The responsiveness and proactiveness of VET – a comparative case study report of changes in VET on the occupational level

Skills2Capabilities Working Paper
December 2024

Markus Roos Breines (Fafo), Torgeir Nyen (Fafo), Johan Røed Steen (Fafo) and Terence Hogarth (Institute for Employment Research, University of Warwick)

ABSTRACT

How VET interacts with a work field is a key question for both VET policy and skills policy at large. Responsiveness of VET content to skill demands in the work field needs to be balanced against a proactive approach, where learners are provided with a broad range of skills, a solid knowledge base, and/or skills believed to be in demand in the future. There is a key distinction between countries that have feedback mechanisms to adjust VET content rapidly to employer demands and countries where VET change more slowly through state-led or social-partner led processes. While the former countries run the risk of becoming too focused on short-term needs, the latter countries may be slow to react. This cross-country study of change in VET content on the occupational level in four occupations shows empirical evidence of the above. In general, state- or social-partner led systems change more slowly than employer-led systems. However, there are also substantial occupational differences. In the industrial mechanic occupation for instance, Germany, with a social partner-led process have shown clear ability to reform VET content, while England, with a more rapid feedback mechanism, seems to have been able to both implement new technologies and keep a degree of consistency despite the many changes in the overall VET system. The study also shows that introducing a greater degree of flexibility for firms to specialise training within a given national standard/curriculum has been a key response to adapt to change and heterogeneity across different types of VET systems.

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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Content

1. Introduction: The responsiveness and proactiveness of VET

1.1. The renaissance of vocational education and training

The skills landscape has changed markedly over the past 20 years across Europe. Educational attainment has increased, especially tertiary level attainment, but concerns persist about skill mismatches (McGuinness, Staffa, and Redmond 2024; European Commission 2023). The 2019 EU Company Survey reported that 26 per cent of establishments found it very difficult to find candidates with the skills they required, and 51 per cent found it fairly difficult (Cedefop/Eurofound 2020), while the second European Skills Jobs Survey reported that 28 per cent of workers felt they were over-qualified and 12 per cent were under-qualified to carry out their current job (Cedefop 2022). While there may be a degree of bias attached to these estimates, they nonetheless give an indication of the state of skill imbalances across Europe. With skills seen as vital for competitiveness, the issue of skills imbalances, and especially skills shortages, has increasingly captured the attention of policy makers.

The growth in educational attainment on the tertiary level has in some respects been in anticipation of the impact of technological change on the demand for skills. From the late 1970s onwards, technological change was seen to favour those who had completed university level education. It was also seen to disadvantage those with intermediate level skills. The tasks they carried out were seen as routine; to be carried out according to a predictable sequence of steps, which meant that they could be programmed to be undertaken by machines (Autor, Levy, and Murnane 2003; Sebastian and Biagi 2018).

However, it turned out that the demand for intermediate level skills did not decline to the levels expected. In many European countries, companies struggle to recruit skilled workers with a vocational education. There has been a resurgence of interest in VET in policy debates over the past 20 years. There is a view that because VET is more closely related to labour markets - especially when delivered in the form of apprenticeships – it is assumed to be relatively responsive to emerging skill demands at all levels. Accordingly, policy makers have sought to strengthen the role of VET in their respective national education systems (Cedefop 2020).

This policy discourse sometimes tends towards a view that VET is, almost by its very definition, responsive to labour market demands. However, the responsiveness of VET cannot be taken for granted, rather it is a topic to be analysed. Responsiveness has different meanings depending upon the configuration of national VET systems and the nature of the economic and labour market issues VET is being used to address. In practice, what constitutes responsiveness in one country may be very different to that of another, despite the shared rhetoric that VET systems need to be demand-led.

To address the concept of responsiveness the study compares changes in the content of VET programmes over a 20 year-period in selected occupations or work-fields:

- health care worker,
- industrial mechanic,

- ventilation technician,
- warehouse logistics worker.

Comparisons are made across countries with widely differing VET systems: Germany; Italy; Korea; Austria; Norway; and England.

The comparisons are in this report used to address two empirical research questions: (i) does the content of VET programmes for a specific occupation or work field change differently across countries in the face of technological change, and, if so, why; and (ii) have the changes in content affected the relevance of the VET programmes for the work field as assessed by employer organisations and other labour market actors.

These empirical questions address the overarching issue of how VET systems respond to changes in the work fields.

1.2. The concepts of responsiveness and proactiveness

The concept of responsiveness refers broadly to what extent and how the VET system changes when work tasks and skills needs in the work field change. A responsive VET system is one which matches the emerging demand for skills to supply. In its simplest form, a responsive VET system is one which meets employers' demands for skills in current jobs. Responsiveness, however, may not only be about the needs explicitly expressed by employers. Many European countries have invested heavily in their skill anticipation systems over the past 20 years, more recently especially in relation to the digital and green transitions, to avoiding or mitigating future skill mismatches (Cedefop 2018). This future orientated view of matching skills supply to demand is labelled proactiveness to distinguish the anticipatory approach from the responsiveness one where change is reactive.

VET may also be proactive in a different sense in that it helps shape the future use of skills. If those who are trained for a given occupation are provided with a wider set of skills through VET that go beyond what is required in (many) current jobs, this provides employers with a degree of choice about the organisation of work and production. Providing students and apprentices with such skills offers a potential range of benefits on employers depending upon how effectively they utilise those skills, which may in turn benefit the worker. Of course, the benefits these skills offer depend upon the skills being relevant to what the needs may be in the occupation or work field in the future. It is question of balance between responsiveness and proactiveness. There is also an issue about the balance between stability and change. If VET curricula are changed too often, stakeholder and employer commitment to VET could be undermined simply because it proves hard to keep up with the changes being introduced.

Summing up, **responsiveness** is related to skills needs in current jobs, expressed by employers, while **proactiveness** is related to future skills needs (anticipatory approach) or training which deliver a wide range of skills beyond the immediate skills needs in many jobs (occupational approach).

VET systems delivering broad, occupation-oriented skills have historically developed along with certain other factors, especially in the industrial relations domain. It is therefore by no means obvious that establishing broad, occupation-oriented VET alone will lead to more skill-based production. Upskilling attempts frequently fail to influence work quality and skill demands when the factors conducive for skills utilisation are absent (see Aspøy 2020 for an example).

Beyond the concepts of responsiveness and proactiveness, education systems, including VET, have other instrumental goals related to society at large, such as citizenship and social cohesion. Education, including VET, also has the intrinsic aim to develop the capabilities of individuals independent of any considerations relating to the labour market or society.

1.3. Responsiveness in different institutional contexts

The responsiveness of VET regulations, standards, and curricula to change will be determined in large measure by the processes in place to introduce change and the representative characteristics of those involved in the process. This requires consideration to be given to the formal institutions and procedural rules that govern or regulate the processes through which change takes place. These institutions may be permanent or ad-hoc, while the procedural rules assign roles and powers to the key actors, which include government/public bodies, social partners (employers, unions) and education providers.

There are overarching, general theories from which perspectives on VET content change can be derived, not least the literature on the political economy of skill formation (Busemeyer and Trampusch 2012). The collective skill formation systems hinge for instance on a social contract which presupposes the engagement of social partners in the design and provision of VET. There is nonetheless relatively little scientific literature that directly addresses the issue of the responsiveness of VET content. An exception is Markowitsch and Hefler (2018) who used the concept of formal feedback mechanisms to categorise different ways of organising the process of translating input from the world of work into changes in the VET system. They distinguish between four types of formal feedback mechanisms in Europe:

1) the statist model, where the content of "state-funded, state-run and state-controlled" VET is revised by ad-hoc boards or working groups and ultimately decided by national education authorities,
2) the participatory model, which is similar to the statist model, but assigns formal consultative rights to social partners (national level organisations of employers and unions),
3) the co-ordinated model, where firms play a central role in delivering VET through apprenticeships, and where organised employers and labour unions initiate or mediate and propose content change and have a large say in decisions on content and examinations/assessment,
4) the liberal model, where the state sets the conditions for an education market, including rules for the development of VET programmes and quality assurance. Individual enterprises are given a key role in initiating VET programmes. The state is assumed to refrain from any intervention in the type of programmes offered or curricula taught. It is assumed that VET

providers respond to the needs of the labour market in a direct and non-mediated way (ibid p.290).

For a classification of our six case countries according to these typologies, see table 3 in chapter 3.

The four mechanisms differ mostly along two dimensions: first, the degree of influence employer and employee organisations hold relative to government in deciding changes in the content of VET, and second, whether skills demands are coordinated and brought into decisions about VET primarily by such organisations, or by individual or groups of enterprises. In the statist system, input from work life comes mainly from expert within the field of work, with the social partners largely absent, but the social partners play consultative role in the participatory system and a decisive role in the coordinated system.

The liberal system differs from the others in a fundamental way. In this system, skill demands from employers in the labour market are not mediated/aggregated through organisations to decide curricula on a national level, instead they are communicated directly and decentralised from enterprises to qualification regulation bodies or even to the provider level. The underlying idea is that of an educational market being responsive to skills needs among employers. There may, however, exist professional norms which providers may adhere to.

Lack of coordination among employers, which is inherent in the liberal system, could lead to a fragmented system, with small group of employers furthering their skills needs through demands for specific VET content. This may come at a cost for labour mobility and students' ability to navigate in the education landscape. Alternatively, lack of coordination among employers can also be associated with a state-led VET system, where the ministry of education or other ministries administer change processes, and employers (and unions) play a minor role. However, the presence of employer associations does not guarantee that skills demands are coordinated as there might be divergent interests between employers, which the association(s) are not able to resolve.

Proactiveness can in principle be incorporated in all models depending on the interests of the actors, but are more easily incorporated in the statist, participatory or coordinated models. Not only the state, but also the social partners may ask for a level of anticipatory proactiveness from VET when faced with for instance large technological changes in the work field. The statist model provides a top-down approach where the ministry of education appoints a committee or similar with clear responsibilities for ensuring the VET system delivers the skills deemed necessary. The participatory model provides more opportunity for the social partners to be engaged in the process of articulating skill needs. There are questions about which social partners are included, the extent to which they are representative of particular groups, and the amount of influence they are able to exert over the content of VET curricula and standards. The co-ordinated model is dependent upon agreement with representatives from employers and workers, respectively, and require coordination at various levels, which may lead to a slower pace of chance. On the other hand, the coordinated feedback mechanism is often associated with VET qualifications aimed at matching skills needs for broader occupations. The liberal model in essence cedes much control over the

content of VET to the employers. There is a danger that they are focused on current rather than future skills demand and those skills which have economic value in the labour market. In other words, liberal systems may be less proactive compared with the other feedback mechanisms.

1.4. Other aspects that influence responsiveness

The feedback mechanism-typology provides a useful tool in analysing comparatively how VET content responds to labour market changes. However, there are some additional dimensions and nuances that also need to be considered.

First, curricula are formulated at different degrees of specification in countries regarding goals, content, pedagogy and assessment. Curricula may for instance be formulated in general and open-ended terms, which allow employers and schools considerable discretion to adjust training within the curricula. This reduces pressures to change curricula as some work field change can be "absorbed" within the limits of existing curricula, while similar work field change in other cases would need to be handled by chances in curricula.

Second, stakeholder interests and perspectives on VET are not given by their position as 'employer organisation', 'labour union or professional organisation", but may differ both between and within systems. The state/education authorities and stakeholders may adhere to views on VET formed by their past experiences and beliefs on what is right, which will influence how VET profiles change. Stakeholders may have different views, not only from a labour market perspective, but also an education system perspective or pedagogical/epistemological perspective on VET (Cedefop 2020). A coordinated feedback system, as described above, will for instance mostly correlate with a broad, holistic "whole-building" pedagogical approach to VET training, which not only the state, but also stakeholders may adhere to. Schools/training providers is also an actor in the process of curricula change. While they have a clear say in the statist model, it is less clear how they are brought into the process in the other feedback mechanisms, but to the degree their voice is heard, they may also bring views on the epistemological knowledge base on VET.

All this illustrates that there are also other aspects than those defining the typology of feedback mechanisms which may influence how VET responds to work life changes. Informal norms may influence the actual workings of a particular formal mechanism, as in the case of Austrian vocational schools, where there is a considerable degree of informal consultation with work life actors despite the basically statist feedback mechanism. Furthermore, as touched upon above, there may be norms for which type of skills demands that are considered "legitimate" within a VET system. In many countries there will be norms within the VET system about the breadth of education required to obtain formal qualifications, which potentially limits its degree of responsiveness to some types of skills demands.

2. Aim of the study – methods and data

2.1. Overall approach

The empirical analysis focuses on responsiveness and proactiveness at the **occupational** level. The aim is to analyse whether national VET systems have responded differently to similar technological and other changes, over the last 20 years, by concentrating on changes in the curricula associated with selected occupations/work fields. The interest is in the content of VET by which is meant the curricula or standards that set the norm for the skills, knowledge and behaviours typically required to enter and progress in an occupation.

We use the term "occupation" in a wide sense to include not only legally protected, "recognized", occupations. An "occupation" denotes here a category of labour with the ability to carry out a set of tasks related to particular work processes (Clarke 2011). The term "work field" describes these work processes. The advantage of focusing on occupations and work fields is that it allows for a more specific comparison between countries for that particular segment of the labour market (allowing us to disregard heterogeneity within the country).

Table 1 shows the occupations/work fields selected for inclusion in the study by country.

Table 1: Occupations in the study, by country.

	Austria	England	Germany	Italy	Korea	Norway
Health care worker	X	X	X	X	X	X
Industrial mechanic	X	X	X		X	X
Ventilation technician	X	X	X		X	X
Warehouse logistics worker	X		X	X	X	X

The occupations were chosen to include occupations which are well-defined in most of the countries in which the study was conducted, and where there are relevant qualifications to be found within the VET system. A further selection criterion was that of task content being subject to substantial technological or organisational change. In warehouse logistics, the introduction of automated storage and retrieval systems is one of several changes that has affected the work field. In the ventilation engineering field, active ventilation systems and more recently building automation systems have affected skill demand. For the industrial mechanic, various technological changes have affected the work field at different times over the past 20 years from the introduction of CNC machines to automation and 3D-printing. In the case of health care workers care institutions, technological change may have been more piecemeal than the other occupations but have nevertheless affected documentation and communication activities. Equally important is demographic change which has forced many countries to re-think task distributions

between different professional and occupational groups, which in turn has implications for the skill demands of health care workers.

The countries selected differ considerably in skill formation and VET system (see Table 2). Austria and Germany are considered having "collective" skill formations systems (Greinert 2004; Busemeyer and Trampusch 2012) with Norway having a hybrid between collective and statist systems. Korea was previously considered having a segmentalist system with in-house training in large companies, similar to Japan's, but is presently more placed in a statist or liberal camp (Park 2013). England is also considered having a liberal skill formation system with an enduring reliance on a competitive education market, supported by various state initiatives. Italy on the other hand is usually characterised as a statist system with a reliance on vocational schools and weaker links to employers and social partners (Baumann and Vossiek 2022).

Table 2 Countries, by skill formation system.

	Austria	England	Germany	Italy	Korea	Norway
Statist	X			X	X	(X)
Collective	X		X			(X)
Liberal		X			(X)	
Segmental						

2.2. Fieldwork and analysis

The fieldwork has been done by partner institutions in the Skills2Capabilities project in each of the six countries that are part of the comparison. The partner institutions delivered country reports which includes case studies of the relevant occupations. The partner institutions are 3s (Austria), IER/University of Warwick (England), BIBB and TU Dortmund (Germany), University of Padua (Italy), KRIVET (Korea), and Fafo (Norway). Detailed guidelines for the case studies were developed by Fafo and all partners took part in briefing sessions organised by Fafo. A separate document was developed that defines the occupations on the basis of what tasks they include. The occupational definitions are not equal to ISCO-definitions, although some of the occupations have a considerable overlap with a specific ISCO-code.

The occupational case studies covered three main areas: (i) description of work field changes; (ii) description of VET content changes; and (iii) description of the process of change. The occupational case studies draw on data[1] from:

a) present and previous curricula,
b) other documents related to curricula change,

[1] We have explored the possibility of using the EU Tasks Database to systematise the description of changes in tasks in the work fields, but it has proven difficult to apply this at our occupational level analysis. For further work focusing on the relationship between vocational and basic competences, PIAAC data may be considered.

c) interviews with a limited number of key informants within industry and the VET system (2-5 per case),
d) education and labour market data on apprentices/students and the composition of the work force in the selected occupations/work fields.

The analysis of change in VET at the occupational level was complicated by changes in the overall design of the curricula which can made comparisons over time challenging. In some countries, it has also been difficult to find the old curricula. However, mostly these challenges have been overcome. The main data problem lies in lack of adequate data on the specific change processes in many cases. Comparative process tracing is therefore not possible, but the design still allows us to see whether different outcomes are associated with different ways of organising employer and labour involvement.

3. Changes in VET

3.1. Introduction

VET systems have proven adaptive in the face of large-scale changes in the labour markets over the past 20 years (Cedefop 2018). Still, European VET systems have seen less change in the past 20-30 years than in the period of more transformative change between 1970 and 1995 (Hogarth 2022). In most European countries, VET systems have evolved and kept their key, distinctive features rather than going through complete transformations. Notable developments have been increased emphasis on workplace training, VET at higher levels, competence-based curricula, and CVET.

In this chapter, we will briefly present the key changes in the overall VET system of the six countries (3.2). This is intended as a backdrop for interpreting the case studies at the occupational/work field level. The changes in the overall VET system condition how actors approach updating curricula and standards at the occupational/work field level. In chapter 3.3 we describe the procedural rules for changing VET curricula and standards in the six countries. These define the "rules of the game" actors play within when they want to change the content of VET. The key characteristics of the six countries' VET systems are briefly summarised in the section that follows (3.1).

3.2. The VET system

Austria, Germany and Norway all have employer-led apprenticeships as a key element of their VET systems. This has been the case throughout the 20-year period which is the scope of the study. Austria also has a large and prestigious vocational school sector. Norway has a somewhat lower degree of employer involvement than Austria and Germany. A hybrid between a "statist" and a "collective" system may be an appropriate description (Olsen 2008), as employers and unions do play a major role in determining the content of apprenticeship curricula. All these systems aim to

equip apprentices with a set of broad occupational skills and knowledge while at the same time fostering broader educational goals such as personal development and civic responsibility.

Italy has a school-based system with five-year national-level technical and vocational schools (EQF 4) and three to four year regional-level vocational schools (IeFP, EQF 3-4). Nationwide changes in the content of vocational education at the regional level require agreements between the regions and the state. Formally this is similar to the relationship between the German Länder and the federal state, but the degree of actual decentralisation of decisions is higher in Italy. VET in England has had a range of different apprenticeships and classroom-based VET, leading to a complex qualification landscape. The system in England aims to be responsive to skills demands signalled by employers. In part, this achieved through the funding of VET where training providers are dependent upon meeting demand from employers for their income. This makes them responsive to meeting the needs expressed by employers, but possibly more to larger employers with greater purchasing power than SMEs. Employers also have a substantial degree of influence over the content of training, including involvement in the design of curricula, especially apprenticeship standards. Korea has had a system with vocational schools and in-house company training, but the latter has been marginalised since the 1990s (Park 2013). A cornerstone of the present system is national competency standards (NCS) with associated learning modules. These are largely determined by the Ministry for Employment and Labour while the government agency HRD Korea handles the practical work. The Ministry of Education is also involved, and so is the research institute KRIVET who acts as facilitators. Firms are playing a modest role in the development of standards and learning modules, only through involvement of industry experts.

3.3. Overall changes in the VET model since 2003

The six case countries have over the past 20 years developed their VET system in different directions to adapt to more rapid technological change in the work field and to correct what policy makers have perceived as deficiencies of their systems. The degree of change is different, with England and Korea having made major changes, while the other countries to a greater degree have maintained the key features of their model.

Although the systems differ in the degree/frequency of change in curricula, there seems to be a more general trend towards increasing the degree of flexibility within programmes and curricula. This is for instance achieved through modularisation (Austria), through more generally formulated curricula (Norway), various forms of specialisations (Germany) and through allowing flexibility in the content of training to the school level in higher VET (Italy). These can be ways of responding to more rapid technological and other change in the work field without having to update curricula continuously.

Modularisation/specialisation have different meanings in the academic literature. The increased flexibility noted above, relates primarily to flexibility for firms or schools to adjust training towards a specific competence within a defined qualification. These can be for instance in the form of elective modules where the regulations define which combinations are allowed. A very different

type of flexibility is individualisation which allows for adaptions according to the specific needs of the individual learner. In this report, we do not discuss this latter type of flexibility. Modularisation in its radical form conflicts with the broad holistic approach to VET competence, such as in Germany, Austria and Norway, among other things because it assumes that competence can be assessed partially, module-by-module, and that learning can take place "sequentially" (Li and Pilz 2017).

In **Austria**, modularisation of apprenticeships has been the key response to allow for increased flexibility in the VET system. The concept of modular apprenticeships was introduced in 2006. Apprenticeships are built upon basic modules, main modules and specialised modules. Basic modules are shared between a range of related qualifications, in addition apprentices need to choose at least one main module to obtain a particular qualification. Specialised modules deepen apprentices' competence, for instance in particular techniques such as additive manufacturing. Choosing specialised modules extend the length of training. While the motivation for introducing modularisation was manifold, it gives the system a degree of flexibility in time as new skills needs may be covered in modules, either main or specialised, without the need to re-negotiate the full VET education. It also allows for flexibility in space as a greater variation in competences is achieved within a formal qualification system which better meet heterogenous skills needs among firms (and possibly learners). However, as the case studies shows, how well modularisation works in this regard differs between qualifications.

While **Germany** also have introduced modularisation and specialisation in some vocational fields, it is more incremental than in the Austrian case. It is far from the key "instrument" to achieve responsiveness, although it has introduced flexibility to some selected fields (Li and Pilz 2017). There are elective modules for specialisation in some areas, such as engineering. Overall, German apprenticeship curricula change slowly. A study of change in German VET shows that the average time since last time the curriculum of a qualification was updated is a staggering 17 years (Blankart, Bretschneider, and Schad-Dankwart 2022). It reflects a complex consensus-oriented process of change in VET.

Italy has also a complex process of change where the regions hold legislative power over vocational education at the upper secondary level. There are five years national VET programmes (EQF 4) and 3-4 year regional VET programmes (EQF 3-4). The VET system has not seen major changes to increase responsiveness over the past twenty years, and there has been little change in the curricula we have studied over the time period.

Norway has over the twenty-year period remained the core elements of its VET system based on school-based education followed by apprenticeships, typically in the form of 2+2-model, with two years of school followed by two years apprenticeship. There have been two reforms of upper secondary education during the period (2006, 2020), where the VET program structure has changed somewhat through a process involving the social partners. However, these changes have been comparatively minor, and the key elements introduced with the fundamental reform of 1994, are still there. The 2006-reform widened the scope of many second-year courses while the 2020-reform

narrowed some second-year courses again, allowing for earlier specialisation in these VET qualifications.

England has over the past 20 years gone through several large-scale reforms of its VET system. Improving the skills supply has by successive governments been seen as a major objective, which has led to frequent reforms and little continuity. A change which has become a key element of the present system is the shift from apprenticeship frameworks to apprenticeship standards. The former often had formal qualifications (NVQs) embedded, which is usually not the case with the standards. With this shift, trail-blazer groups (cluster of firms) were introduced as key in initiating and drafting these apprenticeship standards. The motivation is to make the VET system more responsive to skills needs in the labour market, as signalled by employers. Although an aim was to reduce the overall number of apprenticeship standards, there has instead been a substantial increase.

Korean VET has been in a period of transition of the past 20 years, with the introduction of the NCS system a key element. The NCS can be understood as laying a "map" or classifying framework over existing educations and qualifications which helps to structure the educational landscape as vocational schools take up curricula based on NCS-associated learning modules Simultaneously, existing qualifications such as the National Technical Qualifications (NTQ) may have a content which do not correspond with NCS. These qualifications have their own content, which may or may not be identical to NCS or set of NCS competency units, however, new course-based qualifications aim to bridge this gap. Overall, this can be seen as an attempt to create a more coherent and transparent system, in a situation where in-house company training has been in decline (Lee and Nahm 2024), but it does only partially address the challenge of responsiveness to skills needs, as employers/firms are little involved.

3.4. Procedural rules and norms for changing VET curricula

The six countries participating in the present study differ in how they revise VET curricula and standards. In this study we have gathered data on the procedures and practices for changing these curricula and standards. The variation can in be categorised and analysed in different ways. Our interest in this is primarily in how the procedural rules and practice channel information about skills needs in the labour market into decision-making on the content of VET.

If we use the Markowitsch & Hefler (2018) typology, the authors have themselves categorized Austria's and Germany's dual apprenticeship systems as examples of a coordinated feedback mechanism, while upper secondary VET in England is categorised as having a liberal feedback mechanism. Feedback mechanisms can vary within a country. Austria has a coordinated model for the dual apprenticeship system, but a statist model for the vocational school system. The description in the country case reports in the Skills2Capabilities project largely support the categorisation of Austria and Germany done by Markowitsch & Hefler (2018), although England's system has changed since 2018, becoming possibly even more liberal.

Table 3 summarises key elements of the country case studies regarding their systems for changing VET curricula/standards.

Table 3 Organisation of process of change in VET content. Employer involvement.

	Key arena for employer input	Level of employer input	Employer influence	Feedback mechanism
Austria	Bilateral initiatives towards government. Federal Advisory Board on Apprenticeships	Social partners at sectoral and guilds level	High (on apprenticeships)	Coordinated for apprenticeships. Statist for vocational schools.
England	"Trailblazer groups" give input to IfATE	Small group of employers	High	Liberal
Germany	Bilateral initiatives towards government. BIBB	Social partners at sectoral and guilds level	High	Coordinated
Italy	Unknown	Regional VET: Groups of employers or single employers	Unknown	Statist for technical schools. Unclear for regional VET.
Korea	Expert groups appointed by HRD Korea	Varying level, Skills Councils or experts	Moderate to low.	Statist
Norway	Vocational training councils	Social partners at sectoral level	Moderate to high on apprenticeships. Moderate to low on preceding school-based educ.	Consultative/participatory

In **Austria**, social partners play a leading role in changing the training regulations that determine the content of **apprenticeship-based VET**. Initiatives to develop new apprenticeships, or renew the content of existing apprenticeships, often originate from business associations (40 %) or companies (25 %) (Steiner 2004, 135). The Institut für Bildungsforschung der Wirtschaft (IBW) gather information and draft curricula. Deliberations on the content of curricula take place in the Federal Advisory Body on Apprenticeship. The recommendations of this tripartite body usually play a decisive role, even though the Federal Ministry of Economic Affairs and Labour (BMWA) has the formal decision-making authority. In the other main pillar of Austrian VET, **the vocational school system**, the social partners only have an informal role, but norms within the system ensures that social partners are still consulted. The need for updates to a national curriculum for a vocational school programme is reviewed by a Fachabteiliung, special administrative units under the Ministry of Education. A curriculum commission is established with the task of proposing new curricula if

the Fachabteilung decides there is a need for it. Social partners will be consulted informally throughout the whole process, and through a formal round of consultations on any formal proposals towards the end. The commission will have representatives from VET teachers from the relevant regional schools. Decisions are ultimately taken by the Ministry of Education.

In **Germany**, the content of an apprenticeship qualification is determined by training regulations and framework curricula (for the school-based part). These are based on occupational standards set by the relevant ministries. Changes in standards, regulations and curricula are usually initiated by relevant employer's associations, professional organisations or by these in partnership with unions. When proposal for a change in occupational standards are accepted, the Federal Institute for Vocational Education and Training (BIBB) play a central role in drafting revised training regulations, but in partnership with the social partners. The BIBB board considers the draft before it is sent as a recommendation to the federal government. The process is consensus-oriented and characterised by a partnership between government and the employer and labour organisations with the social partners having a decisive role.

VET qualifications in **Norway** at upper secondary level are normally obtained through a combination of two years of school-based education followed by two years of apprenticeship training. National curricula regulate the content of both school-based training and apprenticeship. While formal authority to decide curricula lies with the Directorate of Education, the social partners have formal influence through ten Vocational Training Councils at the national level, one for each vocational programme. The social partners have a stronger formal role on apprenticeship curricula than for curricula for the school-based part of the education. The directorate commits to implement proposed content changes from the councils on apprenticeship curricula as long it does not have major cost implications or implications for the preceding school-based education, which do set some limitations, though, for instance on the length of training. Change in curricula can be initiated by the Vocational Training Councils, but also from employer or employee organisations, individual employers, counties, training agencies and others. If the directorate considers a proposal sufficiently justified, wherever it comes from, a formal change process will be initiated. A curriculum development group will then be established, which normally includes members from industry/work life. The Vocational Training Council will be involved at various stages of the project: when the curriculum group starts work, when the curriculum development group deliver their draft, when a proposal is sent on public consultation and when input from the consultation is reviewed and again before the new curriculum is formally decided. For the school-based part of training, the training councils have less formal influence (not "decisive"), but they are consulted. During the recent, major restructuring of the vocational programme structure implemented from 2020, the training councils and curricula groups had pivotal roles, although there were some instances where the final decision was not in accordance with their positions, with one of our case qualifications, logistics worker, as one example.

While the procedural rules and practices of Austria (for apprenticeships) and Germany would fit with the coordinated feedback mechanism, the social partners in Norway have a weaker, but still significant role. Norway thus leans more towards a strong variant of the participatory model.

Representatives from the social partners have repeatedly expressed the view that they have a too weak influence on VET (Nyen and Tønder 2016).

In **England**, changes have happened since the analysis undertaken by Markowitch and Hefler in 2018. This is reflective of the rapid pace of changes in the overall VET system over the past twenty years. However, England clearly has a liberal feedback system, with an even stronger role of groups of employers than before, which is in line with a long-term shift to employer-centred or demand-led processes of apprenticeships in England. A newly formed (2017) governmental agency, the Institute for Apprenticeships and Technical Education (IFATE), administers the current Apprenticeship Standards. In the previous apprenticeship frameworks, national vocational qualifications, NVQs, were embedded. The vocational-specific elements of the framework were described in these, but the general criticism of the qualification system was that apprentices worked their way through these qualifications without a holistic assessment at the end. The NVQs were therefore phased out of most apprenticeships. Key in the process for establishing and changing the new apprenticeship standards are so-called Trailblazer groups of employers. These Trailblazer groups have replaced sectoral bodies and are given the task to define the occupation, the skills, knowledge, behaviours and the end point assessment when establishing new standards. Changes in standards can be initiated by the trailblazer groups or others by a formal request to the IFATE, who may ask the trailblazer group for their input if the request comes from someone else, before IFATE-recommended changes go to an approvals committee.

Overall, this reform of the system has led to a ballooning in the number of apprenticeship standards (from 230 to 708 from 2017 to 2024) as employer groups craft apprenticeships for narrowly defined occupation, possibly at the expense of a wider recognition of such standards. While sector bodies may sometimes be present in the trailblazer group, the reform shifts the level of input down closer to the individual employer with less sectoral level coordination. The vocational schools, the providers, are largely left out of this process, which among other things mean that a changes in standards do not necessarily smoothly lead to corresponding changes in curricula. This can be interpreted as resistance to change or as an attempt to preserve some stability, depending on perspective.

In **Italy**, the regions and autonomous provinces have legislative authority over regional vocational education and training (IeFP) at EQF level 3 and 4. In addition, there are national level technical and vocational schools (IFTS) at EQF level 4. National level guidelines for **the regional VET educations** are established through agreements between the regions and the ministries of education and labour. Updates of such guidelines can be slow and infrequent. In one of our cases, the health care worker (OSS), the guidelines are from 2001 and are still valid. The revision of the curricula of the **national level technical schools** happens through a statist model with relatively little influence of employer or labour organisations. Higher VET at EQF 5 in logistics is provided by higher technical institutes (ITS) at national level. According to the Italian case study in logistics, the central guidelines for the programme in logistics only broadly define the content, which leaves room for schools to adapt their curricula to new demands from employers who also take part in the provision of training. This part of the VET system therefore seems to have elements of the liberal model where

employers are able to influence the content of training at the school level, albeit within a defined qualification.

In **Korea**, the government agency Human Resources Development Service (HRD) of Korea plays the pivotal role in change processes in VET. The **National Competence Standards (NCS)** and accompanying NCS-based Learning Modules are updated through a process administered by the government agency HRD Korea. This process is overseen by the Ministry of Employment and Labour and with the Ministry of Education also involved. HRD Korea will appoint an institution responsible for developing an improvement plan for a NCS if it considers that is needed. This institution could be an Industry Skills Council or other industry-specific expert institution. Once a plan is developed, there is a process with an initial review meeting followed by feedback from education institutions, a public hearing, meeting, and validation through feedback from industry experts before a second review meeting is held. The project outcome report will be considered by HRD Korea, who ultimately will take the decision on what the changes in the NCS should be. Learning modules will be updated correspondingly. KRIVET has a role as facilitator of the process.

In addition to the NCS, which is comparatively new (2013), there is a long-lasting system of **National Technical Qualifications (NTQ)** which is of relevance in a discussion of change in VET as it includes qualifications such as craftsman or master craftsman in various vocational fields. HRD Korea is responsible for the tests to achieve these qualifications and the processes to change these. The skills content for acquiring NTQs do not necessarily correspond with an NCS learning module, although NCS course-based qualifications aim to bridge such gaps. NTQs are periodically reviewed through a process where initially experts meet to review examination criteria, opinions of relevant ministries are collected followed by a review meeting and deliberations before the decision is taken.

Overall, the Korean system for changing VET can be seen as a top-down system where the Ministry of Employment and Labour and HRD Korea are taking the lead in updating the NCS and NCS Learning Modules. Industry is involved in the role of experts but play a relatively weak role. The same is true of industry's influence over the qualification system (NTQs), where industry has expressed dissatisfaction with the slow pace of updates to the content of these qualifications.

4. Industrial mechanic

Case countries: 2 Norway, Austria, Germany, England

4.1. Occupation and work field

Industrial mechanics are involved in setting up, adapting and initiating production systems, often employed in manufacturing and related industries (i.e. NACE-code 28). Their work tasks include maintenance, machine construction, production engineering and fine equipment construction.

[2] Data collection was also conducted in Korea. At this stage, Korea is not included in this chapter however, due to difficulties of comparability.

Common skilled work tasks for industrial mechanics encompass:

- Manufacturing elements/parts and assembling them into technical systems
- Read and interpret technical drawings, especially assembly drawings
- Use of machine tools like lathes, mills, CNC devices etc. for the production and adaptation of technical systems and elements
- Use measuring equipment to control whether technical elements and systems are in accordance with requirements
- Control production/manufacturing processes
- Use of hand tools when assembling and disassembling machine elements
- Identify faults and their causes in technical systems
- Check, repair and maintain mechanical equipment
- Coordinating work with any upstream or downstream areas
- Checking and documenting maintenance and assembly work in compliance with the company's quality management systems

Most industrial mechanics will be found within ISCO-08-code 723 “Machinery Mechanics and Repairers". We exclude mechanics with different VET qualifications in this code, e.g. car mechanics. ISCO code 7233 “Agricultural And Industrial Machinery Mechanics And Repairer” and its sub-code 7233.7, “Industrial Mechanic” is most precise but workers with the relevant VET-qualifications can also be found outside this occupational code.

The delineation of the occupation/work field we refer to here as industrial mechanic is based on the Norwegian apprenticeship and VET-qualification at EQF level 4 with the same name (*industrimekaniker*). This work field exists in all the included countries. In Germany, industrial mechanic is a recognised occupation and an apprenticeship within the dual VET system. In Austria, the occupational title industrial mechanic (*Industriemechaniker/in*) is rarely used, while machinist (*Maschinenschlosser/in*), or mechanic engineer (*Maschinenbautechniker/in*) is more common, with the most relevant VET-qualification being metal technology with specialsation (main module) in mechanical engineering. In England, the apprenticeship most closely matching the industrial mechanic occupation/work field are mechatronics maintenance technician (until 2024 part of the engineering technician apprenticeship). In Korea, industrial mechanic as a singular occupation and VET qualification is not identifiable to the same extent.[3] Korea it is thus not included in the following as it is not possible to provide accurate comparisons.

[3] While Korea does have both an important and technologically advanced mechanical and machinery industry, as well as VET qualifications for mechanical equipment installation and maintenance, the work field spans at least eight classified job types that partially overlap the definition used here, with technical skill qualifications at four different levels. Given our limited understanding of this system, it is not possible to provide accurate comparisons. However, it is clear from the country report that digital technologies are gradually changing the work field in Korea, while the qualifications and training required for these occupations have not changed to the same extent. Notwithstanding some efforts to create more comprehensive qualifications and include smart manufacturing and digital technologies in

Technological changes in the work field

In all the countries studied, VET qualifications relevant to the industrial mechanic work field are well established with long traditions. This can be related to the fact that the manufacturing and machining industries are traditional industries where manual work tasks and craftsmanship have had an important role. Historically, industrial mechanics have performed tasks related to machining, many of them manual or using analogue machinery, e.g. welding, drilling, turning etc. However, the work field now appears to be gradually but fundamentally changing with the implementation of new technologies.

The work tasks of industrial mechanics are being reshaped by a suite of technologies enabling digitalisation of machinery, automation and robotization. As processes are automated, certain tasks become obsolete, and others change. Digitalisation and automation have been a reality facing this occupation for several decades. Some advanced technologies, such as computer-controlled machinery (CNC) and industrial robots, were common already in the 1990s and have since gradually evolved and been implemented widely in the work field. Newer technologies relating to the transition to Industry 4.0., such as additive manufacturing, collaborative robots and AI are only starting to affect the work field and VET systems. How this specifically affects the industrial mechanic occupation is not widely studied, but a body of literature exists concerning industry 4.0 and the role and nature of the so-called Operator 4.0, which includes manufacturing operators with mechanics qualifications. This literature points to a decline in manual tasks and increased skill demands in terms of task rotation, cooperation and digital skills as the role of the operator is increasingly to be a supervisor of automated production using and using smart monitoring systems (Wittenberg 2016).

Industry 4.0 involves emerging and future technologies and thus not changes that have already impacted most industrial mechanics. Nevertheless, some of these technological shifts have been underway for many years and are expected to drive further demand for digital skills (Seet et al. 2018). The following technological trends are highlighted in the literature, as parts of the broader processes of automation, digitalization and computerization of tools and machinery:

- Tablets and smartphone applications used on the shop floor
- Robotics and other cyber-physical systems (CPS)
- Computer-Aided Design and Manufacturing (CAD & CAM)
- Computer Numerical Control (CNC) machines
- Sensors and the Internet of Things (IoT)
- Additive manufacturing (3D printing)

Changes in work tasks

The work tasks of industrial mechanics are changing with the implementation of the technologies described above. The more traditional machining skills including milling, lathing, plate-work, boring

curricula and tests, there seems to be an understanding that government policy lags behind industry trends and there are efforts made to be more attentive to employer feedback.

etc. is still central to the occupation, but these processes are also becoming digitalized and mechanics need to learn to operate digital interfaces of machinery and work with digital schematics and designs. CNC machinery, Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM) have been developed and implemented over numerous decades (Field 2004), necessitating mechanics to work with 3d schematics, programming and operating CNC-machines (CNC-operator can also be separate VET-qualification, as is the case in the Norwegian system, but this is nevertheless an important skill for industrial mechanics). Automation, robotics, and proliferation of and connected machines is changing the way industrial mechanics monitor and manage machinery, requiring new skills in data analysis and digital technology. Mechanics need to not only operate but also maintain and troubleshoot digitalized machines, automated systems and robotic devices (Koch et al. 2017). This change in work tasks does not (yet) apply to all companies and there is considerable variation in the level of technology adoption. A general trend is nevertheless that industrial mechanics use machines to perform tasks that used to be manual (e.g. CNC) and work more with computers and computer-controlled machines. The core vocational skills nevertheless 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). Our informants explain that flexibility with work tasks and understanding of technology, including monitoring systems and understanding how sensors and computer controls operate, is becoming a bigger part of the occupation.

4.2. VET Education/Qualifications

All countries studied have relevant VET qualifications for industrial mechanics, with a substantial number of apprentices and long traditions, and a single VET path can be identified as the most relevant for this occupation in most countries. All are at EQF level 4 and includes apprenticeships. Exceptions include some shorter related apprenticeships in England and that in Austria, the relevant VET qualification is also offered at Higher Vocational Education (BHS) with a duration of five years, qualifying for admission to a university.

In Austria, the most relevant VET-qualification to become an industrial mechanic is the main module of mechanical engineering offered within the modular apprenticeship in metal technology (Metalltechnik). It is one of 228 recognized dual apprenticeships. The modular apprenticeship includes a total of nine main modules, four specialised modules as well as process and project management. The main module in mechanical engineering can be combined with the main module in metal cutting technology (Zerspanungstechnik) or one of the four specialised modules, extending the apprenticeship duration from three and a half years to four years.

The Norwegian VET qualification Industrial Mechanic is a four year “2+2” education, meaning that the standard training model is two years at upper secondary school followed by two years as an apprentice. Industrial Mechanic is an apprenticeship within the broad programme “Technology and Industrial Production” which has a shared first year, while the second year is more specialised within “industrial technology”, which in turn qualifies for 29 different apprenticeships, including Industrial Mechanic.

In Germany, the Industrial Mechanic apprenticeship is structured within the dual VET system, combining practical training in companies with theoretical instruction at vocational schools over a period of 3.5 years. Industrial Mechanic is one of the 324 recognised dual apprenticeship training occupations governed by the Federal Act on Vocational Education and Training (BBiG). In the first two years of the apprenticeship, the training emphasizes foundational skills while the third and fourth years focus on deepening the apprentice's understanding of business processes, quality assurance in their area of expertise, and maintaining and optimizing complex technical systems. For the firm-based training of the apprenticeship, there are specializations called *Einsatzgebiete*, where apprentices can choose to specialize within precision instrument construction, production technology, maintenance or mechanical and plant engineering.

In England, the apprenticeships most closely matching the industrial mechanic occupation/work field is mechatronics maintenance technician. Prior to 2024, this apprenticeship was the pathway 'mechanical manufacturing engineering' embedded within a larger apprenticeship entitled 'engineering technician'. The apprenticeship combines on-the-job training with classroom learning. In the following, we focus on this apprenticeships, although a number of related apprenticeships, including some shorter paths at EQF level 3, can also lead to jobs in this work field. Despite a broader policy shift in England away from the system requiring National Vocational Qualifications (NVQs) as an embedded part of apprenticeships, this apprenticeship still requires the completion of two NVQs before taking the End Point Assessment. NVQs are practical qualifications based on national occupational standards, outlining the skills, knowledge, and understanding required to perform a job effectively.

Relevance of the VET qualification in the national work field

In all four countries, VET qualifications are described as the primary path into the work field. Because of the technical nature of the work and safety requirements, it is rare for unskilled workers to be employed directly as industrial mechanics. Even though formal qualifications are not always mandatory, practical experience or some form of vocational training appear almost always necessary. The VET qualifications are very well established, both in terms of the number of apprentices as well as longstanding traditions and industry involvement in curricula development. There appears to be sustained demand for industrial mechanics across the studied countries, although a slow decline in the number of new apprentices is also a common trend. Skilled labour shortage is thus an issue, especially in Austria and Germany but also in England.

In Austria, the Metal Technology qualification (containing the specialization in mechanical engineering) was the second most common VET qualification in the country, accounting for 12.3% of all male apprentices and 3.1% of all female apprentices. From 2014 to 2023, the number of apprentices in metal technology declined by approximately 20% (WKO 2024).

In Norway, the industrial mechanic VET qualification has historically been geared mainly towards maintenance and repair work, with hydraulics and machine maintenance at the core of the skill portfolio. Around 600 apprentices receive a VET certificate as industrial mechanics each year, a number that has been relatively stable over time. It is thus among the largest industrial trades, with long traditions and stable demand from employers. Approximately 20.000 employees are

registered within the occupation “industrial machine mechanic” (7233). Of these, 17 percent hold the formal VET-qualification industrial mechanic as their highest education. Other VET qualifications are also common in this occupation and skilled workers are in a majority. Only 15 percent have no formal education beyond primary school.[4]

In Germany, approximately 330,000 people are employed as Industrial Mechanics (Institut für Arbeitsmarkt- und Berufsforschung (IAB) 2024). They play a crucial role in the manufacturing sector, working with machinery and equipment production, fine instrument construction, and maintenance. Around 40,000 apprentices are in training, making it among the more popular VET qualifications in Germany. There has nevertheless been a downward trend in the number of new apprenticeship contracts per year, from 15 828 in 2008 to 10 212 in 2022.

In England, the metal machining, fitting and instrument making trades (522) employs 216,000 people (2021). The sector has experienced fluctuating employment and an overall slight decline – down six percent since 2010 (Office for National Statistics 2023). There are expected to be relatively high replacement level demands in the future. In other words, although overall employment is in decline there will be many open jobs that will need to be filled by new entrants into the occupation.

4.3. Change in the content of VET qualifications

There have been significant changes to the content of the industrial mechanic qualifications in all the selected countries. In Germany and Austria, technological change has been a main driver, and modularized qualifications/specialisations enable up-to date skills adapted to employer demands. In England and Norway, changes appear less comprehensive, and employers have put emphasis on keeping the core of the traditional apprenticeship intact, while maintaining flexibility through open-ended curricula.

In Austria, the current VET qualification is generally considered to meet employers’ needs. It has undergone significant changes, most notably related to modularisation of apprenticeships. This has been a strategic response to introduce flexibility in the VET system to respond to changes in the work field. The ‘metal technology - mechanical engineering’ qualification was established in modularised form in 2011, replacing sixteen VET-qualifications related to metal work (IBW 2015). A key objective for the modularisation was to clarify the skills and knowledge acquired and increase demand for the qualification. The module structure was reworked in 2022, with additional specialisations. The curriculum now has increased emphasis on digital skills, including 3D modelling and sketching. Specialisations allow for additional focus on technological skills, e.g. through the specialisation in automation technology which include working with sensors and actuators, program logic controllers, operate automated systems and to save and load programs for robots. The curricula are also increasingly open-ended and refer less to specific technologies, methods and tools, allowing for flexibility in teaching.

[4] sammenlign.utdanning.no/sammenligne/yrke#y_ind_mekaniker

In the case of Norway, changes are described as slower and more gradual. Changes to the industrial mechanic qualification have been made primarily as part of the larger cross-cutting reforms of upper secondary education, starting in 1994, 2006 and 2020. Overall, the changes in the curricula are modest, and thus less substantial than the (technological) changes in the work field might suggest. This reflects a consensus among stakeholders on a principle of keeping curricula on a general and technology-neutral level, to enable continued relevance, less need for updates and flexibility in local implementation. Compared to earlier versions, the current curriculum is shorter and less specific regarding techniques, machines and technologies, with an emphasis on transversal skills. The core skills described in the curricula remains similar, though digital technologies, automation and environmental concerns are more prominent than previously. For instance, the curriculum now lists “contributing with mechanical competence in automation of work processes using available technology” as a competence target. While curricula changes appear modest, interviews indicate that actual use of digitally controlled machinery and processes are more significant, both in schools and apprenticeships. The qualification is still seen as relevant by most employers, reflecting the significant flexibility in applying the curricula locally.

In Germany, the Industrial Mechanic qualification was established in its present form in 1987 with the consolidation of several qualifications into a single qualification, with a reform aimed at reducing the number of occupations and offering broader occupational profiles. It has since undergone a number of changes. The latest major update was introduced in 2018, incorporating new digital competencies in the training curriculum, including core qualifications relevant to all industrial metal and electronic occupations, such as "Digitalisation of Work, Data Protection, and Information Security." Additionally, apprentices can now pursue optional supplementary qualifications such as System Integration, Process Integration, Additive Manufacturing, and IT-supported System Modification. These additional qualifications, delivered over a recommended period of eight weeks, are designed to extend the apprentices' skills beyond the core training, enabling them to specialize in specific areas that meet the needs of advanced manufacturing environments.

In England, the core of the apprenticeship has remained – including the requirement of NVQs – but the standards have been updated several times with a growing focus on the use of technology in the position. More advanced technologies, digital tools and sustainability practices are included in the curricula. The earlier ‘framework’ standards (2002 and 2003) had a number of required skills related to manual fitting, machining, and assembly. Since then, standards (2017, 2022 and 2024) have progressively included more technology ranging from the introduction of computer aided design (CAD) and by 2024 expectations of programming and the utilisation of digital tools. Other changes of note include the inclusion of behavioural traits, attitudes and professionalism in 2017. The first iteration of these behaviours focused on personal responsibility, teamwork, communication, quality and problem solving. The newest iteration (2024) of behavioural requirements reflects a shift to incorporate the values of diversity and inclusion and a focus on sustainability, as well as continuous improvement. There is a continuity of core competences required in terms of the machines named in the standards, such as milling, shaping and cutting machines, which have not changed since 2002. The exception is that the 2002 standards included

both computer numerical control (CNC) machines and numerical control (NC) machines, while only CNC is included from 2017. NC machines require operators to manually input punched tape instructions into the machine, while CNC is computer controlled and more flexible. Reflecting this move to computer aided machinery, apprentices are also required to have computer design and programming skills, including producing CAD drawings and programming CNC machines. The 2024 apprenticeship standard goes even further identifying a required knowledge area related to advanced technologies including the principles of robotics and AI applications. While at first glance the core of the apprenticeship has not fundamentally changed since 2002 as NVQs remain and the same type of machines are utilised, the digitalisation of these machines and the skills required to utilise them, is reflected in the apprenticeship standards.

4.4. Process of change

In Norway, the brunt of changes to the industrial mechanic curricula have been part of cross-cutting reforms and thus of a general nature, but the reforms also included reviews of each qualification, which in the latest reform (implemented 2022) was tasked to a curriculum development group that recommended specific changes to the industrial mechanic curricula, subsequently considered – and mostly approved – by the Directorate of Education and Training. The group's initial recommendations were, however, more ambitious regarding automation and new technology than the final version of the curriculum. During the consultation process for this review, some employers in manufacturing objected to detailed competence goals on this, as it could hinder some smaller or less advanced firms in offering apprenticeships. The final wording was thus made less ambitious, but without limiting companies from providing such training if they wish.

In Austria, the adaptation of the qualification to new technologies has been a long-term process, with significant changes already with the 2004 revision, which integrated digital skills, specifically in 3D modelling and sketching. The major changes have been introduced through wider educational reforms. The modularisation of the qualifications underwent the standardized process for all VET qualifications within the Federal Advisory Committee for vocational training (Bundes-Berufsausbildungsbeirat (B-BAB)). The modernisation was supported by both political and industry stakeholders, with a consensus-oriented process with input from various companies and experts. The modernised structure is generally viewed positively, providing flexibility and a broader range of skills.

In Germany, the addition of digital competencies in the training curriculum has been made in response to digitalization and Industry 4.0. The most recent update in 2018 was intended to provide improve the quality of the qualification and give apprentices the opportunity to gain advanced skills, in response to the evolving technological landscape. A goal was to ready apprentices for work in increasingly interconnected and data-driven environments (BIBB 2018).

In England, Trailblazer employers are the primary vehicle for formally updating the apprenticeship standards. Also included in this process are sectoral bodies. Professional and skills bodies such as Enginuity have worked to maintain strong qualifications and core skills for industrial mechanics,

resisting national policy changes – as was the case with the maintenance of embedded qualifications for this apprenticeship. For example, when government representatives pushed to remove the qualification and claim that as it was not explicitly mentioned in job vacancy ads it must not be relevant, sectoral bodies and their representatives pushed back to explain that this requirement was implied and essential to maintain. The time to implement changes to an apprenticeship standard is lengthy, multiple years with no guarantee of an outcome. As such, apprenticeship standards for industrial mechanic are deliberately vague, allowing for discretion between employer and training provider to get the actual skills required.

4.5. Discussion: Interaction between VET and work field?

The national work fields have the main technological changes in common. Still, there appears to be some variation in how much this has affected work tasks and skill demand. As described above, digitalisation and automation, especially in CNC-machinery and increasingly robotics, is changing the occupation. In Germany and Austria, metal fabrication and related manufacturing is an industry of strategic importance, with both large industrial firms and highly specialized smaller businesses that serve as suppliers to e.g. vehicle manufacturing or engineering.

In Germany, industrial mechanic is one of many apprenticeships that have been modernized in response to digitalization and the integration of Industry 4.0. Austria has introduced the modularisation of selected vocational training programmes, including those of industrial mechanics, to address a shortage of skilled labour and the need to keep pace with rapid technological advancements. The German and Austrian modernization efforts appear relatively successful, and to have contributed to an upskilling in the occupation.

In Austria, the demand for skilled workers in the metal industry has increased over the past 20 years due to automation and digitalization and the introduction of new technologies, such as the increased use of composite materials and additive manufacturing. There is now considerable overlap between electricians and industrial mechanics, particularly in areas like robotics. This shift has increased the complexity of tasks within the occupation, demanding new skills and deeper technological knowledge, leading to a higher skill level overall. Employees are now also taking on more management responsibilities in addition to their manual tasks, an indication of upskilling within the occupation.

In Norway, industrial mechanics has traditionally been an ”all-round” qualification for operators in these industries, with a clearly defined ‘core’ of mechanical work tasks that has remained relatively unchanged, despite technological change and digitalization. Industrial mechanics are still in high demand in various industries, but some employers have shifted demand towards VET-certificates geared more towards automation and supervision of production, such as production technician (*produksjonstekniker*) and automation mechanic (automatiker). Although our informants describe considerable technological advances in the industries and digital tools becoming more important for apprentices, the VET qualification appears to have retained much of its former content. The clear technology-related upskilling in the work field, as described in Austria, is less apparent in the

Norwegian case. Changes in structure and curricula also seem considerably less geared towards (proactively) responding to technological change than in Austria and Germany; suggested skill requirements related to automation were not added to the Norwegian curriculum, as a result of objections from employers.

In England, mechatronics maintenance technicians are trained to work in a variety of manufacturing and engineering capacities in the 'leading-edge' sectors of aerospace, electronics, automotive and marine engineering as well as and 'mature engineering' sectors of electrical, metal goods, mechanical and transportation equipment. Despite some employment decline in the occupation, it is expected that high replacement levels will uphold demand for apprentices. The evolution of the apprenticeship standards for mechatronics maintenance technician indicates a responsiveness to the needs of employers. Firstly, by progressively including more technology ranging from the introduction of computer aided design (CAD) and by 2024 expectations of programming and the utilisation of digital tools. Secondly, the maintenance of embedded NVQs for this apprenticeship reflects the strength of professional and skills bodies that advocated for this continuity.

4.6. Summary and conclusion

The industrial mechanic VET qualifications continue to be highly relevant for the occupation and work field, in all the studied countries. Though apprenticeship numbers have declined somewhat, there is continued high demand for skilled workers in this field and an apprenticeship-based VET certificate remains the main path into the occupation.

Austria and Germany have implemented notable curricula changes responding to technological change and Industry 4.0. Digital skills are more prominent in the curricula, and modularisation/specialisation allows apprentices to choose additional technology-specific training. This appears successful in terms of the qualifications remaining relevant and valued by employers, as well as in terms of supporting an upskilling in the occupation. The strategic importance of the industry and the strength of the social partners, in combination with the consensus-oriented feedback mechanisms could be an explanation of this responsiveness.

In England as well, the curricula (standards) have been updated in response to technological changes. The core of the apprenticeship has been preserved insofar that apprentices are still required to know how to use a milling or cutting machine, but they now have to be able to use the computer aided versions, understand basic programming and computer aided design. There is thus a responsiveness to technological changes in the work field, but employers and sectoral organizations have also acted as a conservative force in ensuring the continued embedded NVQs.

In Norway, curricula changes have been more limited. Nevertheless, open-ended curricula and considerable flexibility for local implementation has ensured that the qualification has remained relevant and valued. Responsiveness to technological change is not obvious from the curricula but our informants still describe the training as up-to-date insofar that digital skills are increasingly

taught and companies that have implemented advanced technologies are free to – and do – incorporate these in apprenticeships.

Employers have been involved in and influenced the processes of change in all the countries studied, albeit with differing effects. In Austria and Germany, consensus-oriented processes around the major educational reforms and attentiveness to the increased demand for technological skills have ensured that the qualifications have been modernized and remained relevant for employers. In Norway and England, employers appear to have been more of a conservative force, in the sense that they have valued the traditional core skills of the qualification as well as the inherent flexibility in open-ended curricula, and thus resisted changes that could erode this. In England, the requirements towards apprentices have nevertheless shifted significantly towards computer and digital skills. In Norway, the VET-qualification has remained relevant despite limited curricula changes, with long traditions for the apprenticeship and strong employers preferring flexibility of generally worded curricula. The latter is also seen in England, where open-ended apprenticeship standards enable flexibility and sectoral bodies have worked to maintain qualifications and core skills for industrial mechanics.

Table 4: Key characteristics of VET qualifications associated with the industrial mechanic occupation

	Type of VET qualification	EQF	Major content changes	Actors' response
England	Apprenticeship (3,5 -4 years)	4	Yes, more on digital skills. Continuity of core skills and embedded qualifications despite systemic changes. General curricula allowing flexibility in local adaptation	Employers worked to keep core skills and NVQs
Austria	Apprenticeship (3,5 -4 years) Vocational school (5 years)	4	Yes, modularization, more on digital skills, specializations allow focus on e.g. automation	Employers generally positive. Skill shortage
Norway	2+2-model (2 years at vocational school, 2 years apprenticeship)	4	Slower and gradual changes, technology-neutral curricula and flexibility in local adaptation	Employers mostly positive. Some prefer more specialized qualifications.
Germany	Apprenticeship (3,5 years)	4	Yes, more on digital skills and supplementary qualifications on advanced technologies	Employers positive

5. Healthcare worker

Case countries: Austria, England, Germany, Italy, Korea and Norway

5.1. Occupation and work field

Health care workers work mainly in care institutions, hospitals and in people's homes, and the tasks they perform are primarily centred around care of patients. In the five case countries, there are local names of the occupations related to VET qualifications, but here we refer to them as 'health care workers' to work with a common title across borders. In Austria, this is called 'Pflegeassistenz'', in Germany it is 'Pflegefachleute', 'operatore socio-sanitorio' in Italy, 'healthcare support worker' in England, 'yo-yang-bo-ho-sa' in Korea, and 'helsefagarbeider' in Norway.[5]

There is significant variation between countries in the kinds of work health care workers perform. This variation is shaped by the organisation of health care provision in the five case countries, the kind of institution where health care workers work, as well as the national, regional and local task distribution between nurses, health care workers and unskilled workers. Health care workers provide practical, personal, and basic health care for patients and users in various care institutions, including nursing homes, rehabilitation centres and hospitals. Typically, they will work in long-term inpatient care, where they help patients with practical, everyday activities while also taking care of basic health care needs. Broadly speaking, their roles generally tend to include:

- Assist patients with personal care needs such as showering, toilet and getting dressed
- Assist patients with moving and exercising
- Lift, turn and transport patients
- Change bed-linen and keep facilities clean and tidy
- Prepare meals
- Administer treatments
- Provide patient education
- Coordinate care plans
- Provide social support
- Assist patients with communication needs
- Observe and report changes in patients' condition or behaviour
- Help with basic health care, taking blood samples, change bandages etc.
- Assist patients needing help with eating and drinking
- Participate in planning the care of patients
- Help patients with rehabilitation exercises, basic treatment and delivery of medications
- Sterilise surgical and other instruments and equipment
- Document, keep records, report care/treatment
- Assist doctors, nurses and any other professional medical staff

Health care workers have many tasks and responsibilities, but in addition to the variation described above, there are broader societal changes that impact the organisation of work, as we turn to next.

[5] The health care worker will in some countries be registered in ISCO-O8-code 5321 only, while in other countries be distributed between 5321 (Health Care Assistants) and 3221 (Nursing Associate Professionals). The most common NACE code where this work is done would be 8710 (Residential nursing care facility services) and 8730 (Residential care activities for the elderly and disabled). Medical assistants mostly employed at GPs in ISCO code 3256 fall outside the scope of the case study.

5.2. Changes in the work field

In many of the countries, there appears to be an ongoing widening of tasks for health care workers. The persistent shortage of health professionals across Europe has made health care workers increasingly important. Adding more health care workers is probably a faster and cheaper way to get more hands-on deck than training nurses and doctors, but the growing proportion of health care workers also mean that their tasks and responsibilities are expanding. They are increasingly expected to take over some of what nurses have previously done (partly in response to the need for nurses to take over larger parts of doctors' responsibilities). This shift is the most significant factor driving change in work field, though there is variation in terms of the extent to which these changes are formalized or simply resolved and distributed within workplaces.

There have been several technological developments in the field of health care and digital technologies are also central in shaping the work field. Health care in institutions has traditionally been a hands-on and person-centred endeavour, but new technologies are rapidly evolving and changing the tasks of health care workers. Many of these advances are commonly referred to as welfare technology, which can be understood as 'technological assistance that contributes to increased security, safety, social participation, mobility, and physical and cultural activity, and strengthens the individual's ability to cope on their own in everyday life despite illness and social, mental, or physical disability' (Norwegian Directorate of Health 2012, 15).

The first widespread uptake of digital technology in nursing homes was for billing purposes and for recording mandatory clinical assessments of patients (Morley 2012). A range of more advanced technologies have also been available for some time, although nursing homes and other health care institutions have been slow to embrace these technologies, partly due to initial difficulties in using them and lack of relevance to residents (de Veer et al. 2011). Based on the overview provided by Morley (2012), relevant technologies can be grouped as follows.

- Electronic Medical Records and other databases concerning patients and treatments, increasingly available on tablets or healthcare workers' mobile phones.
- Telemedicine (real-time two-way communication between the patient and the healthcare provider) is being used in assisted living and nursing homes, particularly for night calls.
- 'Smart home' technologies and sensors are used to detect potential problems, e.g. if a person has fallen. Sleep tracking, monitoring vital signs and GPS data allow for keeping track of sleep activity, pulse, hydration, glucose levels and other health data remotely, as well as notify if patients stray from their permitted areas.
- Health apps and exercise aides are used for stimulation and prevent isolation.
- Social media and socially assistive technologies are user-appropriate devices and tools that enable real-time connectivity to enhance social interaction (Macdonald et al. 2021), and augmentative communication devices.
- Augmentative communication devices include hearing aids and cochlear implants.

- Robots have a wide potential applicability in health care institutions, spanning from the already common use of medicine robots that alert the patient when medication should be taken and dispense pre-packaged medicine to the patient, to more advanced AGVs, robotic arms and nursing robots that could alleviate health care workers from physically demanding tasks.

Welfare technology can help improve accessibility, resource utilisation, and the quality of health services, and serve as technological support for workers and relatives. New digital technologies can help with the provision of care and improve patients' quality of life. In some places, there is growing emphasis on the need for healthcare workers to regularly update their digital skills to operate different kinds of welfare technology (Norwegian Directorate of Health 2012; Havreberg and Sylte 2021). Even though there appears to be a need for many health care workers to adapt to the introductions of new technologies, they have mainly been incorporated into existing occupations rather than radically transforming the work organisation. The new tasks that health care workers have been given and the widening of their tasks and responsibilities over the past two decades do not appear to be related to these technologies, but rather to the demographic shift and growing demand for staff. Next, we take a closer look at how this changing work field is reflected in the current VET qualification in the five countries.

5.3. VET education/qualifications

There are similarities as well as differences in the VET education of health care workers in the five countries. They all provide VET qualification. In Austria, Germany and Norway, the qualification is placed on EQF level 4, whereas in Italy and England where this qualification is on English Level 2, which more or less corresponds to EQF level 3. The VET qualification for health care workers can be summarized for each country as follows:

Austria: The Education and Training for Healthcare Professionals has traditionally taken place in specific schools (Schulen für Gesundheits- und Krankenpflege) and required a minimum age of 17 years. To address the increasing demand for skilled healthcare workers, Austria introduced new, dual apprenticeship-paths in September 2023 as a pilot program until 2029. This now allows youth to start health care worker education at the age of 15 when they complete compulsory nine-year schooling. This is a three-year apprenticeship, with the possibility of adding a fourth year to become a higher status health care worker. The apprenticeship vocational model combines learning at workplaces and schools, though the practical learning on the traditional school-based education is also quite extensive. Approximately 31% of the workforce in the healthcare sector are health care workers (Rappold and Juraszovich 2019). There have been no major shifts related to technological development in the VET qualification for health care workers related to the technological developments in the field. There have been several other changes in the curriculum over the past two decades, and particularly to prepare for an aging population, shifts in tasks and to make the health care worker occupation more attractive for young people. There has also been changes related in the pedagogical principles to prioritise relationship building, effective communication

and social inclusion related to for example gender and sexual orientation, among other dimensions.

England: There are no set entry requirements for starting work as a health care worker, but those who are recruited may be asked for qualifications such as GSCEs, BTEC or NVQ, and will be trained on the job through an apprenticeship to achieve a Care Certificate. The apprenticeship has a duration of 12-18 months before they enter their assessment stage, which can take a couple more months to complete.

From 2003 to 2013 there was a requirement to have completed a National Vocational Qualification (NVQ) in Clinical Healthcare Support (level 2) to start an apprenticeship, but this was ended to remove reliance on qualification and instead focus on the knowledge, skills and behaviours of an apprentice that would be assessed at the end of the apprenticeship period. With the exception of the removal of the NVQ requirement, the apprenticeship guidelines standards for healthcare support workers and senior healthcare support workers remain largely unchanged, and with little reference to technology or technological skills. There has been some attention to the technological developments in the work field and guidelines from 2022 have included statements about the need for health care workers to develop skills related to the use of technology for recording and storing information, selecting and using appropriate tools and equipment for physiological measurements, moving and handling equipment to safely assist individuals. Despite these changes, the specific skills, knowledge and behaviours required of healthcare workers are largely unchanged in the apprenticeship and curriculum over time.

Germany: The education of health care workers is situated outside the broader dual VET system which combines workplace training with classroom instruction. Instead, it is a school-based VET with two years of education before moving on to a third year of working in an institution. This education is on EQF level 4. In 2023, a total of 54,360 people completed their VET education as health care workers, out of which about 27% (14,559) were men. There are a total of 1.69 million health care workers across different institutions in Germany. Most of these are female (82%) and more than half of them work in part-time positions. There is also a substantial number of health care workers who are foreign nationals (16%). The VET education has undergone several changes over the past two decades. In 2004, there was a shift to include more theoretical training, whereas in 2020, three separate pathways (general, paediatric and geriatric health care work) were merged into one education. Despite these changes, this education continues to be offered at schools and in hospitals, as well as inpatient and outpatient care facilities. The students take a general health education the first two years before they choose an area of specialisation for their practical training. After completion of a year of training, they will be qualified to work as health care workers. The curriculum is updated by an expert commission regularly, at least every five years, to ensure its relevance. In recent years, educational authorities have focused on making the vocational education of health care workers more flexible to respond to both internal and external factors. The internal factors refer to the need to modernise the educational framework to better align with contemporary healthcare demands and to ensure that the curriculum adequately prepares nursing professionals for the diverse challenges inherent in their roles. Externally, the rapid advancements

in digitalisation and healthcare technology, coupled with the growing complexity of patient care, underscored the necessity for restructuring a more comprehensive and flexible training programme. The merging of the former more specialised VET pathways into a generalist one, is thus a response to the shifting needs in the sector and to ensure that health care workers are well prepared for both technological and demographic changes. This training programme aims to equip nursing professionals with a comprehensive set of competences that are applicable across different age groups and healthcare settings and will enable them to deliver high-quality care across various healthcare settings.

Italy: This model offers different options for qualifying as health care workers. The VET qualification for health care workers is a one-year programme that combines school learning and practical training in institutions. This degree has not been referenced in the Italian qualification system and, hence, it is not allocated to an EQF level. Students need to have completed mandatory schooling to register for the education. The VET qualifications are organised by the regions and there are variations between the programmes, but the qualifications are valid throughout Italy. While there have been attempts to make changes in the VET qualification for health care workers, there have been no major changes over the past 20 years. The lack of change suggest that digital technologies have not been included in the VET qualification. Currently, there are about 118,000 health care workers working in care homes, but there are not statics available regarding the total number of health care workers in Italy. There is no uniformity across regions in terms of providing further education for health care workers, but some regions have started providing this. Moreover, for those working in the public sector, there is no increase in pay as a result of taking further education which makes it less attractive.

Korea: The education of healthcare workers (‘certified caregivers’) was established in 2008. This is certification is achieved through 320 hours of training. The training consists of 126 hours of theory, 114 hours of practical skills and 80 hours of practice in institutions. A total of 564,243 certified caregivers worked at long term elderly care institutions by the end of 2022. There is also a 1520-hour vocational training path to become a ‘nursing assistant’, but these are found primarily in hospitals. The curriculum for this training has not undergone major changes since a qualification test was introduced in 2010, but the Ministry of Health and Welfare, which is responsible for the content of training, publishes caregiver training guidelines with minor changes every year. There does not seem to be much of a channel for stakeholders, such as the Association of Long-Term Care Organisations, the Association of Care Workers, and the Association of Care Worker Educational Institutions, to provide input or influence the guidelines. The standardised textbooks that training institutions use in their programmes were revised in 2014, 2019 and 2024. Among the recent changes was the more in-depth description of age-related diseases such as dementia, stroke, and Parkinson’s disease, inclusion of insights from Japan and France on ‘people-centred care’, focus on digital skills to use PCs, pads, and mobiles to work with patients and log work, as well as updated information about relevant laws and regulations. From 2024, a senior caregiver scheme was introduced, which requires at least 60 months of work experience and additional training. This role was set up to facilitate career progression and make the work field more attractive for new staff.

Norway: There is a 2+2 pathway to become health care workers. Students can enrol after completing 10 years of compulsory schooling. Year 1 is the fundamental year that is the same for different VET health pathways whereas year 2 year is specialized for health care workers. The first two years take place in schools and the students will then be apprentices in institutions year 3 and 4. The health care worker VET education used to be two separate degrees, but these were merged into one in 2006. Initially, the new degree contained a larger part of the care component, but this has gradually been reduced and replaced with more emphasis on medical knowledge, especially with the curriculum changes in 2017. This can be understood as a response to the need for health care workers to take a larger part of what used to be nurses' tasks and responsibilities. It is possible to pursue further higher vocational education degrees to expand on this qualification.

5.4. Discussion

In the countries considered in this report, there is a shortage of staff in the health care sector. This is largely caused by demographic shifts where a growing proportion of the older population have more complex health needs, which increases the demand for health care. At the same time, there have been technological changes that have impacted the work of health care workers. Their roles, however, have not drastically changed as a direct result of this. The welfare technologies that have become present in different kinds of institutions do not appear to have radically transformed their occupation across the countries. Health care workers still largely perform roles that centre around different dimensions of care, but the technological tools have improved communication within institutions and help transfer information about patients between different staff. However, it appears that most stakeholders in the different countries have not seen a strong need to change the education of health care workers to accommodate technological changes. More than digital technology it is the shortage of staff that has impacted the contemporary health care worker occupation.

Overall, it appears that there are different ways of adapting the education of health care workers to the new realities in the work field over the past 20 years and different approaches on how to use health care workers in a sector with high demands for workers. That said, in some of the countries there seems to be ongoing efforts to find new ways of preparing health care workers to work across a wider area of the health sector. Instead of training them for a specific role that they are expected to remain in throughout their careers, they are in some cases being trained with a greater degree of flexibility. The flexibility is needed for them to take on different roles and compensate for the shortage of workers in the health care systems by enabling them to work with different health care needs and across several areas of specialisation. This is particularly the case in Germany where the health care worker education has been changed to become more general to make workers more flexible in terms of where they can work in the health care system, both as a result of the rapid changes in the work field and to respond to the digital advancements. Similarly, in Austria, there have been several efforts to adapt the health care worker education to the current and future demands from the labour market. These changes have included the introduction of a trial of a dual apprenticeship path to train healthcare workers and changes in the school-based education to make

it more suitable for what is needed in the work field, with a particular focus on the social dimensions such as relationship building, effective communication and inclusion regardless of gender and sexual orientation. This is a different development than what has been taking place in Norway, especially from 2017, where there has been greater emphasis on preparing health care workers to take a larger part of nurses' tasks by shifting the learning objectives from care towards medical knowledge. This shift has generally been welcomed among different stakeholders, but there have also been concerns about the reduction of care emphasis as that reduces health care workers skills in providing support for patients and their families. In these three countries, there seems to have been efforts to make the health care workers more central in the health systems by adapting their trainings to current and anticipated needs across the health care sector, though the content of the training and the way they are organized differ.

On the other hand, the three other case countries have taken other approaches. In England, the demand for labour in the health care sector means that people without VET education can be recruited and learn the necessary skills on the job and obtain certification in the process. This approach allows for easy and continuous access to workers, but the training on the job may not necessarily generate the transversal skills that are needed for a flexible system that adapts to the shifting needs of the older patient group. The specification of training regulations for care workers in England provide the care worker occupation with its occupational identity, though the lack of training guidelines and occupational ladders may be seen as a result of limited respect for this occupational identity among policy makers. Many skilled manual jobs are ones which have a long history. Custom and practice over time have tended to define what is undertaken where the purpose of training regulations is essentially that of codifying the skills practiced and setting standards of performance. This is less true of some care occupations. The massive increase in the demand for social care is a product of increased longevity – linked to relatively poor levels of health. This is a relatively recent phenomenon, even though it has been well known and anticipated for several years already. Compared with traditional skilled manual jobs, the training regulations serve to define the health and social care occupation to a much greater extent. They are also designed to confer professional status on the care worker occupation and make it a more attractive job in which to work. The health care sector is also dependent upon recruiting people from abroad to work as carers.

In Italy there has been little, if any, change in the training of health care workers. Korea also presents a different case in the sense that the training is short, but accessible to many. This means that it is straightforward to train certified caregivers, but at the same time it does not provide much in-depth learning. This leaves little room for flexibility and movement of workers between different areas of health care. In these three countries, it seems that there has been less responsiveness in terms of developing strategies for managing the future demands in the work fields through curriculum and organization of the training.

Table 5: Key characteristics of VET qualifications for health care worker

	Type of VET qualification	EQF	Major content changes	Actors' responses
England	Apprenticeship (12-18 months)	3	Removal of requirement qualification as part of apprenticeship	The training is not valued on the job
Austria	Healthcare assistant school (1 year, 1,600 hours of training) Apprenticeship pilot (3,5-4 years) (2023-2029)	4	Minor changes to make content relevant to the work field, but major system change by introducing new pathways	Unknown
Norway	2+2-model (2 years at vocational school, 2 years apprenticeship)	4	Two former VET programmes were merged in 2006, and the curriculum content has increasingly shifted towards medical knowledge	There appears to be agreement that the changes to VET qualification have made it easier to use health care workers in different areas of the work field
Italy	1 year programme	3	No major changes	Perceived low prestige of the health care worker occupation related to it not being responsive to the dynamic landscape of healthcare delivery
Korea	320 hours of training	N/A	Gradual increase of content and focus on specific areas of care	Companies have expressed dissatisfaction with the slow updates of the qualification system because this creates a mismatch between supply and demand in the rapidly changing job market
Germany	School-based with training in companies (3,5 years)	4	Unification of three different degrees into one degree. Generalization of content and greater focus on digitalization and healthcare technology	Need for the qualification to be better aligned with current healthcare needs

6. Warehouse logistics worker

Case countries: Austria, Germany, Korea, Italy and Norway

6.1. Occupation and work field

Warehouse logistics workers work primarily in industrial and commercial companies and other logistics service providers. They are qualified to engage both in the administrative tasks (keeping records, controlling flows) and the manual ones (picking and physical transportation of goods). They are primarily registered in ISCO-08-code 4321 (Stock Clerks). Some may also be found in 4322 (Production Clerks), and many warehouse logistics workers will be found within NACE-code 521 (warehouses) and in the logistics departments of firms with warehouse functions in other sectors, such as in retail or manufacturing. Despite the rapid increase in use of digital technology, there has

also been an increase in the number of people working in this field. There is limited comparative data on the proportion of workers qualified as warehouse logistics versus unskilled workers. Most workers are men. The local titles that correspond to warehouse logistics worker in the different countries are 'Betriebslogistikkaufmann/frau' in Austria and 'Fachlagerist/-in' in Germany. In Korea, 'mul-lyu-woon-young-ja' and 'mul-lyu-gwan-li-ja', whereas in Italy 'Operatore dei sistemi e dei servizi logistici', and in Norway 'logistikkoperatør'.

The role of warehouse logistics workers varies between the case countries, though the occupation of warehouse logistics worker includes a range of tasks. The following are the most common ones:

- receive, check and sort goods
- internal transport of goods for storage or dispatch to customers
- prepare and secure goods for shipments (picking, packing and loading goods)
- keep records of goods stock and flows
- take care of shipping and transport documents and warehouse order processing
- use manual and electronic tools for transport, goods flow and order processing
- plan, or assist in planning of, goods stocks and flows.

Despite the commonalities in the tasks that warehouse logistics workers perform, they work in a dynamic work field subject to rapid change, which we turn to next.

6.2. Changes in the work field

In recent years, the logistics field has seen significant changes. The rapid digitisation and automation are transforming job roles within the industry. There is an increased usage of digital tools and technological changes in warehouse logistics have been transformative, significantly impacting the efficiency, accuracy, and speed of operations. The increasing automation and the changing level of interconnectivity between systems, machines and equipment, is also changing work organization and the work tasks of warehouse logistics workers.

There is an increased need for warehouse logistics workers to be able to use digitalised cargo handling gear (cranes, trucks, forklifts etc.) as well as all forms of assistive digital tools including handheld computers, mobiles, tablets and scanners. Wearable technology such as headsets, smart glasses, activity trackers etc. are also increasingly introduced and workers need to learn how to use them. The focus on minimising storage times and costs, while ensuring quick delivery to customers, is part of a 'just-in-time' approach that requires advanced technical, computing, and organizational skills (Stockhammer et al. 2022). Some workers are shifted towards planning, directing, and programming tasks as complex IT and AI systems are introduced. This points to an ongoing need for upskilling within the occupation and for continuous skills enhancement to keep pace with evolving technological advancements.

The rapid implementation of digital technologies has fuelled concerns about the future of the jobs in logistics. With a reduction of work tasks performed by human operators, automation seems likely

to reduce the total work force number and the physical presence of people on the shopfloor and in warehouses. Predictions, however, vary significantly, ranging from massive reduction of jobs to suggestions of a future with a surplus of new jobs. At the same time, there is still need for manual labour for some of the tasks and the fears for redundancies, especially in unskilled and low-wage jobs, have not yet materialized. Nevertheless, the changes in the field present significant challenges for companies and their employees, necessitating comprehensive change management strategies. Up-skilling the workforce, especially with new skills and competencies related to digital technologies is often upheld as key to avoid potential job losses, but interpersonal and methodological skills to deal with complex and integrated smart logistics environments are also becoming increasingly important (Cimini et al. 2020).

6.3. VET education/qualifications

There are differences in the education in the case study countries, but the VET qualification of warehouse logistics workers we study are at EQF levels 3 and 4. In some of the countries, there are VET educations at higher levels, but these have not been included in this review. We here provide an overview of the VET qualifications most closely related to warehouse logistics work in each country and the key changes that have taken place in response to the ongoing changes in the field:

- Austria: The VET education is regulated and is a three-year qualification at EQF level 4. The curriculum outlines the required occupational and vocational competencies, and the core competencies include operational logistics, warehouse management, materials management and operational accounting. The curriculum was changed in 2004 and this involved an increased focus on training within companies on business management and logistics, were included. The curriculum was again revised in 2016. The core competencies have remained largely the same over time, but since 2016 there has been greater emphasis on administration, digital skills, sustainable logistics solutions and automation technology. The main purpose of changing the curriculum was to align the qualification with national educational standards and ensure its relevance to industry developments, and the qualification also includes transversal skills applicable to other occupations.
- Germany: There are two VET apprenticeships that lead to the warehouse logistics worker occupation. One is a two-year qualification (EQF level 3) and the other one is a three-year qualification (EQF level 4). About 75% of the time is spent in companies and the remaining 25% in vocational schools The last major revision of the curriculum took place in 2004, and included greater attention to teamwork, customer-orientation, communication, and other topics to adapt the education to the needs of the commercial sector. There have not been major changes to the curriculum over the past 20 years, but there are ongoing debates about the impact of technological change on the work field. Still, there does not appear to be any effort to change the curriculum, but companies are adapting the in-house education they provide in response to the increased digitalization of their work processes. After gaining practical experience, warehouse logistics workers can continue training to become a ‘Certified logistics master (EQF level 5), and after three years of professional experience they can enter higher education for further specialisation.

- Korea: The 'logistics management competency unit' was introduced as part of the National Competency Standard in 2015. Prior to this, companies, universities and research institutes had provided education on logistics. In the current National Competency Standards system, the logistics VET qualification is organised into three separate entities, but it is the 'Logistics Management' unit that aligns most closely to the warehouse logistics worker. This is taught in vocational high schools and by other training institutes. Competency units and learning modules were introduced in 2015, and these were updated in 2022. The curriculum is updated when needed and under the leadership of Ministry of Employment and Labour, HRD Korea and KRIVET, but in collaboration with associations and organisations. The most significant changes that were made were the additions of further performance criteria and required knowledge. These included topics such as 'Logistics Centre Management' that focused on the on-site management to eliminate waste and improving the work environment, 'Warehouse Safety', partly in response to several fires in logistics centres, as well as 'Inbound and Outbound logistics Management' and 'Logistics Planning'.
- Italy: The VET qualification in logistics that is most relevant to work in warehouses was fully introduced in 2011 and is a vocational education (IeFP) provided by regional governments. This is a three- or four-year education that includes education on warehouse management and goods handling, but also basic subjects common across all upper secondary education curricula. Upon completion, students will obtain a professional qualification at EQF level 3 as 'Operators of Logistics Systems and Services', and with an additional year of study they can obtain a qualification as 'Logistics Services Technician' that is at EQF level 4. There is also a five-year programme on 'Transportation and logistics' on EQF level 4 in national level vocational schools (not under regional government). There are different pathways for pursuing higher technical education, such as the one-year programme in logistics (IFTS) at EQF level 4 that has been available since 1999 and two- or three-year programmes in logistics (ITS) at EQF level 5 offered by higher technical institutes since 2008. Both the VET qualification and higher technical educations in logistics have connections with employers, though the higher technical educations appear to have closer links with both public and private partners than the VET education. There have been efforts to strengthen these relations to ensure that they provide a practical-oriented education and useful skills for the labour market, and part of this was related to the need to meet the skills demand emerging from technological advancements. The VET curricula are quite broad, which enables schools to adapt their teaching to the skills demands from employers.
- Norway: There is a 2+2 VET education at upper secondary level (EQF4) for warehouse logistics workers. Year 1 of the VET education is a broader school-based course called 'Technology and Industry'. This is followed by another school-based year that is centred on 'Transport and Logistics', before undertaking an apprenticeship in a company in years 3 and 4. Warehouse logistics worker education has undergone several changes over the past two decades. A VET programme was introduced in 2006. Prior to this, there were two separate VET pathways where one was practically oriented for those who would do manual labour in warehouses and other companies, and the other was more focused on the administrative parts of the logistics field. In 2006, the two VET pathways were merged into a single warehouse logistics workers VET programme, and in 2020, the warehouse logistics workers VET pathway was moved from the VET programme 'Sales, Service and Tourism' track to the

VET programme 'Technology and Industry'. As part of the debates prior to this move, representatives from the main confederation of Norwegian enterprise proposed to split the warehouse logistics workers VET education into two separate logistics pathways where one would be more practically oriented and the other more white-collar, but this has not been implemented. The current warehouse logistics workers VET programme is considered by some informants to have limited relevance for many logistics companies, both because it does not offer sufficient administrative skills and because the qualification gives the workers higher pay even if they perform the same tasks as workers without qualifications. There are opportunities for further specialisation in logistics through degrees or shorter courses at higher vocational colleges.

6.4. Discussion

There have been major technological advancements in the field of logistics over the past 20 years, and there is a tendency to work being less centred on manual labour and more of the logistics work being operated with machines. Despite some jobs being replaced with machines, workers are still needed in warehouses. Many warehouse logistics workers need higher skills to manage digital tools, but there are still large numbers of low-skilled workers in the sector who perform manual labour. As such, the technological changes have to some extent changed the work field and the use of automation technology has been central in changing how warehouse logistics operate. While some have predicted that warehouse logistics workers, there is rather a tendency that warehouse logistics workers get different tasks, which tend to involve less physical labour than in the past. The manual labour in warehouses appears to a greater extent to be left to the workers without formal qualifications.

The changes in the logistics work field are significant, and most countries have taken some measures to adapt the VET education to the new realities. Even though the way they have done it differ, several countries have each sought to make the VET education better suited for the new realities of the work field. It appears that it is especially Austria that has been responsive to the needs of the work field by adapting the curriculum and focusing more on digital skills, while also working to make the field of logistics more inclusive and appealing to women. The German case appears very different in the sense that there has been no change in the curriculum, but, at the same time, the companies are updating their work processes and students therefore learn up-to-date knowledge as part of their education. There appears to be flexibility in the curriculum for students to learn what is needed in companies. Italy and Norway seem to have a similar approach in terms of national curricula being developed on the national level, while schools have room to manoeuvre within this framework to ensure that employers' needs are met locally. The quick adaptation to local needs is useful from the employers' perspective but might make the education more responsive to short-term demand rather than centring students' long-term employability. In Norway, this is countered by the two first years of the education being in schools, seeking to ensure a broader set of skills. The changes in Italy have been centred around making the education more relevant for the labour market, but the change in Norway seems to be more of a result of broader curricula renewal processes rather than a direct response to the technological changes and needs

in the logistics work field. However, as illustrated by the lack of change to the VET education, the education system does not always respond to the needs in the work field. In Korea, there have been changes in the education to deepen students' knowledge of the field.

Table 6: Key characteristics for qualifications for warehouse logistics worker

	Type of VET qualification	EQF	Major content changes	Actors' responses
Austria	3-year dual system apprenticeship	4	Minor changes in 2016	Stakeholders request updates to the curricula and have a say in how they should be developed, which suggests that will be content if they are heard
Norway	2+2-model (2 years at vocational school, 2 years apprenticeship)	4	Two former VET programmes were merged into one	Dissatisfaction with the current VET qualification
Italy	1 year programme	3	Minor changes to ensure that the education is of relevance to employers	The curricula can be rapidly changed to short term needs of employers
Korea	Vocational high schools (3years) or vocational colleges (2 years)	4-5	Frequent and minor changes to the curriculum to keep it up to date with changes in the work field	General consensus that the qualification is more suitable for office work than what is needed for warehouse logistics workers
Germany	2- or 3-years apprenticeship (75% in company and 25% in school)	3 and 4	No major changes	Concerns about the how the changes in the work field will impact recruitment. A tendency to rely on upgrading of skills internally to ensure access to workers

7. Ventilation technician

Case countries: England, Norway, Germany, Austria, Korea

7.1. Occupation and work field

A ventilation technician installs, configures, repairs and maintains ventilation and air-conditioning systems with fans, sensors, actuators, control units and decentralized and connected computing. This work role/occupation consist of manual work of varying complexity, incl. to draw electrical cables, change sensors and fans, clean system for leaves etc, but will also often involve some planning, for instance the positioning of actuators (valves), and configuring parameters of the ventilation system. The physical laying of channels and ducting pipes is a task that may belong to this work role in some countries, for instance in England, Germany and Korea, but usually not in Norway or Austria.

The ventilation technician work role described above is a distinct work role in some case countries, like Austria and Norway. However, other countries have less differentiation of ventilation work from other HVAC tasks. Heat pumps, refrigeration and solar cell panels are also installed by HVAC technicians in several countries, in addition to ventilation systems. In some countries, those who install and operate ventilation systems may also do installation of waterborne systems, both fresh water and sanitary. The degree of specialisation of the work role therefore differs considerably.

The work role/occupation as ventilation technician is not new and has existed since mechanical ventilation systems became widespread in the 1970s. However, the introduction of integrated building automation systems, digital control systems and smart ventilation systems have changed the work field considerably over the last two decades, with sensors and electronic components increasingly replacing mechanical components, and with integration of different systems. There is also an increased emphasis on energy efficiency due to the green transformation and rising energy prices, which has led to stricter building codes/higher standards and increased customer demands.

These developments have led to significant changes in the work tasks for ventilation technicians. Knowing how to tweak systems in practice, while also having a theoretical understanding of how air flows in a building, are seen as important competences with the advent of this technology. There has also been an increasing need for understanding of electronic equipment and the skills to work with such components, and for the digital skills needed to work with building automation systems with digital control systems. In countries like Austria and Norway, changes seem to have largely come in tasks within-job, with little change in work organisation. In countries with a less specialised work role, technological changes influence work organisation as the increasing complexity of control and regulation systems increases the need for specialised knowledge of these digitalised systems. Integration of building systems technologies on the other hand points to a need for competences across different systems. A general trend is an increasing demand for a theoretical system understanding and less emphasis on manual installation skills.

Precise data on the educational background of workers within this work field is lacking because ventilation is not separated from other work, like plumbing, in ISCO codes. However, VET qualifications are described as primary pathways into the work field in Austria, Germany and England, indicating that VET-qualified workers account for a major share of employment within the work field. In Korea, a certificate as HVAC craftsman is increasingly in demand, but the number of certificate-holders is still low compared to employment within the relevant occupations.

In Norway, where a specific VET qualification was lacking until 2022, interviewees say that most had an adjacent VET qualification, primarily as electricians, automation technicians and refrigeration and heat pump fitters, but also tin smiths and others. There are also workers without formal VET who have learnt the job through work. Still, the work has been considered skilled work in terms of wages and working conditions. An interpretation is that it may be a spillover effect of the wider work field being largely "populated" by skilled workers, or simply that work tasks are too complex for experienced workers to be easily replaced by lower paid unskilled workers.

7.2. VET Education/Qualifications

Most countries have over the whole time period had one or several VET qualifications (at EQF-level 4) which covers this work field. In England, an apprenticeship in Building Services Engineering is the primary pathway into this work field. This covers heating, cooling and ventilation. In Austria, there are two VET pathways. Ventilation technician is a specialisation within the three-year apprenticeship as an installation and building technician. The basic module is two years in installation and building technology covering a wide range of tasks (heating, gas, sanitary), while third-year apprentices can select a main module in ventilation technology or other main modules. There is also a four-year school-based technical college for building services engineering. In Germany, there is a VET qualification within the apprenticeship system as a HVAC technician, which covers a wide work field, including installation of bathroom and sanitary facilities. Specialisation in heating, climate and ventilation technology on EQF 5 or 6 is possible, but as further education after having achieved the qualification as a HVAC technician. In Korea, vocational high schools give education in ventilation which has become more systematic with the introduction of the overall NCS system from 2013. However, work certification has not been specifically on ventilation and cooling, but to the wider HVAC field, and a vocational education is not required to achieve certification. Norway stands apart from other countries. It had no specific VET qualification in ventilation until 2022, when a new ventilation technician education was established as an apprenticeship within electrical engineering. Until that there was only a qualification as tin smith in the construction programme which had a small ventilation component as these may be involved in the laying of (complicated) ducting channels. There was a second-year course in climate, energy and environmental control within construction, but it did not lead to ventilation apprenticeships, but primarily to plumbing (water, sanitary) apprenticeships and a few other smaller qualifications.

In several countries, it is possible to build on the VET qualification to qualify for higher level work, for instance planning functions (the design of the ventilation system) which are otherwise on engineer level. This can be done through an extra year in vocational school to (Austria) or through a vocational college education (Norway). In addition, it is possible to specialise into ventilation work in countries with a broad EQF level 4-education, as in the case of Germany above.

7.3. Change in the content of VET qualifications

On first inspection, there have been large changes in curricula/standards in many countries. However, much of this reflect changes in the overall system, which has caused changes in how curricula are written. This may make the skills description for the ventilation technician more detailed (England, Korea), less detailed (Norway, tin smiths, ventilation) or be divided between modules (Austria). A more thorough analysis focusing on the skills content, disregarding difference in structure, shows less change. However, there are still noticeable changes in all countries, with the general trend being inclusion of more competence elements relating to active ventilation systems, digital skills and gradually also building automation systems (BAS). Qualifications are also becoming more specialised, in some cases as optional modules.

In Austria, modularization of apprenticeships (2006) has been the key strategic response to introduce flexibility in the VET system to respond to changes in the work field. In the ventilation field, a specialisation as ventilation technician was developed within the installation and building technician apprenticeship. There has been a shift in the content of training regulations from practical skills, such as working with tools and assembling ventilation systems, to theoretical knowledge, such as understanding airflows, calculating cooling and heating loads, and selecting the appropriate equipment for energy recovery systems. This shift is evident in the newer modules established in 2016 and reflects the growing complexity of ventilation and climate control systems, based on digitalisation and regulation technology. However, the sanitary, heating and ventilation guild in Austria has been dissatisfied with apprentices' competence on building automation systems and modern, interconnected systems, which has not yet been adequately reflected in the training modules. Apprentices lack a profound, theoretical understanding of energy/air flows, as the employers see it, and also competence on subjects like heat pumps and photovoltaics and building automation. This has led the sanitary, heating and ventilation guild in Austria to call for a reform in the gas, sanitary and heating VET programmes so curricula/training regulations would better respond to technological developments and changes in building requirements.

In England, the Building Services Engineering craftsperson apprenticeship is the principal apprenticeship standard currently offered for those intending to work as ventilation engineers. This is a 3–4-year apprenticeship on EQF-level 4 (English RQF level 3). The framework/standards regulating this apprenticeship and its predecessors have changed no less than nine times over the past 20 years. One reason is that the overall VET system has changed significantly in this period, with the shift from apprenticeship frameworks to apprenticeship standards being a key change. With it, the earlier apprenticeship (2011) of Heating and Ventilation became the current Building Services Engineer. In the previous apprenticeship frameworks, national vocational qualifications, NVQs, were embedded. The vocational-specific elements of the framework were described in these, but the NVQs were phased out of most apprenticeships, including that of Building Services Engineering. It made it necessary to specify skills and knowledge elements to a greater degree in what had now become an apprenticeship standard. The standard therefore contains much more detail than the earlier framework.

The 2024 apprenticeship standard list six "behaviours", 36 skills and 46 knowledge competencies. A comparison of the evolution of the content of the standard/framework over the 20-year period show modest changes. There are more details on a) elements of pipework, and b) work on electrical systems, with the latter including more knowledge items on electrical safety testing techniques, fault-finding and the operating principles for testing of new and existing (electric) systems. While supervision skills were part of the 2015 standards, it is not included in the 2024 standard. Skills in the use of digital technologies are considerably more detailed. While in 2015 the standard simply listed "understand opportunities for ICT systems", by 2024 several digital skills and competences are specified, most notably principles of Computer Aided Design (CAD) and Building Information Modelling (BIM). More general digital skills are also listed, such as the use of digital communication techniques, use of information technology and digital systems (to support building engineering), GDPR and cyber security. The abolition of NVQ also changed end point assessment with

behavioural attributes moved from entry screening to end-point assessment. Furthermore, the removal of NVQs mean that apprentices now need to show a portfolio of video clips, photos and statements to document their skills and knowledge by the end of their apprenticeship. We don't know the opinions of employers on the specific changes in the Building Services Engineering standards.

While standards have become more detailed, the above description shows that they still leave a substantial amount of discretion to the individual employers and instructors and to the external training providers. How this flexibility is used through the negotiations between employers and training providers is something of a black box, particularly in the construction sector which is dominated by small firms, and unlike other sectors lacks major actors who may set widely used standards across firms and regions.

With the introduction of apprenticeship standards, the process of establishing the standards also changed, from sectoral bodies to smaller "trail-blazer" groups of individual enterprises. The elimination of NVQs allows in principle for more rapid change in the apprenticeship standards, but it is difficult to gauge the impact of this in practice. The number of revisions of the ventilation technician standard may indicate that this has been the case, on the other hand, the changes in content are modest. It is notable that in certain areas – such as digital technologies – the apprenticeship standard has become more prescriptive than the framework it replaced.

In Norway, the new ventilation technician education fits a well-defined work field which lacked an education programme. According to an interviewee, there has been talk about the need for a new qualification for twenty years, but no formal initiatives were taken until around 2016 when a process was started that led to a new apprenticeship qualification from 2022. The newly developed apprenticeship qualification is focused on installing, regulating ventilation systems, including motors, sensors actuators and cabling systems. Laying of ducting channels is not an integral part of this qualification. The content of the new apprenticeship is seen by employer representatives as matching the skills needs of this field well. The tinsmith and ventilation qualification with emphasis on building the channels has not changed considerably, but the present curriculum is more limited than before on initiating, operating and maintain the whole system. It is reasonable to see this as a delineation of tasks between the tinsmith and ventilation qualification and the new ventilation technician qualification.

In Korea, the NCS-related learning modules for refrigeration and HVAC machinery were more detailed in 2018 than the previous ones from 2013 with more emphasis on inspection and maintenance. These adjustments were made to reflect technological change and new skills (requirements with the aim of providing a more comprehensive and systematic education. However, concern has been raised that the education is too wide and comprehensive with too many NCS subcategories for all elements to be learnt through practice. It becomes too theory-heavy due to lack of time. On the other hand, obtaining certification as HVAC craftsman does not require education but is open to any applicant who can obtain the certification by passing the test. While the certification is in high demand from employers, there seems to be a disconnect between the

certificate and the NCS-system. Certification is in demand from employers to meet increased skills demands.

In Germany the national framework curriculum for HVAC technicians includes not only ventilation, but also installation of drinking water, sanitary facilities and heating systems. The qualification covers a broad range of tasks and is one of the largest apprenticeships in Germany measured by the number of apprentices. There is a specialisation in heating, ventilation and air conditioning, but that is further education at EQF levels 5 or 6. However, within the EQF 4 HVAC qualification, there are so-called *Einsatzgebiete*, which allow internal differentiation in the initial qualification according to the needs of the individual firm. A firm specialised in ventilation may train mostly towards the specialisation in *Lüftungs- und Klimatechnik*. The *Einsatzgebiete* applies to the firm-based training within apprenticeships only but may account for a high percentage of the time in firm-based training. It therefore provides flexibility within the qualification. The HVAC curriculum has from 2016 on incorporated more training on digitalisation, smart buildings management systems and renewable energy solutions. Employers seems largely content with the content change but there are signals from employers that a shared basic education covering a very wide range of tasks from metalwork to BAS operations is no longer desirable. Employers also experience severe numeric skills shortages.

The following table summarise the present VET qualifications and the major changes in their content over the 20-year period:

Table 7: Key characteristics of VET qualifications associated with the ventilation engineer occupation.

	Type of VET qualification	EQF-level	Major content changes	Actors' response
England	Apprenticeship (3-4 Years)	4	Yes, more specified on pipework, electrical systems and some digital skills. More on behavioural "skills"	No data specifically on this standard. Employers play a large role in designing standards.
Austria	Apprenticeship (3-4 years) Vocational school (4 years)	4	Yes, more theory, less practical skills, more on digital skills, active ventilation, electronics and regulation in the apprenticeship	Employer's guild want more theoretical skills, want new education
Korea	NCS learning modules provided by polytechnics, vocational colleges and other (? years) Work certification not related to education.	4?	Yes, more inspection, maintenance, new technologies	Too little practical training, equipment not available at school
Norway	2+2-model (2 years at vocational school, 2 years apprenticeship)	4	New qualification, specifically on ventilation, focus on active ventilation, digital	Employers positive

			skills, electric engineering	
Germany	Apprenticeship (3,5 years)	4	Yes, more on active ventilation, regulation, digital skills, process orientation, work in teams, sustainability	Employers positive to changes, but signal a need for more specialised skills

7.4. Discussion: Interaction between VET and work field?

Technological development has had a major impact on the ventilation work field. Although active ventilation systems started to emerge already well before 2000 with the development of sensors, these systems are now everywhere, which together with the development of building automation systems (BAS), integration of functions and digitalisation, have fundamentally changed the work field. This has increased the level of skills required to install, operate and maintain these systems. Looking at the very long perspective, some informants note on the other hand that the introduction of ducting decades ago decreased skill requirements as craft skills were usually no longer needed for the simpler process of laying ducting pipes. However, over the last 20 years, the skills demand from employers seems have increased in all countries. This is related to increased demands from customers (of installation firms) and society (through building regulations). Energy efficient ventilation systems also fit well into the larger societal trend of the green transition with emphasis on energy efficiency and sustainability.

In this particular case study, change in the content of VET qualifications/education is evident in all countries. As mentioned above, there are more competence elements related to understanding and using digital technologies, modern ventilation systems and more widely building automation systems. Improving the theoretical understanding of air flows and an overall system understanding has also been part of the changes in countries like Norway, Austria and Korea. Through modularisation, there has been an increasing specialisation in the VET qualification for ventilation technician tasks in the Austrian apprenticeship system. Similarly, a new, specialised ventilation technician qualification has been established in Norway, which has a stronger emphasis on electricity and electronics and is based the electrical engineering VET programme. In contrast, the German apprenticeship qualification has a very broad base, including metal work, which is absent in the Norwegian qualification. There are opportunities for specialisation towards ventilation work in the initial qualification, but in the firm-based part of training only. In England there have been frequent revisions of the apprenticeship standard, maybe because of the ease of revising standards with the introduction of trail-blazer group of enterprises. Still, changes in the written standards have been modest, and seemingly not more substantial than in the countries with more inert procedures of change. In Korea, the latest NCS competence units and corresponding learning modules has become more detailed. The NCS learning modules seem to some extent be disconnected from the realities of the class-room in the vocational schools where the skills should be learnt. There is a lack of adequate equipment and opportunities to build practical skills, so the education becomes too theoretical and not practical enough. Besides, the competence elements are more detailed than what is often practically possible to cover with the available equipment.

Employers are discontent with the content of the present qualifications in some countries. Austria is a noteworthy example, where the guild would like to see more emphasis on interconnected systems and building automation, as well as heat pumps and photovoltaics (solar cell panels). Furthermore, specialisation has not worked very well to attract youths into the occupation, as very few students choose the ventilation technology module, forcing employers to recruit other skilled workers rather than people with the right apprenticeship. Although employers are content with the new ventilation technician qualification in Norway, the numbers are still very small, so it remains to see if specialisation will work in this case.

In the case of the ventilation technician, an interpretation would be that curricula do not seem proactive enough. Employers in some countries want a more overall system understanding than the VET system in these countries provide, despite changes in that direction. Furthermore, there are severe numeric shortages in almost all countries, the number of newly qualified workers are far below what is required, forcing employers to find other recruitment strategies. There is a dilemma in that skills requirements in the work field move toward increased demands for specialised yet theoretical skills, but when establishing more specialised qualifications/educations in the VET system, not enough young people select these programmes, possibly exactly because they are specialised.

Despite these differences, examples of discontent among employers, and a severe numeric skills shortage, VET qualifications seem to be the preferred skills background for work as a ventilation technician in all countries. It is noteworthy that even in Norway which has lacked a specialised VET qualification, ventilation technician work has usually been considered skilled work in terms of wages and working conditions. It has often been carried out by people with adjacent VET qualifications such as electricians, plumbers and refrigeration and heat pump installers. It appears that even when the VET system fails to deliver the content and numbers of people that employers want, there are no clear signs that employers shift their recruitment preferences to recruiting unskilled workers, at least not in countries like Germany, Austria and Norway. These may because the adjacent fields are “populated” by skilled workers who can drift in to cover also this type or work and that the tasks are complex.

8. Conclusion

This study set out to address two empirical questions which in turn address the over-arching question of the responsiveness of VET to changes in the work field.

- Does the content of VET programmes for a specific occupation/work field change to different degrees and directions across countries, and why?
- Does the degree and type of change affect how employer organisations and other actors assess the relevance of the VET programme?

The study draws on data from countries exhibiting differing approaches to the governance and provision of VET. There is also variation between occupations, with both long-established

occupations and relatively new ones, which have been subject to differing levels of technological change. This provides the required variation to address the above questions.

8.1. Liberal vs. coordinated or participatory systems

The VET systems all face similar challenges, but their overall responses are influenced by past changes. Systems such as Austria, Germany and Norway display a degree of stability in their core. The broad contours of the VET system and what it should deliver was agreed some time ago by the social partners and has been maintained through the period. This is reflected in a holistic conception of an occupation or profession, which VET is aimed at qualifying for, rather than being focused on meeting the employers' current, articulated skill needs. It also means that the curricula are not amended as often as in the case of England. In England, the long-term goal has been to cede an increasing share of control over the VET system – especially apprenticeships – to employers. This is because employers are seen to be best placed to articulate the demand for skills which have economic value in the labour market. This is reflected in a fairly fluid system leading to a large and increasing number of apprenticeship standards and more frequent changes in these. Korea is a country that has also gone through comparatively large changes in their VET system, but unlike England, the employers are not awarded a key role within the system. Rather it is the government that through the introduction of NCS tries to increase the coherency and transparency of the VET system. There are attempts to involve business (see chapter 3.4), but it is a challenge to match the NCS with the national technical qualification systems on the one hand and to apply it to the realities of a vocational school classroom on the other. The Italian VET system display a degree of stability at its core, where a governance system requiring agreement between the federal state government and regions is a key element.

A major distinction between countries lies in the role VET curricula fulfil toward the work fields. At one end of a continuum, standards/curricula codify a shared conception of an occupation or profession and safeguard its integrity in the face of myriad pressures for change. At the other end, VET curricula or standards provide a framework which set out the core competences but leave employers freedom to shape that training to meet their specific skill needs. There is a correspondence between the Markowitsch's and Hefler's (2018) categorisation of feedback mechanisms and the two curricula archetypes presented above. Countries with coordinated feedback systems, such as Germany and Austria, comply with the former, and countries with liberal feedback systems, like England, to the latter. In the former, change is seen to take place relatively slowly and infrequently in part because existing curricula accommodate change. There is a shared conception among actors of the occupation which imposes an element of stability on the curriculum reducing the need for change. Countries like England which fall into the liberal type tend to minimise the role of the state and prefer to cede the design of curricula or standards to employers. The voice of the learner/worker is also missing from the system. Change is more frequent. If employers view existing curricula unsuited to their needs, they can develop new curricula or standards albeit subject to the rules the state establishes for doing so. This is clear in the English case studies which, despite the flexibility offered by VET standards, experience much more frequent change in these standards than qualifications for the same occupation/work field in

the other countries. The conception of skill seems to be related to the economic value it offers in the labour market with less emphasis on proactiveness.

There are clearly tensions here with respect to the capacity of the respective approaches to adapt to change. Providing employers with a relatively high degree of freedom to adapt training to meet the needs of the workplace may well increase the responsiveness of VET but in a way that limits it to meeting current rather than future demand. This may be particularly the case where, as in England, that flexibility extends to employers being able to develop entirely new publicly funded training programmes specific to their needs. A multitude of standards may emerge in any work field, each focussed on a relatively narrow range of skills, which may inhibit mobility of learners. On the other hand, where VET curricula or standards safeguard the identity and integrity of the occupation, there is the danger that this can also act as a bulwark against change to such a degree that curricula or standards lose their currency in the labour market. That is unless there is a shared understanding of the principles which determine the identity of an occupation that acts – proactively – to guide adaption to the drivers of change from the work field.

There is evidence of both outcomes in the case studies from countries with this approach to curriculum change. The ability of the coordinated systems such as Germany's to adapt to change seems to differ between occupations/vocational fields, depending on the commitment of social partners to invest in the VET system and their ability to achieve consensus. For the industrial mechanic occupation, the social partners and government have been able to agree and implement major changes in curricula in Germany to adapt to technological development. For the logistics field, the qualifications have not changed over the 20-year-period, despite changes in the field.

8.2. Flexibility within curricula as a tool for adapting to change

The case studies provide important nuances to the distinction described above. Giving firms more flexibility to specialise training within a qualification has been an important VET policy tool also in countries with coordinated feedback mechanisms. How standardised and specified standards/curricula are, is therefore a dimension which to some degree runs across the liberal vs. coordinated divide. Germany and Austria have both introduced greater flexibility within their VET programmes over the 20-year period the study has focused upon. Modularisation of curricula has been introduced in Austria, for example, to increase flexibility and adaptability allowing for more tailored training pathways that better align with the diverse needs of employers and learners. From an employer perspective this has been successful for the industrial mechanic, but less so in the ventilation technician field. In Germany, various forms of differentiations within qualifications have been introduced. In both countries this allows for a degree of responsiveness without altering the core parts of the curriculum. In Norway, which has a participatory model, curricula have been deliberately re-formulated in a more technology-neutral and general terms, which allows less frequent changes to the curricula, and provides employers with flexibility to adapt.

Introducing various forms of flexibility seems to be an important way for these systems to respond to the increasing pace of technological change, but without reducing the ambition of VET to accredit and shape an occupation/work field. Providing greater flexibility does not seem to compromise the

value of the qualifications in their respective labour markets. Neither does it seem that learners just complete parts of a qualification rather than the full qualification, which has otherwise been a concern regarding modularization attempts.

8.3. The occupations

The study provides examples of long-established occupations (i.e. industrial mechanic and to a lesser degree, ventilation engineer) which has experienced technological change, an occupation which has become increasingly important in response to external pressures (i.e. health care worker), and a not very-well established occupation which has been subject to large scale automation over the last 20 years or so (i.e. warehouse logistics worker).

In the well-established industrial mechanic occupation, apprenticeship-based VET has remained the key qualification in all countries. This is despite some countries having made large, proactive changes in curricula/standards to address technological change, while others have made comparatively minor changes. The countries with a coordinated feedback mechanism, Austria and Germany, have displayed a considerable agency for change among the key stakeholders and implemented significant curriculum changes which are generally considered successful. It is noteworthy that it is exactly the coordinated systems, which are often expected to be slow in implementing change, that have enacted the largest changes within this occupation. In Norway, curricula/standards changes have been more limited, but open-ended curricula and flexibility for training firms to emphasise different elements of the curricula has ensured that the qualification has been considered relevant by a range of different employers. The employers and their organisations have been a more conservative and less proactive force when it comes to curriculum change, possibly due to differences within industry. In England, there have been many revisions of curricula, and especially the recent revisions have addressed many technological changes related to digitalisation and computer aided machinery, yet the core elements of the apprenticeship standards have remained. The resulting change in VET seems to lie somewhere between the Norwegian and Austrian/German cases, but through different mechanisms. While the English system is categorized as having a liberal feedback mechanism, which is not associated with any strong role for organised interest groups, employers - in the form of trailblazer groups and sectoral interest organisations - have in this case had a decisive role, e.g. in the maintenance of embedded qualifications in the apprenticeship. A distinguishing feature of this occupation across countries is that there seems to be a widely shared conception in work life about what the occupation is about and what its core competences are, which is codified by the standard/ curricula, but is not entirely dependent on it. It is interesting to note that this occupational orientation, which is normally associated with coordinated systems, here also extends to the English case.

In the case of the health care worker, the occupation and associated training programmes have become more important due to an ageing population, limited workforce and the ensuing difficulties countries face in meeting their health and social care needs. Technological change has affected the occupation, but most stakeholders in the various countries have not seen a strong need to change the education of health care workers to accommodate technological changes. Rather, it is the shortage of staff and the shifting of tasks between doctors, nurses and health care workers that

has affected health care workers' education the most. In Germany, Austria and Norway, important changes have been made in curricula and training, including a shift to apprenticeships in Austria and Norway, while the education has remained outside the apprenticeship system in Germany. Changes have taken different directions, with a shift towards more generalist nursing training and later specialisation in Germany, more emphasis on communication and relationship-building in Austria, and more emphasis on medical knowledge in Norway. All changes can, however, be seen as an attempt to make newly qualified health care workers more flexible in where they can work. In England, curricula and standards appear to be instrumental in giving shape to the occupation, essentially codifying its skills and behaviours. The curricula might be seen as a safeguard in the face of exacting pressures to find sufficient personnel to fulfil caring roles. Italy is a case where several initiatives to strengthen training, including proposals for establishing new qualifications, have been made, but these have ultimately failed. This lack of responsiveness may be a problem, as it increases the strain on the health system, especially as the health care operator (OSS) is a comparatively narrow qualification in terms of the tasks that they are expected to do. The Korean system offers different VET courses for this vocational field, the certified caregiver covered in the case study is a relatively short course, which is relevant, but due to its short nature leaves little flexibility and room for mobility across fields of care.

The ventilation technician is an occupation which is not as well established as the industrial mechanic, but which has been differentiated from a wider set of tasks related to installation, operation and maintenance of building systems, such as sanitary, water, heating and cooling. The occupation is very much affected by technological changes in the form of active ventilation systems and, to a lesser extent, building automation systems. The provision of VET education in different countries displays a variety of scope and specialisation, which is also true of the work field across countries. Where a distinct work role as a ventilation technician is developed, a change over the 20-year period is that VET content has been more specialized and more focused on an overall theoretical understanding of the system. In many countries, curricula have lagged severely behind the technological changes taking place in the work field. In Norway a VET qualification was lacking, and in others, the changes have not been sufficiently proactive according to employers. This has not led employers to look elsewhere for recruits, probably because the surrounding work fields are mostly filled by skilled workers.

Finally, in the case of warehouse / logistics workers there is evidence of curricula struggling to come to terms with changes in technology which have automated many activities within warehouses. There is a tension in curricula reform in warehouse logistics which tries both to accommodate the skills required to operate or work with automated systems and provide skills to those in manual jobs, where task requirements often remain more modest. It may be that this provides a case of a fracturing work field which poses a particular challenge for those countries where the VET curricula serve to reinforce the integrity of a particular work field. However, we do see efforts to change VET curricula in response to changes in the work field in countries like Austria, Italy and Korea, while an attempt from social partner representatives to split VET into two qualifications instead of one failed in Norway, and no major change has been made in Germany.

The study has only to a limited degree analysed the role of the training provider, but the study show they often possess the flexibility to tailor training within existing programmes to ensure it meets local labour market demand. In the statist, participatory, and co-ordinated systems, providers – or at least their representatives - tend to be represented in the process of design and reform of training standards and regulations. To this end they can be said to be involved in the process of ensuring that supply meets demand.

8.4. Final notes

In summary, the study provides detailed evidence about curricula development in initial VET programmes across four distinct occupations in countries which have differing national skills systems. This evidence has been used to gauge the extent to which they may be considered reactive or proactive in response to the manifold changes affecting the task content of work. The occupational case studies reveal several important issues to be followed up in future research:

- the tension between providing a highly specified training regulations relating to the skills and behaviours to be acquired versus a more generalised approach which provides vocational schools and employers with a degree of discretion over training content,
- the use of modules or options within VET programmes to provide flexibility without the need to resort to the provision of more generalised training specifications,
- a need to balance stability and change,
- the use of curricula to give structure to occupations which are less well developed than those which have a long-history.

While all countries face the same external pressures, principally the impact of technological change on the tasks people undertake in their jobs, the way in which this affects the content of training regulations and curricula varies by country, or type of feedback mechanism, as explained above. The liberal employer-led approach relies on the demand side sending signals, mainly from employers, about the skills which they value and which the supply side is expected to respond. In contrast, the statist/ consultative / coordinated approach takes more a top-down approach where the social partners and/or technocrats interpret the signals and then agree training content, which might well extend beyond the production of skills employers consider valuable in the short term.

A key question is the relative efficiency of these mechanisms for adaptation to change in the work field. In the former case it can result in a relatively large amount of change. It suggests high short-term responsiveness, but with some risk to the long-term stability of the system along with relatively high transactions costs incurred by stakeholders. Consultative / coordinated approaches avoid this outcome but with an attendant risk that they are too slow to react.

The evidence provided here shows that the consultative /coordinated approach in most cases does not imply a low responsiveness, though the evidence is mixed. In some occupations where the social partners have been substantially engaged in updating VET, for instance in the case of the industrial mechanic, the coordinated approach has resulted in major changes in VET standards, but in other occupations, such as logistics, VET standards have changed more slowly and more incrementally

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