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Master thesis

An Investigation on Supporting the Energy Transition Education through Blended Learning

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Purpose: This research aims on supporting (re)training processes in the energy transition. The objective of the study is a set of guidelines for a system that enables blended learning for technicians who already need (re)training for carrying out their daily work activities.
Methodology: The study is conducted in two phases. A desk review sheds light on the current problem of (re)training technicians in the energy transition and how blended learning could help reduce the tension in the technical labor market. The research is continued by a field study consisting of semi-structured interviews with academics, experts and technicians related to training processes and/or the energy transition. The findings of these phases result in a set of guidelines for supporting the energy transition through blended learning.
Findings: This study offers a model for the application of a digital system to enable blended learning. The research confirms that current training courses in the industry's rapidly changing environment do not match demand. The upcoming generation of learners requires on-demand, digital training solutions. Hands-on suggestions are proposed for developing a digital tool that enables the digitalized aspect of blended learning. Using alternating forms of media, the learner can practice the theoretical study materials. By this, less time is spent at the physical training location. Physical practicums than should focus on solely spending time on practice and collaboration. The digital platform also offers opportunities for lifelong learning and a database.
Added value: The research provides insights into how to support training in the energy transition. It offers an overview of existing literature on the topics of e-learning and blended learning in the energy transition. Besides that, a qualitative field study provides insights from the perspective of experts in the energy transition and possible users of such a blended-learning environment.
Limitations: The study is limited to a selective group of respondents and could therefore be expanded to include more stakeholders from the sector. Moreover, the research is limited to only offering design requirements, which must be optimized through design, development and evaluation to a product that meets the wishes of the sector.
Keywords: energy transition, technical personnel, lateral entrants, education, retraining, vocational education, lifelong learning, teachings methods, learning styles, blended learning, e-learning, digital platform, design research, field study
Paper type: Qualitative empirical study

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Abstract

The Paris Agreement of the United Nations sets the goal of significantly reducing greenhouse gas emissions. Energy-saving installations, sustainable energy generators and other smart technologies must therefore be installed at an increased pace. Due to these recent changes and the aging of current workers, the required labour force related to the energy transition is increasing enormously. This rising call for technical personnel, together with fast evolving work dynamics and an increasing demand for additional competences brings a need for staff to continuously improve and train themselves.

However, current teachings methods in this sector are labour intensive and require fulltime commitment A proven solution to improve such learning is blended learning (Kaur, 2013). It helps adjust training to personal learning styles and speeds and increases student engagement, leading to students needing half of the time for learning the same amount of content. This thesis focusses on developing a digital platform to support blended learning, specifically for retraining practically trained staff for technical firms in the energy transition.

The research starts with a desk review in which current literature and existing solutions to the problem are investigated. The current status quo in the technical labour market is researched and a mismatch between what is needed by installation firms and what is offered by educational systems is explained. Studies suggest improving above mentioned challenges by blended learning and gamification, which is further researched in the desk research.

Through a qualitative research, 12 stakeholders of the sector of this retraining process in the energy sector are interviewed. An emergent theory structures interviewees' view on current training. This qualitative study section discusses positive experiences with training, shortcomings of current training courses and the emerging demand for centralization of learnings.

The study then continues with structuring interviewees' view on shaping a blended learning system. It is suggested that learners prepare the course theory on their own pace before a planned training, making more time available for collaboration and practice. The themes on-demand learning, lifelong learning, interactive digital learning, intrinsically motivating learners, and a future proof learning ecosystems are discussed in this section. Lastly, the research critically evaluates the deployment of blended learning by discussing potential challenges.

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1. Introduction

In the Paris Agreement of the United Nations (2015), many countries agreed on reaching climate goals by boosting the implementation of renewable energy sources. Additionally, recent geopolitical developments such as the sanctions on Russia (BBC, 2022) highlight the need to reduce EU dependence on imported hydrocarbons. Those events lead to a growing need for technical skilled people in the sectors related to the energy transition. The energy transition in the Netherlands alone creates over 75.000 extra full-time jobs for which people need to be trained (Energieonderzoek Centrum Nederland, 2017). According to Topsector Energie (2022), which is responsible for innovations and investments of the Dutch government, properly trained people are essential for maintaining the position in the energy transition the Netherlands has.

Those people have to be deployed in a changing work reality, impacting the current matrix of employment and leading to an accelerating demand for skilled people. It is expected that if people do not train themselves, it might lead to unemployment for them. In a sector where staff shortages are increasing, it is therefore of great importance that the increasing number of training courses is in line with the wishes of these technicians. Especially as people who previously attended vocational studies are generally reluctant to following training. Current employment of properly skilled staff has a big impact on our speed towards a world with solely sustainable energy. The shortage of skilled people is a limiting factor on how fast we can proceed actions resulting from the energy transition. Mainly practically skilled (in the Netherlands, MBO and HBO educated) people are needed as enablers of this rapidly evolving changes. New competencies in the sectors offshore wind, solar energy, hybrid heat pumps, energy storage, sharing and usage are needed on a large scale (Topsector Energie, 2022). This consists, according to Technopolis Group (2016), of skills such as customer contact, teamwork and understanding embedded IT-systems.

A rising call for technical personnel, together with fast evolving work dynamics and an increasing demand for additional competences that fit within complex technical systems brings a need for staff to continuously improve and train themselves. Focussing on a specific case of the energy transition, the installation of hybrid heat pump, shows that installation is currently executed by professionals from different disciplines. Retraining reduces the number of technicians to one (SBB, 2020) and is currently executed by physical training programmes. A collaboration between Dutch installation firms and educational institutions currently offers a training course where lateral entrants are withing six months trained to install hybrid heat pumps (van der Zee, 2021). An online interview by the major installation firm Bonarius (2021) shows that the current method is labour intensive for trainers, a fulltime commitment for half a year is needed from the lateral entrants and last mentioned might miss supplementary tools when following the course.

A proven solution to accelerate such learning paths and improves the understanding of students is, according to Patchan et. Al. (2015), blended learning. Blended learning is defined by Masie (2006) as "The use of two or more styles of content or context delivery or

discovery" (p. 22). In the context of this research, we will use as the specific mixture of e-learning with classroom learning. Blended learning enables adjusting training to personal learning styles and speeds. In addition, the study by Patchan et. al. (2015) investigating the effect of blended instruction on accelerated learning, shows that it not only provides advantages for students on how to learn, but also increases student engagement, leading to students needing half of the time for learning the same amount of content. In this way, blended learning can save costs while also becoming modular and scalable (Biewener, 2021). Developing a digital platform to support blended learning can help to solve the supply chain issue of a shortage of staff. This thesis we will address the development of such a digital tool that will facilitate blended learning, specifically for retraining practically trained staff for service dominant technical firms in the energy transition.

2. Research goal

A changing world leads to an increasing need for people to be retrained. However, currently people consolidate in class and the process is costly and time precious. For this, the problem needs to be solved in different, perhaps parallel, approaches. Potential directions are another orientation of internal structures, a program for attracting the right people, increasing the efficiency of labour and training people. This thesis will explore how blended learning can stimulate retraining practically trained staff for service dominant technical firms in the energy transition. As this research focusses on a solution for the social problem of shortcoming in staff, this research will be approached from a design perspective where the outcome is a design suggestion that might be of potential for the sector and could be prototyped and further tested afterward.

Technopolis Group (2016) published a report with a graphical representation, displayed in figure 1, of the expected changes for employment per sector related to the energy transition in the Netherlands. This clearly shows the impact on employment opportunities will be off the highest in the activities related to energy savings, such as the installation of hybrid heat pumps and isolation, and the realization of wind and solar energy systems. Therefore, this research will also focus on this sector. As such, the thesis will answer the following research questions:

- The main research question:
  "How can we address the lack of specialized labor in the energy transition by an e-learning platform that helps fostering capabilities by transforming current practical trainings into blended learning processes?"
  - Sub-question 1:
    "What is the current status of training and learning in the energy transition?"
  - Sub-question 2:
    "How could the design of an e-learning platform to enable blended learning contribute to solving current challenges related to training and learning in the energy transition?"
  - Sub-question 3:
    "What is the view of leading firms on the potential design for supporting the energy transition education through blended learning?"
  - Sub-question 4:
    "How should the blended learning system that helps fostering missing capabilities for firms in the energy transition that are lacking practically trained staff look?"

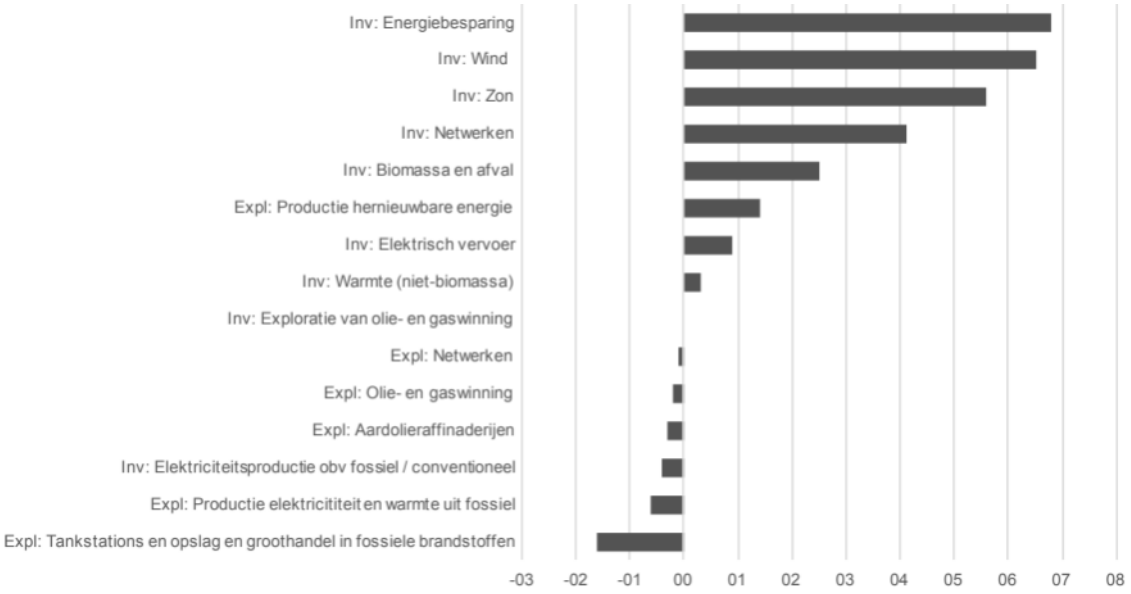

Figure 1. Impact of the Energy Agreement on employment based on established and intended policy for investment and exploitation in The Netherlands (Ligtvoet, Pickles, & van Bar, 2016)

3. Methodology

This study focusses on supporting the energy transition education through blended learning and is conducted in two phases: desk research and field study. At first, a desk review sheds a light on the current problem of (re)training technicians in the energy transition. A combination of whitepapers by European (governmental) Research Institutes and academic articles forms the basis for creating an overview of the status of employment and training facilities within the sector. As the status of the energy transition is fast evolving, a selection criterion is that sources should represent the status and thus be not older than five years. Questions such as 'Which employee shortages do exist in the Netherlands, related to the energy transition?' and 'What solutions are already developed, related to fostering capabilities for service dominant firms?' are investigated. As the goal of the study is gaining a better view on the current situations at firm level, online information offered by leading Dutch companies in the energy transition is included. By this investigation, a better insight on the question "What are current ways of learning in the energy transition?" is created. From these insights, a set of challenges related to retraining processes in the energy transition is given.

The desk research continues by exploring how blended learning can reduce the tension in the technical labour market. By digitalizing conventional learning methods, trainings can be better aligned with personal learning styles and physical trainings can be reduced to a minimum. As conventional synchronous on-location trainings will stay part of the (re)training programs, certification and personal guidance can still take place in traditional ways. Hence the research focuses on the e-learning aspect of the blended learning program. Literature points to the added value of this type of learning and proposes concrete suggestions for implementations. These suggestions are explored in order to get a better understanding of design requirements for the digital system. Important factors related to blended learning are explored in the light of Kaur's (2013) proposed three major components: learning environment, instructional and media. These components form the basis for the development of a literature study reviewing different papers writing about these.

The research continues with a field study existing off semi-structured interviews with academics and professionals on (the topic of) training processes and/or the energy transition. In partly digital and partly on-location interviews, the stakeholders were for 45-60 minutes asked on their vision on digitalizing the retraining processes in the energy transition. The interviewees were informed about the process of using their answers in this thesis and did all approve to participate. Also, University of Twente's BMS ethical committee did formally assess the ethical aspects of this research project and approved to carry out this field study. In order to transcribe, code and process the results of the conversations in this research, all the interviews were recorded. After transcription, the recordings are removed.

The question 'What problems do stakeholders currently face and which design requirements are essential for realizing a blended learning?' is the focus in the semi structured interviews. At first, introductory questions give insights in the interviewees

role/function and its relation to the theme of '(re)training for the energy transition'. The interviews are continued with questions related to current (re)training processes. How are current (re)training programs formed in the energy transition? And which aspects of processes are experienced as valuable/good and which as problematic/challenging? Lastly, the interviews focus on the topic 'digitization'. How does the stakeholder think e-learning can help in training processes? And which elements would be essential in a tool that facilitates blended learning? However, as the interviews where set-up as semi-structured, in practice the content of questions varied based on the stakeholders' background and the course of the conversation. The full list of questions can be found in appendix A. Transcriptions of the conversations are available on request.

The output of the interviews is used for systematically analysing the current situation. A data structure is created by aggregating 1st order concepts, 2nd order themes and resulting aggregate dimensions, based on the methodology developed by Gioia et al. (2021). The goal of this is uncovering current social processes and developing a theory on supporting tensions in (re)training processes of practically trained staff through blended learning.

The findings of this study result in a set of guidelines for supporting the energy transition through blended learning. How should the (online) digital tool to foster capabilities for service dominant technical firms in the energy transition that are lacking practically trained staff look? To answer this question, a set of design requirements form the conclusion of the study. These findings can be used for further research and can support in the development of a digital system to support (re)training processes related to the energy transition.

4. Desk research

To gain insights on the current situations and tensions related to (re)training processes in the energy sector, this research starts with a desk review. In the Netherlands, institutions such as PBL (Netherlands environmental assessment agency) and EIB (economic institute of construction) write in whitepapers about a growing tension in the technical labour market. This mismatch between what is needed by installation firms and what is offered by educational systems is first studied trough an investigation on current training methods. From this review, it is concluded that the inflow of new employees can be divided into employees from (other) sectors and the young talent leaving vocational studies. Continuing the desk study on current training processes offered to these employees brings insights into existing challenges. At first, the targeted group of personal is generally hesitant to participating in retraining programs, leading to a shortage of inflow. Also, training processes currently exist of mainly conventional, classroom-based education with high levels of physical meetings, personal guidance and time-intensive collaborations. Lastly, the rapid speeds in which technologies change in varying compositions advocates a need for continuous learning across the whole sector.

Studies suggest improving above mentioned challenges by blended learning. This topic of combining classroom-based teaching with digital platforms is the next topic of the desk research. Blended learning better aligns learning styles and teaching types and differentiates instructions. When developing such a blended learning environment, studies suggest involving multiple factors. Environmental factors such as classrooms, virtual rooms, practice labs and interactive platforms should be developed such that it enables an asynchronous learning environment. Mobile learning platforms can help to enable such environments. The desk study concludes with suggesting implementing gamification elements that help learners to reach a state of flow. Leader boards and online competitions can create social comparison dynamics and increases learning results.

4.1 Ways of learning in the energy transition

The energy transition causes a growing demand for trained staff, and a major question is whether there are enough people for these jobs (ECN, 2016). An investigation by a Dutch environmental assessment agency (2018) shows that the energy transition leads to a growing tension in the labour market and solving this shortage of technicians is difficult because of the specialistic training required (Weterings, et al., 2018). This section investigates the current deployed ways of learning in the energy sector and proposes additions and/or alternatives for improving current processes, in order to increase the supply of trained staff.

An analysis by Koning et al. (2016) on the effects of the Energy Agreement on the labour market shows that mainly experienced personnel from other sectors is attracted and with respect to other sectors, more people are aged 45 and older. However, what firms need from these newly attracted people does not match their current skillset. Less than one in ten young people consider a job in the sustainable energy sector when making their choice of study (ECN, 2016) and very few former students enter the energy sector immediately after their education. Consequently, the influx of people under 25 is limited and significantly lower than other sectors (Koning, Smit, & van Dril, 2016). Combining these findings, shows that the challenge of offering training in the energy transitions can be divided into two fields: attracting and training young talent and retraining employees from (other) sectors.

When looking on training young talent, hardly any vocational education course is focused on a specific profession within the new energy sector. The reason for this is a shortage of interested students and the rapid speed in which technologies related to the energy transition change (Koning, Smit, & van Dril, 2016). Marsha Wagner, expert in the human capital agenda of the energy transition, believes that professions change rapidly and as a result, education is lagging the needs of practice (Eneco Groep, n.d.). This is a challenge, as especially renewable energy solutions require special skills, such as for the generation, consumption, storage and sharing of solar and wind energy (Ligtvoet, Pickles, & van Bar, 2016)

Current teaching methods for post-secondary education are practical and focused on conventional, classroom-based education about general topics. In a two-to-three-year fulltime course, students learn about common subjects such as Dutch, mathematics and citizenship in a group setting. The preparation of installations, measuring techniques, mounting and wiring, planning, organizing and giving instructions are included during the training (Kies MBO, 2022). Branch specific experiency is mainly gained via several internships during this fulltime education (Koning, Smit, & van Dril, 2016).

An alternative to these fulltime courses, are apprenticeships in which students work for four days at an installation company and attend school once a week. An example to course for a specific profession related to the energy transition is a training developed by vocational schools and installation firms Breman, Feenstra and Bonarius, in which trainees learn how to become a mechanic specialized in installing hybrid heat pumps. An

inside in the process of these trainings offered by van der Zee (2021) shows that this course consists of a high number of physical meetings, personal guidance, and time-intensive collaborations. As the shortages of teachers and trainers in the renewable energy sector is increasing, this type of learning is not infinitely scalable (UNFCCC, 2020).

Currently, it is challenging to attract enough young people to these courses as under 10% of MBO students considers a job in the sustainable energy sector (ECN, 2016). According to Wagner (n.d.), the reason for this is the current image among students about these technical studies. She thinks that appealing technologies such as serious gaming and online solutions should be implemented in order to attract younger talent (Eneco Groep, n.d.). A major advisory council for government and parliament on socio-economic in The Netherlands advises to make vocational education flexible and demand driven. For this a tool is needed that continuously responds to the developments in the energy transition and makes continuous learning accessible. This should be easy scalable and properly aligned to train employees with skills during their job (SER, 2018).

As mentioned before, the other major part of the employment in the energy transition is fulfilled by experienced personnel attracted from other sectors. According to Koning et al. (2016), these people need to be retained in order to work in the new energy sector, as it requires specific qualifications, such as the use of ICT tools. In order to better align these people's skills with the growing demand of technicians, Weterings (2019) suggests that modular and flexible educational programs are needed which are tailored to employee and employer needs. As the attracted personal are generally hesitant to participating in retraining programs and are often at a stage of life where it is less common to return to full-time studies, flexible times and locations for training are essential to make it accessible (UNFCCC, 2020). In addition, according to the United Nations (2020) , it is likely that many jobs will be created at locations very different from those suffering job losses. As job seekers are rather unwilling to move for a new job, this should be solved by very local training in order to maintain enough talent (Weterings, et al., 2018). A practical example of this in the Netherlands is the remaining coal-fired power stations which will most likely be closed before 2030, leading to over two thousand experienced technicians needing a different job in the surrounding area (SER, 2018).

Another challenge related to retraining employees is that the deployed technologies in the energy transition are ever faster changing in varying compositions (Ligtvoet, Pickles, & van Bar, 2016) and training institutions lack behand in offering the needed training. An investigation on three Latin American countries, showed that the reason for growing gap between employee supply and labour demand in the energy transition sector is related to the fast-developing technologies and its accompanying needed competencies (Ravillard, et al., 2021). As a result, firms mainly provide courses themselves, to instruct their own employees or their staff is trained by companies who developed the systems (Koning, Smit, & van Dril, 2016). As the technologies are changing this fast Weterings et al. (2018) advocates life-long learning across the whole sector. According to her, retraining in this new energy sector is crucial in order to react relatively quickly to changes in labor demand. An advisory report from the Dutch Social and Economic Council (2018) proposes

newly developed training programs and customized modules focused specifically for the energy transition should be developed in order to fill this existing gap.

Based on this early exploration, it can be concluded that there is a mismatch between what is needed by firms and what is offered by educational systems. Current teaching methods seems to be conventional, classroom-based while there is a growing need for personal guidance and tailored training solutions. Especially as technicians are attracted from different sectors, all with their own built-up skills and expertise, located everywhere in the Netherlands, there is a rising need for flexible, demand driven solutions. In addition, the fast-changing technologies lead to a growing need for lifelong learning. This increasing need for flexible and demand-driven education in the energy transition together with an urging scalability of training conflicts with the shortage of trainers in the sector.

A way to increase flexibility and customization without increasing the workload for trainers could be the implementation of e-learning. Ravillard et al. (2021) emphasizes in a report based on a firm-level survey that the focus should be on 'skilling the unskilled' trough online educational platforms, as it is according to his study a fast way to meet employment requirements of companies. Online learning tools can provide training which is not available locally.

4.2 Blended- and digital learning

The desk study shows the growing need for personal guidance and tailored, flexible, demand driven training solutions. Current training programs have a poor return on investment and are not easily transferable (Renkema, 2006). Therefore, newly deployed tools are required which are demand led and optimized for also post-initial training purposes. Adding online educational platforms to current physical trainings can be a fast way to meet these requirements and increase flexibility and customization without increasing the workload for trainers.

This integration of conventional education on location with innovative digital learning platforms is defined by Wong et al (2014) as hybrid learning. The advantage of hybrid or blended learning over the conventional way of learning is that it is better aligned with variances in learning styles and teaching types, represents active learning and better allows differentiated instruction and optimized reflection across learners (Kaur, 2013). As the conventional way of learning is already deployed in trainings of the energy transition, this section will focus on factors related to the digital learning platforms, also known as e-learning.

Major components of blended learning

Kaur (2013) offers an overview of important factors related to blended learning and distinguished three components, as visualized in figure 2. The first component is the learning environment**.** Environments consist of among else classrooms, virtual rooms, practice labs and interactive platforms and can is generally classified as synchronous or asynchronous. Olapiriyakul and Scher (2006) define synchronous communication as real-time information transmission among users and asynchronous communication as static exchange without concurrently presence. According to a technical paper published by the United Nations (2020), training related to the energy transition should be facilitated in a mainly asynchronous learning environment, as lateral entrants are in general in a life stage where they are inflexible in availability.

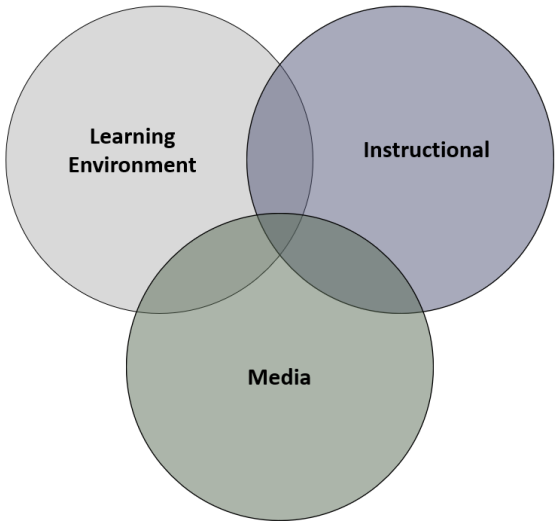

Figure 2. The three major components related to blended learning (Kaur, 2013)

Another essential component that should be considered when implementing blended learning is the media (Kaur, 2013). When considering the media platform, it can bring unique advantages, but also limitations when delivering the content. In a comparative study between e-learning platforms, Korucu and Alkan (2011) suggest that especially mobile learning platforms enable asynchronous learning, as its media offers opportunities for learners to practice any time and place. The interest in mobile learning is growing and has an increasing potential over e-learning platforms on computer devices. Start (2022) says mobile learning enables easy access to training materials via smartphones or tablets and is essential nowadays. As it integrates learning in the flow of life and working, learning can become part of daily routine and information will be better remembered

The last component is the instructional aspect, delivered through learning strategies. Learning strategies should incorporate the transfer of learning trough blended learning systems. This transfer could be achieved by instructor-led classrooms and coaching, but also via web learning methods, video's, databases, and simulations (Rossett, Douglis, & Frazee, 2003). As technicians are attracted from different sectors and already process skills, instructions should be flexible and tailored to a learners need. According to Slaats et al. (1999) study shows a significant difference in learning styles between vocational study domains. Students of technical vocational studies prefer curriculums devoted to self-initiated problem-solving. According to the study the best way to offer instructions to this group, is by offering exercises and challenges focused on applying the skills in a trial and error based, problem solving and creative fashion.

Lepaya

An example of a company developing e-learning platform is Lepaya (2022). In this, they focus on so-called power skills: a combination of soft and hard skill. According to Stanford psychologist Carol Dweck, this combination helps in making room for a growth mindset; where curiosity is triggered and attempts, and failures improves learning. According to Slaats et al. (1999) triggering curiosity and making room for failure especially suits technical vocational students. According to Kaur (2013), attempt-based learning can be achieved in e-learning trough interactive aspects, which is challenging but essential. If not, a danger is to use technology simply because it is possible instead of exhausting the benefits. Wong et al. (2014) adds to the notion that the use of such interactive learning systems is positively related to examination performance and learner experience.

4.3 Gamification

Start (2022) extends the view on interactive learning by a new trend called learning experience platforms (LXP). According to her, LXP platforms maximizes a growth culture for employees and are a new trend that is proven to boost learning growth. Such platforms centralize learning contents, allowing employees to better interact with different types of training, by for instance a so-called Netflix-style. This style embeds artificial intelligence (AI) to personalize learning, by offering adjusted, interesting, and relevant materials based on the users' behavior and stated interests. To improve learning results, she proposes to embed gamification. Gamification involves the implementation of aspects such as competition, forms of teamwork and gathering points. This is a proven tool to increase learning outcomes and can help in creating a flexible setting with on demand accessibility, leading to higher satisfaction and improved learning outcomes (Ciuchita, et al., 2022).

Gamification is viable for influencing behavior and boosting innovation, as involving game mechanics enhances interaction, increases the element of fun, and activates users' motivations (Ciuchita, et al., 2022). Consequently, different studies show that improved customer participation trough a gamified experience increases the change of people reaching a state of flow in which they are strongly engaged with the studied topics (Oliveira, et al., 2021). According to Oliveira et al., literature has not yet shown evidence about which gamification elements should be used yet to increase flow, but states that gamification can help in facilitating personalized learning paths. This impact of individual learning accounts (ILA) on the learning culture is a topic evaluated in a study by Renkema (2006). By examining the effects of ILA in the Dutch technical installation sector, Renkema found out that individual learning accounts really suits this sector with respect to for instance elderly care. In addition, individual learning accounts help in creating learning dialogues with room for discussing developments.

Opposing to the conclusions of Oliveira et al., Chang and Wei (2016) suggests there is an understanding about gamification elements which improves the gamified experience in online open courses. According to their study, a few gamification elements account for over half of the engagingness, with as top elements implementing leaderboards which allows trainees to see their ranking with respect to acquaintances and developing milestones by creating for instance trophies and badges. Chapman and Rich conclude in a quantitative study that especially tracking progress is the most motivating aspect of gamification. Chapman and Rich (2018): "The four most motivating game elements were points for assignments, due date bonuses and penalties, due date flexibility, and current grade indicator. These game elements are related to autonomy, providing feedback for performance, and competency" (p. 317).

Ciuchita et al. (2022) employs in a literature review of gamification a framework to investigate the contextual nature of interactive systems. According to them, gamification consists of interaction between a person and an artifact in a social context. Because of this the activity can not be solely described by a subject (e.g., the learner) using an instrument (e.g., the mobile application) to reach an object (e.g., the learning goals), but should be

extended by adding social and contextual factors. Therefore, implementing the competition and cooperation effects for gamification is proposed. When considering a platform for e-learning in the energy transition, a whole class could be virtually rewarded when reaching certain objectives, such that people will be stimulated to help each other and cooperate. Besides that, leaderboards and online competitions can create social comparison dynamics and increases learning results.

A learning platform that really embedded the aspects mobile learning and gamification in their program, is Duolingo. As a major player in the field of specific e-learning they enabled learners to autonomously study a second language anytime or anywhere. When diving into the application, Shortt et al. (2021) identifies different gamification aspects, such as progress indicators (daily goals), feedback (correct/incorrect answer), fixed reward schedule (experience points), time-dependent rewards (streaks), customization (buying outfits for the mascot), challenges, knowledge sharing (forums), and a virtual economy (Lingots).

The application has an engaging mobile design, offers comprehensive information, is flexible in use, easy to access and users like the feedback on mistakes (Shortt, Tilak, Kuznetcova, Martens, & Akinkuolie, 2021). A case study by Loewen et al. (2019) showed that enabling learners to autonomously decide when and where to practice improves usage. According to the study learners generally experience the flexibility and gamification aspects Duolingo offers as positive.

5. Stakeholders

The desk review shed a light on the current problem of (re)training workers related to the energy transition and how blended learning could reduce the tension in the technical labor market. To develop this tool, the research is continued by offering an overview in which stakeholders of such a blended tool are represented. Information gathered during the field research is added to this overview, to give a more complete picture on the stakeholders. When supporting the energy transition education trough blended learning, focus should be on three groups of learners: young talent from secondary education who should be attracted and trained to work in the sustainable energy sector, lateral entrants who have work experience in other sectors and need to be partially retrained and lastly experienced personnel, who needs be retrained during their job. The content these learners need to be taught is determined and influenced by among others wishes from installation firms for which learners might work, rules and regulations of the government and technical installation guidelines of suppliers of technical systems. As the tool will be a combination of physical learning with an e-learning platform, also current vocational training courses, alternative training solutions and installation inspiration centers do have an interest in the development of this system. All these stakeholders are listed in figure 3.

Alternative training solutions	Competitors such as oZone (2022), Knowingo [ET05], Microsoft Teams [ET01], GoodHabitz [TE02], Aboma [TE04] and Lepaya (2022) are a potential tread in the field of online training solutions. They describe themselves as the learning platforms, in which oZone focusses itself on the technical sector in The Netherlands.
Central knowledge institutes	Scientific research agencies within the sector. Organizations such as ISSO (2022) are a central source for knowledge for the construction and installation sector. Their organizations collect and recent knowledge and developments within the sector.
Current Employees	Practically skilled employees who are already employed at installation firms need retraining.
Current Trainers	The people currently offering the physical trainings to learners.
Developer	Designers, technicians, coders and developers working together for developing this blended e-learning platform.
Government	The Dutch government has regulations regarding training and certification. In addition, they offer subsidies, partly together with the European Union, for tech developments.
Installation firms	Employment firms such as Breman and Feenstra need (re)trained staff for installing systems.
Installation inspiration centers	Installation inspiration centers such as Technische Unie Zwolle (2022) and Kiwa (2021) are examples of physical training locations. Here, technicians can work with hybrid heat pumps or hydrogen systems in a controlled environment.
Knowledge and education developers	Institutions currently developing resources for courses. This concerns textbooks, handouts, video's and other resources used for training purposes.

Lateral entrants	People interested or experienced in the technical sector, who might be of potential for re-training and employment at installation firms.
MBO training courses	Currently, (re)training is executed by training institutions such as IW Noord Holland, Vakschool Technische Installaties and ROC Amsterdam. These parties can implement a digital platform for blended learning purposes (van der Zee, 2021).
Suppliers of systems	These parties, such as Vaillant, Emmea and Intergas, have the knowledge about the to be installed systems. In addition, Nefit-Bosch (2022) offers her own online training modules, aimed at the professional technician who already has experience.
Technicians with experience	Current training is partly offered by technicians and workers with years of experience. According to learners, their way of giving tips and tricks is an important aspect of trainings.
WijTechniek	Collaborative organization of social partners within the installation sector, consisting of the employers' organizations Techniek Nederland and the NVKL, trade unions FNV, CNV and the Union. Conducts activities and projects related to training and development.

Figure 3. Table with the stakeholders related to blended learning in the Dutch energy transition education.

6. Field research

Current trainings in the installation sector consist of classroom-based education with high levels of physical meetings, personal guidance, and time-intensive collaborations. The desk study suggests improving the current situation by blended learning. Combining classroom-based teaching with digital platforms better aligns learning styles and teaching types. In addition, it enables technical trained people to be better align their training with their busy schedule, home situation and location. By making use of gamification elements in the digital system, learners can reach a state of flow and increase learning results. But how should such a system that enables blended learning to be developed?

Semi-structured interviews
To answer this question, a semi structured interview is set up, in which academics and professionals are interviewed on their view on digitalizing the (re)training processes in the energy transition. For the execution, 12 interviews were conducted with experts and experienced workers from the sector. The interviewees consisted of a mix of 2 academics, 6 managers responsible for training in the technical sector and 4 technicians working at installation companies. A more accurate description of the interviewees can be found in figure 4. This combination of people from different backgrounds in the sector has been carefully and deliberately composed, in order to develop a complete representation of the current situation. The academic can shed a light on current trends in digitization. Managers and experts from the sector talk about current bottlenecks that they experience within their course offer. In addition, they have a good idea of how the to be designed target can also be profitable, match the demand well and be realistically achievable. Finally, the technicians are ultimately the target group that will use the system. What are their views on current education? And what requirements do they set for a blended learning environment?

The conversation in which these insights were gained partly took place physically, but also majorly, due to logistic reasons, via Microsoft Teams. During the semi-structured interviews of 45 to 60 minutes each, a set of questions which is included in appendix A formed the guideline. However, the emphasis on certain questions differed per conversation. The reason for this is that the position from which the interviewee spoke greatly determined how much knowledge and experience they had on certain topics. For example, the academic could say little about detailed factors of current training, and technicians knew little about the potential of a blended learning system. All interviews were in Dutch, as this was the best way for the interviewees to express themselves. The transcribing and coding are also performed in Dutch. The conclusions and quotes incorporated in this study have therefore all been translated into English. Some criticism of the interviews may be that there is a large diversification between the topics discussed. This is partly due to the different expertise and backgrounds from which the people came.

The process of transcribing and coding
After the interviews were conducted, these were all transcribed. Content was particularly important in this conversion process, the way someone expressed him- or her selves less relevant for this type of study. That is why an intelligent verbatim transcription was chosen. Hesitations, stop words, half sentences, repetitions, and stutters were ignored. For the spelling of words, the official dictionary of the Dutch language is used [1]. As a follow-up to the transcription, the semi-structured interviews were coded via ATLAS.ti

[1] To be consulted via www.woordenlijst.org

software [2]. Since the main purpose of this is to better understand the data, line-by-line coding was irrelevant. That is why an in-vivo style of descriptive coding has been deployed. The aim of this was to reduce pieces of data from the interviews to a minimalist set of codes. This helped to transform all transcription into a highly dense matter of relevant data.

The type of coding can be described by a combination of structured and emerging coding. At first, a basis of codes was developed by a deductive approach. This framework with codes and themes was developed before the data reviews and is based on the existing research questions, the structured questions for interviewees as can be found in appendix A and the previous deployed literature review. This helped to quickly identify relevant data, while avoiding distractions and detours in the process. A disadvantage from solely approaching data from a structured set of codes, is that it prevents from gaining surprising insights. Therefore, the main findings are developed from emergent coding, also known as inductive coding. While reviewing the transcriptions and assigning codes, themes and codes have been added. This was a stimulation for discovering surprising things in the interview and gaining interesting insides. The major set of codes is developed by an inductive approach. Therefore, the findings lead to an emergent theory, such as described in the Gioia (2021) approach.

Interviewees

AC01.	An academia from the learning department at a technical university.
AC02.	Educational consultant focusing with a team on technology enhanced learning.
ET01.	Training coordinator at a major installation and maintenance firm of central heating and hot water equipment.
ET02.	Project manager education at a development fund for the installation industry.
ET03.	A project coordinator focused on developing and disseminating knowledge for construction and installation professionals
ET04.	National director of a Dutch educational institution in electrical and installation technology.
ET05.	Training expert at a technological test, inspection and certification company, focusing on digitalizing practical trainings.
ET06.	Unit manager at an inspection and certification institution and expert energy transition.
TE01.	Technician specialized in developing digital building information models. Recently attended vocational education in electrical engineering and is currently undergoing further training.
TE02.	Technician who as assembly coordinator supervises installation processes. Regularly follows (mandatory) training.
TE03.	Chief installer who is broadly oriented in fields such as electricity, water and security. Recently completed a retraining in project management and regularly follows (mandatory) training.
TE04.	Technician who as assembly coordinator supervises installation processes. Regularly follows (mandatory) training.

Figure 4. A table with the interviewees who participated in the qualitative research of this study (TE = Technician, AC = Academia, ET = Educational in the technical sector).

[2] To be consulted via www.web.atlasti.com

The results of the interviews are divided into two sections. A first theme that was discussed a lot in the interviews was the current view on training in the sector. The results from the interviews lead to a set recurring theme that form an emergent theory. This data structure of interviewees' view on current training processes, applied of Gioia's (2021) methodology can be found in figure 5. Due to conversations about the current status of training, many interviewees started on their own about digitization and the provision of training at times when it suits the learner. By asking the interviewees their views on this subject, a framework was developed based on the general view on deploying blended learning in the sector. This data structure of interviewees' view on the application of a digital system to enable blended learning can be found in figure 7.

6.1 Current view on training in the sector

The desk study already showed the inflow of new employees can be divided into employees from (other) sectors and young people leaving vocational studies. The field study shows that approximately 70% of the target group consists of lateral entrants, and 30% of so-called BOL'ers and BBL'ers [ET02]. BOL students follow full-time education and, depending on the year of study, must do an internship at companies for a certain period. BBL students combine learning with work, they have a full-time employment contract with an employer and usually follow a training course one day a week. According to ET02, lateral entrants are people who work elsewhere, outside the sector. They often follow a retraining or refresher course at an accelerated pace. This varies from people from healthcare without prior knowledge to people who have years of technical experience [ET02]. The interviews show that the target group who enters the sector as BBL, BOL or lateral entrant is between 22 and 25 years old and knows how to handle digital devices [ET01]. Moreover, several indicate that this group is not only capable of using digital systems, but see a combination of classical courses with digital solutions as a requirement for good education:

> *"(...) the younger, upcoming learners would like the combination and are much more used to being trained digitally. So somehow you just must do this in order to be relevant as a trainer."* [ET06]

Another group that, according to the interviews, receives a lot of training are employees from the sector. Partly due to rapidly changing technologies [ET02] and installations that are becoming more complex [ET01, ET02], there is an increasing need for further training. The interviews show that all installers must deal with training courses to, for example, update NEN certificates, learn new installation techniques and keep up to date with the requirements of the sector. It is expected that the amount of training courses due to political decisions in the field of making buildings more sustainable and installing sustainable energy installations will only increase in the coming years for current workers. This group of workers varies in age. Many of them are practically trained and regard the training as a disadvantage of their work. This target group reacts differently to the digitization of training. However, they all indicate that they would like to be able to better connect training sessions to their own preferences.

Profile of Target Audience

- Training new people in the sector exists for 30% of vocational students between 16 and 22 years and for 70% of lateral entrants mainly between 22-35 years. This group sees digitalization as a requirement for a good education and requires blended learning
- Further training of technicians is already happening and is expected to increase. This group of workers are practically trained, vary in age and react differently to the digitization of training. They are interested in better alignment of training sessions with their own preferences.

6.1.1 Positive experiences with training

Considering the positive experiences the target group has with training, three major themes can be distinguished: (1) meeting others, (2) interaction and practical assignments and (3) the use of digital tools. During the interviews it came very clear that technicians enjoy meeting others during training days. For them, meeting (new) people, visiting manufacturers and discussing present challenges is an important motivation for taking courses. The target group finds it very important during a training to feel heard. They need practical collaboration and a place to ask questions when they get stuck. Two installers from the sector gave good examples of the benefits of working together.

> *"What we also hear from our technicians and our customers, is that they enjoy spending one or two days in the group with fellow technicians. These are the people who have the same profession, have the same questions and want to learn. So, in addition to the fact that they learn something, they also find those collegiate contacts important."* ET04

> *"I personally like the interactive part in which you can consult with each other about things. I like that very much. Because then you also hear from others how they approach challenges. And how to deal with certain parts of the job. (…) I would allocate more time to better discuss the course content with each other, so that it is clear to everyone. I notice that often people only really understand the course content some hours after the PowerPoint presentation, when we talk about it together"* TE04

> *"Sometimes I'm modeling at the same time as someone else. Then you are on the phone for 1.5 hours and you also have the screen that he has on your second window. (…) It's nice that you do the same practice at the same time. It is than the same as if you are sitting together with someone."* TE01

In addition, technicians indicate that they generally have difficulty with presentations in which the instructor solely shares information, based on for example a PowerPoint presentation. They prefer to have more interaction and practical exercises during a course. A consensus is that training is best started with an explanation with a visualization, after which the technicians can immediately put it into practice, supervised by experts. This can be done by means of an installation exercise, but also by means of an online test, a collaborative assignment or a group discussion. According to managers, this method is already a proven, used method in the sector:

> *"In our training courses we work on the principle of visualizing, explaining and executing. For example, when setting valves. You first get a picture of the different types of valves and of the operation of the types of valves. Then our trainer gives a talk. After half an hour we walk to the workshop, where there is a setup for hydraulic balancing. Then he says to the mechanic: you heard it, get the schemes, go and set those valves."* ET04

The last theme that installers are positive about in current training courses is the use of digital tools. According to the interviewees, series of short videos, visualizations and e-learnings reduce the workload for trainers and helps to understand the course content in a shorter time frame. The study shows that this is already widely implemented in the sector and the experiments are ongoing. For example, software such as Knowingo ET05, Microsoft Teams ET01, GoodHabitz TE02, Aboma TE04 and oZone ET02 are used for e-learning. In addition, many companies use videos that can be found online via mainly YouTube or

develop them in-house. According to students, they have a better understanding of the material through these digital tools, and they would like to see this extended further. Moreover, they like that e-learning and videos allow them to watch material in a tailored pace and to pause or rewind if desired. Companies also notice that digital tools reduce the workload of trainers and can also reduce the amount of physical training. The large majority does indicate that a major improvement can be achieved in the field of digital products, the quotes below represent this.

> *"The e-learning and the videos must be well put together. That requires a high degree of professionalism from those who create and manage it. It's not something you do along your other activities."* ET01

> *"Many platforms still seem too simple. If you offer something digital, then only instructional videos or only reading pieces with solely three questions are not enough."* AC01

Positive Experiences with Training

- Technicians are generally positive about meeting others during courses. Interaction with others and being able to discuss content is major reason for following a course
- These people's best method for learning is to first understand the theory, preferably by visualizations. After this, people want to work with their hand and put it in practice by a test, practical exercise or group discussion.
- Interviewees are in general positive about the deployment of digital tools. Series of short videos, visualizations and e-learnings reduce the workload for trainers and helps to understand the course content in a shorter time frame.

6.1.2 Current training courses do not match demand

While discussing current challenges related to training, it becomes clear that current training courses do not fully match the sector's demand. This dimension on stakeholders' view on current training processes can be subdivided into three themes: (1) external restraints to training, (2) personal challenges in training and (3) industry's changing environment.

External restraints to training
While interviewing experts, it appeared that many companies limit further training to the essential or mandatory components. Education is not a priority at companies. Additional training in the field of upcoming installations related to the energy transition is often postponed. Even though the demand for these new installations is expected to grow rapidly, partly due to political changes, companies do not yet see the urgency. Two training managers in the technical sector give relevant examples of this:

> *"Say, you are now a technician for central heating boilers. Then you have enough work for the coming years. They are all fully booked. So, if you want to make that leap to the next generation of heating systems, you must invest. But because you're full, you don't really have the space for that. Because investing means not only spending money, but also losing capacity."* ET03

> *"The technical installation sector is a very traditional industry. Only when we really must, when the gun is pointed, we move on to something new and say goodbye to something old. (…) Many directors I speak to say to me: I am still this busy with those gas boilers, I have a shortage of staff, I really have the agenda full for the next 5 or 6 years with maintaining gas boilers."* ET04

This additional training has therefore not yet been followed often, and according to a project coordinator focused on developing and disseminating knowledge for construction and installation professionals, this is a problem, especially with the current staff shortages in the sector.

> *"If the current energy transition means that the stuff in a mechanic's van must change and his boss doesn't understand that yet, he will continue to perform the old, while the new is already possible. (…) Certain processes could be much better by using other materials, other processes and techniques. (…) Currently, we are wasting a lot of valuable, scarce resources of manpower on work that really shouldn't exist anymore."* ET03

According to a national director of a Dutch educational institution in electrical and installation technology, there is a major challenge in encouraging companies to follow these training courses. Because of thousands of entrepreneurs in the sector, with many freelancers and small companies, the sector should be more stimulated to further train and develop skills. In this it can encourage them to clearly inform them about upcoming demand and help them with the right choice of further training ET03.

> *"The biggest challenge now is not in the design, but in the operation of training. How do you ensure that entrepreneurs make a choice to have their employees trained? In this sector we see that the training intervention is almost always controlled by the boss. As long as the boss doesn't decide, it won't happen."* ET04

Personal challenges in training
Technicians indicate that they have difficulty following training courses. Part of the training group does not participate out of intrinsic motivation, because it is compulsory training for a certain position or because the employee just must follow it. A major challenge here is that the technicians experience a busy schedule, which makes it difficult to prepare for a training.

> *"Most guys start as early as 7 a.m. to 4 p.m. (…) They just want to go to swimming lessons with their children in the evening instead of going through another course and read a book for a course that is a few days later."* TE04

On top of the busy schedule, technicians indicate that full training days do not match their learning preferences. The students find it challenging to focus for a full training day. Often these training sessions are far away from where they live and work.

> *"During a course you get in the morning a course and around noon a repetition of previous days. In the afternoon you have an exam for two hours. The problem is you've been busy all day. In the afternoon you still must focus on an exam. If I could divide the lesson content myself, then we could take hours off in the morning. In that scenario, you can train in the morning. In that way you could schedule it yourself: 'I feel good now, let's take an exam'."* TE04

The target audience is generally training-aversive. The average learner likes to execute practical tasks and has for a reason chosen a profession where they could follow the training parttime to working. Finally, learners indicate that the lesson pace often does not match their skills. During training, it is striking that instructors often must adjust their pace to learners who do not yet understand the theory well, so that others spend unnecessary hours during the training.

Industry's changing environment
The desk research already shed a light on the rapid speeds in which technologies change in varying compositions. This advocates a need for continuous learning across the whole sector. Current knowledge about for instance heat pumps lays behind. Interviewees acknowledge this.

> *"The tasks for someone in the installation sector requires regular further training, because technology changes quickly. A boiler from five years ago is outdated, so you must keep up with that."* ET02

In addition to rapidly changing technologies, they also quickly become more complex. This creates an increasing demand for further training of workers. More skills from different disciplines are expected from installers and there is a growing requirement for soft skills. A training coordinator at a major installation and maintenance firm of central heating and hot water equipment who was interviewed gave as an example the thermostats which become digital.

> *"You can adjust the temperature via a thermostat, maybe you can set a clock program. It's not all that complicated for the mechanics. Soon there will be half a computer on the wall. For example, if I want to set up an air conditioning, installers must grab the manual."* ET01

To narrow this gap between current and required knowledge, training must be continuously updated and easily accessible. Interviewees indicate that this is difficult with courses that are followed once. Teaching resources get outdates and further training programs require to take special days off. Especially in BOL trajectories, where learners spend most of the week at school for several years, they notice that the lesson content lags what is needed for when these students leave school.

> *"In general, too many old-fashioned teaching materials exist, certainly within regular education, and I suspect also within curricula. (…) Photos of techniques of equipment and installations are out of date by 1.5 to 2 years. Then you must renew this content."* ET02

> *"Regular education lags four years behind, because it takes four years to train a new generation. In 2026, the obligation for hybrid heat pumps installations, or the changed laws for renewable energy, will apply. Everything that has entered from 2022 will graduate vocational education when that obligation applies."* ET03

Current training does not match demand

- Current training does not match the needs of technicians. Long travel distances, not aligned with busy work schedule, not in line with their learning style, outdated teaching aids and insufficient connection to existing knowledge are examples of practical problems they meet.
- Education is generally not a priority for companies. Their focus is on current projects rather than on long-term plans. Due to a busy schedule, it is difficult for technicians to retrain.
- It is expected that the work will change quickly. Techniques will become more complex, and installations will change rapidly. An increasing demand for training is expected.

6.1.3 An emerging demand for centralization

The interviews show that the sector consists of many thousands of small entrepreneurs, including many self-employed. To train people in the rapidly changing technologies related to the energy transition, it is important that the large majority is reached quickly and effectively. As an example, the entire industry needs to learn about CO legislation now [ET02]. Currently, initiatives in trainings are still very fragmented throughout the ecosystem. Today, instead of bundling strength, there has been an enormous fragmentation of commitment to blended learning. As a result, the body of knowledge has exploded.

> *"Currently, systems are emerging side by side, with their own networks, their own financing, their own entrepreneurs and their own stakeholders. (…) Partly because of COVID, we all needed digital learning very quickly and we all did it in our own way."* [ET03]

This fragmentation of systems is especially a challenge with respect to digitization. The interviews show that further digitalization or training takes a lot of time. In addition, many small companies have a lack of resources for developing trainings. As an example, one of the installation companies mentions that they are not able to develop an optimized training for only four students. Stakeholders agree that there is a major challenge in optimizing current learning systems. By tackling this challenge together, a higher efficiency may be achieved.

> *"I think the biggest challenge is the available time that the trainers have, because they are super busy. If you are going to do a blended design, it usually requires a large investment. Especially in the first year."* [AC02]

> *"In general, digital education requires much more time, especially in preparation."* [AC01]

> *"Now I view content generation as the biggest challenge, as that takes a lot of time. You must plan that time somewhere."* [ET01]

This joint development seems to be taking place within the sector now. There are quite a few hopeful standardization initiatives to identify. As an example, skills mapping is already performed centrally, and it is expected that the sector gets a centralized register in which individual competences and certificates are stored in a digital database.

An emerging demand for centralization

- The sector consists of many small entrepreneurs who don't have the resources to develop optimal training internally for the rapidly evolving technologies.
- Training resources and digital initiatives are fragmented throughout the ecosystem.
- There is a need for joint development, of which already some initiatives are taking place.

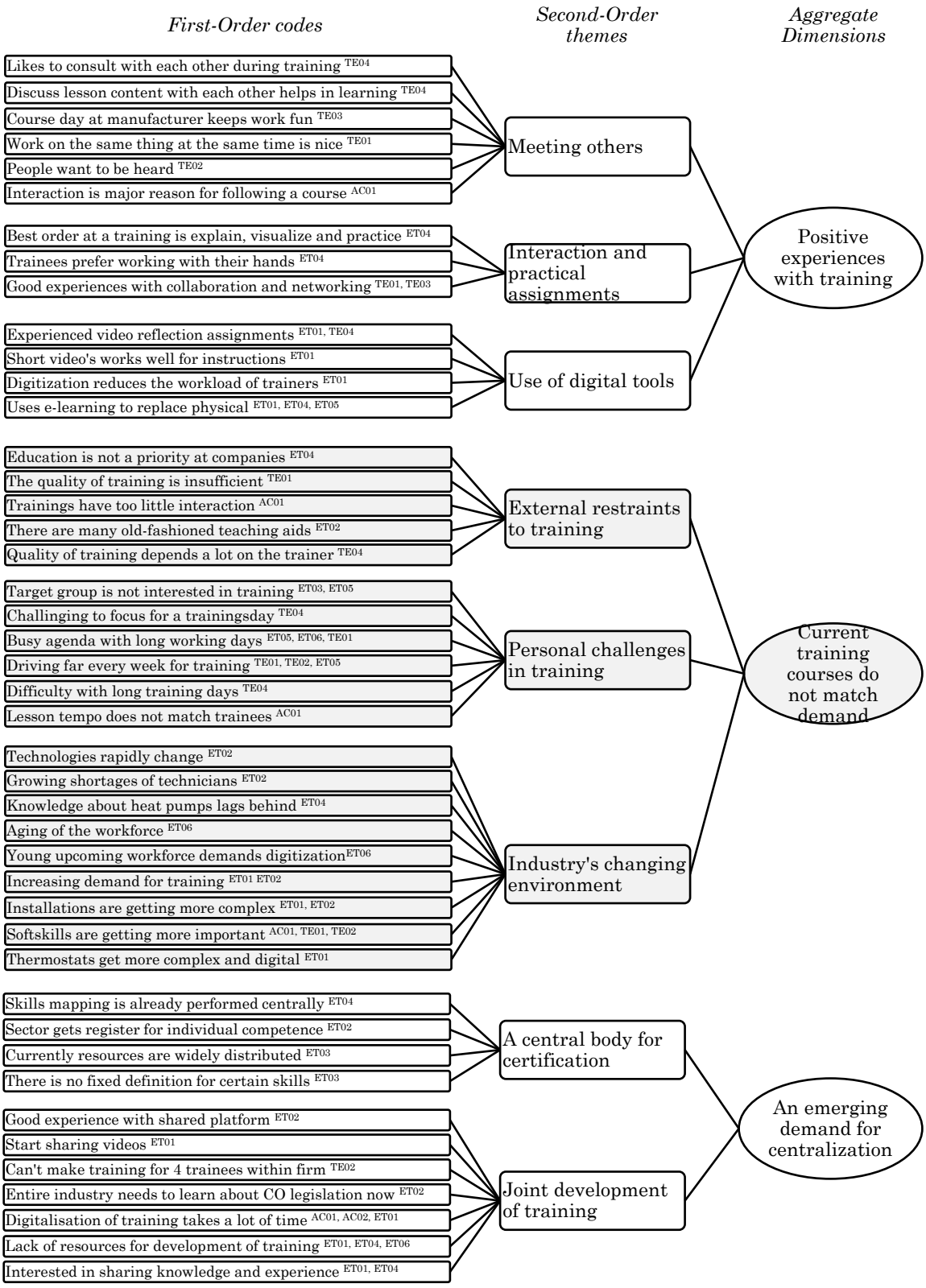

Figure 5. Data structure of interviewees' view on current training processes, applied of Gioia's (2021) methodology. The first order codes are conceived from the interviews and categorized in second-order themes and three aggregate dimensions.

6.2 View on deploying blended learning in the sector

The previous section suggests digitalization and blended learning as a possible solution for current challenges related to training purposes in the sector. While discussing the topic of blended learning in the interviews, the interviewees unanimously agreed that further digitization can have a positive impact on further training. Several reasons are mentioned for further digitization. Digitization can ensure that learners can follow training at their own pace and time, it can stimulate life-long learning and by further digitalization training can be made attractive for potential entrants to the sector.

> *"If you nowadays follow a practical course, you must take an exam immediately afterwards. There is a part that is missing that you can solve very nicely with digital means."* ET05

> *"My experience is that an electronic form is more attractive than a book or binder. (…) Current e-learning for the hydrogen training centra, for example, works very well. The students indicate that it is pleasant."* ET06

> *"As a result of governmental discissions related to the energy transition, the sector should be three times as large. That is why you must make maximum use of digitization and its advantages, in order to achieve the task within the time frame that we have."* ET04.

By asking the interviewees their views on deploying blended learning in the sector, a framework is developed. This data structure, which can be found in figure 7, shows that multiple dimensions seem to be a driver for implementing blended learning.

6.2.1 Emerging need for on-demand learning

The desk research already showed that processes currently exist of conventional, classroom-based education with high levels of physical meetings, personal guidance, and time-intensive collaborations. The field study confirmed this. The first driver for implementing blended learning that is identified is the emerging need for on-demand learning. This dimension can be subdivided into four themes: (1) learning optimized to trainee's wishes, (2) spending less time at training locations, (3) creating time for collaboration and practice and (4) reducing costs through improving efficiency.

Learning optimized to trainee's wishes
The field study already explained that current training courses do not match that demand. A major personal challenge for learners is that the course is not optimized to a person's situation. By enabling blended learning, the trainee can prepare the course theory before the planned training and keep its own time, place and pace.

> *"... I see that one starts a training with more baggage than the other. A trainer often spends an hour trying to catch up with those who come in with less luggage. The other thinks: an hour has now passed, and I have heard what I already knew. You can easily level that with forms of blended learning."* ET04

Technicians require spreading training throughout the week, which can be enabled through this. By varying the range of practice, video, interaction and resources and by adapting the course content to personal difficulties TE02, less time can be spent on the training, while maintaining the same output. An assembly coordinator who supervises installation processes suggests the industry will be interested in a type of training in which certain course content is optimized to a trainee's need, to achieve selective further training throughout the year.

> *"We organize training days at our workshop for starters. The technicians come to the headquarter at least once a month, where they all do exercises, additional training. They do this under supervision of the engineer on the construction site. He says for example: 'That boy needs some extra attention on one part'."* TE02

Spend less time at training location
At the start of a career in the sector, most technicians currently spend between 20% and 40% of the week on location for training. The interviews show that is still too much classical training, which can partly be solved by a trend called hybrid teaching.

> *"Currently there is a trend called hybrid teaching. This means that you provide education to a group that is on location, and at the same time to another group that is somewhere else."* AC02

But in general people have difficulties making time for training. Interviewees suggest offering the theory digital, so that they are prepared when they are attending a training. According to technicians, it often happens that certain learners master theory less quickly and less well, consequently a lot of time is spent on central presentations in which the theory is discussed. Because the quality of the instructor who presents varies, it often happens that a lot of unnecessary time is lost on sub-optimal theoretical training.

> *"People at our trainings are from different backgrounds, so we need an hour to level. One likes it, the other is annoyed. You can tackle these types of problems with*

forms of blended learning, with a different approach, with the use of digital resources." [ET04]

By offering the theory on-demand and adapting it to the learner's speed, time can be saved, and trainers won't have to attend physical classes as often. In addition, this allows the digitization to be optimally developed once, such that the quality of the content is better, and the learner needs less time to understand the teaching material. According to interviewees, this way the course content can also be learned on-the-job, thus reducing teaching time.

"In a five-day working week, they are outside with the van for 60% of the time. 40%, Two days, they are at the training location. Maybe I can reach 80%, so that only 20% is spend in the classroom." [ET01]

Free up time for collaboration and practice

The interviews show that the technicians and installers need practice and cooperation during training. The majority therefore indicates that cooperation and practical assignments are the most interesting aspects of training. Nevertheless, several interviewees say that too much of the training is still filled with theory. There is a consensus that the amount of theory can be reduced and replaced with practical assignments.

"The people who follow our courses, whether it is a lateral entrant or an experienced mechanic, wants to learn skills by doing it, smelling it, tasting it. (…) Our technicians learn by doing it in real life on a real device. These men also like to undergo training as a group of fellow learners. You don't reach that whenever everyone works on their own, from their own location" [ET04]

By offering the theory from a blended approach, in advance, the amount of training can be significantly reduced. The freed time can be used by the learner to independently carry out the e-learning. Or it can be made available to participate in projects of the installation company, which give the technicians more hands-on experience. The physical training days can be used for practical assignments and collaboration. As an example, by informing students that the training starts immediately with independently disconnecting a central heating system, students are triggered to follow the e-learning beforehand. In this way, added value can be created during the moments when learners are at the training center. Interviewees say that they have good experience with projects in which the student prepares the material in advance in this way, and the teacher walks around as a kind of coach during a practical session. The training coordinator of an installation and maintenance firm of central heating and hot water equipment already deploys this and told during the interview:

"One of the students had watched all the e-learning videos on his own. When he attended the first day of class, he immediately started with the last topic of the theory. He didn't know any actions yet, but he knew everything else. He asked questions that he couldn't have asked if he hadn't looked at the e-learning. (…) You notice during training that certain people grow exponentially because they do something about it at home, for example." [ET01]

However, this also leads to a changing role for the instructors. These instructors turn from lecturers who give a presentation to coaches who walk around and answer questions. The interviewees indicated that they like it when experienced technicians supervise and give

smart tricks that cannot be summarized in a presentation or e-learning. This role should be assigned to the trainer or supervisor.

> *"Your role as a teacher will also change. You will no longer be presenting lectures of one and a half hours, but you will focus much more on interaction with students. So, you provide more information in advance, such that you can focus more on practice, the social and the interaction during the physical moments."* AC02

Reducing costs and improving efficiency

The advantage of investing more in e-learning, is that courses could be almost infinitely scalable, as they will be less teacher and classroom dependent. The experiences with e-learning show that blended learning is effective with respect to traditional ways of teaching. Moreover, by reducing the necessary time for training, more time can be spent on billable projects of the firm.

On-demand learning

- Technicians require spreading training throughout the week. By preparing course theory before a planned training, learners can determine their own training time, place and pace.
- By adapting content to personal difficulties, less time can be spent on training, while maintaining the same output. Additionally, selective further training throughout the year via e-learnings can decrease overall training time.
- Vocational technicians and installers want to learn by doing. By offering the theory in advance through an interactive e-learning, more time can be assigned to collaboration and practice.
- As e-learning is easily scalable, it has the potential to reduce costs and improve efficiency for companies in the sector.

6.2.2 Enabling continuous knowledge acquisition

The emergent theory about interviewees' view on current training processes showed that the industry's rapidly changing environment is a major challenge in the sector. As an example, technologies quickly change [ET02], and thermostats get more complex and digital [ET01]. The conversations with both technicians as managers made clear that there is an increasing demand for continuous knowledge acquisition. The young upcoming workforce demands to use this content through digitization. The need for continuous knowledge acquisition consists of three under arching themes: (1) a need for lifelong learning, (2) a databank for on-demand information access and (3) an online community for collaboration.

Lifelong learning
The field study already highlighted the manager's view on the rapidly changing technologies. Installation instructions are generally outdated in 1.5-2 years and NEN standards change regularly. In an interview with technicians, it becomes clear that workers currently need refresher courses and additional information for certain jobs at recurring times.

> *"The work of someone in the installation sector requires regular additional training, because technology changes quickly. A boiler from five years ago is outdated, so you must keep up with that."* [ET02]

> *"We must follow several additional training courses from [company name], that is for the NEN. You must be constantly trained in the fire alarm system part. That is once in a few years. And then the simpler things; a retraining program, etc. (…) At a certain point you also must take a NEN1010 course, than you get the basics. There you learn to work with materials, to look it up. Once you've finished that, all you need to do is retrain. There you will be updated about the new things in the standard once every few years. Retraining is mostly covered in a day."* [TE03]

A large proportion of the interviewees indicate that they are interested in a digital variant of this, with the option of a refresher course. Often the retraining content consists of redundant information and the course does not connect well with already possessed knowledge. It seems interesting to them, for example, if they receive a reminder online that they can renew their certificate by means of an online webinar, short videos or an e-learning.

Databank for on-demand information
Moreover, technicians sometimes need a refresher for which they ask colleagues or consult the internet. Finding certain information online is not always easily accessible. Several firms already experiment with the use of an online database to offer relevant content in a dense manner via an online platform. Interviewees indicate that they sometimes need to review previous studies, want to quickly access instructions and solutions and therefore would like an online expanding bookcase with manuals, tips and tricks. A training coordinator supplements this with a practical example:

> *"A mechanic from Alkmaar, for example, has a lot of a certain cv-installations in his neighborhood. So, he's very experienced in that. We also have a branch in Arnhem [red: 1,5 hours driving], where there are maybe five of those installations. The moment there is a malfunction with that brand of appliance, you now send the experienced technician from Alkmaar there. But you could also make sure that he*

has made videos with tips and tricks about solving malfunctions on that device, which the mechanic from Arnhem can reach." [ET01]

Not only vocational installers benefit from this database. The managers themselves also indicate that they can make good use of this.

"Another important target group is formed by people who work at the office, as I have done. These are people who do their work by mouth, but they must know how to do the work on the field. If you don't remember exactly, it would be useful if you have software, a digital environment, where you can look around for a while." [ET06]

An online community for collaboration.
As said earlier, technicians want to ask questions and discuss challenges. Some say there might even be a need for an industry-wide discussion forum.

"It makes a lot of difference if you could keep coming back to such an environment, where you can continue to practice and where you have a chat function, for example, so that you can discuss" [ET05]

As an example, the existing online forums for challenges in other sectors could be considered. Online communities are used internationally to solve often technical problems within IT or construction. This approach, in which an open community helps each other and better connects the sector, can complement the current resources. There appears to be a differing opinion between those interviewed as to whether these communities should be kept within their own company, or whether this should be shared across the sector.

Continuous knowledge acquisition

- Offering refresher and update courses as a digital variant seems interesting to technicians. An online webinar, short videos or e-learning could be used to renew certificates.
- An online database with refresher courses from previous trainings and relevant content such as manuals, tips and tricks can help technicians in their daily activities.
- There is a need for discussion forums where work-related challenges can be discussed.

6.2.3 Interactive digital learning

An important aspect in the application of a digital system to enable blended learning is, according to interviewees, the interactive element of especially the digital system. The target group experiences long listening to or reading information without interaction as difficult. Some had bad experiences with inactive schooling. The average technician likes to work in a solution-oriented way and prefers to work with his or her hands. That is why interaction and discovery is very important in a digital learning system. The way in which the teaching material is presented must be varying and activating. Moreover, it is extremely important to apply interaction, especially in the case of more complex matter. Trial-and-error seem to be a good method for the target group to learn the material through discovery.

> *"It concerns a target group which is not always motivated to prepare at home. So, if you use e-learning, you really must do it in an interactive way, so that they are really engaged with the teaching material. We used to prepare with textbooks, but nine out of ten times that textbook is not read. That is why we at [Company name] are looking more closely at how we can offer more active teaching methods, e-learning, so that the students do it."* ET05

Explainer video is a proven method to make an e-learning personal and relevant. An instructor who gives short explanation videos and videos in which practical examples are shown can form the basis of an e-learning. According to interviewees, informative videos ideally last 60-120 seconds.
Animations and infographics can be used to explain a technical system or explain abstract concepts such as heat flows
Textual summaries can be implemented occasionally. It is advised to use this to a minimum, and to support it with audio.
Clickable photos in which highlighted aspects of a figure are clickable to discover the information of an image.
Quizzes trough which learners can check their skill level, the system can adapt the course content and supervisors can review the progress and skill level of the learner.
Sorting assignments in which the learner must link definitions or images to sections of text.
Simulations and virtual reality (VR) are a solution to show digitally realistic situations and to emerge a learner to relevant locations.
Fast-forward questions are a method to adapt the content level to the current knowledge of the learner. If the questions are answered correctly, the learner can proceed to the next part, without the need to review the information first.
Podcasts can be listened to in the van, a place where technicians typically spend some hours a day. It can be a spoken version of the information, or a more discussion-based format, where two people discuss a certain topic. This would give the possibility to combine the theory and the practical appliance.
A discussion area can aid in the wish to speak with people from the same field of work and enhance the social interaction
Separate explanation of terms will reduce the amount of text. By making the explanation of specific terminology optional for the reader, the amount of text for more experience learners will be reduced and hence enhance their speed.

Figure 6. A list with suggestions for the use of video, media and visualizations in e-learning for the technical sector

As the target group is generally visually oriented, the use of multimedia is an effective method of transferring information. According to the interviews, most prefer to use videos to understand instructions and currently, video is the main form of digitization. The younger generation in particular reads less and has a shorter attention span. The desk research already discussed the theme of gamification as a goal-oriented approach to train vocational people in a modern way. Figure 6 has been compiled based on desk research and interviews and provides a suggestion for types of resources that can be used to address the target group and to optimally deploy e-learning.

Both technicians and industry managers mention that it is important that the content learned is closely related to current work activities. In general, a learner is much more interested in course content if it is closely related to his or her current work. Moreover, practical examples make a course relevant and interesting. It is very relevant to place the systems to be learned in the right context, because installers often notice that installing a central heating boiler, for example, involves working in small, awkward spaces where you often must improvise in order to achieve the intended result. In a digital system, 360° photos and videos can provide a clear picture of the work context. According to managers, this will help to lower the threshold for learners to experience it in practice after this, because they have already become acquainted with the practical environment digitally. Managers suggest that people practice through e-learning, after which they immediately implement this in the field or in a practical location. They film this output and forward it to their supervisor, after which they receive feedback or get access to additional materials within the e-learning.

> *"You can achieve a lot with blended learning. I think a very interesting development are assignments where you must execute tasks, such as making a video of your work and submitting it. (…) So, if you want to make more use of short explanations via a film or animation, I see potential in that."* ET04

Interactive digital learning

- The target group prefers to learn in an interactive, solution-oriented way, where information is discovered through trial-and-error exercises
- Using of multimedia is an effective method of transferring information. By combining short fragments of teaching material via video, images, quizzes and assignments, an attractive e-learning can be developed. Figure 6 offers some examples.
- Content needs to be closely related to current work activities, by for example using 360° visuals and assignments where learners film their practicum

6.2.4 Creating an active interest in following training

It remains challenging to encourage the target group to learn. Companies feel no urgency to offer extra training and technicians themselves find it difficult to take time for further training. This study shows that further training is now mainly followed because it is required by the manager or company. But what if we could make training more attractive and stimulate people more? In order to make people learn, it is important to isolate them from their current activities. The desk research showed that this can be partially achieved by applying gamification to an e-learning. Interactive assignments, competitive elements and the use of visuals can help get the user into a state of flow, where someone is pulled from his or her environment. That is important according to interviewees.

> *"Our work and the sector are so hectic now. The discipline to spend 10 minutes every day on training preparation is almost impossible. (…) What you have to do with such a home training is really pulling people out of the environment."* [TE03]

In addition to the fact that people must be isolated from their environment by means of digital tools, it is important that the employer facilitates the training. By giving workers opportunities to take some time off, or to schedule the digital e-learning courses during the week, employees can be encouraged. In addition, incentives can encourage the worker to follow the training. The completion of an e-learning could be used as a milestone for admission to a physical training day.

> *"You register digitally, you do several assignments in your spare time or during working hours, you answer a few questions and with that you qualify to come to the two-day training courses. Only when you have completed those assignments correctly, your coach will say: 'Congratulations, you have qualified. You can now participate in day one of hydronic balancing, or day one of installing the heat pump. Because I now know that you have the required prior knowledge'."* [ET04]

For example, it could help if people were informed in advance that they must immediately connect a heat pump at the start of a physical training. Or if they could only participate in the training if they have obtained the online certificate via the e-learning. In the period preceding the training, they receive reminders for following the training via a mobile application or by email. This incentive can lead to people being more inclined to successfully completing the online training.

E-learning offers the possibility to provide more incentives, but moreover there is a general tendency among the interviewees that digitization makes training more attractive. Certainly, the new generations of learners have an increased need for digital tools. E-learning prior to physical training can lower the threshold for physical classes and training. Moreover, a digital learning system can be used to reach high school students to spark interest in the sector. And potential lateral entrants can test via an accessible online training how much additional training they need and whether this suits them.

Creating an active interest in following training

- Technicians needs to be isolated from daily activities in order to learn. This can be achieved via gamification and by employers facilitating time off for training purposes.
- Making the completion of an e-learning the admission of a physical training day is a much-suggested incentive.
- Appealing digitalization can spark interest in the sector and lateral entrants can use it to test their prior knowledge.

6.2.5 Developing a future proof learning ecosystem

The last dimension that has been discussed a lot in the semi-structured interviews is a growing demand for a future proof learning ecosystem. The industry's changing environment, together with an emerging demand for centralization, might be reasons to take the learning ecosystem within the technical energy sector to the next level. When designing a blended learning environment, there is a demand for a connection between parties. Currently, not all refresher courses are counted on your resume, and this is not kept centrally either. This takes away an incentive to take an interest in lifelong learning as technicians.

> *"Learning changes, how we as humans learn and the resources with which we can learn. As a result, we are increasingly able to make things that change our own at our own pace. It is only difficult that the infrastructure is not yet ready for this. Currently, everything you learn about the energy transition tonight doesn't count for your resume."* ET03

> *"Suppose you do something extra-curricular, or you have developed certain skills, in the future you'll get an online badge for that, so that you can show that you are proficient in it. This is mainly used for extra-curricular or lifelong learning. That is also something that comes up all the time."* AC02

The sector does not need an extra separate system for selective training but is more looking for an overarching infrastructure where training and credentials are gathered. The sector is currently developing a central database for registering individual competences. Registering these micro-credentials can help boosting lifelong learning but must therefore have industry-wide value. E-learnings, directly linked to this database, could even further innovate an ecosystem supporting lifelong learning.

In addition, centralization can also ensure that training programs can be further optimized. E-learning leads to increased efficiency and digitization helps in standardizing and optimizing systems, because it can be continuously refined and updated. By collecting data from students who follow the training, analytics can ensure that the programs are optimized.

> *"... what could you do with all the data you collect? For example, it says something about the success factors and about your study material. Suppose you have used videos; how many students have watched those videos? And did they watch it all the way through, or did they stop somewhere in the middle? These kinds of research could help a lot."* AC02

Developing a future proof learning ecosystem

- An online national infrastructure where training and credentials are gathered, can boost lifelong learning
- Centralization of online training enables further optimization via design cycles and data research.

Figure 7. Data structure of interviewees' view on the application of a digital system to enable blended learning, applied of Gioia's (2021) methodology. The first order codes are conceived from the interviews and categorized in second-order themes and five aggregate dimensions.

6.3 Challenges within the deployment of blended learning

The field study shed a light on the possibilities and opportunities that blended learning can offer. However, the interviewees also express concerns about further digitizing the system. First, developing a digital system is a major and complex challenge. Collecting and optimizing dynamic, professional content requires a lot of preparation and time. In addition, maintaining, updating and optimizing the platform is also a recurring cost item.

And, to what extent is it possible to further standardize current training towards a standardized digital system? Training courses on NEN standards and the new CO regulations are uniform and theoretical, so there will solely be few challenges associated with this. However, most training courses are more variable, while the number of participants in these types of training is lower. This will make it a challenge to find a good balance between professional training that is also financially profitable.

In addition, it is a challenge to continuously motivate learners to follow an online training. Interviewees expressed their concern that the digital skills of some professionals are low because they do not need it during their work. The vocational trained target group needs external incentives to keep their attention on a training, which is more difficult with an online system. Can the same learning efficiency be achieved if learners follow this on their own time, without a supervisor?

> *"It has been scientifically proven that watching a recorded lecture is much less effective than when you are in the room yourself. That has a lot to do with concentration, with the feeling of being seen repeatedly."* AC01

> *"You are dealing with a target group that is not always very motivated to prepare at home. (…) The danger with e-learning is and will always be that people have to do it in advance."* ET05

Currently technicians already have this reluctance towards conventional training. Yet they still attend training, because it is simply mandatory by their supervisors. In the blended learning environment design it will be a challenge to ensure that learners get an intrinsic motivation, as intrinsic motivation is worth much more than just the obligation from an external party.

Moreover, it is questionable whether companies will recognize the need for additional training by making learning blended. The field research showed that education is no urgency for companies, and that will not change overnight. And are companies willing to cooperate in the development of training? After all, they are each other's competitors. By developing training internally, they could have a competitive advantage. And if they are open to cooperation, why isn't it there yet?

> *"Some trainings are very strict. The sessions are offered digitally, but you will only get access to them if you have a good reason why you couldn't attend."* AC02

> *"The problem in our industry is a shortage of people. Shortage of education would be a luxury problem, which we can solve."* ET02

Several interviewees indicate that there is an irreplaceable need for classroom education. People prefer being together, which can't be achieved online. Full digitization has no potential, which is why blended learning is a mixed form of physical and online of training.

The classroom element is important to keep in touch with the learners, to organize practical assignments and to bring the best of both worlds together.

> *"The older technical man, in general, likes to physically attend a training. (...) The best way to learn something is in my opinion by practice, doing it with someone next to you."* ET05

> *"It is of course okay to use a picture, a short instructional video, an animation, an online lesson. But I do not believe that you can teach hydronic balancing trough solely a beautiful e-learning module."* ET04

> *"Interaction is very important in an educational setting. Make someone think, ask questions and respond to the answer. That is more difficult in a virtual or automated environment."* AC01

> *"Imagine that you must replace a hydrogen meter in the cupboard. If you only learn that virtually, you will not experience that the space is very small. You may learn that for instance a shoe can get in the way, but you don't experience hitting your head or elbow. (…) I personally do not see it happening that digital tools will take the entire practical training over. I do see an expansion of digital, especially in preparation and support."* ET06

An important next step of this research is a prototype with a test group. Only by starting and experimenting, it can be tested how blended learning can make a good contribution to the current ecosystem. This tool could be developed by the ADDIE approach, an implementation model in which development, implementation and evaluation repeatedly follow each other.

> *"It is exciting how it will be received by participants. Do they think it is attractive? In the beginning you must monitor a lot. You make something, you see how it works and whether it is watched. You ask for feedback, you recover, and you improve. That will be the biggest challenge."* ET01

7. Discussion

This research aimed on supporting (re)training processes in the energy transition. This finalizing section reflects on the questions and sub questions set in this paper and addresses the guidelines for a system that enables blended learning for technicians needing (re)training for carrying out their daily work activities. A combination of a desk review and 12 semi-structured interviews with academics, experts and technicians related to training processes and/or the energy transition shed a light on the current problem of (re)training technicians in the energy transition and how blended learning could help reduce the tension in the technical labor market. The findings of this result in a set of comprehensive guidelines for supporting the energy transition through blended learning.

Current research has so far not focused on specific training purposes related to the energy transition. This study offers an overview of existing literature on the topics of e-learning and blended learning in the energy transition. As a result, valuable literature has been collected to find a concrete set of guidelines that can help improve current education. Because this research focuses on the Netherlands and interviews several key stakeholders from the sector, it provides a representative insight into the market and the various interests at play. As the interview topics have not yet been discussed much by academics in countries like the Netherlands, the aggregated data of the respondents is innovative and an addition to the academic field. The outcomes of the research result in concrete guidelines on supporting the energy transition education through blended learning. These results can help further researchers as a starting point to develop an ecosystem or digital system for training, and organizations can use them as tools to improve current education.

The status of training and learning (Sub question 1)
The energy transition causes a growing demand for trained staff (ECN, 2016) and demands specialistic training within the sector (Weterings, et al., 2018). Due to the rapid speed in which technologies related to the energy transition change, the need for (re)training is expected to increase even more (Koning, Smit, & van Dril, 2016) However, the investigation on literature about the current status quo in the technical labor market shows a mismatch between what is needed by installation firms and what is offered by educational systems. The rising call for improving (re)training processes in the energy transition accounts for two types of new employees. Employees from (other) sectors and the young talent leaving vocational studies (ECN, 2016).

According to the interviewees, interaction with others and being able to discuss content is a major reason for following a course. Technicians' best method for learning is to first understand the theory, preferably by visualizations. After this, they want to work with their hand and put it in practice by a test, practical exercise, or group discussion. Current deployment of digital tools, such as series of short videos, visualizations, and e-learnings, reduce the workload for trainers and helps to understand the course content in a shorter time frame.

An investigation on the status of training and learning in the energy transition shows it is challenging that the targeted group of personal is generally hesitant to participating in retraining programs, leading to a shortage of inflow (Weterings, et al., 2018). As training processes exist of mainly conventional, classroom-based education with high levels of physical meetings, personal guidance, and time-intensive collaborations, it does not fully align with the target group's preferences (van der Zee, 2021). The emergent theory developed from the field study shows that long travel distances, busy work schedules,

differing learning style, outdated teaching aids and insufficient connection to existing knowledge are practical problems learners experience. Moreover, education is in general not a priority for companies. Their focus is on current projects rather than on long-term plans.

The interviews suggest it is expected that work will change quickly in the upcoming time. Techniques will become more complex, and installations will change rapidly. This rapid speeds in which technologies change in varying compositions advocates a need for continuous learning across the whole sector (Koning, Smit, & van Dril, 2016), leading to an increased demand for training. On top of that, the sector has an emerging demand for centralizations. The sector consists of many small entrepreneurs who don't have the resources to develop optimal training internally for the rapidly evolving technologies.

Designing an e-learning platform to enable blended learning (Sub question 2)
To better match energy transition education resources with the current wishes and needs from the sector, it is recommended to make vocational education more flexible, demand driven and tailored to employee and employer needs (Weterings, et al., 2019). For this a tool is needed that continuously responds to the developments in the energy transition and makes continuous learning accessible. This should be easy scalable and properly aligned to train employees with skills during their job (SER, 2018).

Studies suggest improving above mentioned challenges by blended learning, which embraces combining classroom-based teaching with digital platforms (Wong, Tatnall, & Burgess, 2014). Blended learning better aligns learning styles and teaching types and differentiates instructions (Kaur, 2013). When developing such a blended learning environment, studies suggest involving multiple factors. Environmental factors such as classrooms, virtual rooms, practice labs and interactive platforms should be developed such that it enables an asynchronous learning environment. Mobile learning platforms can help to enable such environments. The desk study concludes with suggesting implementing gamification elements that help learners to reach a state of flow. Leader boards and online competitions can create social comparison dynamics and increases learning results (Ciuchita, et al., 2022).

The view of leading firms on the deployment of blended learning (Sub question 3)
But what is the view of leading firms on the potential design for deploying blended learning? A field study consisting of semi structured interview with 12 stakeholders of the Dutch sector investigated the current view on training and the consensus of deploying blended learning to support education related to the energy transition. Several interviewees indicate that there is an irreplaceable need for classroom education. People prefer being together, which can't be achieved online. Full digitization has no potential, which is why blended learning is a mixed form of physical and online of training. The classroom element is important to keep in touch with the learners, to organize practical assignments and to bring the best of both worlds together.

Interviewees suggest there is a growing need for continuous knowledge acquisition. Offering refresher and update courses as a digital variant could be used to renew certificates. Moreover, an online database with refresher courses from previous trainings and relevant content such as manuals, tips and tricks can help technicians in their daily activities. By embedding discussion forums in a digital environment, technicians can discuss work-related challenges.

In addition, according to the interviewees it is challenging to continuously motivate learners to follow an online training. They expressed their concern that the digital skills of some professionals are low because they do not need it during their work. The vocational trained target group needs external incentives to keep their attention on a training, which is more difficult with an online system. It is questions if the same learning efficiency can be achieved when learners follow a course without a supervisor. Stakeholders suggest technicians needs to be isolated from daily activities to learn. This can be achieved via gamification and by employers facilitating time off for training purposes. Making the completion of an e-learning the admission of a physical training day is a much-suggested incentive. Also appealing digitalization can spark interest in the sector. Lateral entrants can use it to test their prior knowledge.

The field research showed that education is no urgency for companies, and that will not change overnight. An investigation on the view of leading firms on the deployment of blended learning shows a restraint for cooperation in the development of training, as they are each other's competitors. By developing training internally, they could have a competitive advantage.

Fostering missing capabilities via an (online) digital tool (Sub question 4)
To foster missing capabilities for firms in the energy transition that are lacking practically trained staff, it is suggested learners prepare the course theory before a planned training via a digital system. On this platform, they can determine their own training time, place, and pace. This content should adapt to personal difficulties. Figure 8 offers a digested list with proposed requirements for developing such an environment to support the energy transition education.

By offering the theory in advance through an interactive e-learning, more time can be assigned to collaboration and practice, which is important as installers want to learn by doing. The target group prefers to learn in an interactive, solution-oriented way, where information is discovered through trial-and-error exercises and where the content is closely related to current work activities. Using multimedia is an effective method of transferring information. By combining short fragments of teaching material via video, images, quizzes and assignments, an attractive e-learning can be developed. Figure 6 offers examples for types of media. By centralizing the system into an online national infrastructure where training and credentials are gathered, lifelong learning can be boosted. Also, this centralization enables further optimization via design cycles and data research.

Addressing the lack of specialized labor in the energy transition
The study shows that properly trained technicians within the energy transition are essential for maintaining the position in the energy transition the Netherlands has. There is an increasing need for developing a future-proof learning ecosystem. However, the training courses currently do not match the wishes of both companies and learners. As this is a growing problem, it is extremely important that academic research is conducted this early to identify challenge and set requirements for a solution. The study therefore suggests that transforming current practical training into blended learning processes helps in addressing the lack of specialized labor in the energy transition.

Limitations
A limitation of this study is that the research is limited to a selective group of respondents. It is advised to expand the set of respondents with extra installers from the professional field and stakeholders within the industry. In this way, the findings can be expanded, and conclusions can also be better supported with data. Moreover, it is important to further

investigate digitization of training within the sector, as the current set of requirements solely form the basis. It is advised to continuously supplement and update these requirements, with carefully considering the concerning challenges within the deployment of blended learning, such as discussed in section 6.3. Can these challenges be overcome? And how does this reluctance towards digital learning materials prevent the use of an e-learning system?

It is also advised to conduct further research into user-specific wishes for the blended learning set-up. The next steps are to further elaborate on the design requirements and to develop a first demo set-up of the system. In this way it can be tested in practice to what extent these theoretical findings are in line with practice. By means of the design, development and evaluation, a renewed training can be developed which better meets the wishes of the sector. In the beginning, a lot of monitoring must be done. This can be achieved by making a first model, seeing how it is received, asking for feedback, and adjusting. In addition, the challenge surrounding energy transition education cannot be solved solely by digitization and the use of blended learning. The problem should not be approached in that way. By viewing knowledge-gathering broadly within the sector as a larger process, in which digitization is an interesting topic for partly solving the tension, a new balance must be sought for training related to the energy transition.

List of Suggested Requirements

Enabling on-demand blended learning

- Course content is spread throughout the week. Learners can determine their own training time, place, and pace. Employers facilitate time off for these training purposes.
- Theory is digitally offered in advance through an interactive e-learning.
- By finishing the course, trainees qualify for attending a day on location.
- The physical training is near by the installer.
- The training alternates forms of coaching, collaboration, and practical assignments.
- Virtual rooms and interactive platforms enable an asynchronous learning environment.

Digitizing training and gamifying e-learning

- The e-learning is offered via both a web app as a native mobile application.
- The course majorly exists of multimedia. Figure 6 offers suggestions.
- Videos, images, quizzes, assignments, and other forms of interactive media provide a varied, interactive offer.
- The e-learning is divided into manageable chapters and paragraphs, in which the course content is divided into multimedia fragments of approximately 30-90 seconds.
- The content is closely related to current work activities, by implementing e.g., 360° visuals and assignments where learners film their practicum.
- The teaching material is goal-oriented and has a minimal amount of side information.
- Exercises in de training are interactive, solution-oriented and information is discovered through trial-and-error exercises.
- Leader boards and online competitions are implemented to create social comparison.

Personalizing learning content

- The content adapts to a learner's prior knowledge and difficulties.
- The e-learning offers selective further training throughout the year.
- Course content differs in learning styles and teaching types.
- The digital system includes refresher and update courses.
- An online database offers manuals, tips and tricks that help technicians in their daily activities.
- A discussion forum exists where work-related challenges can be discussed.
- An online webinar, short videos or e-learning can renew certificates.

Centralization

- The blended learning system is collectively developed by different organizations in the sector.
- Credentials for the course are registered in an online national infrastructure
- Repeating design cycles and data research continuously improve the system

Figure 8. A digested list from this research with proposed requirements for developing a blended learning environment to support the energy transition education.

Appendix A. Field study interview questions

1. Introducerende vragen voor geïnterviewde
   EN: Introductory questions for interviewee
   a. Wat is uw naam en wat is uw rol/functie waar vanuit ik u interview?
      EN: What is your name and what is your role/function from which I interview you?
   b. Hoe verhoud uw functie zich tot het thema '(om)scholing ter behoeve van de energietransitie'
      EN: How does your position relate to the theme of '(re)training for the energy transition'
   c. In welke activiteiten/thema's op het gebied van (om)scholing binnen de energietransitie' ziet u zich zelf als ervaren/expert
      EN: In which activities/themes in the field of (re)training within the energy transition' do you consider yourself to be experienced/an expert?
2. Vragen met betrekking tot het huidige (om)scholingstraject
   EN: Questions related to current (re)training processes
   a. Hoe zijn huidige (om)scholingstrajecten in de energietransitie vormgegeven?
      EN: How are current (re)training programs formed in the energy transition?
      i. Studieonderwerpen
         EN: Subjects of courses
      ii. Type studenten
         EN: Type of students
      iii. Trainingslengte
         EN: Duration of training
      iv. Personeelsintensiteit
         EN: Personel intensity
      v. Locatie
         EN: Location
      vi. Inzet van hulpmiddelen en digitale tools
         EN: Use of (digital) tools
   b. Welke aspecten in huidige (om)scholingstrajecten ervaart u als een waardevol/sterk en welke als een probleem/ uitdaging
      EN: Which aspects of the training process do you exerpience as valuable/good and with as a problematic/challenging
   c. Welke oplossingen ziet of overweegt u om deze problemen/uitdagingen te reduceren?
      EN: What kind of solutions do you consider to tackle these problems/challenges?
3. Bespreking van het onderwerp digitalisering
   EN: Discussion of the topic digitization
   a. Op welke manier denkt u dat e-learning kan bijdragen binnen deze sector?
      EN: How do you think e-learning can help in training?
   b. Op welke manieren wordt e-learning momenteel toegepast bij (om)scholingstrajecten?
      EN: In what ways do you include e-learning in (re)training of employees?
   c. Welke problemen/uitdagingen ervaart u momenteel bij het digitaliseren van trainingen?
      EN: Which problems and/or challenges do you currently experience regarding the digitalization of training?
   d. Welke elementen zijn essentieel voor een blended learning system?
      EN: Which elements would be essential in a tool that facilitates blended learning?
   e. Veel opleidingen leiden tot certificering. Op wat voor manier zou hier bij de ontwikkeling van een onlinesysteem rekening mee gehouden moeten worden?
      EN: Many courses lead to certain certification. To what extent should this be considered when developing an online system?

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