AKADÉMIAI KIADÓ

The changing epistemology of VET: Reflections on analysing content change

WOLFGANG WITTIG* (ID)

Forschungsinstitut Betriebliche Bildung (f-bb), Nuremberg, Germany

THEMATIC ARTICLE

ABSTRACT

The paper discusses the options for a conceptual framework to describe how the knowledge created and acquired in VET is changing due to technological innovation and the shift towards a knowledge economy. The discussion sets out from the question how vocational or professional knowledge may be distinguished from other forms of knowledge and what philosophical and epistemological traits may underpin this distinction. Building on an analysis of 'intrinsic' and 'extrinsic' conceptions of knowledge, the paper explores how appropriate descriptors for the classification of theoretical or propositional knowledge as well as practical knowledge may be identified. As a result, a proposal for structuring vocational knowledge is presented. The concluding part addresses the question how the proposed categories may serve to characterise changes in vocational knowledge and explores the requirements for applying the conceptual framework in empirical studies on the effects of technological innovation and societal developments.

INTRODUCTION

A recurrent theme in contemporary research on the content and function of vocational education and training (VET) is the notion of an ongoing change of skill requirements in the labour

---

* Corresponding author. E-mail: wolfgang.wittig@f-bb.de

AK Journals

market and a corresponding adaptation of VET curricula. The spread of digital technologies and the shift towards an economy based on knowledge-related services brought about significant changes in job profiles as shown, for instance, by the European skills and jobs (ESJ) survey (cf. Cedefop, 2018). The 'knowledge society' of the 21st century seems to require skills and competences that cut across traditional disciplines or areas of specialisation, and enable individuals to work in settings characterised by complex and often unpredictable problems. Information and communication technology (ICT), communication and social skills are frequently mentioned among the crucial 21st century competences (cf. Voogt & Roblin, 2012), as are problem-solving, teamwork and learning to learn (cf. Cedefop, 2018, pp. 28–30). To be sure, the above challenges and the associated sets of skills are not entirely new. Dealing with complexity and unpredictability, for instance, may obviously be regarded as part of the human condition. Still, it can be argued that the particulars of the 21st century add a new quality to this continuing challenge and call for new configurations of knowledge and skills.

Any analysis of the changing 'content' of VET needs to start with a clarification of what is understood by vocational knowledge. More specifically, it needs to be considered how vocational or professional knowledge may be distinguished from other forms of knowledge and what philosophical and epistemological traits may underpin this distinction. Within the epistemological-pedagogical perspective developed as part of the theoretical framework for Cedefop's 'The changing nature and role of VET in Europe' project (cf. Cedefop, 2017; Cedefop, 2020), the notion of knowledge can be approached from philosophical, sociological and pedagogical angles, more specifically from the point of view of philosophy of education, sociology of knowledge and theory of expertise. In the following, we will briefly discuss the relevant concepts from these 'schools of thought' with the aim of identifying appropriate descriptors and situating the topic within a wider theoretical context.

Before turning to this discussion, however, it must be pointed out that this article cannot claim to cover the full range of disciplinary perspectives with regard to knowledge and knowledge creation. The philosophical and pedagogical approach adopted here is obviously not exhaustive, and focusing on this perspective inevitably means to leave out insights from other important research strands, most notably psychology and neuroscience. While it would be exciting to cover these as well and to attempt a synthesis, it is clear that this cannot be achieved within the limits of a single paper. Accordingly, certain limitations need to be acknowledged. The epistemological-pedagogical perspective, and thus the concentration on a largely philosophical approach, is suitable for a conceptual framework that describes knowledge requirements. This is reasonable as far as the subject matter of VET and possible changes of its characteristics have to be described. However, the approach cannot contribute to the empirical explanation of these changes. Furthermore, the philosophical perspective will not yield any insights into learning processes or allow conclusions on what teaching and learning methods may be suitable for responding to changing skill requirements.

STRUCTURING VOCATIONAL KNOWLEDGE: TOWARDS A CONCEPTUAL FRAMEWORK

Rationality, knowledge and agency

It seems appropriate to begin the discussion on vocational knowledge with some brief reflections on the concept of knowledge itself and its relationship with the concepts of skills and

competence, all of which play a fundamental part in VET and VET research. The term 'knowledge' is typically understood as the body of facts, principles, theories and methods acquired by a person through learning (cf. Cedefop, 2014, p. 147). Unlike a mere opinion, knowledge implies a justified or at least justifiable claim to truth, i.e. knowledge is a well-founded belief that a particular proposition is true. Knowing something means that one explicitly or implicitly assumes that something is or is not the case, that a certain predicate does or does not belong to an object or that a certain cause entails a certain consequence. This begs the question on what basis such truth claims may be justified. To justify something is to give convincing reasons for it, which means that knowledge is ultimately a matter of rationality: the validity of the underpinning truth claims depends on the possibility to present reasons that support them. Reasons are employed to explain, judge or guide human behaviour (cf. Raz [1975] 2006, p. 17), which means that they have an epistemological as well as a practical dimension and are relevant for knowledge and agency alike.

Knowledge relates to agency in the sense of intentional behaviour in that it is applied and used to direct actions and bring about the intended result. It has to be acknowledged that this notion of agency is by no means exhaustive. Apart from activities directed at some practical purpose, human agency also comprises other types of behaviour such as communication and deliberation as is well known (see e.g. Habermas, 1981). Giving a complete account of the various notions of agency would exceed the limits of this article, which is why the discussion will be limited to the practical and instrumental, albeit somewhat narrow dimension of the concept. Here, the notion of rationality comes into play once more: an action can be explained by showing it to be consistent with a specific belief and attitude on the part of the agent, i.e. by identifying a reason that rationalises that action (cf. Davidson, [1963] 2006). The ability to translate knowledge into agency is covered by the concepts of skills and competence. Accordingly, agency always presupposes knowledge, and skills and competence can be interpreted as the link between knowledge and agency. This means that knowledge on the one hand and skills and competences on the other are not to be regarded as mutually exclusive categories. A professional action does not require either knowledge or skills, but integrates propositional knowledge, abilities, attitudes and judgement (cf. Winch, 2020, pp. 1–2).

In the philosophy of education, Ryle's (1949) dichotomy of 'knowing that' and 'knowing how' continues to be highly influential. According to this distinction, the knowledge exhibited by the ability to perform a given action (knowing how) is distinct from the propositional knowledge that consists in the awareness of facts (knowing that) and cannot be reduced to the latter. It is a commonplace that vocational knowledge involves practical knowledge in the sense of 'knowing how' as well as propositional knowledge in the sense of 'knowing that' while the accounts of their exact relationship and their relative importance vary (cf. Hordern, 2018; Winch, 2010, 2017). The first important conceptual differentiation to note, then, is the dichotomy of knowledge and practice (or 'experience'), which also mirrors the difference between a philosophical and pedagogical account of vocational learning on the one hand and a socio-economic perspective on the other. While the former emphasises the concept of knowledge as a systematically organised body of true statements, the latter concentrates on the practical experience that guides the behaviour of agents, asserting that it is this very experience rather than systematic or theoretical knowledge that is essential for vocational learning.

Before looking at the details of these two main concepts, however, we need to take a step back and examine the theoretical approaches or 'schools of thought' that provide the

background for the understanding of these concepts. As the above list of sub-disciplines in-dicates, there is an abundance of intellectual strands that address the subject of vocational knowledge and whose relative position to each other is far from clear. The variety of categories and perspectives used for the description and classification of knowledge and skills is so great that the theoretical approaches seem to be incommensurable. In order to organise the material in spite of this difficulty, we will attempt an initial classification of the theories on the basis of elementary criteria that can be expected to apply to any discourse about knowledge and learning. Following a suggestion by Streeck (2012, pp. 325 and 334), we propose to distinguish two classes of theories, namely those that define and analyse knowledge in terms of substantive or 'intrinsic' characteristics relating to the nature and content of knowledge, and those that do so in terms of 'extrinsic' characteristics which deal with the outside of knowledge and its relationship with the world.

Intrinsic conceptions of vocational knowledge

Theories that can be assigned to the first group originate in disciplines such as pedagogy, epistemology and cognitive psychology. What classifies these approaches as 'intrinsic' in the above sense is that they focus on the cognitive dimension of knowledge, i.e. knowledge as a property or quality of the (human) mind, setting out from the fundamental question what it actually means to know something. The theories in question typically identify various types of knowledge and skills on the basis of epistemological criteria and explore the importance of different types of knowledge within vocational education and training. One central claim within this theoretical strand is that systematic and theoretical knowledge generated within or linked to academic disciplines is essential for the VET curriculum. This position is taken by Young (2008), who points out that academic or scientific knowledge is not exclusively theo-retical but also has practical effectiveness in the sense that it enables the mastery of vocational tasks in a way that mere experience does not. Put differently, this type of systematic, disci-pline-based knowledge is materially different from pure experiential learning, which means that the former cannot be completely replaced by the latter in the preparation for working life. The reason is that experiential knowledge is useful for solving problems only when its application is guided by rules which themselves cannot be derived from experience alone (cf. Young, 2008, p. 6).

Theoretical knowledge (as opposed to practice or experience) can be differentiated according to the degree to which it is systematised. Hordern (2016; 2018) discusses two sub-types, which are labelled 'specialised' and 'non-specialised' vocational knowledge. Specialised knowledge re-fers to subjects or disciplines, i.e. structured sets of propositions that relate to a certain class of objects and are accepted as true if they meet the epistemic standards that apply within the discipline in question. The propositions or 'elements of knowledge' are linked by inferential relations and thus organised in a logical order. Non-specialised knowledge, by contrast, lacks this systematic structure (cf. Hordern, 2016, p. 464).

In a similar vein, Wheelahan (2010; 2019) develops the argument that the information imparted in vocational education and training needs to include systematic and theoretical contents in order to give learners access to the criteria they need to identify and select the very knowledge and skills that help them to respond to professional problems in a creative and innovative way. Her position draws on the work of Basil Bernstein (1999; 2000; 2003), whose

theoretical approach combines reflections on the content or substance of knowledge with an analysis of the social conditions of its constitution and application. The fundamental distinction in Bernstein (and Wheelahan) relates to the communicative structures within which knowledge is expressed. These 'discourses', as they are labelled, define the structure of knowledge and reflect the social relations in which it is generated and shared. Two types of discourse and hence two types of knowledge are distinguished. In the case of 'theoretical' knowledge, the underpinning discourse is 'vertical', which means that a body of knowledge is integrated in a hierarchical way on the basis of abstract meanings. 'Everyday' knowledge, by contrast, is embedded in 'horizontal' discourses and integrated only by its relevance to a particular context. Everyday knowledge is always contextual while theoretical knowledge is independent of any context (cf. Bernstein, 1999; Hordern, 2017, pp. 192–193; Wheelahan, 2019, p. 100).

Building on the above-mentioned distinction by Ryle, Winch (2010) presents a conception of expertise that effectively establishes a link between 'knowing that' and 'knowing how' by proposing a notion of 'practical' knowledge on the basis of a theory of agency. According to his argument, practical knowledge consists in an awareness of the normative requirements in a given social context such as an occupation or profession. A person who possesses practical knowledge in this sense – an 'expert' – understands the purpose or *telos* of a specific domain as well as the rules that govern the activities within that domain. Following rules in the course of some professional activity involves propositional, procedural and inferential knowledge, which is why practical knowledge is claimed to be both distinct and closely related to propositional knowledge or 'knowing that' (cf. Winch, 2010, p. 177). Expertise has come to be used as an umbrella concept for describing the relationship between VET and work, bridging the gap between formal (organised) and non-formal or informal (experiential) learning (cf. Guile & Unwin, 2019, pp. 28–33). Unlike the other concepts mentioned so far, the concept of expertise does not seem to allow for a bipolar classification. Instead, Guile and Unwin (2019, p. 36), following Barbour, Sommer, and Gill (2016), suggest a taxonomy of four dimensions or 'modes' of expertise, namely 'technical', 'arcane', 'interpersonal' and 'embodied', which relate to the different intellectual and physical resources that have to be mobilised when exercising one's expertise.

The following Table 1 summarises some of the substantive or 'intrinsic' approaches to knowledge:

Table 1. Intrinsic conceptions (examples)

Concept/dimension	Classificatory principle	Poles	
Knowledge	Practice-orientation	Academic	Practical (experiential)
Vocational knowledge	Degree of systematisation	Specialised	Non-specialised
Educational knowledge	Type of integration	Theoretical knowledge (vertical discourse, integration by meaning)	Everyday knowledge (horizontal discourse, integration by context)
Expertise	Knowledge involved	Propositional; procedural; inferential	
	Mode of expertise	Technical; arcane; interpersonal; embodied	

Extrinsic conceptions of vocational knowledge

Theories of the second group, i.e. those that build on 'extrinsic' features, view vocational knowledge and skills in terms of their function and usability in a given social and economic context. The focus of these research approaches is thus on the social or socio-economic structures in which knowledge is embedded rather than its content. This research has its disciplinary background in economics and sociology. Examples of economic approaches are labour economics, comparative industrial relations and human capital theory, all of which draw distinctions between 'general' and 'specific' skills according to factors such as the status of a person with a given set of skills within a regime of corporate work organisation or the portability of skills in the labour market (cf. Streeck, 2012). From the point of view of labour economics, knowledge and skills are labelled 'specific' when they are related to (or give access to) relatively well-paid jobs with a high level of responsibility and job security while 'general' skills are those associated with a lower employment status. This interpretation applies, albeit with some variation in the details, to labour market regimes as diverse as the United States and Germany (cf. Streeck, 2012, pp. 317–323). What is noteworthy about this approach towards knowledge and skills is that there is little or no reflection on the qualities whereby one body of knowledge rather than another is linked to some employment status. Another influential strand is human capital theory (cf. Becker, 1993), which views knowledge and skills as a form of capital and argues that the value of this capital depends on the possibility to use the skills in question in different workplaces at different employers, i.e. on the portability of knowledge and skills. Skills are classified as 'general' when they are portable from one employer to another, and as 'specific' when they are not. Again, the content and possible acquisition of these skills are not taken into account, which means that the classification has nothing to do with the question whether the knowledge and skills relate to some academic discipline or occupational domain, or whether they are acquired in class or by practical experience (cf. Streeck, 2012, p. 325).

In the sociology of knowledge, or at least some of its branches, (vocational) knowledge is treated as an outcome of social practice and as a reflection of power structures underpinning any form of social interaction. The notion that knowledge is socially constituted in the sense that it is embedded in and developed through the activities within an area of practice is expressed by theories of situated learning (e.g. Lave & Wenger, 1991) and the notion of the reflective practitioner (Schön, 1983). It is argued that occupational or professional competence does not consist in some form of propositional or declarative knowledge in the first place but in practices observed in the workplace, which is why the analysis of activities that are displayed in the workplace and accepted by the members of the professional community as legitimate practice is taken to be the main source of information about occupations (Dreyfus & Dreyfus, 2005). Radical versions of the conception of the social constitution of knowledge maintain that knowledge consists only in practices that are accepted in a given social group by virtue of the standing and relative power of those group members who define these practices. The upshot of these 'postmodernist' positions is that knowledge is virtually identical with the practice of knowers, which would inevitably lead to a relativist position that casts doubt on the very possibility of reliable intersubjective knowledge. This latter position has been criticized as a 'debunking of epistemology', which effectively replaces knowledge with the experience of speakers whose truth claims are merely backed by their power. Knowledge, in other words, would simply be a reflection of power relations (cf. Young, 2008, pp. 4–6). One potential

consequence of theories that build exclusively on extrinsic features, then, is that they can give rise to relativism towards any sort of truth claim that may be made with regard to theoretical knowledge. Whether or not some proposition is true would always depend on the situation and the actors involved, and a proposition that is accepted as true within one community may be false in another. Hence, an intersubjective identification and classification of vocational knowledge would be impossible to achieve. This epistemological indeterminacy can be observed in VET research where researchers from different disciplines arrive at strikingly different conclusions when it comes to distinguishing vocational skills from general and transversal ones (see e.g. Streeck, 2012). Another potential consequence is a notion of primacy of practice over systematic knowledge in vocational education and training. This is to say that practical experience is taken to be the principal element of vocational education while theoretical knowledge is regarded as less relevant for work (cf. Hordern, 2018). An overview of the 'extrinsic' theories is given in the following Table 2.

The discussion of the two groups of theories also suggests that there seem to be two different notions of practice so that our initial distinction of knowledge as opposed to practice needs to be refined. One concept of practice concerns practical knowledge in the sense of 'knowing how' or Winch's theory of expertise. The other concept refers to practice as a medium of learning, i.e. practice as experience.

An integrative approach

In recent years, several attempts have been made to integrate the different paradigms, and to bridge the gap, as it were, between 'philosophical' and 'sociological' stances towards vocational knowledge. A synthesis of these two strands in the theoretical discourse about vocational knowledge is social realism, which is exemplified in particular by the above-mentioned work by Bernstein. The approach is rooted in the sociology of education but also takes a philosophical stance by acknowledging that knowledge is not exclusively dependent on social structures and power relations but also warranted by epistemological criteria that allow for the assessment of truth claims. The main argument has been put forward, inter alia, by Young (2008), who points out that the investigation of the role of knowledge in education should not start with the concept of knowledge itself and its clarification from a philosophical point of view, but rather with the relationship between humans and the world. The fundamental claim of social realism, and the sociology of knowledge more generally as mentioned above, is that knowledge is 'social' in the sense that it is embedded in or constituted by social structures and forms of social interaction. Thanks to its multidimensional perspective, which also takes into account epistemological criteria such as external validity and internal consistency, this position avoids the above-mentioned relativism that arises when knowledge is identified with the mere experience of speakers in a given social setting. The social realist position also reconsiders the relationship between knowledge (in the sense of theoretical knowledge or 'knowing that') and practice (in the

Table 2. Extrinsic conceptions (examples)

Concept/dimension	Classificatory principle	Poles	
Skills (human capital)	Portability	General (portable)	Specific (non-portable)
Skills (labour economics)	Employment status	General (low status)	Specific (high status)

sense of practical knowledge or 'knowing how'), departing from the notion of primacy of practice mentioned above. Rather than assigning epistemological priority to practice, social realism is consistent with a more balanced view and considers how occupational practice may be analysed and classified according to the underpinning theoretical knowledge (cf. Hordern, 2016, p. 454), effectively reversing the relationship.

In the following, the main differentiations of vocational knowledge that can be identified within the above-mentioned research approaches are summarised, and their relationship with each other is explored. At the beginning of this section we referred to the distinction of 'knowing that' and 'knowing how', and it is this one that we adapt to our purposes as the first basic differentiation, namely the one between theoretical and practical knowledge. This distinction is closely connected to a second one, namely the one between the 'cognitive view' on the one hand and the 'tacit knowing view' on the other (see e.g. Cedefop, 2017; Neuweg, 2004). While the former views knowledge predominantly in terms of information, the latter is concerned with practical knowledge in the above-mentioned sense, which often cannot be articulated in full. This reflects Polanyi's (1966) concept of 'tacit' as opposed to 'explicit knowledge', which claims that the performance of practical activities involves the application of rules of which no exact verbal account can be given ("We know more than we can tell"). The idea of tacit knowledge, however, has been anticipated two decades earlier by R. G. Collingwood in his seminal 'Essay on Metaphysics' (Collingwood, 1940), which claims that any statement is accompanied by unexpressed presuppositions on the part of the speaker and thus always involves thoughts beyond those included in the verbal expression (cf. Collingwood, 1940, p. 21).

Within theoretical knowledge ('knowing that' or 'explicit knowledge'), two sub-types can be identified, whose denominations vary from one source to another but whose descriptions are largely congruent. As discussed in the section on substantive or intrinsic approaches, the knowledge in question may either be systematically organised as a discipline or only loosely integrated in a less formal way. The first alternative may be called 'specialised', following Hordern's terminology, and the second may accordingly be referred to as 'non-specialised'. This distinction is similar to Bernstein's dichotomy of 'vertical' and 'horizontal discourses' (or 'theoretical' and 'everyday knowledge' respectively). Finally, specialised knowledge can be further subdivided according to the distinction between pure and applied disciplines, which is also used in Bernstein's writings where pure disciplines are referred to as 'singulars' while applied disciplines are termed 'regions.' The 'pure vs. applied' dichotomy also applies at the level of specialised vocational practice. The ensuing typology is depicted in the following Table 3.

Table 3. Typology of knowledge

Concept/dimension	Examples	Poles		
Theoretical knowledge (knowing that)	Vocational knowledge (Hordern)	Specialised		Non-specialised
		Pure	Applied	
	Educational knowledge (Bernstein)	Theoretical ('vertical')		Everyday ('horizontal')
		Pure disciplines ('singulars')	Applied disciplines ('regions')	
Practice (knowing how)	Vocational practice (Hordern)	Specialised		Non-specialised
		Pure ('general')	Applied ('contextual purpose')	

Table 4. Categories of vocational knowledge

Concept/dimension	Variants	Examples
Theoretical knowledge (knowing that)	Specialised and structured according to 'pure' disciplines	Physics, chemistry
	Specialised and structured according to 'applied' disciplines	Engineering, architecture
	Non-specialised	'Everyday' knowledge, taxi driver knowledge
Practical knowledge (knowing how)	Specialised and structured by context-independent purposes	Scientific literacy
	Specialised and structured by contextual purposes	Occupation-specific or firm-specific skills
	Non-specialised	General and basic key competences, e.g. literacy or numeracy, or job-related key competences, e.g. leadership

This terminology may be standardised as follows. We draw a distinction between theoretical knowledge (knowing that) and practical knowledge (knowing how), which covers the term 'skills' as well. As mentioned above, theoretical knowledge as well as practical knowledge/skills can each be divided into 'specialised' and 'non-specialised' versions, depending on whether or not the knowledge in question is systematically structured. We argue that the abilities that are associated with the non-specialised variant of 'knowing how' also cover those that are referred to as 'transversal skills'.

This leads to a total of six categories of vocational knowledge, three of which belong to the realm of theoretical knowledge while the other three fall under the heading of practical knowledge. In the following Table 4 these types are summarised and illustrated by some examples.

It needs to be emphasised that although the article pays a good deal of attention to dichotomic categories, there is no intention to suggest that a person's knowledge and skills always match one and only one of the extremes. Instead, the categories should be thought of as a continuum in which sets of knowledge and skills are situated between the extremes and combine the above-mentioned types in various configurations. Vocational knowledge requirements will always be a combination of theoretical knowledge (knowing that) and practical knowledge (knowing how), i.e. they will always contain at least one element from the 'know-that' category and at least one element from the 'know-how' category. In general, the contents of vocational education and training present themselves as configurations of the six variants, for example as a mix of technical and 'transversal' components. Changes in VET can accordingly be interpreted as shifts in these configurations and as changes in the frequencies of certain patterns.

ANALYSING CONTENT CHANGE: THE KNOWLEDGE ECONOMY AND INDUSTRY 4.0

Dimensions of technological change

In the contemporary discourse on the epistemological basis of VET, the concepts of 'knowing that' and 'knowing how' have found their expression in the paradigm of the 'knowledge society'.

This paradigm emphasises both knowledge as information in the sense of the cognitive view and the notion of 'expertise' that corresponds to the tacit knowing view discussed above. It is argued that knowledge society, service orientation and the use of artificial intelligence give rise to a new type of 'algorithmic' knowledge that blurs the distinction between explicit and implicit (tacit) knowledge. For instance, Susskind (2018, p. 10) points out that machines follow self-determined rules that have nothing to do with the way humans perform tasks, such as making decisions by calculating probabilities on the basis of previous events. For this reason, the distinction between routine tasks, which may be automated, and non-routine tasks, which continue to require human labour, may be called into question.

This links to the topic of computerisation and its implications for future skills needs in the age of Industry 4.0. For some time, the distinction between explicit and tacit knowledge had given support to the hypothesis, advocated by Autor, Levy, and Murnane (2003), that computers may substitute for humans only in the performance of routine tasks. This is because the explicit knowledge required for these tasks can be fully articulated and transformed into instructions for machines. By contrast, non-routine tasks like problem solving were taken to be less susceptible to automation due to the 'tacit' knowledge required. Hence, the expectation was that artificial intelligence would complement but not replace human labour in this area.

These suppositions have been challenged on various grounds. On the one hand, the increasing capability of IT systems to perform tasks formerly classified as 'non-routine' seems to indicate that the distinction no longer applies and that substitution effects may be expected in any area of activity that is at least 'routinisable' (Susskind, 2018, p. 13). Moreover, objections have been raised to the prevalent understanding of non-routine work. Pfeiffer (2016; 2018) argues that a more complex notion involving holistic perception, exploration and dialogue, intuition and empathy is required. Based on the incidence of non-routine work as per the re-conceptualisation of the term, she suggests a revision of the predictions concerning substitution effects in certain sectors such as assembly work in the automotive industry.

In order to assess these divergent claims about the implications of technological change, it is necessary in the first place to delineate the major development trends and to identify, if possible, distinct types of change. There are several theoretical approaches to this task, which vary in terms of granularity and specificity. While some authors (e.g. Beer & Mulder, 2020) tend to focus on specific technologies or subjects such as 'artificial intelligence', 'Big Data' or 'Internet of Things' with a view to analysing their impact on concrete work processes, others apply broader categories to describe more fundamental trends. One approach that has turned out to be particularly influential is Zuboff's (1988) model of the dimensions of social change brought about by the use of information technology. According to this approach, technology may have an impact on work processes in three different ways, which are labelled (1) automation, (2) information and (3) transformation.

Automation is arguably the simplest and most basic effect that technological change may have on the organisation of work and hence on the demand for vocational knowledge (or specific types thereof). Automation means that functions previously performed by humans are instead fulfilled by machines without the necessity of human intervention. To put it differently, the impact of technology consists in the replacement of human labour by machines. This effect is simple and basic in the sense that automation does not necessarily change the structure of existing business processes but merely modifies the way certain steps of the process are per-formed. An example would be the automatic scanning of products in a warehouse and the

subsequent updating of the information in a management information system (cf. Boos, Guenter, Grote, & Kinder, 2013, p. 455). Each of these tasks is an ordinary part of business operations in logistics irrespective of whether they are performed automatically or manually. Historically, this version of technological change is associated with concerns over substitution effects in the labour market and 'technological unemployment' (for a summary see Frey & Osborne, 2013).

The second dimension of change, information, relates to the effects covered by Zuboff's newly-coined term 'to informate', which denotes the generation and supply of information. According to this concept, the application of digital technologies adds a new quality to work processes by making available large amounts of process-related data, which renders previously non-transparent work processes transparent and creates new opportunities for process management and decision-making. Boos et al. (2013, p. 455) cite vibration exposure of construction workers as an example of how certain aspects of work activities become accessible for cost-efficient monitoring and analysis thanks to 'Internet of Things' technologies.

Finally, computerisation and digitisation may change the structure of existing business processes and lead to the creation of new processes. This effect is labelled 'transformation' in Zuboff's terminology. New technologies may enable the provision of new services and change the role of the customer from the mere reception of goods to active involvement and participation. Possible examples are self-lending in public libraries (cf. Boos et al., 2013, p. 455) or self-service check-out at supermarkets as well as the so-called mass customisation of products, which is made possible by highly individualised manufacturing methods such as 3D printing. In this case the 'Internet of Things' technologies have the effect of creating an interactive business process in which the client becomes the designer of the product. Another example of transformation is the availability of a global digital infrastructure that connects consumers, producers and all kinds of resources and commodities, enabling various types of economic transactions through digital platforms, which in turn prompts the emergence of new business models that have come to be known by the label of 'platform capitalism' (cf. Guile & Unwin, 2019, p. 26).

Knowledge requirements

Each of these three dimensions of technological change is associated with specific knowledge requirements, which could be related to the knowledge categories developed in the previous section. More specifically, some processes involve an automation of cognitive tasks and hence lead to an outright substitution of technology for human minds, which at first sight seems to imply that in some areas there will be no knowledge requirements anymore, at least as far as the human intellect is concerned. This process is not limited to the automation of more or less complex physical tasks such as the assembly of cars (practical knowledge structured by contextual purposes), but may also concern cognitive tasks such as legal reasoning (theoretical knowledge structured according to applied disciplines). On the other hand, human actors have to interact with computerised work environments and to use the outputs of computerised work processes in a responsible manner, which begs the question of the types of complementary knowledge required on the part of individuals to remain in control. Finally, there are work tasks that are less susceptible to computerisation than others and are expected to continue to require human labour for the foreseeable future (cf. Frey & Osborne, 2013, pp. 24–28). These tasks fall into three categories, namely (1) perception and manipulation of physical objects, (2) creative

intelligence and (3) social intelligence. The types of vocational knowledge that underpin these activities will retain their relevance, and their relative importance may increase as other knowledge categories become less important.

The problem of analysing changing knowledge requirements with the help of the above-mentioned typology finally points to the vocational curriculum, which can be regarded as the medium, as it were, through which the demands of the world of work are transformed into actual knowledge and skills. The operationalisation of the knowledge categories proposed in this article needs to take place in curriculum research. This poses the challenge of giving due consideration to the process of knowledge acquisition, which is not explicitly addressed in the categories outlined above. Different types of knowledge may correspond to different learning processes, and these mutual interdependencies[1] need to be taken into account in the further development of the conceptual framework.

ACKNOWLEDGEMENT

REFERENCES

Autor, D. H., Levy, F., & Murnane, R. J. (2003). The skill content of recent technological change: An empirical exploration. *The Quarterly Journal of Economics*, *118*(4), 1279–1333. https://doi.org/10.1162/003355303322552801.

Barbour, J. B., Sommer, P. A., & Gill, R. (2016). Technical, arcane, interpersonal and embodied expertise. In J. W. Treem & P. M. Leonardi (Eds.), *Expertise, communication and organizing* (pp. 10–12). Oxford: Oxford University Press.

Becker, G. (1993). *Human capital: A theoretical and empirical analysis with special reference to education*. Chicago: University of Chicago Press.

Beer, P., & Mulder, R. H. (2020). The effects of technological developments on work and their implications for continuous vocational education and training: A systematic review. *Frontiers in Psychology*, *11*, 918. https://doi.org/10.3389/fpsyg.2020.00918.

Bernstein, B. (1999). Vertical and horizontal discourse: An essay. *British Journal of Sociology of Education*, *20*(2), 157–173.

---

[1]This point was suggested by Martin Weinel.

Bernstein, B. (2000). *Pedagogy, symbolic control and identity* (2nd ed.). Oxford: Rowman & Littlefield.

Bernstein, B. (2003). *Theoretical studies towards a sociology of language*. London: Routledge. https://doi.org/10.4324/9780203014035.

Boos, D., Guenter, H., Grote, G., & Kinder, K. (2013). Controllable accountabilities: The internet of Things and its challenges for organisations. *Behaviour* & *Information Technology*, 32(5), 449–467. https://doi.org/10.1080/0144929X.2012.674157.

Cedefop (2014). *Terminology of European education and training policy. A selection of 130 key terms*. Luxembourg: Publications Office of the European Union.

Cedefop (2017). *The changing nature and role of vocational education and training in Europe. Volume 1: Conceptions of vocational education and training: An analytical framework*. Luxembourg: Publications Office of the European Union. Cedefop research paper; No 63.

Cedefop (2018). *Insights into skill shortages and skill mismatch: Learning from Cedefop's European skills and jobs survey*. Luxembourg: Publications Office of the European Union. Cedefop reference series; No 105.

Cedefop (2020). *Vocational education and training in Europe, 1995-2035: Scenarios for European vocational education and training in the 21st century*. Luxembourg: Publications Office of the European Union. Cedefop reference series; No 114.

Collingwood, R. G. (1940). *An essay on metaphysics*. Oxford: Oxford University Press.

Davidson, D. (2006). Actions, reasons and causes. In D. Davidson (Ed.), *The essential Davidson* (pp. 23–36). Oxford: Clarendon Press. [original work published in 1963].

Dreyfus, H., & Dreyfus, S. (2005). Peripheral vision: Expertise in real world contexts. *Organization Studies*, 26(5), 779–792. https://doi.org/10.1177/0170840605053102.

Frey, C. B., & Osborne, M. A. (2013). The future of employment: How susceptible are jobs to computerisation? *September*, 17, 2013. https://www.oxford-martin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf [Accessed 4 Aug 2020].

Guile, D., & Unwin, L. (2019). VET, expertise, and work: Situating the challenge for the twenty-first century. In D. Guile & L. Unwin (Eds.), *The Wiley Handbook of vocational education and training* (pp. 19–41). Hoboken, NJ: John Wiley & Sons.

Habermas, J. (1981). *Theorie des kommunikativen Handelns*. Frankfurt am Main: Suhrkamp.

Hordern, J. (2016). Differentiating knowledge, differentiating (occupational) practice. *Journal of Vocational Education* & *Training*, 68(4), 453–469. https://doi.org/10.1080/13636820.2016.1234506.

Hordern, J. (2017). Bernstein's sociology of knowledge and education(al) studies. In G. Whity & J. Furlong (Eds.), *Knowledge and the study of education: An international exploration* (pp. 191–210). Didcot: Symposium.

Hordern, J. (2018). Knowledge, practice, and workplace learning. In S. McGrath et al. (Eds.), *Handbook of vocational education and training: Developments in the changing world of work*. Springer International.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York: Cambridge University Press.

Neuweg, G. H. (2004). Tacit knowing and implicit learning. In M. Fischer, N. Boreham, & B. Nyhan (Eds.), *European perspectives on learning at work: The acquisition of work process knowledge* (pp. 130–147). Luxemburg: Office for Official Publications of the European Communities.

Pfeiffer, S. (2016). *Beyond routine: Assembly work and the role of experience at the dawn of Industry 4.0. Consequences for vocational training*. University of Hohenheim, Department of Sociology. Working Paper 01-2016.

Pfeiffer, S. (2018). The 'future of employment' on the shop floor: Why production jobs are less susceptible to computerization than assumed. *International Journal for Research in Vocational Education and Training*, 5(3), 208–225.

Polanyi, M. (1966). *The tacit dimension*. New York: Doubleday.

Raz, J. (2006). *Praktische Gründe und Normen [Practical Reasons and Norms]*. transl. R. Zimmerling. Frankfurt am Main: Suhrkamp. [original work published in 1975].

Ryle, G. (1949). *The concept of mind*. London: Routledge.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Streeck, W. (2012). Skills and politics: General and specific. In M. R. Busemeyer & C. Trampusch (Eds), *The political economy of collective skill formation* (pp. 317–352). Oxford: Oxford University Press.

Susskind, D. (2018). *Re-thinking the capabilities of machines in economics*. Department of Economics Discussion Paper Series No 825. University of Oxford.

Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies*, *44*(3), 299–321.

Wheelahan, L. (2010). *Why knowledge matters in curriculum: A social realist argument*. London: Routledge.

Wheelahan, L. (2019). Knowledge, competence, and vocational education. In D. Guile & L. Unwin (Eds.), *The Wiley Handbook of vocational education and training* (pp. 637–651). Hoboken, NJ: John Wiley & Sons.

Winch, C. (2010). *Dimensions of expertise: A conceptual exploration of vocational knowledge*. Bloomsbury Publishing.

Winch, C. (2017). Knowing 'Wh' and knowing how: Constructing professional curricula and integrating epistemic fields. *Journal of Philosophy of Education*, *51*(2), 351–369.

Winch, C. (2020). Forming and exercising professional judgement. *Journal of Vocational Education & Training*. https://doi.org/10.1080/13636820.2020.1860117.

Young, M. F. D. (2008). *Bringing knowledge back in: From social constructivism to social realism in the sociology of education*. London: Routledge.

Zuboff, S. (1988). *In the age of the smart machine: The future of work and power*. New York: Basic Books.