B Yes later. In any case, when we have our physical courses, we try to encourage discussions all the time. We don't hold lectures, but we run quite openly, like, if there are questions, we ask them and then we have the discussions and so on, so we are quite, there are usually quite a lot of discussions and I don't think you should stop that either because a question comes up and then you have to take it. It is not certain that it will remain after an hour.

Interviewee A And then we usually, I still think it's important, at the beginning we always let everyone introduce themselves. And it has been, even if it takes a little time, and it has still been very much appreciated because then you get to hear where people work, what their expectations are and a little about their background. And it has also meant that those you have seen on several occasions have started talking to each other and contacting each other and realize that this person can do with the information that I want and so on.

Interviewer How did you think when choosing the content of your courses? So, how do you select what is absolutely most important? Because I can imagine that you have so much material. So how would you say that one would be able to select in a good way, as a tip for us.

Interviewee B No, but we. We spend quite a lot of time evaluating the target group and if we now look at this battery course, the battery safety course that we have, it runs over one day and there can be 30 people something like that at our physical courses and there we really try look at as well as the target audience. What mixes do we have, how much time should we spend on the basic parts? And so on, because of course the level of competence is quite different. And we try to set a low level and then we try to look at the target group during the course to, is this too basic or is it or something? We are looking a little closely at how what should we put the emphasis on during the training also when we have seen the list of participants and so on. But we want everyone to have the basics with them, so we run introductions with basic electrical knowledge. So that we understand all the concepts and so on. We run basic chemical properties and batteries, even if half of everyone can do this, we still want to include it so that you can keep up with 1 full

day, so we try to satisfy everyone then.

Interviewee A And I usually, now I got my material here so to speak so that was the only thing that has sat and thought through the most important pieces. But something that I have done when I have worked on it is to check, because then I have a lot that refers to research reports or scientific articles and they are general: firstly, I make sure that they were updated that you were not this article from twenty-twenty, but then I find a newer one that is like for this year preferably and the way I usually do is that I first explain something in general and then maybe I take an example from an article to explain it very simply, but then still bring the reference and say something that you who want to read more here in all the details because they are good, but they are usually very difficult for beginners to understand but. So I usually do it simply and then a slightly advanced example explains simply and then some links to it as well. And we always hand out the material afterwards, and we also say that clearly at the beginning so that people then know: here I have it. Yes, I can read on if I want.

Interviewee B And always contact details on us at all times, including everyone so we can take any questions afterwards as well.

Interviewer When you have designed these trainings as we and I have understood it, has it been based a lot on experiences and research? Or yes, there is something like when you have implemented the trainings themselves, have you started from some pedagogical design, some learning model? Did you have something in mind in this way, or was it a bit of learning by doing, i.e. developing the courses based on how the outcome turned out?

Interviewee B Yes, I would probably like to say. We go more for learning by doing yes.

Interviewee A Having said that, that's the way it is, yes, but at Chalmers when you did your doctorate, a big part of it was that you've been to many conferences and heard people who spoke and didn't understand a word because they were, quite frankly, completely disaster to present and then we have been there for a large part that you have to learn to present research then popular science. Those of us who are doing training at [redacted] have also chosen it voluntarily, and maybe have a little of it in our nature or know how to do it, after all, they haven't just taken someone. You are an expert here and you should stick with it, without learning by doing. But we know what we're doing. So we probably make some models and such without anyone knowing about it. We've kind of learned. Yes, over time, for example, I have learned that the material must be simpler than you think, you yourself are so involved in what you do that when you first wrote your presentation for the thesis, for example, then it was like no one understood a word, so okay, we'll have to rethink and start like that. How is a three-year-old supposed to understand this, I usually think, and so you start there and then you build on it. And then you get 800 abbreviations in 3 minutes and that. So it's an important focus, we have it, our

training always starts with going through from the beginning, like what are batteries. What is charge level, what is cycling, what is and we almost never prioritize that because we see that whatever level you are at, you need a refresher and then depending on the target group, this piece might be for fifteen minutes or half an hour.

Interviewer Yes, but thanks for that. Our next question is kind of like this, if you have any exam elements when you have had the trainings or if you people just leave it or something like that? Any follow up in any way?

Interviewee A No, but it's one of the things that we want to work on in how the material later actually gets a little follow-up or some kind. Possibly, we have also talked about leaving some kind of study material before in some cases. But, we haven't quite gotten there yet.

Interviewee B I have it in my ESD courses. There we have examinations in some cases. But that, it's not at that's not at my request, but it's more the company that wants it in order to get it into their education plans and so on then, well, there can be examinations then. With larger groups, I can see, or with an education, I can see the need for it in a different way, but it's always hard to know. You have to do this because yes, I've done one exam for production staff then and it's quite simple questions then. Then I have had more advanced courses also in ESD and it comes from different companies, maybe 10 people so open courses and there we have had an examination with that as group work. It is group work and then you go through the questions as a conclusion when everyone has understood this. Then if it's a rule to set it belongs to that we that I don't know, but. It has been quite appreciated then, because then you don't have that nervousness in the room but yes, we will have an examination. But it will be like a group distribution like in the end then.

Interviewee A Something that I have been thinking about, that I would like to have with this menti survey, what is it called, they are just like an app and then just press and you can prepare some questions and then you get the results straight away. And yes, like someone like this kind of gift stack and I myself have been to the training that has had and think it is quite good because you are also there anonymous when you maybe become a little more in a group and then you can immediately that they have understand this or not, you can talk further, then if it were to be about something like that, we have still thought about implementing it.

Interviewer How large groups do you accept at a time during the courses?

Interviewee B Being open trainings on site, we can take in 30-35 people. Since team training, it has been a little bit different. On our fire safety courses, battery, battery, safety courses. We have had quite a few participants there, no major restrictions. At my courses for production staff, there I try to limit it to 10. 10 people more or less to be able to keep the dialogue even digitally then huh. Then I can ask targeted questions when there are no more than 10 people and so on, and you can't do that in 40-person digital trainings and so on then.

Interviewee B Then there is a difference between the training courses for battery safety courses where we have many lecturers and so on. The courses I have are three-hour courses for production staff and then I tried to limit it to 10 max 15 people so I always have the participant list ready for me and can throw out a few questions.

Interviewee A I think in general that you notice the more the more participants, almost the fewer the questions, we see everything online that it becomes like a little. Yes, so it is important and yet not too many have it, I think.

Interviewer Yes, do you have any tips for us on what we might need to think about in terms of form, that is, when we think about the pedagogical framework, and things like that, so what do we need to think about when we have to think about how, how do we teach? How do we teach basic skills in the most educational way possible.

Interviewee B No, I stress primarily that you should have a humility when you when you present material. As a course participant, you should feel that you are in contact with the lecturer. And so on so that you really show yourself humble. Direct questions, but still humble questions, you should never, you should never dismiss a person in front of a group.

Interviewee A Yes, yes, but exactly and it is mainly so that people dare to ask questions and so we sometimes say wrong and then we joke a little about it. And there's nothing strange about that, and Ingvar and I can have slightly different opinions about different things, and that's just the way reality is. But my advice then is that if you think you have it easy, maybe you should still make this introduction a little easier, and then if you have the time and opportunity, then the material that we have worked on well is nice slides and that's it always appreciated as well or at least so that it works because you have also seen it. I'm still like all the conferences when you figure out how to get there and then it says like a slide where it's something that you learned 20 years ago. It can't have, like, text to size 12, but like it's still the material, it does what it's supposed to.

Interviewee B Late. Now, now I don't talk so much about battery safety courses either, but if we look at my shorter trainings, I always try to run the same information in some way a number of times that you first explain what is in a standard for example and then then you tell them that what it actually says, what do you mean and then show how it also with measuring instruments, real measurements and so on, so that you. So that you can translate these steps in a good way. That's what I try to do in the training courses that yes, here we have the standard text, here you have my theoretical explanation and here you have the proof, as it were, in purely measurement technology. So I often have oscilloscopes and instruments the measuring instruments and everything, so I can show you online also then in digital so you get the same information in 3 different ways. So you understand the basics that yes, this is what it's all about then. I think that can be good in some respects anyway. And you often get a good response to that as well. Yes that man. Not.

A learning ruler so you get closer and closer to the answer somehow. And I think we actually do that in our battery safety courses as well, just as you try here in the basics and here we have a newspaper article about something that has happened. And then you show films on our tests and so on, when you actually understand that this has arisen and this is what it looks like in reality, as well as with our tests and so on, so there is some pedagogic thought in that too then

Interviewee A And that we also try to synchronize a little between lecturers on what to say, for example talk to Ingvar about even if he has a battery as an example. Then I have made sure that I have the same battery in a smaller one as an example so that it doesn't just end up in a brand new thing. And then it gets easier. And then you can kind of constantly link back to yes, but the same in and then we have the introduction. Then this would mean this for this type of cell and that you sort of sync up a bit anyway. Even though we are from different departments, have different experiences with materials, we still put time into it.

Interviewee B Yes, I can say that too. I can also say that during the time that we have had the training, there has been a lot. Yes, quite complex, difficult things that we are trying to teach and of course we are all children at the beginning, as well as course leaders and we have tried that even if we have if we have specialists who are not particularly pedagogical, they can still be there as a support for the lecturer who holds. That's what I did when I started. Then I had a mentor who absolutely did not want to hold courses. But my first courses then, he was always there so that you could take these targeted questions. These difficult questions that you are not quite sure about and have nervousness about. So it is also a tip that you guide your course leaders. With qualified help. Yes, it will. After all, there will be a mentorship in the training phase as well.

B

Thematic Analysis

B.1 Necessary skills

Figure B.1 illustrates the compilation of necessary skills, that was done after the interviews were held. The skills at this point, were not properly defined and were divided under the categories operators, engineers and shift managers, which were the work roles that the interviewees obtained. The numbers beneath the skills represent the number of times that each skill was mentioned by the respective work role in the interviews.

Figure B.1: Compilation of necessary skills after held interviews.

Figure B.2 shows the compilation of necessary skills, that was done after the workshop and the collection of information through research. The skills were not yet properly defined and the numbers beneath each skill represent the amount of times that each skill was mentioned during the workshop.

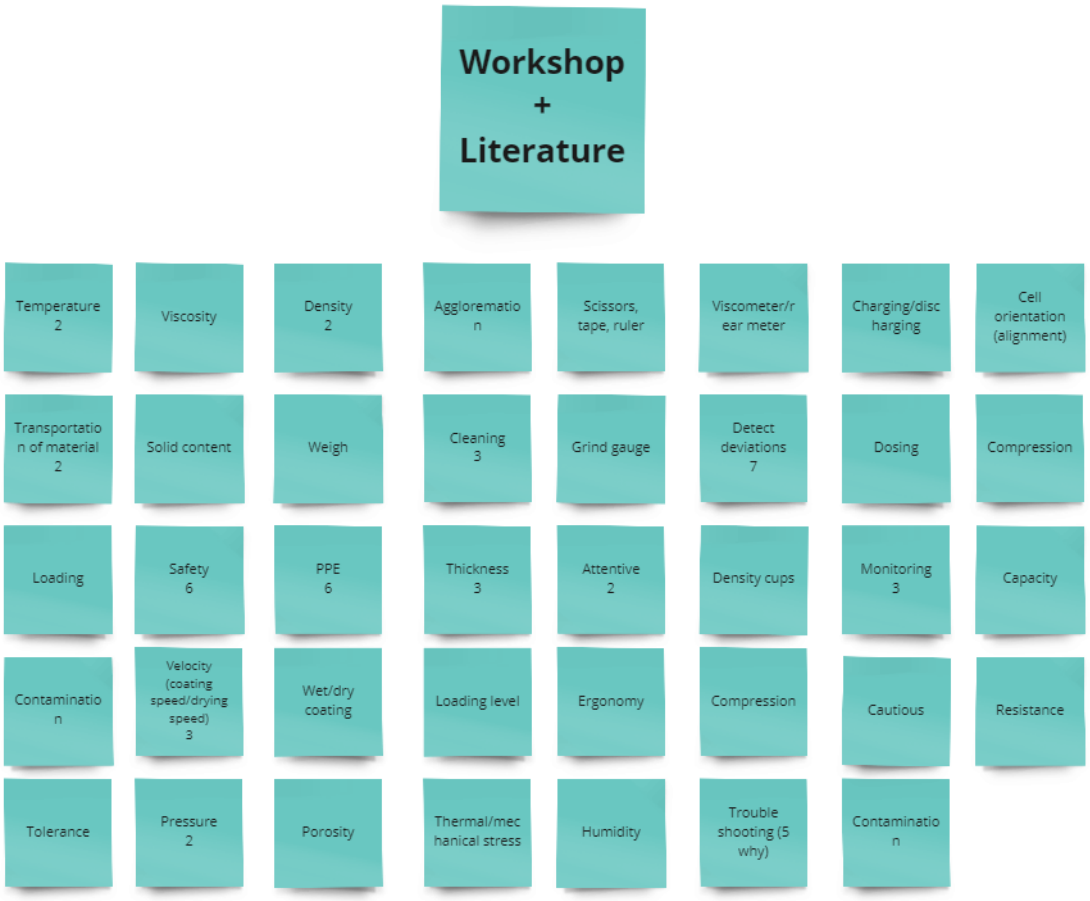


Figure B.2: Compilation of necessary skills after held workshop and research.

C

Survey

C.1 Survey Template (Swedish)

Battery skill gap analysis

1. SAMTYCKE ATT DELTA I VETENSKAPLIG FORSKNING

Genom att fylla i denna enkät deltar du i en studie om färdigheter och kompetensbrister inom battericellindustrin. Denna studie utförs av Karin Isaksson och Theres Saad, två studenter från Chalmers Tekniska Högskola. Målet är att utveckla och bredda kunskapen inom battericellindustrin i Sverige.

Dina svar behandlas konfidentiellt. Informationen kommer inte att vidarebefordras och rapporteringen av resultaten kommer att säkerställa att enskilda respondenter inte kan identifieras. Resultaten kommer att presenteras i vetenskapliga publikationer.

Jag förstår att deltagande i studien är frivillig och att jag när som helst kan meddela att jag inte önskar delta i studien, men att det hittills insamlade forskningsmaterialet kommer att användas i studien.

Jag har läst sekretessmeddelandet och har fått tillräcklig information om undersökningen och behandlingen av mina personuppgifter i den. Jag har förstått den information jag har fått och vill delta i studien.

2. Jag har läst och bekräftar mitt samtycke till ovan text.

- ◯ Ja
- ◯ Nej

Next

3. Var läser du din utbildning just nu?

- ◯ Gymnasiet
- ◯ Yrkeshögskola
- ◯ Annat, nämligen: [ ]

4. Skriv i din tidigare arbetslivserfarenhet och hur länge du haft respektive tjänst/roll. Om du inte haft tidigare arbetslivserfarenhet, skriv "saknas".

[ ]

Nedan hittar du skills för batteriproduktions-operatörer, som vi har tagit fram genom vår studie. Skills är färdigheter som behövs för att kunna utföra ett eller flera arbetsmoment.

5. Placera ut markören baserat på hur viktigt du tycker att varje skill är för ditt arbete och hur väl du presterar inom varje skill.

Relevans - 1 (inte alls viktigt), 2 (inte viktigt), 3 (ingen åsikt), 4 (viktigt),5 (väldigt viktigt)

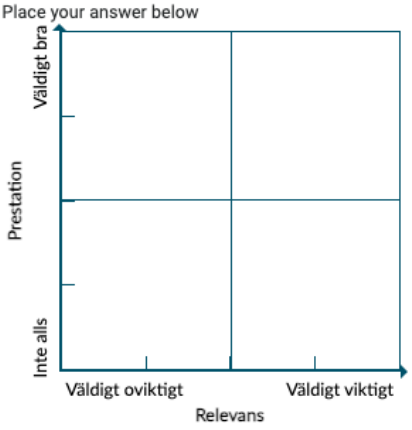
Prestation - 1 (inte alls), 2 (otillräckligt), 3 (ingen åsikt), 4 (tillräckligt), 5 (mycket väl godkänt)

1. **Tillämpa och följa standardiserade arbetsinstruktioner och branschens arbetsmetoder**
2. Beräkna och förstå nyckelvärden och parametrar
3. Rengöra utrustning och maskiner
4. Samarbeta, kommunicera och arbeta i team
5. Nyfikenhet och livslångt lärande
6. Upptäcka defekta produkter
7. Dokumentera och övervaka produktionsdata och arbetsprocesser
8. Fokusera/koncentrera sig
9. Följa arbetsinstruktioner och recept
10. Hantera känsligt material, utrustning och produkter
11. Hantera maskiner
12. Provtagning av produkt
13. Tänka i flera led
14. Felsökning och problemlösning
15. Användning av personlig skyddsutrustning

1. Tillämpa och följa standardiserade arbetsinstruktioner och branschens arbetsmetoder

Next

Place your answer below



C.2 Survey Respondents

In Table C.1 the survey respondents' previous field of work experience are presented.

Table C.1: The previous field of work of the survey respondents.

Previous Field of Work	**Category**
Assistant nurse with 5 years of work experience in care, elderly care and hospital. Operator in the food industry for 3 years.	Health and Social Care, Food Industry
Worked as an operator in the car industry for 2 years. Worked at various government agencies for 6 years.	Automotive and Transportation Sector, Economy or Public Sector
Car mechanic for 5 years.	Automotive and Transportation Sector
Previously worked in bakery/pastry and had no experience in technology	Food Industry
Warehouse and logistics, hairdresser and babysitter	Logistics or Manufacturing, Health and Social Care
Worked in healthcare for over 10 years.	Health and Social Care
7 years as a process operator on a paper machine and steam boilers. Nowadays vocational teacher for process operators	Logistics or Manufacturing, Health and Social Care
18 years of experience as an assistant nurse, habilitation staff within LSS group housing	Health and Social Care
Worked at a car manufacturing company for 2.5 years. Have experience within the car industry	Automotive and Transportation Sector
Worked for more than 15 years in finance.	Economy or Public Sector

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