D3.3 Comparative report on change in VET profiles - In-depth studies of how VET adapt to changes in the work field.

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ABSTRACT

This working paper is divided into three sections with an introduction. The earlier report "*The Responsiveness and Proactiveness of VET – a comparative case study report of changes in VET on the occupational level*" (D3.2) gave an account of the findings of all the 17 comparative case studies on change in vocational profiles. However, this present working paper (D3.3) goes in-depth through sections with research papers that all develop further central themes from our research. Section 1 explores how three perspectives on vocational curricula are embodied in curricula in England, Germany and Norway. The three perspectives are a Skills perspective, a Holistic Occupational Competence perspective and a Capability perspective. The countries show some differences in the relative emphasis of the three perspectives in national apprenticeship standards for heating, ventilation and air conditioning (HVAC), with for instance the Skills perspective more evident in England. Context is important, leading to larger differences in actual training. The paper also makes a novel contribution by operationalising what a capability perspective may imply for curricula analysis. Section 2 compares the process of re-designing the health care worker/assistant nurse education from a school-based education to apprenticeship in Austria and Norway. We find similar underlying reasons for these transformations, as both VET systems aim to respond to changing recruitment practices and attract young people to the workforce. In Austria, sector-specific challenges have been the primary drivers of change, whereas in Norway, the

Skills2Capabilities, a Horizon Europe study, is about understanding how skills systems need to develop if they are to assist people to make labour market transitions – i.e. between jobs, employers or sectors – and thereby reduce the level of skill mismatch which might otherwise arise.

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transformation has occurred through a two-step process shaped more significantly by educational policies. Section 3 presents a case study of how the process of adapting the industrial mechanic apprenticeship standard to technological change has enfolded in Germany. The German governance system is consensus-based which can sometimes lead to slow adaption, but in this vocational field, we find that the social-partner led system has been able to respond rapidly to technological change, partly because a more dynamic practice 'within' formal procedures has been developed, without abandoning the broad competence approach. The case study will form a basis for a later comparative analysis of the three countries England, Germany and Norway.

ACKNOWLEDGEMENTS

This collection of research papers builds on analysis of apprenticeship standards, framework and curricula, and interviews with key experts and stakeholders within the field. We are indebted to all informants who have contributed to the study. Furthermore, country case studies were prepared in 2024 that provide an important background for these research papers. The following have contribute to the case studies: Tessa Pittrof, Jörg Markowitsch, Lynette Mayer, Klaus Lehner (3s), Emily Erickson, Terence Hogarth (IER, University of Warwick), Philipp Grollmann, Pujun Chen (TU Dortmund University), Daniel Neff (BIBB), Giorgio Brunello, Clementina Crocè, Lorenzo Rocco (University of Padova), Soorin Yoon, Jaeho Chung, Hanna Moon (KRIVET), Tove Mogstad Aspøy, Markus Roos Breines, Torgeir Nyen and Johan Røed Steen (Fafo).

Introduction

Both the work fields and the vocational education and training (VET) systems are changing amidst rapid technological, social and demographic developments. These transformations include the green transition, digitalisation, AI and ageing populations. All of them affect what skills and competences are needed in the work fields, which in turn influence the content of VET through changes in curricula or through students' exposure to tools, technologies and work processes. On the other hand, changes in VET programmes may also impact the work fields as companies will adapt to the training and skills students obtain through VET. Ideally, well-functioning VET programmes help structure the work field and increase the utilisation of skills.

How VET programmes are altered in response to work field changes depends on a variety of factors and vary between countries, sectors and work fields. These processes are not deterministic or predictable, but reflect the values underlying the VET systems, the decision-making rules for changing VET content and the agency of actors within the system, such as employer organisations and unions.

The Skills2Capabilities Work Package 3 project has been centred around studying these processes. By studying specific occupations, the project has compared how different countries and institutions modify VET standards to address transformations in these work fields. Our attention to occupations has demonstrated the heterogeneity within countries, where technological change has led to large changes in VET programmes in some qualifications, but not in others.

In the previous report in this series (D3.2), we gave a comparative overview of the responsiveness and proactiveness of different national VET systems and explored the relationship between work fields and VET qualifications (Breines et al. 2024). The report provided an account of VET content change and the processes that led to them based on 17 case studies in four occupations in six countries over a 20-year period. The countries were Austria, England, Germany, Italy, Korea and Norway. Overall, the analysis showed how national systems for adapting VET content work very differently. Three distinctively different approaches to VET change were identified: the direct responsiveness offered by employer-led systems like the English, the more mediated responsiveness of the German/Austrian social-partner led system, where change impulses are cushioned by consensus-based governance and an occupational conception of competence, and the state-led responsiveness of systems like Korea's where the government tries to develop new structures to influence VET and the work fields.

In the current report, we shift the attention to specific studies of different VET qualifications and present three working papers. We do this by analysing how understandings of competence and skills underpin national curricula/standards in specific occupations (section 1) and by providing more in-depth insights into the processes of changing VET qualifications, the conditions that influence these transformations, the resulting changes in curricula/standards and how these have been received in the work fields (section 2 and 3).

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Section 1 employs the capabilities concept in a novel way to curricula analysis. The paper analyses to what extent three distinctly different perspectives on competence; a skill-oriented, a holistic-vocational and a capabilities perspective, are reflected in apprenticeship standards/regulations in England, Germany and Norway. It complements the work done by Grollmann et al. (2025) in WP6 of the Skills2Capabilities project. We focus on how VET systems can support people in developing the capabilities they need to manage labour market transitions effectively and to live rich and fulfilling lives. By applying the capability perspective to curriculum analysis, the paper connects to the larger theme of Skills2Capabilites and how we understand the purpose of VET systems. The paper is written by Pujun Chen (TU Dortmund), Philipp Grollmann (TU Dortmund), Daniel Neff (BIBB) and Torgeir Nyen (Fafo).

Section 2 is a study of the introduction of apprenticeships in the training of health care workers in Austria and Norway. The countries have transformed school-based VET qualifications to either partly or fully include apprenticeship-based training, at different times, and the paper considers the motivations and processes for this change. It considers if the shortage of health care workers, ageing populations and concerns around the social inclusion of youth have contributed to the introduction of apprenticeships in VET health care qualifications in the two countries. Through this examination, we demonstrate significant differences between the countries and that the reasons for introducing apprenticeships are not solely about meeting current and future demands for labour. The paper is written by Tove Mogstad Aspøy (Fafo), Markus Roos Breines (Fafo) and Tessa Pittrof (3s).

Section 3 applies skill formation theory to the process of change in the industrial mechanic apprenticeship regulations in Germany. It gives an account of the major changes since the 1980s and highlights the agency shown by social partners in changing the programme, and even in changing the institutional procedures that regulate curricula/standards change for the industrial VET programmes. It pinpoints the institutional and historical premises for this. The paper is written by Philipp Grollmann (TU Dortmund), Daniel Neff (BIBB), Torgeir Nyen (Fafo) and Johan Røed Steen (Fafo).

Together, these papers illustrate that changes in VET programmes are shaped not only by the specific features of each national system. Instead, it emerges that they are also influenced by conditions in individual work fields and the different interests and power dynamics among the actors. These factors influence if and how government, social partners and other actors within that field act towards qualification reforms. In some cases, a degree of path dependence is evident, where present changes are only fully understood through an analysis of the historical trajectory that led to the present day.

The three sections/papers in this report are based primarily on qualitative methods. Researchers in each of the case-study countries interviewed key actors in the work fields and VET policy makers. Document studies have been used to analyse curricula and other written materials that give insights into the workings of the VET systems. Statistics have in some cases been used to identify trends and change over time. More information on data and methodology is available in each paper.

Recommendations

The key issues dealt with in Work Package 3 in the Skills2Capabilites project are how VET governance systems respond to rapid and profound change in the work fields, why change processes lead to certain results, and how the resulting VET profiles align with the work field. These are complex questions that are not amenable to straightforward policy recommendations. There are still some important findings that are of relevance to policy development.

Even though the formal structures of fairly well-functioning VET governance systems can be identified for the purpose of learning and emulation in other contexts, it is far more challenging to reproduce the actual beneficial practices within them. The successful workings of VET systems are not conditioned by skills policies alone but is contingent on a host of other factors. First, there must be actors willing and able to take a degree of collective responsibility in maintaining, updating and reforming VET profiles. Also labour market regimes, supply-demand of different types of labour, industrial relations and other factors that influence production, recruitment and training decisions are central. These impact the willingness and ability of actors to invest resources on the institutional level on standards and curricula change. And while some of these premises are national, many are not: the occupational-level studies conducted within Skills2Capabilities show great heterogeneity in how the VET systems respond to work-field changes, even within countries.

A key lesson from our previous report and this collection of papers is that any kind of policy or institution cross-country learning and development of practices requires an awareness of the underlying premises of their successful functioning (and whether these will work in the new context). For instance, a VET profile is better built on an already existing occupational understanding in a work field and cannot easily be created solely by skills or VET policy. VET policy can contribute to make relevant skills available to the labour market, but the conditions conducive for the acceptance of these profiles in the labour market and by youths seeking education are shaped elsewhere.

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Section 1

Vocational curricula in light of the capability approach: Comparative insights from three countries using the example of mechanics for sanitary, heating and air-conditioning technology

Introduction

Across OECD and EU systems, vocational education and training (VET) is undergoing profound restructuring processes driven by digitalisation, new work task profiles, and shifting governance logics. A narrow focus on task-bound skills has proven increasingly inadequate to guide curriculum reforms and to assess their quality (cf. Wheelahan & Moodie, 2011). In this context, a capability perspective can be particularly fruitful, as it broadens the evaluative space by asking whether VET actually expands learners' substantive opportunities "to lead the kind of live they value and they have reason to value" (Sen 1999, pp. 18) in work and life, rather than merely accumulating course hours, qualifications, or employability proxies (cf. Chiappero-Martinetti & Sabadash, 2014, pp. 207-209; Forcher-Mayr & Mahlknecht, 2019, p. 6).

This study builds on comparative VET debates that emphasise the necessity of complementing skill-centred logics with competence-based and capability-oriented perspectives when profiling occupations and revising curricula (cf. e. g. Bonvin, 2019; Bruin et al., 2023; Carvajal Muñoz, 2024; López-Fogués, 2014; Lambert, Vero & Zimmermann, 2012; Powell & McGrath, 2019a, 2019b; Wheelahan & Moodie, 2011). Accordingly, both the capability approach and the holistic occupational perspective can be regarded as alternative conceptions of competence to the skill-oriented perspective, each grounded in distinct theoretical assumptions.

The overarching research question guiding this inquiry in its overall project context[1] is: How do national institutions and procedures for modifying VET profiles address the ramifications of the digitalisation and transformation of work across selected occupations and work fields? By anchoring the analysis in the capability approach enables a conceptual shift from the mere cataloguing of amended skill sets to evaluating whether curricular revisions and their implementing procedures, especially within the initial vocational education and training field, are framed in a way to broaden learners' substantive opportunities (cf. Heckman & Corbin, 2016). This includes strengthening the conversion of curricular resources and institutional arrangements, leading to the identification of valued professional roles and activities such as adaptive problem-solving, ethical judgment, and collaborative agency.

[1] The research in this paper was carried out within the EU funded project „Skills2 Capabilities", https://skills2capabilities.eu/.

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This pilot analysis of vocational curricula from three countries – England, Germany and Norway – by using the capability approach is conducted from a multiple perspective: while taking into account the efficiency and alignment concerns of human capital theory, it simultaneously applies a human capability perspective in order to assess whether these procedures genuinely are suitable to expand learners' substantive freedoms to learn, to act, and to participate meaningfully across different groups and programmes.

Theoretical framework of the capability approach in VET

In this section, our emphasis lies on the translation of concepts from the capability approach into an analytical framework that can be operationalised for empirical curriculum analysis. The purpose is therefore not to provide an exhaustive review of existing competence concepts as they are formulated in German, English, or Norwegian curricular traditions. Instead, the contribution of this paper rests in adapting and applying the capability approach as a heuristic lens, which allows for a systematic examination of curricular content and its potential to expand learners' opportunities for capability development. This focus can be justified on two grounds: first, it provides a coherent theoretical language that transcends national terminologies of "skills" and "competence"; second, it offers a more fundamental perspective by moving beyond descriptive curricular comparison towards an evaluative framework that connects curricular intentions with learners' real freedoms to achieve valued functionings. By making this choice explicit, we aim to clarify both the scope and the innovative character of our approach.

VET and the capability approach

The capability approach (CA), initially formulated by Amartya Sen and further systematised by Martha Nussbaum, conceptualises well-being in terms of capabilities, understood as people's real freedoms to achieve valued functionings – that is, the beings and doings they have reason to value (cf. Sen, 1999; Nussbaum, 2011; Robeyns & Byskov, 2011; Saigaran, Karupiah & Gopal, 2015).

Building on Sen, Nussbaum distinguishes three types of capabilities: basic capabilities refer to innate faculties that make later development and training possible; internal capabilities denote developed, trained traits and abilities (such as skills, dispositions or self-confidence) typically formed through interaction with social, economic, familial and political environments; and combined capabilities designate the actual set of opportunities a person can choose from, arising from the interplay between internal capabilities and the surrounding institutional, socio-political and economic context (Nussbaum, 2011, pp. 20-25; Saigaran, Karupiah & Gopal, 2015). Combined capabilities thus correspond closely to Sen's notion of "substantive freedom", emphasising that abilities alone are insufficient unless institutions and structures enable their genuine exercise (cf. Sen, 1999; Nussbaum, 2011).[2]

[2] There is a certain correspondence between Nussbaum's the distinction of basic, internal and combined capabilities and the comptence concept from VET and cognitive psychology. Both also incorporate a match between internal dispositions and external tasks. The notion of holistic vocational competence comes close to the notion of combined capabilities but is mainly related to the vocational context of application.

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In line with this, CA insists on a means–ends distinction: resources, inputs, and formal entitlements are normatively secondary and matter only insofar as they can be converted – via personal, social and environmental conversion factors – into capabilities and ultimately into achieved functionings (cf. Robeyns & Byskov, 2011). Because these conversion factors vary systematically across individuals and groups, equal educational inputs do not necessarily yield equal capabilities or opportunities for learners (cf. McLean & Walker, 2016; McLean et al., 2020). Importantly, CA is not merely descriptive but a normative and evaluative framework for judging individual well-being, social arrangements and policy designs (cf. López-Fogués, 2016; McLean et al., 2020; Robeyns & Byskov, 2021). Drawing on Walker (2018), the capability approach enables analysis at the institutional level of the department, where pedagogical processes and professional curricula are concretely operationalised. Even when a curriculum has not been explicitly designed in capability terms, analysing it through a CA lens allows one to assess in different contexts which basic, internal and combined capabilities are fostered, which are constrained, and where capability-enhancing revisions of curricular aims, content and pedagogical arrangements may be warranted.

Applying the CA to VET

The CA provides a flexible evaluative lens to analyse whether VET curricula and institutional arrangements genuinely are suitable to expand learners' capability sets. As Bonvin (2019) highlights, the CA shifts VET research "beyond human capital" by conceptualising education not merely as an investment in future productivity, but as an expansion of substantive freedoms to lead meaningful professional and personal lives (pp. 275-278). In this way, the CA offers both a complement to and a critical distance from human capital theory: while recognising education's productive effects, it also accounts for intrinsic values such as dignity at work, social participation, and agency (cf. Chiappero-Martinetti & Sabadash, 2014, pp. 210-213).

Multiple levels

At the curricular and pedagogical level, the CA emphasises the importance of how knowledge, skills, and competences are structured and delivered. It draws attention to the process through which curricular content is translated into individual abilities such as problem solving, reflective judgement and collaborative action (cf. Lambert et al., 2012, p. 166; Wheelahan & Moodie, 2011, pp. 25-28). While this focus resonates with broader debates in vocational education, it is important to distinguish it from parallel conceptual traditions. Brockmann, Clarke, and Winch (2011), for instance, do not situate their argument within the CA but develop a holistic occupational perspective. From this vantage point, vocational qualifications should be evaluated not only in terms of narrow skill acquisition but also with respect to their potential to provide learners with broader occupational knowledge and a sense of professional identity (pp. 42-45). This line of reasoning complements the CA in that both perspectives offer critical alternatives to human capital approaches, while originating from distinct theoretical traditions.

At the institutional level, the CA directs attention to the procedures and governance structures that shape profile revisions. Powell and McGrath (2019a) stress that curriculum change must be understood as a process embedded in institutional arrangements that can either enhance or constrain learners' real freedoms (pp. 22-24). Their subsequent work (2019b) claims that orienting

VET towards capabilities rather than employability alone provides a more coherent and social justice framework, ensuring that learners are not reduced to labour market units but recognised as agents capable of shaping their futures (pp. 379).

Finally, at the socio-economic level, the CA situates VET and occupational standards within broader opportunity structures. Carvajal Muñoz (2024) shows in the context of training policies for vulnerable groups that a capability perspective uncovers the structural barriers that prevent individuals from converting educational inputs into real opportunities (pp. 1153-1159). In comparative VET research, this is particularly relevant, as similar reforms can have highly uneven effects depending on national institutions, training pathways, and labour market contexts (cf. Mulder, Weigel & Collins, 2007, S. 73).

Multiple perspectives on curriculum

Curriculum theory traditionally distinguishes between three analytical layers at which educational content and meaning are defined and enacted – the intended, implemented, and realised curriculum (Goodlad, Klein & Tye, 1979). This threefold distinction provides a useful lens for linking macro-level policy design with institutional practices and individual learning experiences. Within the present paper, the focus lies primarily on the intended curriculum and its conceptual alignment with the Capability Approach (CA).

The intended curriculum refers to the officially prescribed aims, contents, and structures of learning formulated by policymakers, qualification authorities, and curriculum designers. It expresses what learners are expected to know and be able to do and conveys the social, economic, and pedagogical purposes assigned to education systems. In the light of the Capability Approach, the intended curriculum defines the range of learning opportunities formally available to learners and institutions — that is, the potential freedoms designed into the system. These formally defined opportunities constitute the framework of educational options within which individuals may later exercise agency. The present study therefore analyses how these options, as formulated in national curricula, can be conceptually interpreted through the lens of the Capability Approach, in particular how they shape the space of potential capabilities made available to learners. Focusing on the intended curriculum allows the paper to examine how the normative and structural design of vocational curricula aligns with the CA — that is, how curricula formally articulate educational opportunities, valued capabilities, and human development aims. This provides a conceptual foundation for subsequent analyses of implementation and learner outcomes in future phases of research.

In sum, the capability approach offers VET research a multidimensional analytical framework that complements rather than replaces established perspectives such as the holistic vocational competence (HVC) approach. While HVC has traditionally emphasised the integration of technical, social, and personal competences within occupational practice, the capability approach introduces an additional focus on the extent to which curricula, pedagogical practices, and governance arrangements create real opportunities for learners to convert formal learning outcomes into valued capabilities. In this sense, the capability approach enables an assessment of curricular and institutional arrangements in terms of their potential to expand learners' capability

sets, thereby providing a broader analytical perspective on the conditions under which professional agency and adaptability in rapidly changing work environments can be developed.

Conceptualisation of the capability approach for curriculum analysis

The categories of the curriculum analysis framework differentiate between content-related and context-related dimensions based on the Cedefop's Analytical Framework for Comparing VET (2013). This distinction aligns with the core concepts of the capability approach (cf. Forcher-Mayr & Mahlknecht, 2019; Robeyns & Byskov, 2011; see Figure 1): content-related dimensions are associated with functionings and capabilities, whereas context-related dimensions correspond to conversion factors.

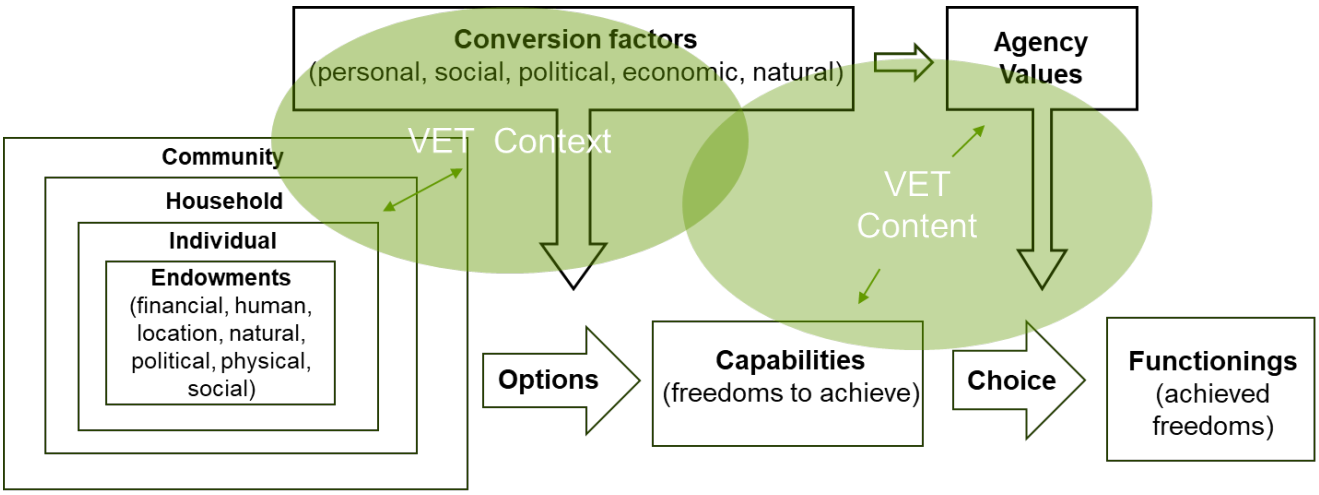

Figure 1.The capability framework (based on Forcher-Mayr & Mahlknecht, 2019, p.21)

The content-related dimension in the framework is structured to allow for a layered analysis of VET content. This layered perspective distinguishes three analytical levels: first, the immediate learning outcomes expressed as skills, which reflect specific task-bound functionings; second, the integrative competences that capture the complexity of vocational practice and professional judgment; and third, the broader potential for learners to develop capability sets that enable them to pursue valued life and work trajectories. By making this differentiation explicit, the framework establishes a continuum from narrowly defined performance outcomes to wider opportunities for personal and professional development. Brockmann et al. (2011) distinction between skills and competences, combined with the capability approach's differentiation between functionings and capabilities (Robeyns & Byskov, 2011), provides a coherent conceptual basis for operationalising these categories in curriculum analysis.

The first category, **Skills (S)** in curriculum, captures the extent to which curricula specify and organise discrete technical or occupational skills. In the context of the capability approach, skills are the fundamental components of potential functionings: they represent the instrumental means that learners need in order to achieve valued outcomes in work and life.

The second category, **Holistic Vocational Competence (HVC)**, reflects a multidimensional understanding of vocational practice that goes beyond the mastery of technical skills (cf. McGrath,

2007, pp. 229-230). In VET discourse, HVC is conceptualised as the integration of cognitive, social, and reflective dimensions into occupational action, enabling learners to perform complex tasks in a responsible and context-sensitive manner (cf. Syverstad & Kristiansen, 2024, p. 111). While this notion has its own conceptual lineage within VET research, it also resonates with the language of the capability approach insofar as it captures higher-order functionings. From a capability perspective, HVC can be viewed as encompassing not only the ability to execute tasks, but also the freedom to apply knowledge and skills flexibly within evolving work processes, to adapt to new requirements, and to collaborate meaningfully with others.

The third category, **Capabilities Development (C)**, explicitly connects VET curriculum analysis to the core of the capability approach. While the preceding category of HVC focuses on learner's comprehensive ability to act responsibly and autonomously within occupational contexts, the capability perspective extends the analytical lens beyond professional domains. Skills and competences, even when holistically integrated, remain tied to employability and occupational performance. Capabilities, by contrast, emphasise the expansion of learners' substantive freedoms to pursue lives they have reason to value (cf. Chiappero-Martinetti & Sabadash, 2014; Robeyns & Byskov, 2011). In this sense, the capability approach highlights that the value of education does not only reside in its instrumental contribution to human capital and employability but also in its role in enlarging learners' agency, aspirations, and opportunities for participation in social, civic, and personal spheres (cf. Chiappero-Martinetti & Sabadash, 2014). Under this category, VET curriculum can be analysed in terms of the opportunities they provide for fostering critical thinking, personal development, resilience, citizenship, and lifelong learning etc.

Context of the study

England, Germany and Norway were selected to maximise institutional variation while holding occupational domains constant. England exemplifies a liberal, market-based, employer-led VET regime; Germany represents a paradigmatic collective skill formation system organised around dual training; and Norway constitutes a Nordic hybrid with a 2+2 school–apprenticeship model and strong cross-curricular aims such as citizenship and sustainability. Bringing these three types into one analytical frame makes it possible to investigate how capability-oriented elements are inscribed into vocational curricula under contrasting governance and coordination logics, while the same occupational fields serve as a common reference point. The selection is further justified by feasibility considerations, as the research team has embedded expertise and secure access to authoritative curriculum documents in all three countries, which is a recognised precondition for rigorous qualitative curriculum analysis. The following section will provide a basic overview of the curriculum framework for initial VET in these three nations.

Curriculum framework in British initial VET

The relevant curriculum documents for the English part of the study are occupational standards and apprenticeship standards. Occupational standards specify the knowledge, behaviour and skills deemed required for a particular occupation (but do not constitute a legal requirement). Occupational standards provide the foundation for apprenticeship standards, the latter which will

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also include assessment procedures (EPAs) not found in occupational standards. In our study, training for the selected occupations is normally delivered through apprenticeships, so there will be relevant apprenticeship standards related to the occupational standards.

Formerly the Institute for Apprenticeships and Technical Qualifications were responsible for overseeing and managing occupational standards and apprenticeships standards. This authority has recently (2025) been transferred to a new governmental institution called Skills England. Hitherto, both types of standards have been developed by so-called "trail-blazer" groups of employers who volunteer to create and maintain a given standard, but whose composition can vary from year to year. The role of trailblazer groups reflects the English government's goal of an employer centred system. When developing standards, there are formal procedures for how trailblazer group collect information from other stakeholder at various stages in the development process, including formal consultation around drafts. The final version needs to be approved by Skills England. The apprenticeship standard standards are often formulated at a general level, which while intending to be prescriptive, is also leaving some room for discretion for companies and training providers to adapt training to local needs and capacities.

Curriculum framework in German initial VET

The overarching curriculum framework of the curriculum in German initial VET is organised around the dual principle of learning at two coordinated sites – company and vocational school – under a federal-state governance architecture. Legally, company-based training rests on the Vocational Education and Training Act (*BBiG*) and the Crafts Code (*HwO*), while school-based provision is governed by state school laws. Coordination is institutionalised through the Federal Institute for Vocational Education and Training (*BIBB*), the Standing Conference of the Ministers of Education and Cultural Affairs (*KMK*), and the social partners, producing a stable yet adaptive regime that combines standardisation with responsiveness to the needs of specific sectors (cf. Frommberger et al., 2024).

In principle, the intended and implemented curriculum is guided by two national programmatic documents that are jointly developed and deliberately interlocked. For the company side, the federal government issues a training regulation (*Ausbildungsordnung*) for each recognised occupation. It prescribes nationwide standards: the occupational profile, a time-structured company training plan (*Ausbildungsrahmenplan*), assessment requirements, and the training duration – usually two and a half to three and a half years. For the vocational school side, the KMK adopts a framework curriculum (*Rahmenlehrplan*) for the same occupation. Since 1996, framework curricula are structured by the action-oriented "learning fields" (*Lernfeld*) that integrate professional knowledge with typical work tasks in designed vocational learning situations. These two national programmatic documents are drafted in parallel under a long-standing federal-state coordination procedure (KMK, 1972), with explicit cross-referencing to ensure that learning fields and company training sequences align in content and pacing (cf. Frommberger et al., 2024).

While the KMK framework curricula establish binding national standards, the practical responsibility for implementation rests with the individual federal states. At this level, the national

framework is operationalised into state-specific syllabi and time allocations, thereby maintaining nationwide comparability while enabling moderate regional adaptation, for instance, in the weighting and sequencing of learning fields (KMK, n. y.). Chambers of commerce and crafts function as competent authorities overseeing company-based training quality and the conduct of qualification examinations, whereas vocational schools are responsible for the didactic realisation of the curriculum through learning-field-based lesson planning and context-sensitive training arrangements (cf. Frommberger et al., 2024). Overall, the German VET curriculum operates within a dual logic: it is prescriptive in defining national outcome and assessment standards, yet simultaneously contextualised through decentralised interpretation and school-level implementation, thus balancing coherence and flexibility within a multi-level governance framework.

Curriculum framework in Norwegian initial VET

Most of Norwegian VET is based on a combination of school-based training followed by apprenticeship training in a company. Most VET follow a 2+2 model. This means that a vocational student spends two years at vocational school and then enter apprenticeship which lasts two years. There are variations of this, for instance plumbers follow a 2+2,5-model and automation technicians a 3+2 model, but all follow this sequential principle, apart from a few purely school-based educations such as pharmacy technician which has a 3+0 model with no apprenticeship training. The first school-based years are divided into vocational subjects (*programfag*), common core subjects (*fellesfag*) and vocational specialization (*yrkesfaglig fordypning*) with a designated number of hours for each of the three parts. Apprenticeship training is not similarly divided into parts with a designated number of hours.

The content of Norwegian VET is regulated by national-level curricula which guide the education and training provided by schools and companies. The legal status of curricula are regulations pursuant to the Education Act. The latest revision of the curriculum framework was implemented starting from 2020. The curriculum framework relevant to VET consists of the general overarching curriculum common for all primary and secondary education, which states the basic principles and values underlying all education, and separate curricula for each part of vocational education and training. For the school-based years it means that there are separate national curricula for vocational subjects in year 1 and year 2. There are also national curricula for each common core subject, such as mathematics, Norwegian etc. in vocational education. For vocational specialisation while at school, each school develop a local curriculum within a frame of national principles. For apprenticeship training, there is a curriculum for each apprenticeship or occupation. This means that for a given occupation, for instance industrial mechanic, there are altogether three vocational curricula that we study, the first-year school curriculum, the second-year school curriculum and the apprenticeship curriculum that applies to the third and fourth year (provided that the occupation follow a 2+2 model).

All vocational curricula follow a structure decided by the Directorate of Education. This includes learning outcomes, relevance and core values, core elements, basic skills, a set of cross-curricular elements and assessment. The content of curricula is formulated by curriculum development

groups which for vocational curricula would normally include members from the relevant industry. Formal authority to decide curricula lies with the Directorate of Education, but social partners wield influence through ten Vocational Training Councils at the national level, one for each vocational programme. There is a degree of flexibility for schools and companies to adapt within curricula, among other reasons because curricula are based on learning outcomes allowing variations in activities. The final practical-theoretical test and assessment after apprenticeships are organized by occupation-specific assessment committees in each country, normally consisting of experienced skilled workers within the relevant industry.

Methodology

This study employs qualitative thematic content analysis in the tradition of Kuckartz (2019) to reconstruct meaning structures in curriculum texts while preserving context, polysemy, and cross-national comparability. The approach combines a deductive category system (see part 2 of the theoretical framework in this paper) with iterative, data-driven refinement during coding and memoing. This enables transparent category application and, at the same time, sensitivity to country-specific formulations and latent meanings that would be flattened by purely quantitative techniques (cf. Kuckartz, 2014). To secure intersubjective traceability, the analysis is guided by a coding manual specifying category definitions, decision rules, and anchor examples. This follows established guidance on coding guidelines and their role for coder agreement and process transparency, thereby supporting both replication and subsequent descriptive quantification of code frequencies for comparative purposes (ibid.).

We purposefully sample national-level curricular documents (see Table 1) for three occupational fields that are both highly standardized and widely offered across Europe, and that are saliently exposed to labour-market transformations through digitalization and related restructuring of work: (a) *Mechanic for sanitary, heating and air-conditioning technology* (HVAC), (b) *Nursing* (assistant nurse), and (c) *Industrial Mechanic*.

For each country we include the intended curriculum at the national level as follows:

Table 1. Data sources of this study

Country	Intended curricular sources (national)
Germany	Framework curriculum (*Rahmenlehrpläne*) and federal training regulations (*Ausbildungsordnungen*)
England	Occupational standards, occupation summaries, and end-point assessment specifications
Norway	National vocational curricula (*læreplaner*)

This configuration facilitates an analogical analysis of nationally authoritative curricular texts that articulate occupational profiles, learning outcomes, and assessment regimes at system level. Consequently, it provides a robust basis for subsequent cross-country analysis of profile change under the pressures of digitalisation and related structural transformations. In line with the

project's framing, the analytical focus lies on how institutions and procedures manage change in VET profiles and whether a narrow skills orientation is being superseded by broader holistic vocational competence approach and/or capability-oriented perspectives. Against this background, the selection of the exemplar occupations can be justified not only because they make visible the tension between skills, holistic vocational competences and capabilities, but also because they fulfil further criteria of relevance: they are numerically significant, widely offered across countries, and comparable in terms of their curricular delineation. In addition, each of them is subject to large-scale changes in the respective work fields. Industrial mechanics and HVAC are strongly affected by technological innovation and digitalisation, and nursing is undergoing profound reconfiguration under the pressures of demographic change, which often results in processes of task shifting and re-assessment of occupational roles.

The analysis applies Kuckartz's six-phase workflow for qualitative thematic content analysis (2014, 2019), adapted to curricular documents. Using a coding book with theoretically derived main categories (S, HVC, C), the process combines deductive framing with inductive refinement, ensures full corpus coverage through iterative coding cycles, and concludes with matrix-based cross-case comparison to capture national differences and patterns in curricular articulations of skills, competences, and capabilities.

The team relies on the shared coding guideline, periodic coder-calibration sessions using multi-country exemplars, and explicit recording of decisions in a research log. The complete category system (with rules and anchors) is made available as an appendix to meet transparency criteria for internal credibility and external transferability.

Presentation of primary findings

This section presents the primary findings[3] from the comparative curriculum analysis of the vocational programmes *Plant Mechanic for Sanitary, Heating and Air-Conditioning Technology* (Germany), *Refrigeration, Air Conditioning and Heat Pump Engineering Technician* (England), and *Refrigeration/Heat Pump/Ventilation/Electronics* (Norway). The results demonstrate how the capability approach can be systematically operationalised to analyse the intended vocational curricula together with the two other perspectives (skills-oriented/human capital and holistic vocational). The findings are structured according to a category-based analytical framework that reflects the theoretical and methodological design of the study.

In the first sub-section, the results integrate both the content and context dimensions for each national case, showing how the curricula vary in their emphasis on task-specific skills, holistic competence orientations, and capability-enabling elements. In the subsequent sub-section, these

[3] Coding was carried out by two researchers and one trained student assistant after discussions about the application of codes to text segments. While this has increased the intercoder reliability of the coding procedure, the present findings should be understood as exploratory, serving primarily to demonstrate the feasibility of applying the capability approach to curriculum analysis. A systematic assessment and consolidation of intercoder reliability can be carried out in subsequent stages of the research.

national findings are examined comparatively, enabling a deeper discussion of the convergences and divergences among the three countries in terms of their curricular emphases and capability-oriented potential.

Primary findings in each national case

The comparative analysis of the three national curricula demonstrates marked variations in how different content dimensions are embedded within the respective curricular documents. Yet, a converging tendency emerges in their shared aspiration to integrate capability-oriented elements with vocational skills and competences. The structuring of content fluctuates between narrowly task-related skill acquisition, the development of integrated vocational competences, and curricular provisions aimed at fostering broader, transferable capabilities. In all three cases, the curricula specify technically defined learning outcomes, though these differ in the extent to which they are situated within authentic work processes, encourage reflective engagement, and connect to wider societal aims (see coded anchor examples in Table 2).

Table 2. Comparative thematic matrix with coded anchor examples in curricula from England, Germany, and Norway

Category	England (examples)	Germany (examples)	Norway (examples)
Skills (S)	"*...test, charge with refrigerant and commission vapour compression systems*"; "*perform routine service, maintenance, fault diagnosis and rectication procedures and techniques on electrical and electrical control systems ...*"	"*They put the gas system into operation, check the function of all system components and adjust the output of the heat generator.*"; "*manufacture components with machines according to design, technological and quality specifications*"	"*...build and programme a product ... consisting of a microcontroller, analogue circuits, sensors and actuators*"; "*...install and commission a small-scale renewable energy production and storage system...*"
Holistic vocational competence (HVC)	"*...communicate with others... adapt their style... apply collaborative working... to promote teamwork and solve mutual problems*"; "*apply project leadership and work organisation principles*"	"*...select a suitable [equipment]... create material lists, check interfaces with other trades*"; "*present the finished equipment to the customer, explain how to operate it and provide care instructions*"	"*...carry out systematic troubleshooting,*"; "*find solutions in co-operation with others and manage differences of opinion*"

Category	England (examples)	Germany (examples)	Norway (examples)
Capability development (C)	"*…reflect on their own practice and seek CPD [continuing professional development] opportunities*"	"*…to develop learning techniques and learning strategies and to use these for lifelong learning*"	"*…express what they feel they have mastered and reflect on their own professional development*"

(a) Skills (S)

England – Skills

The English occupational standard for the *Refrigeration Air Conditioning and Heat Pump Engineering Technician* (RACHP) codifies "skills" as a tightly bounded set of task verbs, each aligned to typical RACHP work processes.

"Skills" embedded in the analysed English curricular document are predominantly oriented towards the safe, compliant, and standardised execution of occupational tasks within a specialised domain, encompassing the *installation*, *maintenance*, *commissioning*, and *decommissioning* of vapour-compression systems.

Germany – Skills

Germany has specified the required "skills" for the federal training occupation of *Plant Mechanic for Sanitary, Heating and Air-Conditioning Technology*[4] through the training regulation and its framework curriculum in the context of vocational schools. One explicit example of this can be found in the § 9 exam-field "Supply engineering" (*Versorgungstechnik*) of the training regulation. Candidates are required to demonstrate skills such as the *use of technical documents*, the *planning of work steps*, and the *determination of work equipment*. Moreover, the § 12 exam-field, entitled "Customer order" (*Kundenauftrag*), provides additional explicit evidence of the skill orientation in a customer-order context: "*plan and implement work processes… systematically identify, localise and rectify faults and malfunctions… use device-specific software*," thereby coupling hands-on techniques with order processing and device-specific software use.

In harmonised school learning fields, the work-process logic is reflected when learners engage in tasks such as "*installing drinking water systems*," which encompass calculations, documentation, testing and acceptance protocols. Here, skill is conceptualised not as the performance of isolated techniques, but as the conduction of integrated activities within a complete business process.

[4] Anlagenmechaniker Sanitär, Heizung und Klima. The abovementioned is the translation from the official Europass Supplement. The jobs in this occupation usually target installations in buildings. „Plant" refers to technical facilities/systems here.

The prescribed learning fields (*Lernfelder*) within framework curriculum define skills via activity-systems tied to typical occupational situations and customer orders, blending tool-handling and calculation with planning, documentation and reflection. In Learning Field 1, the objective is explicitly defined as "*doing*", situating performance within a production process: "*The students have the competence to manufacture components according to design, technological and quality specifications ... [they] select suitable tools ... and carry out the machining work under health and safety regulations*." In Learning Field 5, the scope extends toward applied system work: "*Students have the skills to plan, construct and install domestic drinking water supply systems... carry out appropriate calculations ...*".

Across learning fields, many skill statements remain concrete and technical (e.g., "*install heat distribution systems*," "*carry out hydraulic balancing*," "*commission gas systems*"), yet they are consistently framed by order processing, customer interaction and system optimisation, shifting "skills" from isolated procedures to task-clusters within authentic processes.

Norway – Skills

Norwegian curricula articulate "skills" as compound task-sets that integrate installation and measurement with programming, digital diagnosis and energy performance reasoning. Typical formulations embed digital control and sustainability in the action verbs: "*install, programme and commission demand-controlled systems for lighting, heating and various power outlets and discuss the energy savings of the selected control system*," and "*install and commission a refrigeration and heat pump system and assess the energy efficiency of the installation*."

In curricular document of *Ventilation*, the skills language remains operational but widens to cyber-physical integration and verification: "*assemble and install ... sensors, adjust actuators and controllers to optimise process performance*," and "*carry out energy assessments of ventilation systems by measuring temperature, pressure and power consumption and calculating specific fan power and temperature efficiency*." Even the foundational electronics curriculum encodes "skills" with explicit programming-and-build requirements (e. g. "b*uild and programme a product... consisting of a microcontroller, analogue circuits, relevant sensors and actuators*"), signaling a curricular baseline in which skill means technical execution fused with digital configuration and measurement literacy.

(b) Holistic vocational competence (HVC)

England – Holistic vocational competence

The English curricular document conceptualises holistic vocational competence (HVC) through the triadic structure of *knowledge, skills, and behaviours* (*KSBs*), designed to elicit integrated performance in authentic professional contexts, and the design of end-point assessment. However, this integration is primarily operationalised through assessment-driven mechanisms. In the *Refrigeration, Air Conditioning and Heat Pump Engineering Technician* standard, apprentices are required to maintain an "*apprenticeship development journal synopsis*," in which selected evidence is systematically mapped against the KSB framework. This portfolio is complemented by

a professional discussion intended to demonstrate the integration and reflective understanding of competences, thereby making explicit the expectation that learners curate qualitative and contextually grounded evidence.

Within the practical assessment, holistic competence is exemplified through a complex, task-based scenario: "*The apprentice must perform a change of refrigerant on a system operating at −18 °C and +4 °C.*" This task demands the application of multiple forms of knowledge and skill – *conducting a risk assessment*, *performing calculations using pressure-enthalpy diagrams*, *isolating and testing the system*, *commissioning and documenting processes*, and *optimising performance*. Such an integrated requirement reflects an intention to simulate authentic workplace demands, where technical precision, safety awareness, and procedural accountability converge.

In addition, the standard explicitly includes behavioural and collaborative dispositions as integral components of vocational competence. Apprentices are expected to "*communicate with others… adapt their style… apply collaborative working… to promote teamwork and solve mutual problems*," and "*apply project leadership and work organisation principles*." These formulations indicate that interpersonal, organisational, and self-regulatory competences are conceived as integral, not ancillary, dimensions of vocational competence.

Environmental responsibility is also embedded, as apprentices must "*adjust the operating parameters to achieve a reduction in carbon emissions*." Technical optimisation is thereby directly linked to broader societal objectives, positioning environmental awareness as a normative element of vocational professionalism.

Germany – Holistic vocational competence

The German framework curriculum aligns HVC with a broad definition of *competence to act* (*Handlungskompetenz*), which is regarded as the overarching educational goal of initial vocational training in vocational schools. It is described as the "*willingness and ability to act thoughtfully and responsibly in professional, social, and private contexts*." Instruction is consequently guided by the pedagogical principle of *action orientation* (*Handlungsorientierung*), which requires learning processes to mirror complete, realistic work tasks. Learners are thus expected to "*independently plan, execute, and evaluate work activities*," drawing learning directly from authentic work processes that reflect all stages of professional practice.

This competence orientation is concretely embedded in the learning-field structure of the curriculum, which mandates occupationally realistic learning tasks involving *planning*, *documentation*, *communication*, and *client interaction*. For instance, in the field of sanitary room equipment, learners are required to "*select a suitable [equipment]… document their plans, create material lists, check interfaces with other trades, verify*" and to "*present the finished equipment to the customer, explain how to operate it and provide care instructions*." This sequence demonstrates the interconnection of technical expertise with reflective judgement, coordination, documentation, and customer communication – core indicators of holistic vocational competence.

Furthermore, the curriculum explicitly links occupational responsibility to wider societal goals. Learners in plumbing-heating-air-conditioning occupations are expected to "*consider buildings as integrated energy systems*," "*advise clients on energy efficiency and renewable technologies*." These formulations combine technical proficiency with ecological awareness and ethical responsibility, highlighting the multidimensional nature of competence.

Finally, the federal training regulation complements the curricular framework by emphasizing integrative capacities such as "*planning and monitoring work processes, evaluating results, and managing customer-oriented orders*." These requirements illustrate that holistic vocational competence is not confined to school-based instruction but is systematically embedded across both learning venues of the German dual system – school and enterprise – reflecting a coherent and practice-based approach to competence development.

Norway – Holistic vocational competence

Norway's vocational curricula embed the notion of HVC throughout programme objectives, core elements, and assessment criteria, consistently linking technical proficiency with cognitive, social, and ethical dimensions of professional action. Across curricular documents, the emphasis lies not merely on the execution of occupational tasks but on their contextual understanding, reflective justification, and collaborative enactment.

In the *Electronics* curriculum (first year), for instance, students are expected to "*plan, carry out, assess and document tasks related to electronic circuits and networks, individually and in co-operation with others, and justify the choices made*." This formulation combines technical implementation with reflective reasoning and teamwork, thereby transcending a narrow skill-based orientation. Teachers, in turn, are instructed to evaluate "*how the student demonstrates understanding, ability to reflect and think critically, and how they master challenges and solve tasks in different contexts*," underscoring that competence development includes interpretive and adaptive dimensions alongside practical mastery.

Similarly, the *Refrigeration and Heat Pump* curriculum (second year) foregrounds "*system understanding*" and the capacity to make informed professional decisions. Learners are required to "*install, programme, adjust and function test*" control components and to "*carry out systematic troubleshooting*," while demonstrating the ability to "*find solutions in co-operation with others and manage differences of opinion*." Here, competence entails not only technical control but also communication, problem-solving, and negotiation.

The *Ventilation* curriculum (third and fourth year) illustrates integrative orientation even more prominently, as it explicitly connects vocational learning with processes of identity formation, ethical reasoning, and sustainability. Its overarching objective is defined to "*develop independent skilled workers… build up learners' occupational identity and ethics… through critical thinking, ethical judgment and reflection [they] make responsible choices*" concerning resource use and environmental considerations. This direct invocation of reflection situates learners as capable professionals who can act responsibly within and beyond their immediate work contexts. Moreover, the curriculum mandates that apprentices "*risk assess, plan, carry out and document*" their work

according to company control systems, "*train operating personnel*," and "*propose measures to improve energy efficiency and air quality*." Particularly notable are the clauses requiring learners to "*document their own work, assess working methods, suggest improvements and reflect on possible changes*." This institutionalises processes of self-evaluation and continuous improvement as constitutive elements of vocational competence rather than optional add-ons. While such provisions are not exclusive to the HVAC curriculum, they exemplify a broader curricular trend across vocational programmes, where reflexive and metacognitive competences have been increasingly emphasised in recent years.

Explicit formulations have been developed which link reflection, ethics and collaboration with technical expertise. These formulations establish a coherent curricular embedding in which reflective agency is central to competence development. This orientation is further reinforced by the curriculum's assessment guidelines, which state that "*learners demonstrate and develop competence in ventilation engineering when they apply knowledge, skills and critical thinking to solve tasks in the programme subject*." Thus, Norway's curricular documents operationalise holistic vocational competence not as an abstract ideal but as a concrete, assessable concept to act knowledgeably, collaboratively and responsibly in complex professional contexts.

(c) Capability development (C)

England – Capability development

In the English occupational standard and the corresponding End-Point Assessment (EPA) for *Refrigeration, Air Conditioning and Heat Pump Engineering Technicians*, capability development is articulated through the triadic structure of "knowledge, skills and behaviours" (KSBs). These KSBs function as both evaluative and developmental categories that extend beyond the mastery of technical procedures toward the formation of professional, ethical, and reflective practitioners. The EPA thus establishes professional responsibility, ethical awareness, inclusion, well-being, and continuous learning as fundamental prerequisites for sustainable and adaptable vocational practice, rather than as supplementary competencies.

Apprentices are required to demonstrate how they "*apply ethical principles*," "*support an equitable, diverse and inclusive workplace*," and "*report unethical behaviour*." These provisions connect occupational functionings to moral agency and civic participation, thereby extending the scope of vocational competence beyond technical proficiency. While moral agency could arguably be classified under HVC, we interpret its explicit integration as an illustration of the capability approach's added value. Furthermore, the inclusion of requirements such as identifying "*issues, symptoms and warning signs related to stress, anxiety and depression*" and describing "*how to access sources of help*" integrates health-related capabilities into the conception of vocational competence. This acknowledges personal well-being and resilience as intrinsic components of professionalism rather than perceiving them as extrinsic conditions.

Reflectivity and self-directed growth are also central. Apprentices must "*reflect on their own practice and seek CPD [continuing professional development] opportunities*," articulating how they "*keep up to date with industry developments*." Environmental and sustainability-oriented

capabilities are explicitly codified as well. Apprentices are expected to "*comply with environmental and sustainability regulations*" and, at a distinction level, to "*explain how their compliance contributes to reducing the environmental impact ....*"

Finally, the EPA's behavioural descriptors – such as being "*team-focused*," "*taking responsibility for work*," "*acting ethically*," and "*prioritising health and safety*" – translate participation, accountability, and ethical agency into observable and assessable indicators. Thus, the framework broadens the scope of employability, adopting a broader view of human capability. In this view, technical performance, moral reasoning and social responsibility are considered key aspects of capability development.

Germany – Capability development

Germany's framework curriculum for the occupation of *Plant Mechanic for Sanitary, Heating and Air-Conditioning Technology* integrates the language of capabilities within both the educational mandate of vocational schools and their underlying competence model. The educational mandate obliges vocational schools to foster "*vocational and cross-occupational competences*" that enable learners "*to help shape the world of work and society in a socially, economically, and ecologically responsible manner,*" while simultaneously promoting "*lifelong learning*" as well as "*professional and individual flexibility and mobility*." In this sense, capability development is conceived not merely as a functional adaptation to labour market demands but as a formative process oriented towards responsible agencies and sustainable participation in social and economic life.

The competence model complements this vision by defining "self-competence" as the ability "*to formulate and develop life plans*," highlighting "*independence, critical judgment, and self-determined commitment to values*." This conception corresponds closely to the capability approach's central concern with practical reasoning and the freedom to design one's own life trajectory. Similarly, "learning competence" is described as the capacity "*to develop learning techniques and learning strategies and to use these for lifelong learning,*" thus embedding meta-cognitive self-regulation as a transversal competence that extends across occupational and biographical contexts.

Beyond immediate occupational preparation, the framework explicitly encourages "*perspectives of different employment including self-employment in order to support self-responsible career and life planning*." Consequently, it articulates an institutional commitment to the development of agency and professional autonomy that transcends narrow employability paradigms.

When considered as a whole, Germany's framework curriculum conceptualises capability development as a process of *Bildung*-like formation (cf. Andresen, Otto & Ziegler, 2008). This integration of self-authorship, social responsibility, and durable learning-to-learn capacities into the fabric of vocational education and the cooperative relationship between school and enterprise is a distinctive feature of the curriculum.

Norway – Capability development

The analysed Norwegian curricula embed the development of capabilities as an explicit and structuring principle across programme rationales, cross-curricular themes, and assessment frameworks. Vocational learning is thus conceptualised not merely as the acquisition of occupational skills, but as the systematic expansion of learners' agency, judgement, and participation in work and society. In the programme of *Refrigeration, Heat Pump and Ventilation Technology*, for example, students are expected to become "*independent with the ability to take initiative, cooperate and contribute to an equal working life regardless of gender and culture*." Such aims link vocational competence to ethical and civic responsibility, framing vocational action within broader commitments to equality, sustainability, and informed participation.

This capability orientation is operationalised through three interdisciplinary themes: *public health and vitality*, *democracy and citizenship*, and *sustainable development*. The first highlights the development of "*mastery and pride in one's own work and having confidence in one's own resources*." The second frames democracy and citizenship through "*active student participation*" with "*knowledge and understanding of … how working life is structured…*." The third defines sustainable development as an ethical capability, requiring learners to make responsible choices and to reflect on environmental dilemmas and resource use.

At the assessment level, capability development becomes a concrete pedagogical practice. In the Electronics curricular document, teachers are instructed to assess "*understanding, reflection and critical thinking,*" while students are given the opportunity to express "*what they have mastered*" and to reflect on their own professional development. These provisions institutionalise meta-cognition and self-assessment as integral elements of learning.

Taken together, the Norwegian curricula do not treat capabilities as abstract aspirations but as systematically embedded learning outcomes and evaluative criteria. Through their integration in curricular goals, cross-subject themes, and assessment practices, they make the expansion of practical freedoms – ethical, civic, and environmental – an institutionalised expectation of vocational education. Learners are thus positioned as reflective and responsible agents whose professional formation encompasses not only the mastery of tasks but also the capacity to reason, to participate, and to act judiciously within complex and changing work environments.

Primary findings in comparison

In presenting the results of the curriculum analysis, the findings indicate that all three countries integrate task-bound skills, holistic vocational competence, and broader capability development into their VET curricula. Yet, they do so in different ways, often producing hybrid forms in which skills, holistic competence orientations, and capability-enabling elements intersect.

Across the curricula in countries, "skills" are consistently defined as observable and assessable actions tied to occupational artefacts, procedures, and systems. In the English framework, the formulation of skills emphasises accessibility and compliance, resulting in a highly fragmented structure of narrowly defined, task-specific statements (e.g., charging, decommissioning). Such descriptions conceptualise skills primarily as measurable outputs within specialised roles. In contrast, the German curriculum, structured around work-process-oriented learning fields, re-

integrates these fragmented tasks into coherent procedural sequences. Here, skill elements often combine tool operation and technical calculations with planning, documentation, and quality assurance embedded in workflows. This integrative framing extends the notion of skills beyond mere technical execution toward the development of holistic vocational competence. The Norwegian curriculum further expands this orientation by linking installation and commissioning tasks with programming, data acquisition, and energy analysis, explicitly orienting skills toward digitally mediated practice and sustainability-related reasoning. While all three systems define skills as means for effective action, the English skills-approach restricts them to narrowly bounded operational tasks. In contrast, the German and Norwegian curricula situate them within broader work-process or contexts, thereby enlarging their transformative potential into holistic vocational competence.

All the analysed curricula of England, Germany, and Norway also integrate elements that enable the development of learners' capabilities, though at different locations in the curricular architecture and with varying degrees of operational clarity. In England case, capability development is explicitly codified through the triadic framework of "knowledge, skills, and behaviours" and operationalized within the design of the end-point assessment, thereby linking learning outcomes directly to demonstrable standards. In German case, capability-oriented intentions are expressed more programmatically, embedded within the educational mandate of vocational schools and the national competence model, which systematically integrates vocational, individual, social, and learning dimensions as interdependent facets of holistic vocational competence. In Norwegian case, by contrast, capabilities are not confined to specific vocational domains but are mainstreamed throughout the curriculum, particularly through the "cross-curricular themes" and assessment criteria that emphasise critical reflection, ethical reasoning, democratic participation, and the learner's agency in knowledge construction.

The comparative coding confirms a shared trend toward hybridization while revealing distinctive modes and depths of integration (see Figure 2). Holistic vocational competence dominates in the German case (57% of all coded segments in the analysed German curricula), while Norway balances competence development with a relatively higher share of capability-related provisions (24% of all coded segments in the analysed Norwegian curricula) compared to the other two systems.

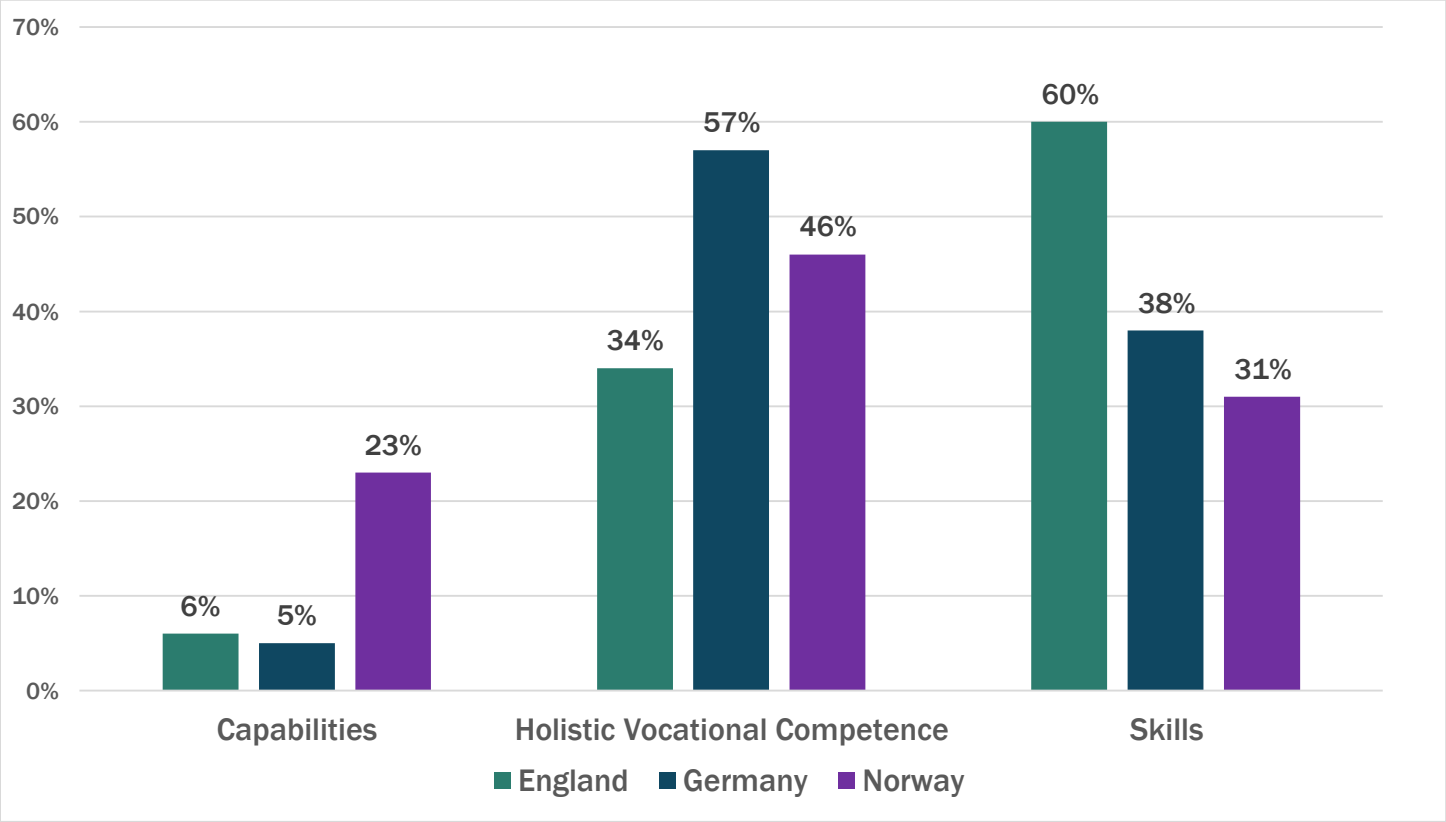

Figure 2. *Percent coverage of the codes across countries*

In the English case, the integration of skills and broader competences is operationalised most explicitly through the framework of "Knowledge, Skills and Behaviours" (KSBs) and assessment-driven curriculum. The Occupational Standard for *Refrigeration, air conditioning, and heat pump engineering technicians* requires learners not only to demonstrate technical tasks, such as recovering refrigerants in compliance with environmental regulations, but also to reflect on their practice in relation to sustainability and ethical responsibility. This mapping of work activities against KSBs in portfolios, interviews, and assessments into verifiable units embodies however a strong skill orientation. 60% of coded segments fall under "skills". Interestingly the English case shows a similar share of capabilities as the German case (6% and 5%). This suggests that the English model prioritises skills in action, strongly shaped by assessment logics that require evidence of learners' capacity to transfer skills into reflective, value-oriented practice.

In the German case, hybridisation is mediated by the longstanding paradigm of "competence-to-act" (*Handlungskompetenz*). The framework curriculum explicitly combines vocational, social, and individual competences, situating them within learning fields that are designed to mirror typical work processes. It is clearly prescribed that vocational schools aim to enable learners to "*fulfil professional tasks and to help shape the world of work and society in a socially, economically, and ecologically responsible manner*." Reflection on work and learning strategies is integral and learning fields consistently combine technical mastery with self-directed career planning and civic responsibility. In coding terms, the German case exhibits a comparatively higher share of task-bound skills (38%) alongside holistic competence (57%), with only a marginal proportion allocated to capability provisions (5%). Of course, the relative position of capabilities in comparison to skills

must also be interpreted against the very detailed consideration and operationalisation of skills: while it embeds holistic competence systematically across curricula, the dual model still attaches strong weight to occupational skills, with capability dimensions remaining less explicitly foregrounded than in Norway.

The Norwegian case presents a more comprehensive integration of capability-oriented perspectives. The curricular architecture mainstreams some cross-cutting themes – sustainability, democracy, digitalisation, and public health – into the fabric of vocational learning outcomes. Learners are expected to "*plan, carry out, assess and document*" technical tasks while simultaneously engaging in reflection, critical thinking, and inclusive collaboration. Capabilities such as *citizenship*, *ethical judgement*, and *digital fluency* are not added as supplementary aims but embedded as structural requirements across "*core elements*" and interdisciplinary themes. This integration is reflected in the coding pattern: skills (30%), holistic competence (45%), and capabilities (24%) are more evenly distributed, indicating an integrated logic of curriculum design in which technical proficiency, vocational competence, and capability development are interdependent and co-constitutive.

In conclusion, the comparative analysis demonstrates that while all three cases hybridise skills, holistic vocational competences, and capabilities, they do so through national-specific pathways. England institutionalises hybridisation through evidence-driven KSBs and assessment-driven curriculum, combining task-specific requirements and operational performance with environmental and ethical standards. Germany embeds hybridisation within the concept of competence-to-act, balancing detailed skill requirements with broad competence aims, though capability dimensions remain less accentuated. Norway, in contrast, integrates hybridisation structurally by embedding cross-curricular themes into vocational tasks, thereby making capability development inseparable from technical learning itself. The shared trend towards broadening vocational learning beyond narrow task-orientation is thus differentiated by governance traditions: assessment-driven integration in England, holistic competence frameworks in Germany, and systemic embedding of cross- cutting values in Norway.

Discussion of the capability approach for further use

Taken together, these analysed curricular documents reveal both nationally distinct orientations and hybrid zones of convergence, where the logic of task-specific skill formation, the integration of holistic vocational competences, and the broader capability perspective intersect. This interplay reflects an underlying tension and productive synthesis between instrumental aims of employability and emancipatory aspirations of personal autonomy, civic engagement, and lifelong learning. The comparative analysis thus underscores how vocational curricula, while differing in structure and language, increasingly seek to balance labour-market responsiveness with the broader human development goals central to a capability-oriented vision of vocational education. A further development of this capability driven concept of analyzing intended curricula could produce interesting insights how strongly VET curricula integrate capabilities; however, this

analysis would look at the intended curriculum, and it might underemphasize the different contexts of applying skills, competences in different contexts.

The implemented curriculum, by contrast, concerns the enactment of these curricular intentions in institutional settings such as schools, training centres, and workplaces. It reflects how teachers, trainers, and organisations interpret and deliver the prescribed content, thereby translating curricular aims into practice. From a CA perspective, this level corresponds to the conversion factors — personal, social, and institutional conditions — that influence how intended opportunities are transformed into actual learning practices. While the current paper does not analyse implementation processes in depth, this level provides an important contextual backdrop for understanding how curricular intentions may or may not be realised. It was analysed in WP 6 of the project, and it will be an interesting research question to analyse the relationship between the intended and the implemented curriculum in CA terms in further studies.

Finally, the realised curriculum represents what learners actually experience and achieve: the knowledge, competences, and forms of understanding they internalise and the capabilities they are able to develop. It reflects the extent to which learners gain real freedoms to pursue valued learning pathways and to act autonomously in professional and personal life. Although this study does not primarily examine outcomes at the learner level, the conceptual framework acknowledges that the realised curriculum is the point where capabilities and agency become visible in practice and lead to concrete functionings. This was also part of the research in WP 6 of the project and the relation between intended and realized curriculum can also be part of further analysis and studies.

Building upon these findings of this study, a future task will involve a further refinement of the coding grid with regard to the “summative” scope of individual skill statements and their alignment with HVC and CA statements. This refinement will aim to capture more precisely how different curricula articulate the depth, level, and coverage of capability-related elements beyond task-specific learning outcomes. Such an extension is essential to strengthen the analytical validity of the coding framework and to enable more nuanced cross-national comparisons of the curriculum analysis.

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SECTION 2

Introducing apprenticeship-based VET qualifications in health care: A case study of Austria and Norway

Introduction

Apprenticeships serve different purposes. They provide companies with skilled labour and facilitate young people's transition into employment (Fuller and Unwin 2011). The option of learning through apprenticeships can be an attractive option for young people to obtain qualifications (Billett 2014; Tanggaard 2007). It offers the possibility for practical learning and occupationally oriented education, which make apprenticeships useful as tools for policymakers seeking to reduce dropout rates and support marginalized groups (Schmid 2020). Vocational education and training (VET) also needs to be attractive to companies in terms of their content and the skills that people obtain through them. These and other purposes of VET are reflected in the varying priorities of stakeholders - some emphasizing immediate labour market needs, others advocating for more broader educational outcomes and skills than current needs of employers.

Across Europe, demographic shifts are reshaping healthcare provision. The proportion of individuals aged 65 and older has steadily increased, placing growing pressure on health systems already facing a shortage of qualified personnel. This dual challenge has prompted policymakers to reconsider how healthcare education and workforce development are structured. There has been a shift away from purely school-based models toward more practice-oriented training pathways for health care workers, including an expansion of apprenticeship-based VET. Considering that reforms in VET are shaped by a complex interplay of institutional interests, policy ambitions, and contextual factors such as technological innovation and demographic change, the shift to apprenticeships are sometimes contested. In contexts where school-based models dominate, for example, stakeholders have questioned the relevance of apprenticeships (Andersson et al. 2015).

This working paper investigates the motivations and processes behind the introduction of apprenticeships in VET health care qualifications in Austria and Norway. VET qualifications in health care have not been as common as in other vocational fields but both countries have introduced apprenticeship-based VET training in the healthcare sector over the past two decades. In the Skills2Capabilities project (2022–2025), we compared the transformations in VET qualifications in several case study countries to better understand the relationship between changes in work fields and curricula. Through a comparative analysis of the introduction of apprenticeships in the training of health care workers, we show how the context and the goals of the transformations differs between the two countries.

Researchers in Austria and Norway employed a qualitative approach to explore the processes of changing health care worker VET qualification curricula, with particular attention to the

transformation of the former singular school-based education into apprenticeships. The researchers reviewed policy documents and historical curricula, which informed semi-structured interviews with key stakeholders. A total number of seven interviews (two in Austria and five in Norway) were conducted between 2023 and 2025 with representatives from education authorities, trade unions and other experts in the field in the two countries. The interviews were recorded and transcribed. Because of the relatively small number of interviews, they were examined alongside documentary data rather than undergoing a thematic analysis.

The case studies: Austria and Norway

Both Norway and Austria have introduced apprenticeship-based VET for healthcare workers. These changes have taken place at different times, and, in the following, we investigate how and why apprenticeships in healthcare work have been introduced in these two countries.

Austria

Apprenticeship-based healthcare training was introduced as a pilot programme in Austria in 2023. The amendment to the Vocational Training Act and the Health and Nursing Care Act in 2023 introduced two new training options for the health care field. These two dual-training paths, *Lehrberuf Pflegefachassistenz (PFA)* and *Lehrberuf Pflegesassistenz (PA),* were established as pilot apprenticeship programmes until 2029. In line with standard practice in Austria, the new apprenticeships were set up as pilot training programmes at selected vocational schools around the country. Around 1,000 apprentices per year are expected ten years after the programme's introduction. Both apprenticeship models combine workplace training with vocational schooling, offering an alternative to the school-based model in place. These newly introduced training paths last three (PA) to four (PFA) years and are aimed at younger people, requiring only nine years of compulsory schooling and with no minimum age. The new apprenticeship model aims to broaden participation and enhance practical skill development through earlier entry, structured age-appropriate training, and offering a salary. The new apprenticeship qualifications are similar in terms of content to the school-based qualifications (see below) while offering more workplace training and a salary during training.

The reason for introducing apprenticeships in Austria was to offer young people the opportunity to embark on a health care worker qualification assistant nurse programme with less rigid entry requirements. Workforce shortage has placed significant pressure on the healthcare system, leading to staff shortages in hospitals, long-term care facilities, and home-based services, while also prompting policy debates on workforce training, recruitment, and retention strategies (Rappold and Juraszovich 2019). These circumstances, combined with increasing complexity in care, prompted the shift. According to the government bill, the amendment in the Austrian Healthcare and Nursing Care Act was intended to expand existing training opportunities to make the training more attractive to young people and thereby increase the number of students pursuing VET in healthcare. The introduction of apprenticeships in the training of health care workers is intended to create new prospects for young people and young adults but also to provide flexible educational pathways that can lead to higher-level health and nursing services.

Before 2023, school-based nursing programmes mainly constituted of two professional profiles: *Ausbildung zur Pflegeassistenz (A-PA),* lasting from 12 to 20 months in training[5] and *Ausbildung zur Pflegefachassistenz (A-PFA)*, lasting two years in full-time training. These were introduced in 2016 through an amendment in the Austrian Healthcare and Nursing Act to improve the quality of the previous health care qualification, but these school-based trainings have rigid entry requirements and lacks financial incentives because it does not offer a salary during training (only pocket money). This led to a low number of students choosing the school-based education, but they still exist alongside the apprenticeship pilot programme.

The shift to apprenticeship-based training in Austria can be viewed as a needs-based decision to expand training capacity and providing more qualified people to the labour market. However, the introduction of the 'Pflegelehre' triggered considerable debate reflecting scepticism about the apprenticeship model within political parties. Critics highlighted structural weaknesses, including insufficient permeability, inadequate alignment with vocational school structures, and the risk of creating (yet another) source of low-cost labour rather than a sustainable training pathway. At the same time, proponents stressed the urgency of expanding all available routes into the care profession in light of severe future labour shortages, noting international examples with significantly higher care provision rates (Parlament Österreich 2023). The discussion underscores the need to potentially refine the model after its pilot span to improve accessibility and long-term effectiveness while responding to the growing demand for skilled care workers in Austria (until 2030, an average of over 75,000 people would be needed to cover existing shortages).

Whether the school-based and apprenticeship VET qualifications will continue to exist side-by-side, and in what form, or if one qualification will be preferred over the other will probably be seen closer to the end of the apprenticeship pilot in 2029.

Norway

In the Norwegian case, the introduction of apprenticeship in the VET health care qualification happened in two steps. First, with the 1994 reform that integrated apprenticeships as a key part of most VET programmes, two partly overlapping qualifications in health and care were created: one school-based and one apprenticeship-based. Second, in 2006, when the decision was made to replace the two qualifications with a single apprenticeship-based qualification.

Historically, apprenticeships have been common within traditional crafts and industry but were far less common in other vocational fields in Norway. Apprenticeship-based VET in combination with school-based education (two years in school and two years in apprenticeships) was established as the new norm within most vocational tracks in 1994, partly to share costs and responsibility between schools and companies. The decision to expand the use of apprenticeships was based on

[5] The length of the training depends on the number weekly training hours (which can be from 25 to 40 hours per week during the training period).

a view that the apprenticeship-based model was considered a good way to obtain vocational skills and the most efficient way of securing youths' transition into the labour market.

Until 1994, there was a school-based health care worker VET qualification, which was then replaced with two qualifications: one school-based and one apprenticeship-based. The three-year school-based education was somatically oriented and aimed at hospital work, whereas the other one was a four-year programme consisting of two years in school and two years of apprenticeship with a stronger emphasis on care - intended for work in care institutions and home care (Nyen et al. 2011). The introduction of apprenticeship-based training as an alternative to the school-based track was an effort to counter dwindling numbers of young people obtaining training as health care workers, which was of concern for education authorities and politicians at the time (Høst 2007). The majority of students, however, pursued the school-based path, whereas the apprenticeship route was not very popular (only about 10 per cent of students chose this).

As a result of the low uptake of the apprenticeship-based VET, the training options for health care workers were reconsidered in the early 2000s. A committee was established in 2003 to consider how the health care worker training could be changed into a more suitable format rather than having two partly overlapping qualifications, and where the apprenticeship-based option struggled to recruit students. Even though the school-based option was popular, the fact that the apprenticeship-based model had been established in the VET system in 1994 can be seen as having generated a path dependent trajectory that made it a natural option to establish an apprenticeship-based qualification for health care workers. Moreover, the broader societal changes that had shifted the student group towards youths rather than adult women (who were often already working in the field), were compounded by a shift in the education reform in 1994 that gave youth the legal right to pursue upper secondary education. The changes in the student group brought forward certain challenges for the teachers as the students were much younger and had no work experience, and employers found that the school-based education with 12 weeks of placements in institutions was not sufficient for them to develop the skills needed for the work field. These circumstances in the early 2000s made apprenticeships stand out as a feasible option to align students' skills with the needs of employers.

At the same time, there were arguments against introducing apprenticeships. Some were concerned that the quality of the training would be lowered through the introduction of apprenticeships. For example, it was argued that the reduction of time at school from three to two years would reduce the theoretical content of the training and therefore give students' weaker skills. There was also concern among schools and employers about employers' ability to take over the provision of education, which would give them more responsibility. Another source of disagreement among key stakeholders was that the vocational training council wanted the curriculum and training to be more centred around medical knowledge than care, but politicians decided to emphasize the care dimension in the new VET qualification.

In 2006, the two qualifications were replaced by a new VET health care worker qualification ('helsefagarbeider'). This qualification was structured around the common VET model of two years

of school-based education and two years of apprenticeships. The shift away from the school-based education was a major change and initially there were challenges in obtaining apprenticeships for many students. This has improved over time and there have been several gradual developments of the curriculum content, such as the increasing focus on learning medical rather than care skills - driven by employer feedback and changing healthcare needs. Although the shift to an apprenticeship pathway for the VET health care qualification in 2006 was contentious, subsequent reforms have been endorsed by the vocational training council, trade unions, and other social partners, and implemented with minimal resistance. Still, the majority of those studying the current health care worker qualification do not move on to apprenticeships after completing the second year in school as intended but rather end up with alternative paths towards gaining university admission and completing degrees in higher education as nurses or other degrees. In these terms, there are some persistent problems in using apprenticeships in the training of health care workers.

Discussion and conclusion

In both Austria and Norway, there have been concerns about the recruitment of students to the health care worker VET educations. This was a factor when making changes and introducing apprenticeships for health care workers in Norway in 1994 (Høst, 2007). Similarly, in Austria the introduction of apprenticeship-based training was an effort to counter dwindling numbers of young people obtaining training as health care workers. While both Austria and Norway face growing proportions of elderly people and shortages of qualified people in the health sector, the reforms differ and are not simply about meeting current and future demands for labour.

The introduction of apprenticeships in this vocational field in Austria is a new approach and a response to sector-specific challenges such as an ageing population, increasing complexity in care, and difficulties in recruiting and retaining staff. It is not part of a broader shift in the provision of VET. The reform is targeted and aims to make healthcare careers more attractive to younger individuals by offering earlier entry points, financial incentives, and more practical training. The shortage of staff in the health sector has been a factor in the introduction of an apprenticeship for the training of health care workers in Austria. At the same time, it appears to serve both as a means to provide skilled labour to companies without compromising the content of the qualification, while also making the training attractive to young people.

In Norway, the introduction of apprenticeships for VET health care worker qualification started as part of a large reform of upper secondary education in 1994. Like in Austria, the apprenticeship route was initially an alternative to the school-based option. However, over time it became evident that the learning needs changed when the student group shifted from adult to mainly younger women. The lack of work experience and different learning needs among young students contributed to making the apprenticeship route more desirable for the training of health care workers. Besides, it seems that the predominance of apprenticeships as a general model for VET also framed decision-making and made apprenticeship a the most suitable solution also in this sector. Combined, this led to the removal of the school-based option and the introduction of a new apprenticeship-based qualification in 2006.

The shifts to apprenticeship-based health care worker VET in these two countries share some similarities but also illustrate that there are a variety of factors and motives that have influenced the circumstances and decisions to implement apprenticeship-based VET training for health care workers. The arrangement in Norway is now well established, and the apprenticeship path has generally been well received in the work field as it provides students with a theoretical foundation as well as practical skills and work experience. This makes the VET qualification that students obtain relevant and useful for employers, and, as such, the training model is unlikely to change anytime soon, although it fails to educate a sufficient number of health care workers as many students bridge across to the academic track (to take higher education, for instance as nurses). Less is known about how employers have responded to the new Austrian apprenticeship training. In the coming years, a stronger understanding of the perceived quality and outcomes of apprenticeship-based health care worker training will emerge, and the pilot is likely to be reviewed around 2029 to decide if it will be continued, and if it will replace school-based options or be offered as an alternative route.

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SECTION 3

How a VET system responds to technological change: The case of the Industrial Mechanic apprenticeship in Germany

The rapid pace of technological change has increased calls for VET systems and qualifications to be responsive to changing skills needs in the labour market. However, responsiveness is both conceived of differently and has different implications in different types of VET governance systems with different procedures for changing VET content. Making VET programmes more responsive in a social partner-led system versus a more liberal market-oriented system may lead to markedly different outcomes. Policy recommendations that fail to take these differences into account may lead to unwanted results; for instance, to VET systems too narrowly focused on meeting specific skills needs here and now rather than preparing learners for the future (Billett, 2011).

There are several typologies of VET systems focusing wholly or partially on governance (Pilz, 2018; Greinert, 2004; Busemeyer & Trampusch 2012). Studies of VET governance are often concerned with the macro level, analysing differences between national systems *as such*. Here, we have chosen instead to analyse how national VET systems respond to technological changes in a specific occupation/field. This case study investigates changes on the apprenticeship level, examining the process of developing the industrial mechanic apprenticeship in Germany and assessing whether this conforms to theoretical expectations from the VET governance literature. The occupational approach allows a precise analysis of change in standards/curricula and the processes that led to them. Such occupational-level analysis can uncover heterogeneity within systems. This German case study will be a part of a later comparative analysis of Germany, England and Norway in a journal article. Germany is chosen as case country because it provides an archetypical example of a social-partner-led system, where processes and outcomes are likely to depend on the initiative and configuration of interests among the social partners. For later comparative analysis it provides a clear contrast to the employer-led English system and the mixed Norwegian system (Breines et al., 2024).

Empirically, we investigate how the content of the apprenticeship regulations (curricula) and the process of updating them have evolved since the 1980, with an emphasis on the 2003-2024 period. Our choice of the industrial mechanic occupation is based on several criteria: The occupation employs a large number of workers, and it is an economically important work field and, importantly, it is a work field subject to technological change which the VET system will be expected to respond to. It is also an identifiable and delineable work field with educations that can be compared across several countries (see Breines et al., 2024). Methodologically, we have re-analysed existing interview material found in articles in the German journal “Lernen und Lehren”, especially from 2004, 2011-2013 and 2024-2025). We have also conducted two expert interviews with persons with

in-depth knowledge of the industrial mechanic occupation and the vocational programme, in order to trace the details of the processes that has led to the more recent reforms from 2004 and up to 2021.

Theoretical approach to change in VET

Governance and skill formation

An analysis of responsiveness of VET necessarily focus attention on the governance of VET systems (Chan & Markowitsch, 2021). Governance is a broad concept that in this context refers to the structures/institutions that regulate VET systems or elements of it and the processes that unfold within these. This is a diverse and complex research field in which studies of skill formation systems constitute one of the largest bodies of literature (Mende, Oswald-Egg & Caves, 2025). Here, the type and degree of employer involvement is a key variable used to explain the functioning of the various systems. Both Martin (2012) and Busemeyer & Trampusch (2012) for instance employ the two dimensions, firm involvement and state commitment, to form four categories of VET systems: dual/collective, statist, liberal and segmentalist.

Where both firm and state commitment is high, we find the dual 'collective' German-type systems of apprenticeships with integration of school- and workplace training. Where employer involvement is low, but state commitment high – 'statist' systems – training in vocational schools form the dominant part of the VET system. Where both firm and state involvement/commitment is low, the 'liberal' system, general education/skills take primacy, and apprenticeships play only a supplementary role.

Germany is an archetypical example of a 'collective' system where collective employer (and employee) organisations wield considerable influence in the provision, administration and development of the VET system. The system will at first glance almost by definition be responsive to skills needs expressed by employer organisations either on peak level or industry or guild level. However, coordination of interests needs to take place both within each organisation and with other organisations, including often organised labour, whose involvement differs between different collective systems (Emmenegger & Seitzl, 2020). Depending on the configurations of interests and power, this may make it hard to achieve consensus or even a decision, which may inhibit responsiveness. Dual, collective systems have over the past decades been challenged by 'dualisation', that is shrinking coverage of the VET system in the labour market, and in some countries, 'segmentalisation', where power shifts towards large companies (Thelen & Busemeyer, 2012). The latter, noted in Germany, is especially important as it suggests "collective governance is being replaced by de-centralised, large-employer-oriented governance" (Di Maio, 2020:11).

Feedback mechanisms

The work of Markowitsch and Hefler (2018) applies the skill formation literature but more directly address the question how curricula/standards change. Using the concept feedback mechanisms, they establish a typology of different institutional procedures that affect how skills demand from the 'world of work' are translated into change in VET curricula/standards. Markowitsch and Hefler (2018) distinguish between four types of formal feedback mechanisms in Europe:

1) the statist model, where individual experts from the work field may be represented in boards, committees and working groups when VET standards and curricula are revised, but where education system interests are strongly represented and decisions are made by national education authorities,

2) the participatory model, which is similar to the statist model, but where social partners have formal consultative rights,

3) the coordinated model, where organised employers and labour unions play a key part of the VET governance infrastructure as well as delivery and have a large say in decisions on VET content and structure,

4) the liberal model, where the state sets the conditions for an education market, where individual companies or groups of companies have a key role in initiating VET programmes, but social partners do not play any major role.

The three first mechanisms differ in how much influence social partners are awarded, from largely absent in the statist model, consultative in the participatory model to decisive in the coordinated model, such as the German. All three models aim to arrive at national, widely accepted and portable qualifications; by contrast, a liberal model allows small groups of employers much more freedom to initiate new qualifications and purchase skills directly from the education system. There is less need to coordinate interests through employer organisations.

A feedback mechanism can be interpreted as a set of institutional constraints which set the rules of the game. It defines who are actors with legitimate interests in the process of standards/curricula change, and it influences the relative power of these actors and interests. However, we cannot tell from the formal rules what the outcomes of a particular process will be. The outcome depends on the interests of various actors, how strongly they pursue them and how the process unfolds. Empirical studies of such processes can build up a knowledge base of what outcomes we might expect, and what these outcomes hinge upon. So far there are few empirical studies of how such processes unfold (Antonazzo, Stroud & Weinel, 2023), and far as we know none that directly apply the feedback mechanism concepts above.

Skills or competences

The differences in governance described above are associated with different conceptual understandings of what constitutes a vocational qualification, but the latter constitute a separate domain with possible implications for curricula change. This type of theory focuses on the nature of the competence/skills that each system 'delivers. We can distinguish between a narrower skills-

oriented approach and a broader competence-based approach centred around comprehensive occupational profiles (Clarke, Winch, and Brockmann, 2013).

The skills-based approach is associated with a 'liberal' VET system and feedback mechanism. The skills-based approach is task-oriented and closely aligned with job descriptions, viewing vocational competence as the knowledge, skills and attitudes needed to perform a set of tasks related to certain types of jobs. As a result, curricula grounded on the skills-based approach may be expected to be detailed concerning technical skills and the qualification structure more complex (or fragmented), to account for the variety in demand for skills.

A competence-based approach in contrast, is associated with dual VET systems (like the German) and coordinated feedback mechanisms. The competence-based approach builds on a shared understanding of an occupation, and the competence associated with it, among a sufficiently large number of companies within the work field. The broad competence-based approach sees vocational competence as a comprehensive set of knowledge, skills and attitudes where technical skills are integrated with understanding of vocational theory and competences like critical thinking, teamwork and creativity. Curricula would thus be expected to reflect this and may be less specific on technical skills. The skilled worker is expected to be able to apply his competence and adapt to variety of work settings. Empirical evidence suggest that German apprenticeship standards are more broadly competence-oriented in their skills descriptions than similar standards in other countries (see section 1 in this report).

Theory-derived expectations

Overall, the theory suggests that a collective skill formation system, with a coordinated feedback mechanism and a competence-oriented approach based on broad occupations, would be expected to display relatively low responsiveness (Table 1). When faced with external impetuses for change, for instance technological change, we may assume that the stakeholders, both for regulative, normative and cognitive reasons (Scott, 1981) would tend to make changes in a way that preserve the nature of the competences/skills they have invested in (path-dependence). With respect to skills orientation, actors in coordinated systems like the German would thus be expected to write in new skills slowly in the curricula, partly because the ability to adapt is inherent in the broad competence approach and there is less need to specify tasks and technologies, and partly because major changes may rock the consensus that lies behind the current competence description and a new consensus among the organisations and firms may be challenging to reach.

Table 1: Skill formation, feedback mechanism and expected responses to technological change

	Skill formation system (governance)	**Feedback mechanism (governance)**	**Skills or competence orientation**	**Expected response of standards to technological change (governance)**	**Expected response of standards to technological change (skills orientation)**
Germany	Collective	Coordinated	Occupational competence	Slow change, infrequent re-negotiations of standards	Slow, infrequent, flexibility within standards

At the national level, this seems to find some empirical support in previous research: the German coordinated system exhibits considerable stability, with a long average time since last curriculum update (17 years, cf. Blankart, Bretschneider, and Schad-Dankwart, 2022). A more recent analysis (BMWE, 2025)[6] nuances this picture, however, showing that despite the 17-year average time since last update, 78% of all current apprentices are trained in an occupation which has been modernised since 2010 or is currently being modernised. As many as 42 % are trained in an occupation which has been modernised since 2020 or is currently being modernised. Analysing the underlying data set, we find that this is due to considerable variation at the apprenticeship level: Many apprenticeships, especially the most popular ones, have indeed been updated recently, but a significant number have not been updated for a long time; many around 20 years ago and a few of the smaller ones not since the 1930s (see Figure 1). In the following, we analyse one of the largest and more recently updated apprenticeships, the industrial mechanic.

[6] BMWE - Neuordnung und Modernisierung von Ausbildungsordnungen im Kontext der Transformationsprozesse

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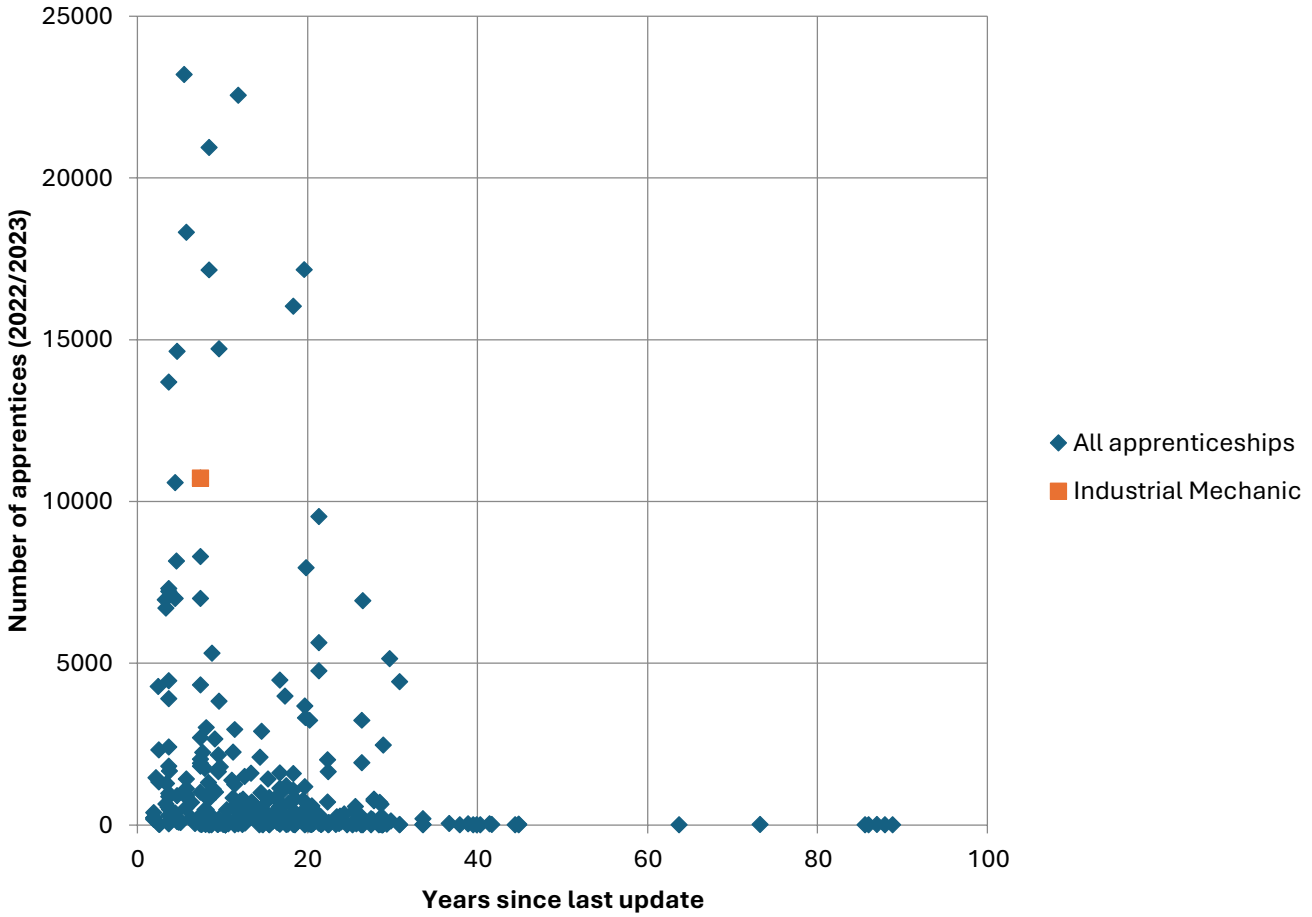
Figure 1: Time since last update and number of apprentices in Germany



Source: Data set "Number of trainees 2022/2023 and new regulations for professions" from BMWE (2025), our calculations.

The industrial mechanic occupation

Industrial mechanics are involved in installing, operating and maintaining production systems. Typical work fields are maintenance, machine and plant construction, production engineering and fine equipment construction. The occupation employs a high number of workers, is a popular VET education and a backbone of the manufacturing sector with long traditions. Historically, the occupational profile was characterized by manual machining and fitting skills – tasks like milling, turning, drilling, welding, and assembling parts were central to the role.

Over the past decades, however, the work field has undergone gradual but fundamental transformation. Many manual or analogue processes have been supplanted or augmented, and the work field is gradually being reshaped by a suite of technologies enabling digitalization, automation and robotization. Computerized machines (e.g. CNC machining tools) became standard in the 1980s and 1990s, robotics have increasingly taken over repetitive assembly or handling tasks, and sophisticated sensors and control systems enabled the advent of semi-autonomous production

lines (Seet et al., 2018). Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) have been developed and implemented since the 1980s (Field, 2004) and have become common tools for modern industrial mechanics. Newer technologies relating to the transition to "Industry 4.0" are only starting to affect the work field and VET systems (Gallo and Santolamazza, 2021). Technologies enabling Industry 4.0 include artificial intelligence and smart equipment and systems such as collaborative robots, cyber physical systems (CPS), the internet of things (IoT), cloud computing, mobile devices, big data analytics, machine-to-machine communication, and new production processes including 3D printing and hybrid manufacturing. The goal is to enable a higher degree of customisation of products and connected services, automation and optimisation of production, and improved information sharing, decision-making, productivity, flexibility and collaboration (Fatorachian and Kazemi, 2018). As work processes are automated, certain tasks become obsolete and others change. An example is industrial robots, capable of performing complex tasks that were traditionally manual, which demands a new set of skills from mechanics who must now program, maintain, and repair these robotic systems, and increasingly work with collaborative robots (Koch et al., 2017).

How this technological development affects the industrial mechanic occupation specifically is not widely studied, but a body of literature exists on Industry 4.0 and the role and nature of the so-called Operator 4.0 (Wittenberg, 2016). The concept of Industry 5.0, promoting the future of industry as more human-centric, sustainable, and resilient (European Commission, 2021) emphasizes the pivotal role of VET-certified operators and their competence. Industrial mechanics increasingly work with digitally connected equipment, requiring them to interface with computer software, programmable logic controllers, and data monitoring systems in addition to wielding manual tools and machinery. Mechanics are increasingly required not only to operate machinery and supervise automated production systems, but also to maintain and troubleshoot digitalized machines, automated systems and robots. They are also increasingly expected to use computers and mobile devices to gather information, report and communicate. There is also an increasing relevance of understanding the logic of the production process as a whole, to interpret display data and to know where in the process to intervene when needed (Achtenhagen and Achtenhagen, 2019).

In sum, the development of the work field has been characterized by the gradual overlay of digital/automated systems onto traditional mechanical work. The impact of these technologies on the core work tasks of industrial mechanics in the studied period (2003 to 2024) should nevertheless not be overstated, as there has been considerable continuity and many of the technologies are only starting to impact the wider work field. The core vocational skills remain relevant, and many companies do not perceive major changes in VET content as very urgent, despite digital skills becoming more central (Achtenhagen and Achtenhagen, 2019; Breines et al 2024). The changes in work tasks does not (yet) apply to all companies and there is considerable variation in the level of technology adoption. Companies with different degrees and concepts of technological automation are likely to display variation in skills needs and interests in curricula change (Hirsch-Kreinsen, 2016). This could have the potential to strain the underlying occupational understanding and consensus on curricula content.

The German VET system and governance structure

Germany's initial skill formation system, similar to Austria or Switzerland, follows a dual approach[7], which has a long history and initially rested mainly upon companies and local chambers (Spöttl, 2016). With the introduction of the Crafts Code (HwO) of 1953 and the Vocational Training Act (BBiG) of 1969, the state entered as an actor providing a legal frame and defining standards for vocational training (Greinert, 2006). With the introduction of the Vocational Training Act, vocational education was also recognised as an independent educational sector within the German education system (Broetz and Schwarz, 2013; Hippach-Schneider and Huismann, 2019). As Germany is a collective *or corporative* system, the steering and governance of the dual VET system rests upon tripartite cooperation between state, companies and social partners. Dual VET in Germany is organized based on the "Berufsprinzip" (vocational principle) and the "Konsensprinzip" (consensus principle). This means that the conception and design of vocational training is oriented towards one of the current 327 skilled occupations[8] that lead to formal qualifications developed by the stakeholders based on consensus[9].

„The consensus principle means that opinions have to be fought for. No one should be so presumptuous as to simply dismiss someone else's opinion out of hand. That would make things move faster, but the social acceptance of occupations would suffer. In-company vocational education and training, however, needs the employers and the employees equally. If they are not taken on board, this system has no future." (K. Heimann. Employers' representative in Cramer et al., 2013, own translation).

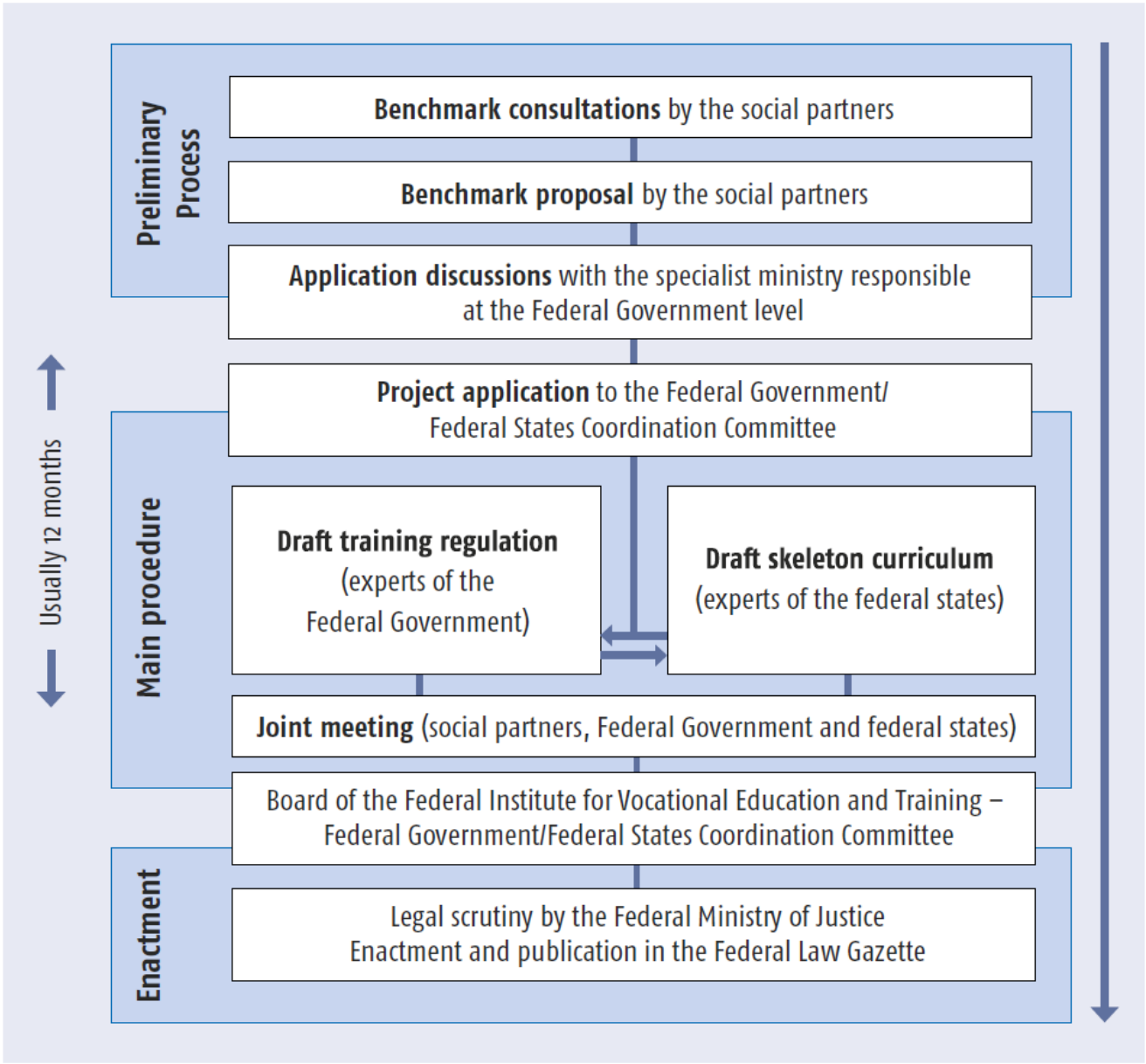
The Federal Institute for VET (BIBB)[10] and its main committee referred to as the "parliament of VET" play a central role in the governance of the dual VET system and the formulation and modernisation of training regulations. One of the essential tasks of the BIBB is to oversee the process and assist in the preparation of training regulations and "[...] the continuous observation of professions with regard to their need for change based on research and evaluation projects, as well as support in the implementation of regulations into training practice" (Conein et al., 2021, p. 53). Before the BIBB was entrusted with the task, the reorganisation of training occupations rested on the purely employer-led "Arbeitsstelle für Betriebliche Berufsausbildung" (ABB), which was more "[...] inclined to preserve old structures than initiate new ones" (Klein & Schlösser, 1993, p. 32). As a result, the training regulations did not keep pace with the changes in the job tasks and updating of training contents was at the discretion of companies (ibid).

[7] Apprentices spend approximately 80% of their time at the workplace and 20% in vocational schools.
[8] https://www.bibb.de/dienst/publikationen/download/20423
[9] In 1985, the Main Committee of the BIBB established the so-called consensus principle in the context of reorganisation of training regulations, see Frank and Euler (2021).
[10] The BIBB, founded in 1970 (following the introduction of the BBiG in 1969), is the is the central competence centre in Germany for the research and further development of VET.

Based on an agreement between the social partners in 1995, the duration of the procedures of the modernisation of a training regulation is generally to be limited to about one year and the development of new training occupations to two years (Bosch, 2018), which secures that the capacity of the Federal Institute for Vocational Education and Training (BIBB) – which oversees the process – is not bound and the modernisation of the current 327 training occupations can be handled and actually implemented in regular intervals.

The regulatory procedures for modernizing training regulations are clearly stipulated. However, the actual process can vary, for different reasons. Usually, the procedure is organised in three steps (see Figure 2): a preliminary process, where the benchmarks are set; the main procedure, where the training occupation is modernised (generally within 12 months) and enacted in a final stage (BIBB, 2025: 19).

Figure 2: Sequence of a regulatory procedure in Germany



Source: BIBB 2025: p. 20

The training regulations are intended to represent minimum requirements[11] of the training occupation (apprenticeship) and are phrased in a technology-open[12] and manufacturer-neutral manner to allow for spaces of innovation (Conein et al., 2021; Hackel, 2022).[13] It is believed that the technological openness makes training regulations more robust against short-term technological changes and consequently allows longer reordering cycles, but it does not replace the need for strategic further development e.g. with regard to the digital and ecological transformation or societal requirements such as inclusion. Hence, regular modernization is essential to keep training professions attractive and future-proof. Training regulations are modernised on the initiative of the social partners.

The industrial mechanic in Germany

The industrial mechanic has always been one of the most common training occupations (among the top 10) and represents a core area of German industry. As an industrial occupation, it is the responsibility of the chambers of industry and commerce and formally issued as a training occupation by the Federal Ministry for Economic Affairs together with the Federal Ministry of Education. As in all dual training occupations, there is no minimum entry requirement. Accordingly, the profession is chosen by the whole range of secondary school graduates, including those who are qualified to study at university.

There are number of related occupations surrounding the industrial mechanic, including occupations with a stronger focus on metal working, such as plant mechanic, construction mechanic, tool mechanic, and cutting machine operator[14] . In curricular reforms where these occupations are targeted, this usually happens in close alignment with the industrial electrical occupations. For both occupational groups, there are more or less the same stakeholders responsible. While the industrial mechanic focusses on materials processing, metal technology, and hydraulics/pneumatics, the mechatronic concentrates on electrical engineering, control

[11] The principle of minimum standards means two things in Germany: Firstly, it refers to the components that must be included in a training regulation according to BBiG (job title, duration of the training, training occupation profile, training framework plan, and examination requirements). Secondly, it means that, due to the structural diversity of companies, minimum standards that make up the core of the newly regulated profession are formulated, in order to maintain the training capacity ("Ausbildungsfähigkeit) of as many companies as possible , see Ulmer et al. (2025).

[12] In Germany, 'technology openness' means that training regulations do not specify technical systems and technologies in connection with the implementation of in-company vocational training. This has two effects: it allows smaller and medium-sized companies, which do not have the required technologies, to participate in vocational training; and it eliminates the need to carry out reorganization procedures at too short intervals, see Ulmer et al. (2025, p. 24).

[13] Training regulations also include a so-called flexibility clause – which allows the deviation from the organisation of training as specified in the training regulation by the training company or apprentice, if need for business or personal reasons.

[14] Anlagenmechaniker/-in, Industriemechaniker/-in, Konstruktionsmechaniker/-in, Werkzeugmechaniker/-in Zerspanungsmechaniker/-in

technology, programming, and IT (Schütte, 2010). If the major criterion for curricular changes were only "metalworking", there would be around 43 relevant occupations from plant to bicycle mechanics, and watchmakers to machining mechanics. This exemplifies that the grouping and internal differentiation of occupations is influenced by various factors, which may be technical or subject-specific in nature, but also have to do with legally regulated responsibilities and the question of politically relevant actors.

Changes in the content of the curriculum/apprenticeship standard

Within the time frame defined for the case study, there were three major reform steps that merit analysis here: the restructuring of the occupation(s) in 2004, 2013, and 2018. However, developments in the selected occupation, as well as within the dual VET system as a whole, can only be fully understood if the reforms that took place before the 1990s are also considered, as these earlier changes were paradigmatic for understanding the significance of vocational education and training in Germany.

1987 reform of industrial metalworking and electrical occupations - Broader Occupations, Action Orientation and Vocational Competence

The first major modernisation of the industrial mechanic occupation was a response to major economic, social and demographic challenges: Germany encountered an economic upheaval in the 70s ending a long period of economic growth (the so-called "Wirtschaftswunderjahre" / *economic growth miracle years*), with a widespread introduction of new technologies and organisational concepts and increasing competition through the technological leadership of Japan at the time. Moreover, the country encountered a rather profound demographic change. While the demand for qualifications increased until the mid-eighties, it subsequently decreased rather rapidly, while also a trend towards higher qualifications emerged leading to a growing mismatch between supply and demand of qualifications.

In this context, the 1987 reform of industrial metalworking and electrical occupations is considered a major milestone in the reorganization of training regulations and also a signpost in the further development of dual vocational training[15]. It marks the completion of a reform project that began in the late 1970s and is an important starting point, in order to understand the changes and its process in the 2000s.

The 1987 reform was the result of a decade-long consensus process involving employer associations (Gesamtmetall, ZVEI), trade unions (IG Metall), the Federal Institute for Vocational

[15] The process of the reorganisation of the industrial metal (and electric) occupations is believed to be a milestone of training regulation work, see Frank and Euler (2021, p. 23). This has heavily influenced all further training regulation work and set standards (such as the definition of the "Eckwerte"), which are still applied today.

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Education and Training (BIBB), policymakers, and companies. According to stakeholders, the reform marks a fundamental change in the concept of the skilled worker (Felkl et al., 2024). Instead of focusing on narrowly defined, instruction-based tasks, the new goal was to develop workers capable of independent planning, execution, and evaluation of work processes. The central aim became the promotion of vocational action competence rather than the mere acquisition of isolated skills. This was intended to improve employability in the long-term, to prepare workers for technological change, and to provide a solid foundation for continuing education. Accordingly, the reform significantly reduced the number of occupations: More than 50 separate occupations were restructured into six core occupations in the metal sector and four in the electrical sector, each with multiple fields of specialization. The whole process was based on a large-scale empirical analysis of the existing jobs and occupations (Cramer et al., 2013).

The reform introduced the educational concept of the "complete action" (planning, executing, and checking), replacing rigid and schematic training courses. Training methods such as task-oriented learning with guiding texts supported more active, learner-centred approaches and promoted autonomy in problem-solving (Cramer et al., 2013). These substantial changes can be regarded as a blueprint, as they were also adapted across all other occupations in the dual system in the years after 1987 throughout the 1990ies. The changes need to be interpreted in conjunction with the first round of digitalisation that took place during this time and that lead to a promotion of a type of skilled worker who is self-reliant and independent:

"*The last comprehensive reorganization of the industrial metal trades took place in 1987 together with the electrical trades. It unmistakably shaped structures and, with its holistic concept, provided impetus that extended far beyond the two occupational fields. The reorganization at that time was influenced by the then-increasing use of computers and IT and their impact on the working world. These changes were largely taken into account by ensuring that trainees were to learn to 'plan, carry out, and control independently.*"

(Grunwald, 2004, p. 114, head of department in BIBB that moderates reform process, own translation).

2004: Introduction of Business Process Orientation and learning fields

The 2004 reform of the industrial metal occupations introduced significant content-related changes compared to the previous system. While the five core occupations—plant mechanic, industrial mechanic, construction mechanic, tool mechanic, and cutting machine operator—were retained, their profiles were fundamentally redefined. In addition to the action orientation that was introduced through the prior reform, the notion of work- and business processes was introduced (Grunwald, 2004).

A further innovation was the explicit orientation of training towards real business and work processes. Both training regulations and vocational school curricula were redesigned to reflect the logic of actual work tasks and organizational processes. At vocational schools, this shift led to the adoption of a learning-field structure, in which teaching units were based on complete sequences of workplace activity rather than abstract subject divisions.

Adaption of the training structure

In addition, there was the introduction of „Betriebliche Einsatzgebiete "(Company areas of application), which is a means of adapting the training regulations to company-specific fields of deployment, such as welding technology, maintenance, or tooling.

Accordingly, the prescribed specialisation that took place in the old model in year 3 and 4 was abolished. This gave companies more flexibility to align training with their individual operational needs while maintaining a strong common cross organisational occupational foundation (see Figure 3 below).

Figure 3: Specialisations in Industrial metal trades in 1987 and in 2004 (according to Grunwald 2004)

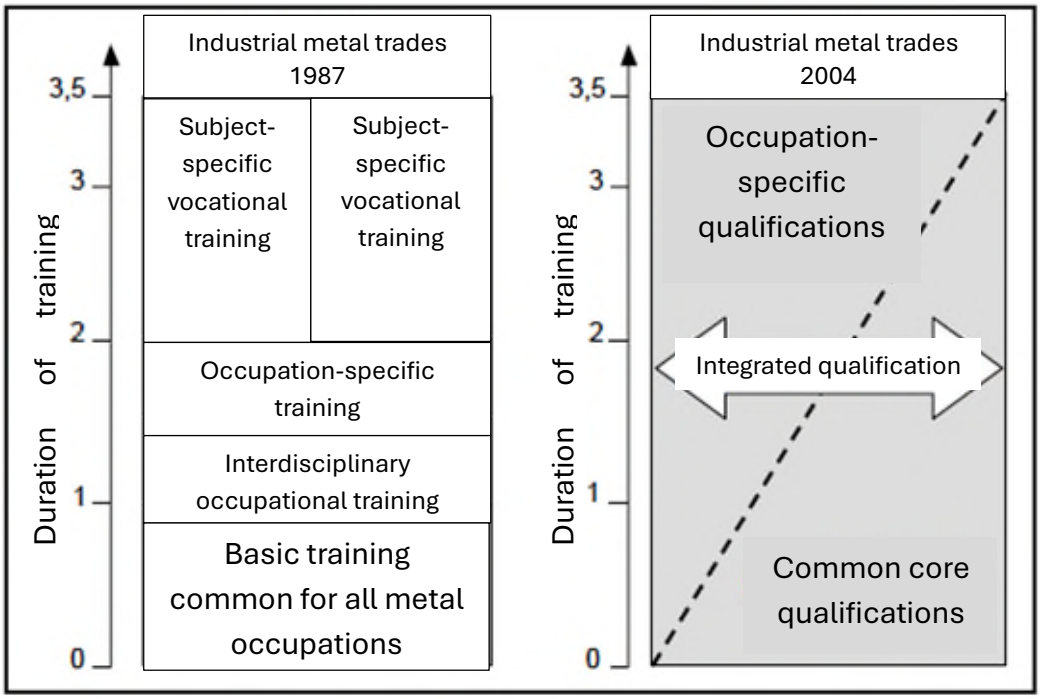

Figure 2: Comparison of the structures of Industrial metal trades in 1987 and in 2004 (adapted from Grunwald 2004)

Section 3 (4) of the Training Regulations (2004) stipulates that qualification in the field of application should be process-oriented: "Within the framework of job-specific professional qualifications, professional competence in a field of application should be expanded and deepened through qualifications that enable the holistic execution of complex tasks in the respective business process. ... Future skilled work is therefore also expected to take into account business management issues and customer-related aspects within the scope of duties, differentiated according to the specific profession, of course. ... The description of competence already included in previous training regulations has therefore been expanded in the new regulation to include action in the overall operational context. In this context, the social partners referred to "European competence" in their aforementioned framework agreement" (Räß, 2013, employer expert in reform process, own translation).

In accordance with a more integrated view on learning with work processes, the training structure itself also changed. The earlier model from 1987 had been based on three distinct phases: basic training, cross-specialization training, and specialization training. The 2004 model replaced this with an integrated approach in which core and specialist qualifications were acquired simultaneously and in close connection throughout the entire training period.

The reform also increased flexibility in the structuring of training time. Instead of rigid weekly schedules, a new time-frame method was introduced that defined learning periods in months. This gave companies and schools more room to coordinate the delivery of core and specialist qualifications and to synchronize learning at the workplace with learning in the classroom.

Some of the innovations introduced in 2004 were viewed with a certain degree of scepticism. The new form of presentation and the designation with time frames was such a novelty. But the original idea which included more aspects was dropped as this was seen as a move towards ”modularization of vocational training” by political decision makers. (Grunwald, 2004, p. 114); The result of this political intervention was however that the implementation / adoption of the training regulation became more difficult in practice, thus limiting the success of the reorganisation of the profession (Expert Interview 2).[16]:

1996/2004: Adapting examination and assessment to action and business process orientation and introduction of learning fields

With the new conceptions of action and business process orientation and a more self-reliant worker type it became increasingly apparent that this also demanded a new understanding of learning. Accordingly, a new curricular concept was introduced: the approach of *learning fields*. The notion is that all content, no matter if taught or learned in school is supposed to be arranged in a series of common vocational or occupational tasks and business processes that are structuring the curriculum. The idea was laid down by the Conference of Ministers of Education and Cultural Affairs in 1996 in a document (Kultusministerkonferenz, 1996) that provides guidelines for the development of vocational framework curricula in accordance with the company training regulations and that successively was integrated into the curricular documents.

Moreover, the examination system was also modernized and a two-part final examination introduced.[17] The first part, taken during training, replaced the former interim examination and contributed to the overall result. The second part was a practical test, which could take one of two forms: either a company-specific assignment tailored to the trainee’s workplace, or a standardized external task designed for comparability across companies. This was a compromise after a serious conflict between major stakeholders, that became particularly apparent in the neighbouring

[16] At the same time, the introduction of so-called “training modules” (Ausbildungsbausteine) was piloted. These were partial qualifications, certified by chambers, designed to support disadvantaged youth and ease transitions into full vocational training. While intended as an instrument of flexibility, they were also criticized by trade unions as a step toward modularising the dual system.

[17] This exam format was introduced in 2004 as a trial regulation and converted into permanent law in 2007, see Felkl et al. (2024, p. 156).

electrical occupations. The joint initiative by ZVEI (the electrical industry employers' association) and IG Metall had proposed to modernize training by introducing practice-oriented examinations, such as company-based projects and oral assessments, and by embedding IT and process-related competences into the occupational profiles. However, the German Chamber of Industry and Commerce blocked the implementation of this agreement. The chamber insisted on retaining their established system of centrally developed test tasks and opposed the reform, arguing that the proposed changes would weaken their control over examinations and challenge traditional standards. IG Metall criticized this as an attempt to preserve outdated examination practices and to resist a comprehensive modernization of training (Grimm, 2013; IG Metall, 2001).

In sum the reform moved away from rigid specializations towards flexible company-based deployment, integrated core and specialist learning throughout the training process, embedded instruction in real business and work processes, and introduced modernized examinations and more adaptable time structures.

2013 reforms – two-year training occupations in the metal trades

Between 2012 and 2016, the metalworking occupations in Germany became the subject of renewed debate and retrospective assessment. The reforms of the early 2000s, which integrated core and specialist qualifications and emphasized action-oriented and process-related learning, were now being evaluated in light of their long-term effects and the growing influence of digitalization and Industry 4.0 (Cramer et al., 2013; Drewes, 2013; Grimm, 2013; Herkner, 2013; Mansfeld & Schütte, 2013; Räß, 2013).

One of the central challenges that continued to shape this period was the implementation of the learning field concept. Although the 2003/2004 reform had aimed to align vocational school curricula more closely with real business and work processes, many teachers still reported feeling insufficiently prepared for this pedagogical shift. Translating abstract curricular requirements into practical classroom teaching proved difficult, and the intended cooperation between schools and companies often remained incomplete (Grimm, 2013).

The reform of examinations also continued to attract attention. The introduction of the two-part or "stretched" final examination designed to integrate the interim test into the final assessment was widely accepted, but it required ongoing legal and procedural adjustments. Questions persisted about how to best balance company-based project work with standardized external tasks (Mansfeld & Schütte, 2013; Räß, 2013). Overall, evaluations from this period indicated that while the 2003/2004 reform had modernized the structure of the metal occupations, implementation challenges remained, especially regarding didactic change and examination design.

Technological change and the emerging paradigm of Industry 4.0 further intensified the need for adaptation. Topics such as automation, process monitoring, systematic fault analysis, and digital control systems entered VET. However, in many cases, such as in the industrial mechanic

occupation, modernization focused primarily on revising examination requirements rather than comprehensively transforming curricula (Schlausch & Ledderer, 2017).

At the same time, newly introduced two-year training occupations (stamping and forming mechanic and the specialist for metal technology) raised debates which highlighted ongoing tensions between flexibility and quality assurance. Employers viewed shorter programs as a means to attract new target groups and to respond more flexibly to recruitment challenges, especially given the option to credit these programs toward longer training paths. In contrast, trade unions and employee representatives warned that such programs might create a "second track" with lower qualification standards and limited long-term career prospects for young people (Mansfeld & Schütte, 2013; Räß, 2013).

In summary, the period from 2012 to 2016 was marked by efforts to balance stability and innovation in the metal occupations. The reforms of this time consolidated the achievements of earlier modernization steps while responding (sometimes only partially) to the technological and organizational challenges brought about by digitalization and Industry 4.0.

2018 reforms - "agile procedure", optional additional qualifications and inclusion of new cross-occupational standards

The social partners in the metal and electrical occupations – IG Metall (union), Gesamtmetall (employer), VDMA (employer), and ZVEI (employer) – agreed in spring 2016 to examine Industry 4.0-relevant vocational training occupations in light of new requirements and career prospects (Gesamtmetall et al., 2017). The metal and electrical occupations thus entered a new phase of modernization that reflected the abovementioned technological changes. The period was characterized by three changes: the introduction of an "agile procedure" by the social partners, the creation of optional additional qualifications, and the inclusion of new cross-occupational standard profile elements, addressing the challenges of transformation and digitalisation.

Agile Procedure

In 2016–2017, the social partners in the field of metal and electrical occupations jointly agreed on a new "agile procedure" for the further development of the metal and electrical occupations to accelerate the process of reorganisation of occupations. This was based on a joint declaration on "recommendations for action on training and qualification for Industry 4.0" (see Gesamtmetall et al., 2017) and descriptions of concrete adaptations of curricula content to meet the requirements of digitalization and Industry 4.0 (Müller, 2018). The social partners were given a more active role in the reform process, representing a change in how occupational reforms were conceived and implemented.

The agile model emphasized self-organization, iterative adaptation, and expert collaboration. Small working groups composed of employer and employee representatives, together with practitioners and researchers, were tasked with identifying emerging technological and organizational developments, drafting proposals, and testing them in workshops. The results were then

consolidated and presented for formal adoption (Expert Interview 2). This seemingly considerably simplified the process of making changes in the content of the apprenticeship standards as it gave the social partners an even stronger influence than in the ordinary process as they could thus shorten or replace the process carried out by the BIBB in order to speed up the process reorganisation itself. As a consequence of the purely social partner-initiated process, no preliminary examination of the occupation was undertaken, and the applied model was not critically reviewed beforehand (which are usually the tasks of the BIBB). The result was thus a reorganisation which did not touch upon the central questions of the shaping of the occupations ("Schneidung der Berufe") or the enhancement of particular topics – such as electrical engineering in the metal trades – and was thus more a political decision than "the objective or professional best result" (Expert Interview 2). Among other things, the shaping of occupations requires an examination of all related professions in the field (metal occupations) as well as an analysis of the industry demand and a decision of what the modernised occupation should look like vis-a-vis the other metal occupations. Thus, the agile procedure in the case of the industrial mechanic did not tackle the fundamental questions and only led to incremental changes and additional qualifications.

Public statements by the social partners underline that the agile procedure was explicitly conceived as a way of accelerating curricular adaptation while preserving the existing occupational structure. In their 2017 joint recommendations on training and qualification for Industry 4.0, it is argued that "the social partners have already developed an innovative structural model and modern occupations. These process-oriented, flexible job profiles also meet the needs of the system-oriented approach of Industry 4.0 and the associated value creation and networking across sectors". The task was therefore to update training regulations through a partial revision of contents (e.g. on data security) and to complement these with additional qualifications (Gesamtmetall et al., 2017: 4).

Additional Qualifications

One of the most tangible outcomes of the agile reform process was the introduction of optional additional qualifications. Apprentices were now able to acquire certified competences that went beyond the content of the core training framework. Examples include process and system integration, IT-based modification of machinery, additive manufacturing, and digital process control.

These qualifications were designed to be modular and examinable, with results documented as part of the final certificate. They allowed apprentices and companies to tailor training more closely to specific technologies or production contexts while preserving the core occupational content across companies. (BIBB, 2018a, 2018b; Gerdes, 2017).

An annual monitoring process was also agreed upon to allow for stepwise adjustments rather than infrequent large-scale reforms (Gerdes, 2017). While employers emphasized flexibility and the potential of additional qualifications, trade unions stressed the need to safeguard skilled work and to prevent a devaluation of occupational profiles. Whether measures like additional qualifications would ultimately necessitate a complete restructuring of the metal occupations was left open,

depending largely on how companies implemented Industry 4.0 in practice (Gerdes, 2017). Trade unions expressed concern that additional qualifications and new forms of presenting training regulations might amount to a gradual modularisation of the dual system, thereby undermining the integrity of the traditional occupational principle. Employers, by contrast, argued that only more flexible and faster procedures could keep pace with technological innovations. However, employers and employee representatives agreed that training for Industry 4.0 would also require more learner-centred approaches, preparing young people to cope with uncertainty as a normal feature of working life and strengthening cooperation between schools and companies (see interview by Spöttl, 2017).

Evaluation findings from BIBB suggest that employers and chambers broadly endorse the substantive direction of the reform, while being more ambivalent about the additional qualifications. Company and chamber representatives tend to regard the contents of the additional qualifications as necessary and often use them as a benchmark when designing their own internal training (BIBB, 2021; Kaufmann, Winkler, & Zinke, 2021). However, the formal additional qualifications with a separate IHK examination are rarely used: the evaluation highlights the additional organizational requirements and need for highly qualified training personnel, which is not always available, particularly in small and medium sized firms. The additional qualifications thus appear only partly suitable as a lever for driving innovation and quality improvement in the work field (Kaufmann, Winkler, & Zinke, 2021).

Cross-Occupational Standard Profile Elements

A third central innovation in relation to digitalisation was the introduction of a new standard occupational profile element on *"digitalization of work, data protection, and information security."* At the instigation of the social partners, it was implemented across all industrial metal occupations in 2018. This addition ensured that every apprentice would develop key competences for working in digitally networked production environments. In an evaluation of the modernisation of the training occupation, a majority of firms familiar with the revised training regulations state that both, the new occupational profile element on digitalisation, and the additional qualifications help them to equip apprentices with digital competences (Becker et al., 2022: 109)

Future perspectives on the reform of industrial metal occupations

In 2020, the BMBF, BMWi, employers' associations and trade unions, chamber organizations, the federal states (represented by state representatives of the BIBB Main Committee and the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany) agreed on the introduction of four standard occupational profile positions. Starting in 2021, all new training regulations now include updated and mandatory minimum requirements in four key areas: 1) organization of the training company, vocational education and labour law; 2) occupational safety and health; 3) environmental protection and sustainability; and 4) the digitalized world of work. These four standard occupational profile elements apply to all apprenticeships that came into effect on or after August 1, 2021. The approach to introduce

standard occupational profiles implies that some part of the need to modernize training regulations can be compensated for through the introduction of occupational profiles which can be applied across occupations, thereby alleviating some of the pressure regarding the modernization of individual occupations. Indeed, the integrative occupational profile introduced during the modernization of the industrial mechanic training regulation in 2018, where an integrative occupational profile "Digitialisation of work, data protection and challenges" was introduced, can be seen as a precursor and model for the standard occupational profiles from 2021.

An evaluation of the modernized metal and electrical occupations (Becker et al., 2022) highlights the growing importance of digitalization and Industry 4.0 for qualification requirements. The evaluation shows that the industrial mechanic continues to play a central role in the training landscape, but its profile is increasingly challenged by the stronger positioning of mechatronics. Industrial mechanic nevertheless remains the most popular training program, with almost 9,800 new training contracts in 2021, far ahead of other occupations such as mechatronics technicians or electronics technicians. The study shows, that while the occupation continues to provide a strong foundation in mechanical assembly and production, the increasing integration of digital technologies is shifting competence requirements. In maintenance, for example, tasks once dominated by industrial mechanic are increasingly being performed by mechatronics technicians, due to their combined mechanical and electrical training. This trend is driven by predictive maintenance, condition monitoring, and IT-based asset management, which demand hybrid skills that go beyond purely mechanical expertise.

For industrial mechanic apprentices, digital competences, such as handling production data, operating Manufacturing Execution Systems (MES), and documenting production processes have become routine. The additional qualifications introduced in 2018, such as additive manufacturing, system integration, and IT security, were designed to broaden their profile and were pushed for by industrial associations (overtly representing the mid- to high scale companies across Germany). This however also had the consequence that implementation has been uneven: some companies for example have successfully integrated additive manufacturing into the training of industrial mechanic, while others lack the infrastructure or examination boards to apply these qualifications consistently. Becker et al. (2022) hold that to remain future-proof, the occupation must further integrate digital and cross-disciplinary competences, ensuring that apprentices are equipped for the demands of Industry 4.0.

Conclusion

The case of the industrial mechanic apprenticeship in Germany challenges the theoretically derived expectation that coordinated, consensus-based governance systems display low responsiveness to technological change. While the collective skill formation system and coordinated feedback mechanism would, in theory, predict infrequent curriculum updates and slow adaptation due to complex negotiations among social partners, the case of the industrial mechanic demonstrates the opposite; such negotiations has produced modernization not only of

the apprenticeship standard, but also of the procedures aimed at updating it. Empirically, the German VET system has shown a capacity for combining stability and rapid adaptation through institutionally embedded, socially coordinated mechanisms that still allow for flexibility.

The reforms of the industrial mechanic apprenticeship since the 1980s display a pattern of structured responsiveness. Major reforms in 1987, 2004, and 2018 successively introduced new skills yet retained and renewed a shared understanding of vocational competence, from the introduction of *action competence* and business process orientation to the integration of digitalisation and Industry 4.0 competences. These processes were led by social partners under the consensus principle, with the Federal Institute for Vocational Education and Training (BIBB) providing procedural coordination.

The 2018 reform is especially interesting due its inclusion of digital competences, elective, technology-specific modules and the new "agile procedure" for updating the apprenticeship, explicitly introduced in response to Industry 4.0 developments. The new standard occupational profile element on digitalization is regarded to contribute to keeping the apprenticeship future oriented. In principle, the optional additional qualifications enable additional responsiveness while allowing for differentiation and technological diversity across a heterogeneous industrial landscape. However, their limited use does raise some questions about the extent to which this part of the reform has led to substantial changes in the work field. Evaluation suggest that they are often implemented informally or via internal training rather than by using the codified additional qualifications, which helps to explain the limited formal uptake of the instrument despite widespread recognition of its relevance (Becker et al., 2022, pp. 109–110). Overall, responsiveness seems to have been achieved without undermining the occupational principle (*Berufsprinzip*) or the portability of the qualification. The new agile procedure for updating training regulations shows that the social partners were able to not only to recognize and agree on the need for increased responsiveness, but also to design and implement new procedural rules to address what they perceived as shortcomings in the established system.

The findings suggest that the conditions for responsiveness within a coordinated system depend on actor agency and the alignment of actor interests and that they are not rigid per se. In the industrial mechanic case, employer associations (e.g. Gesamtmetall, VDMA, ZVEI) and trade unions (IG Metall) shared an interest in upskilling and preserving the high-skilled, adaptable character of the occupation. This convergence of interests enabled both substantial updates to the contents and structure of the apprenticeship, and to the procedure for changing it. In light of our initial theoretical expectations, the German case arguably demonstrates that responsiveness in collective systems is conditional upon actor convergence.

A possible explanation for why social partner interests and power align in this way in the industrial mechanic occupation relates to the industrial structure and technology adoption in the German metal sector: This industry is technologically advanced, highly organized and of key strategic importance to the German economy. The industrial mechanic is a cornerstone of the competence base of this industry, and to let it become outdated could incur high costs. Empirical studies in Germany shows that the manufacturing sector is leading the adoption of digital production

technologies, and that digital technologies are most frequently adopted by companies that are large and have high shares of qualified workers (Ohlert, Giering & Kirchner 2022). Competence demands of different types of industrial companies may vary with the degree of technology adoption and, more precisely, be contingent on the automation concept followed by each company, as suggested by Hirsch-Kreinsen (2016): Smart manufacturing and industry 4.0 is associated with a "complementary automation concept", based on a distribution of tasks between humans and machines. He suggests that this complementary automation concept is adopted by innovative firms with high flexibility requirements: "Typical of these are technology-intensive, strong mid-scale firms who above all have the necessary qualified personnel and capabilities and have made famous the German industrial structure" (Hirsch-Kreinsen 2016: p. 10). Following this logic, a high share of technology-intensive firms with complementary automation concepts – as found in Germany – are likely to shape the interests of employer organizations towards proactively incorporating this technology in training regulations.

However, the influence of associations and the large to medium-sized companies behind them on the actual design of the training regulations at the same time remains constrained: A central aim in the adaption of training regulations has been to ensure the ability of all companies, regardless of their size or degree of adoption of technologies, to provide training in the respective occupation ("Ausbildungsfähigkeit erhalten"). The vocational schools need to be able to handle and mirror these new technologies in their teaching, which they often cannot. The additional qualifications (introduced in the 2018 reorganisation) which are optional and are only taken up by certain companies (Interview 1 and Interview 2) thus appear as a consensus-oriented compromise. Insufficient representation of SMEs in curricular change processes was also put forward at the early 2000s by SME representatives, when there was a climate of finding and eliminating barriers to apprenticeship training (due to a lack of apprenticeship places); this led to measures to make sure that SMEs with diverse work processes can accommodate the same occupation. „Betriebliche Einsatzgebiete" in the case of the industrial mechanic is an early example for this. Overall, this consensus implied that the interest of both - the technology advanced as well as the technology less advanced companies – can be protected.

In sum, the German industrial mechanic apprenticeship illustrates how responsiveness and stability may coexist in a coordinated system. The case provides evidence that consensus-based governance can be not only compatible with but conducive to responsiveness, when supported by a strong institutional infrastructure, shared strategic priorities among social partners, and procedural mechanisms that allow adaptation within established structures. Rather than contradicting the assumptions of how collective governance systems work in curricular change, the case of the industrial mechanic in Germany refines it by showing under which conditions responsiveness may emerge, not despite coordination, but through it.

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