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Torggler, Carmen; Miesera, Susanne; Nerdel, Claudia

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From TPACK to N-TPACK Framework for Vocational Education and Training With a Focus on Nutritional Science and Home Economics

Carmen Torggler*, Susanne Miesera, Claudia Nerdel

TUM School of Social Sciences and Technology, Technical University of Munich, Marsstraße 20-22, 80335 Munich, Germany

Abstract

Context: In Germany, vocational education and training (VET) plays a key role in the transition from school to working life. Due to its proximity to the labour market and an increasingly digitised, connected world, the professional knowledge requirements of VET teachers are changing and an adjustment of competence frameworks for vocational teachers is needed.

Approach: Since its introduction, the TPACK (Technological Pedagogical And Content Knowledge) framework of Shulman and Mishra and Koehler has been repeatedly used in the international research discourse as a framework for capturing teachers' professional knowledge. Given the infrequent reference to TPACK in the field of vocational education and training (VET), this theoretical article aims to adapt the TPACK framework for VET teachers. A literature review revealed the importance of developing an adapted TPACK framework that takes into account the peculiarities of the German vocational school system as well as the non technical personal service sector. Based on this research gap, an appropriately adapted TPACK framework was developed. The focus of this article lies on VET of nutritional science and home economics.

Findings: After considering and analysing the requirements of the VET system in Germany in the context of digitalisation, it is suggested to adapt and enlarge the existing TPACK

*Corresponding author: carmen.torggler@tum.de

framework, thus creating an N-TPACK framework, taking into account "Networking and Collaborative Knowledge (NK)" as an aspect of essential VET teachers' professional knowledge.

Conclusion: The present theoretical article considers the research desideratum of extending the TPACK framework by developing a theoretical N-TPACK framework as well as examining and discussing the various knowledge areas. Building on this theoretical article, a survey of the current status quo of these professional knowledge areas among (prospective) VET teachers in the subject area of nutrition and home economics is necessary, in order to provide orientation and to be able to derive recommended actions for an up-to-date and forward looking teacher education and training.

Keywords: Vocational Education and Training, VET, Digitalisation, Vocational Teachers, Skills and Knowledge

1   Introduction

This section focuses on teachers' professional knowledge in the context of digital transformation and the relevance of the TPACK framework for VET schools.

1.1   Teachers' Professional Knowledge

The skills, knowledge and competencies required by teachers to fulfil their mandate is an area that has been under investigation for some years. Even though the concept of (teacher) competencies is used heterogeneously and there are various proposals for modelling teachers' professional competencies (cf. e.g., Baumert & Kunter, 2006; Shulman, 1986), some basic assumptions find broad agreement. The professional competencies of teachers are usually understood as a combination of professional knowledge as well as teacher's beliefs, values, motivational orientations and self regulatory skills (cf. e.g., Baumert & Kunter, 2006; Bromme, 1997; Shulman, 1986). To be able to offer high quality instructions, a core area of teachers' professional competencies represents their professional knowledge, which unfolds in the facets of Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK) as well as Organisational and Advisory Knowledge (Baumert & Kunter, 2006; Shulman, 1986).

The increasing digitalisation in all areas of life has entailed new challenges for schools and especially new requirements for teachers (Vilppola et al., 2022), in order to be able to integrate digital media in lessons in a way that promotes learning, as well as to prepare learners for a life in a digitised, connected world. Thus, various theoretical models and approaches

have emerged in the national and international context, with regard to the knowledge that teachers need in order to be able to act professionally in the context of digitalisation and to be capable of designing teaching and guiding proper learning processes.

One model that is repeatedly used as a framework for empirical research and can provide guidance for teacher education and training is the TPACK framework, which originated from Shulman's (1986) concept of Pedagogical Content Knowledge (PCK) and extends the original concept by including a technological component in the teaching context. The extended model of Mishra and Koehler (2006) combines the facets CK, PK and PCK known from Shulman with the technological component TK, from which new intersections emerge that have their focus on digital technologies in the context of content knowledge, pedagogical and pedagogical content knowledge. The facet of Technological Pedagogical And Content Knowledge (TPACK) is particularly interesting for VET teachers, because, in addition to the knowledge of how to incorporate digital tools into the classroom, also knowledge about a digital World of Work 4.0 is becoming increasingly important for VET, due to its proximity to the labour market as subject-specific knowledge (TCK), and future-oriented technologies are already frequently used in in-company training, which should be reflected on with prospective teachers with regard to their implications for the working world. Although the TPACK model can be seen as a flexible framework regarding a variety of technological tools and pedagogical approaches (Celik, 2023; Mishra et al., 2011; Valtonen et al., 2017), the authors of this article expect that the TPACK framework will prove to be a robust framework when aligned with the peculiarities and needs of the German VET system, for a better understanding of the necessary teacher knowledge for vocational education in a World of Work 4.0.

1.2   Significance of the TPACK Framework for Vocational Education and Training

The TPACK model had and still has a considerable impact. The importance of the framework has been widely recognized, not only in the US but internationally (Chai et al., 2013; Hew et al., 2019; Tiede, 2020; Voogt et al., 2013). In the course of the diverse and extensive scientific reception of the TPACK framework, many survey instruments were developed. Moreover, numerous further developments of the TPACK model with adaptations to specific contexts or subject areas and accordingly adapted measurement instruments were produced (Tiede, 2020). However, the published articles with reference to the TPACK framework mostly refer to (prospective) teachers of science, mathematics and technology (Arifin et al., 2020a; Chua & Jamil, 2012; Nurhadi et al., 2019), whereas articles on VET related to the TPACK model are still comparatively few and far between, especially in the non-technical and personal and service sectors.

Through a literature review, the authors of this article aimed to determine the importance of the TPACK framework for vocational school teachers. The following research questions formed the basis for the literature review:

1. Does the TPACK framework adequately map the required knowledge of vocational school teachers?

2. Do international studies regarding the TPACK framework in the context of vocational schools exist?

A literature review was conducted (search date: August 31, 2021) with the following keywords: Initially only "TPACK", then "TPACK AND vocational school" as well as "TPACK AND VET" on literature databases such as Literaturdatenbank Berufliche Bildung (LDBB) and Web of Science (WoS) including SSCI indexed journals. This review has shown that studies in the field of VET with reference to the TPACK framework have so far been limited mainly to Asian countries (Arifin et al., 2020a; Arifin et al., 2020b; Arifin et al., 2020c; Nurhadi et al., 2019) or can be located in the field of industrial-technical education (see Figure 1). However, taking into account the peculiarities of the German VET system, such as the "dual" system (which is called "dual" because the VET takes place at two learning venues - in a company and at a vocational school), the authors of this article believe that these international findings are not sufficiently transferable to the VET system in Germany.
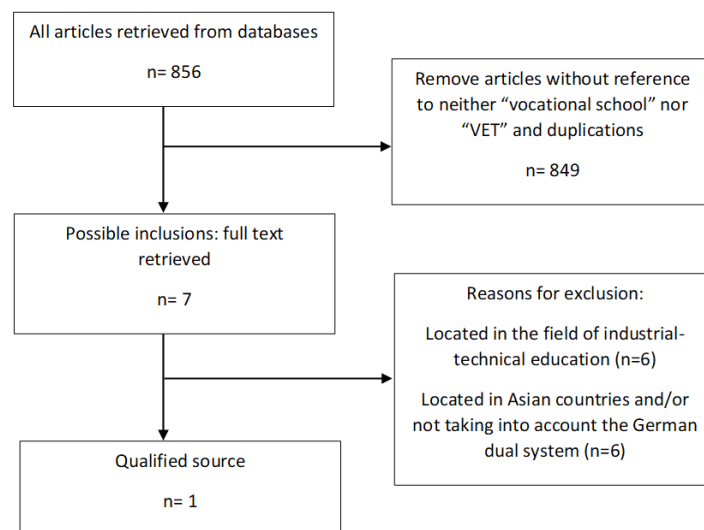

Figure 1: Flow Diagram of Literature Review Process for Articles on TPACK With Reference to Vocational Schools

The literature review was the starting point for developing a new, robust framework that takes into account the specific requirements of the German VET school system, with focus on the non-technical and the personal and service sectors.

Therefore, the key contribution of this theoretical article is to discuss selected peculiarities of the VET system in Germany and the various facets of a VET teacher's professional knowledge, focusing primarily on the non-technical subject area of nutrition and home economics (NaH). The article aims to develop a conceptual framework for the professional knowledge of vocational school teachers of NaH, in the context of the digital transformation, based on the TPACK model by Mishra and Koehler (2006). Considering the peculiarities of the VET system in Germany and the requirements in the context of digitalisation, the authors propose to enlarge the original framework to an N-TPACK framework, taking into account "Networking and Collaborative Knowledge" (NK) as an essential aspect of a VET teacher's professional knowledge in Germany. As a future research proposal, the status quo of the various N-TPACK components among (prospective) VET teachers should be measured. Furthermore, offers which prepare (prospective) VET teachers for the challenges of a World of Work 4.0 and which promote their Networking and Collaborative Knowledge should be implemented.

1.3   Why Networking and Collaborative Knowledge (NK) Matters in Vocational Education and Training?

Prospective digital technologies (e.g., Smart Devices, Cloud Computing, Social Media, Internet of Things, Big Data Analytics, Robotics and Artificial Intelligence) are progressively changing work and business processes, but also the way we inform ourselves, how we learn (e.g., m learning), how we communicate and how we consume - with massive consequences for technological and economic processes, but also for social interactions (Euler & Severing, 2019; Hossain et al., 2021; Hossain et al., 2019). The digital transformation has long since taken hold of sectors and areas that were long considered "digital laggards", such as the personal services sector, that so far had a minor potential for digitisation due to the importance of social interaction (Daum, 2017). Networked, intelligent, automated technologies are increasingly finding their way into our society. The term Industry 4.0 refers specifically to developments in industry, but often also serves as a collective term for the intelligent networking and collaboration of people, machines and objects by means of information and communication systems, and their targeted application in new forms of work and manufacturing processes (Berufsgenossenschaft Nahrungsmittel und Gastgewerbe [BGN], 2020). In the context of this Fourth Industrial Revolution, there is an increasing interconnection of information technology (IT) and software components with mechanical and electronic parts, that communicate via a data infrastructure, such as the internet. Due to the fusion of the physical and digital world and their connection via the internet, it is often called the Internet of Things

(IoT). In addition to new manufacturing processes, forms of work and assistance systems, the merging of processes from the virtual and the real world, as well as their automation, are core elements of the World of Work 4.0 (BGN, 2020). Networked systems make it possible to exchange data and information as well as to react intelligently to each other. Thus, networking and collaboration are central elements of the World of Work 4.0.

As work situations, technologies, forms of work and (customer) interaction forms change, the competence requirements for employees and thus, the demands on VET change too (Euler & Severing, 2019). Due to the proximity to the employment sector, Networking and Collaborative Knowledge (NK) plays progressively an important role for VET, and as a separate VET teacher's professional knowledge facet. On the one hand, this can be understood as knowledge regarding an increasingly digitally networked World of Work with more and more networked systems, and on the other hand, as the ability to network and collaborate with the various actors involved in the VET system in Germany, in order to prepare trainees as far as possible for a World of Work 4.0.

The apprenticeship system in the German-speaking area is known as a "dual system", since it consists of two learning venues, i.e. the vocational (part-time) school and the company. The Federal Government regulates in-company and inter-company training by means of Vocational Training Regulations, whereas the Standing Conference of Ministers of Education and Cultural Affairs of the *Länder (Kultusministerkonferenz [KMK])* develops the corresponding Framework Curricula for the (part-time) vocational school training (Bundesinstitut für Berufsbildung [BIBB], 2011). Along with the German state, both on the federal (*Bund*) and the federal state (*Länder*) level, chambers and companies as well as trade unions represent major actors and players in shaping the VET system beyond government regulation, e.g., when it comes to the on-going modernization of training courses (BIBB, 2011; Deissinger & Gonon, 2016).

A prerequisite for a successful VET is the cooperation and networking between the learning venues. The importance of a "learning venue cooperation" (*Lernortkooperation*) is explicitly emphasised in the original Vocational Training Act (*Berufsbildungsgesetz [BBiG]*) under § 2 subsection 2, however, the act does not make any statements on the nature and extent of this cooperation (Hackel et al., 2017) . Studies show a varying degree of development of learning location cooperation (BIBB, 2018).

Another pedagogical concept that is guiding and established nationwide for the (part-time) vocational school is the "learning field concept" (*Lernfeldkonzept*), which was introduced by the *Kultusministerkonferenz (KMK)* in 1996. The learning field concept is open to development and based on action-orientation. It requires the traditional "division of labour" between the two learning venues (vocational school and company) to be discussed and negotiated, and to that extent an increased cooperation between the two learning venues (Pätzold, 2002). At the same time, lessons structured according to learning fields require much more

consultation and cooperation between the teaching colleagues for planning and organising lessons, since the learning field principle wants to promote interdisciplinary teaching in a didactic sense, while abolishing pure subject-based teaching (Pätzold, 2002). The orientation towards concrete vocational tasks and courses of action is intended to convey key competences that are typical for the corresponding occupational field as well as cross-occupational competences, in order to ultimately enable the trainees to acquire a "vocational action competence" (KMK, 2021; Pätzold, 2002). The learning field concept requires a school and lesson development that enables holistic action-oriented teaching and learning and thus necessitates, in addition to a growing learning venue cooperation, an increased cooperation within teacher teams - the individual teacher is no longer an expert for a specific subject, but a team member as a subject expert (KMK, 2021).

Cooperation of teachers can be a key to successful professional work, in order to successfully cope with new situational demands and complex instructional and pedagogical activities combined with the aforementioned technological innovations (Fussangel, 2008; Gräsel et al., 2006); it is especially a characteristic of school quality (Holtappels, 2020). Studies show that teacher cooperation is also related to better students' performances. Gräsel et al. (2006) distinguish three forms of cooperation: Exchange, cooperation based on division of labour, and co-construction. While exchange as a low-cost method has a low target claim to equalize knowledge levels without a loss of teachers' autonomy, cooperation based on division of labour already aims at increasing efficiency with distributed task fulfilment and shared objectives. Furthermore, joint planning and reliability are required. Co-construction, as the most intensive form of cooperation, uses individual expertise for joint knowledge generation; goals are coordinated and (teaching) actions are professionally planned; pronounced trust and a high level of commitment are required while at the same time restricting the teachers' autonomy. However, the quality and benefits of these activities are high for both team members and the organization. Looking at school organisation, Holtappels (2020) systematizes forms of cooperation into the following categories of increasing intensity and systemic embeddedness from occasional cooperation to professional teamwork: (1) Structured cooperation (committees, conferences); (2) Occasion-induced temporary cooperation (informal and occasional exchange between fixed cooperation partners); (3) Temporary development groups (working groups, development circles); (4) Institutionalized team forms (class teams, year teams, subject teams, steering groups); (5) Professional learning communities (PLC - teamwork focusing on teaching effectiveness and student learning as exchange, division of labour, and co construction). Accordingly, the extension of the TPACK framework by including the networking and collaborative component will be illustrated in section 3, as a basis for further empirical research in this area.

1.4 Digitalisation of the Occupational Field of Nutrition and Home Economics 4.0

The degree of digitalisation of individual professions within the occupational field of nutrition and home economics (NaH) varies greatly and depends on the developments of a single company. However, the current German Digitalisation Index (Bundesministerium für Wirtschaft und Klimaschutz [BMWK], 2022) shows that the manufacturing industry (including food production) as well as the tourism industry are still below average in terms of digitalisation and that small companies have the highest potential for digitalisation. The future of the professional world will be characterised by a "coexistence of highly digitalised and conventional working environments" (Katzer et al., 2017; Zinke, 2019, p. 39). On the one hand, the competency requirements for apprentices remain specific to the occupational field, but cross-occupational competency requirements such as process and system understanding are gaining in importance (Zinke, 2019). The occupational field of NaH is characterised by a broad spectrum of work areas in personal services, crafts and technological manufacturing. The approximately 30 apprenticeship occupations range from hotel specialist, housekeeper, chef, baker to wine technologist and brewer and maltster (Terrasi-Haufe & Miesera, 2018). These fields of work are characterised by interfaces with health and care, commercial occupations and food technology. Cross-occupational knowledge and understanding of related occupations are necessary to meet the demands of the changing world of work. Teachers and trainers within the dual vocational education and training system need to take these requirements into account through cooperation. So far, occupations focused on personal services, such as gastronomy, home economics and food retailing, have been almost unaffected by system-altering technological changes (Brutzer et al., 2018; Kastrup & Brutzer, 2021). The increasing digitalisation of these areas requires an expansion of the professional competencies of employees as well as of teachers and trainers. More and more digitalised processes find their way into the workflows of personal services (Friese, 2021). Digital work processes are increasingly taking place asynchronously and at separate locations from the workplace, and systemic considerations of work processes are becoming more significant (Zinke, 2019). New forms of ordering and payment in the gastronomy sector, smart home facilities in home economics and both digitalised customer contacts and digitalised production in food retailing and production can be found. Previous VET and teacher training has not taken these areas into account (Brutzer et al., 2018). On the one hand, technological knowledge specific to the occupational field is necessary to meet the requirements of everyday working life (Miesera et al., 2021). On the other hand, digitalisation is more than the transformation of manual activities into digitalised processes; rather, digitalisation in the occupational field is characterised by increased networking and interfaces. The interfaces concern both other occupational fields as well as competency areas in dealing with technologies in the commercial occupational field, manufacturing field and the field of personal services. The networking

includes work processes e.g., from ordering to payment and (individualised) production, cooperation with other occupational groups such as suppliers, dealers, IT specialists as well as the loyalty to customers e.g., through customer cards, mailings.

2   Adaptation of the TPACK Framework for VET – With a Focus on Vocational Education of Nutritional Science and Home Economics

Since the existing framework by Mishra and Koehler (2006) has already been adapted for (prospective) VET teachers in Germany in a previous contribution (see Miesera et al., 2021), the authors deliberately refrain from illuminating in detail the individual framework components. This section deals with the technology-related knowledge of vocational school teachers of NaH in the context of the digital transformation. Furthermore, the focus of this article lays on the Networking and Collaborative Knowledge (NK) of VET teachers (see section 3).

2.1   Technological (TK), Pedagogical Technological (TPK) and Technological Content Knowledge (TCK)

With regard to the profound changes that modern, digital technologies entail for forms of work and business processes in companies, but also for social coexistence (Dormann et al., 2016; Gerholz & Dormann, 2017), the term digitalisation falls short. Therefore, the term digital transformation is more appropriate. In the course of a transformed World of Work, the competence requirements for employees are changing and thus the requirements for VET and VET teachers (Euler & Severing, 2019; Funk & Webe, 2017). This is accompanied by changes in the requirements for the to-be-taught learning content as well as for the didactic design of teaching and learning processes. The digital transformation has taken hold of sectors and areas that so far had less potential for digitisation due to the importance of social interaction, such as the personal services sector (Daum, 2017). In the light of the immense technological possibilities, an ever-increasing flood of data and a globally networked society, according to Wittmann and Weyland (2020), topics such as autonomy, security and trust, as well as the tension between these categories, are becoming increasingly relevant for a successful digital transformation in occupation, working life and society. In order to fulfil its educational mandate, VET and especially a VET teacher needs to impart an understanding for these issues, as well as for data protection and security, with the purpose of promoting a sustainable development of the working and living environment as well as the sovereignty, maturity and a self-determined participation in society of all those involved (Blossfeld et al., 2018; KMK, 2021; Seufert et al., 2018; Wittmann & Weyland, 2020). An increasingly digital

World of Work requires VET teachers to have specific technological and methodological skills, e.g., knowledge in dealing with Big Data applications, as well as to know how to impart understanding for the (critical) use of digital media and technologies (Blossfeld et al., 2018). In order to qualify learners for the requirements of a World of Work 4.0, a VET teacher needs to be able to convey complex content on the topic of digitalisation as well as to know how to combine traditional and digital forms of learning in a suitable way (Blossfeld et al., 2018). The role of a VET teacher is changing. A VET teacher increasingly has the task of promoting the learners' ability for self directed learning and enabling them to actively shape their individual learning processes - the VET teacher increasingly and consciously takes a back seat (Blossfeld et al., 2018; KMK, 2021).

A World of Work 4.0 requires VET teachers to have occupational field-specific knowledge of up-to-date digital technologies and tools (e.g., Augmented Reality [AR], Virtual Reality [VR], Artificial Intelligence [AI], Cloud Computing etc.) and, above all, knowledge of their significance for the various training occupations in the corresponding occupational field. For example, a VET teacher of NaH needs to be familiar with subject specific media and technologies, such as evaluation portals, enterprise resource planning (ERP) systems, electronic assistance systems, point-of-sale systems and apps (for ordering and reservation processes, as collection of recipes, for ingredients, regarding food hygiene/safety, waste disposal, etc.) (Arenskötter et al., 2019; Brutzer et al., 2018). Furthermore, he/she should be able to assess how these technologies are affecting and changing the professional discipline. The survey of occupational field-specific knowledge with an adapted TPACK survey instrument shows a lower mean value for the TCK subscale than for the TK and TPACK subscales among prospective VET teachers in the field of NaH (Miesera et al., 2021). The low self-assessment of items such as "knowledge about the significance and importance of innovative media and technologies (e.g., cloud-based software programmes, artificial intelligence, etc.) for the field of personal services (e.g., home economics, gastronomy, dietary assistance)" indicates a need for targeted training offers (Miesera et al., 2021, p. 12).

2.2 Technological Pedagogical and Content Knowledge (TPACK)

For a VET teacher of NaH, it is important to know how digitalisation will change structures and processes in the various training occupations of the occupational field, in order to be able to re-describe the current and future vocational action competence and to adapt the learning content and action-oriented learning situations accordingly (Lund, 2018). According to Bruhn & Hadwich, 2017), the service sector will change significantly as a result of digitalisation; the integration of technologies and intelligent services within value-creating networks will increase. At the same time, the service sector has a profoundly human side and it is up to the VET teacher to keep an eye on what is originally human that needs to be

preserved, what competences the learners need to find their way around a World of Work 4.0 and how, correspondingly, future-oriented learning situations can be designed (Lund, 2018). Furthermore, a VET teacher of NaH must identify subject-specific digital media and technologies with vocational reference and integrate them into the teaching-learning scenarios in a competency-oriented manner by connecting them to the matching vocational field or training contents of the various occupations (Grundmann et al., 2019).

3 Extension of the TPACK Framework to N-TPACK Taking Into Account Networking and Collaborative Knowledge (NK)

As already pointed out in section 1.3, as a result of its proximity to the employment sector, Networking and Collaborative Knowledge (NK) plays an important role for vocational education and training, even more within the context of the digitalisation. To that extent, according to the authors of this article, Networking and Collaborative Knowledge (NK) can be seen as a separate VET teacher's professional knowledge facet. However, a VET teacher needs to be competent not only in terms of the four types of knowledge per se – Networking and Collaborative (NK), Pedagogical (PK), Content (CK) and Technological Knowledge (TK) - but especially regarding their intersection, interplay and combination (see Figure 2).

The proposed N-TPACK framework provides various network related components of a VET teacher's professional knowledge (see Figure 2). In the following, these components of the N-TPACK framework are formulated in concrete terms, principally regarding VET teachers of NaH.
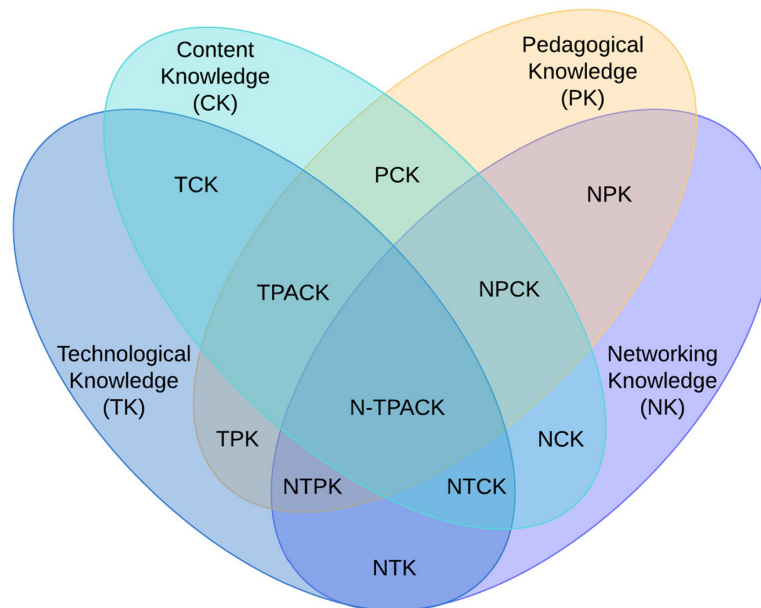
*Figure 2: Conceptual Framework N-TPACK for VET (own representati-
on based on the TPACK Framework by Mishra and Koehler, 2006)*

3.1 Networking and Collaborative Knowledge (NK) as Well as Networking and Collaborative Technological Knowledge (NTK)

Networking and Collaborative Knowledge (NK) of a VET teacher can be considered as knowledge regarding the networking and collaboration with the various actors involved in the VET system, such as other VET teachers, companies, chambers, trade unions, other educational institutions etc., with the aim of preparing learners adequately for cooperation in a World of Work 4.0, whereas NTK can be understood as a VET teacher's knowledge related to the potential and usage of digital technologies and media to achieve the same goals (e.g., knowledge about data sharing, knowledge about cooperation tools such as Teams, Zoom, Adobe Connect, Padlet, Miro etc.). Furthermore, NTK implies knowledge related to the potentials as well as the risks that intelligently networked machines and processes, characterising a World of Work 4.0, can entail.

3.2   Networking and Collaborative Pedagogical Knowledge (NPK) as Well as Networking and Collaborative Technological Pedagogical Knowledge (NTPK)

VET trainees have always had diverse backgrounds. However, (social) heterogeneity in VET in Germany has increased over the last decade, among others, for the following reasons: The strong influx of refugees (especially in 2015/2016) has reached VET so that many trainees come from immigrant families; the signing of the UN Convention on the Rights of Persons with Disabilities (2009) has led to the inclusion of persons with disabilities within the mainstream school system; the proportion of university drop-outs has grown (Euler & Severing, 2020). The increasing heterogeneity in VET requires a constructive approach to this diversity and the individual support of all learners. Teachers need to know how to get support and how to cooperate within internal and external school networks (e.g., with other teachers, school social workers, accompanying social services, professionals from the therapeutic, socio-pedagogical and medical fields, with other educational institutions etc.) in order to enable successful work as multi-professional teams and to ensure inclusive school development (cf. Fischer & Heger, 2011; Heimlich, 2003; Heimlich & Jacobs, 2001; Verband Bildung und Erziehung [VBE], 2017).

Furthermore, NPK includes knowledge about the importance of a "learning venue cooperation" *(Lernortkooperation)*, a central pedagogical concept of the German VET system emphasised in the original Vocational Training Act *(Berufsbildungsgesetz [BBiG])*. VET teachers should be in constant contact with the instructors in the companies, and show willingness to cooperate with them on an organisational but also didactic level (Helm et al., 2017; KMK, 2021).

As already mentioned in section 1.2, elaborated forms of collaboration are found in PLCs. These have a long history for cooperative school and classroom development in general education schools and originated in the United States in the late 1980s (Bonsen & Rolff, 2006). PLGs are mainly characterized by five features (cf. Warwas & Schadt, 2020): (1) They develop common action guiding objectives with a view to instructional design; (2) they have a clear focus on learning with a supportive help and error culture (Bonsen & Rolff, 2006); (3) they engage a continuous, reflective dialogue about the instructional actions of the community members, e.g., by testing/evaluating new instructional approaches; (4) they de-privatize their teaching by having their members share knowledge and professional experiences and direct their activities toward the goal of promoting and improving student learning; (5) they collaboratively construct new knowledge and instructional approaches. Another characteristic of this approach is that members of the learning community can quickly assess success and effectiveness through the feedback of a scientific formative evaluation in parallel with the process, and benefit from these findings as they continue to develop the innovation (Gräsel, 2010; Gräsel & Parchmann, 2004). The importance of cooperation and collaboration as

a condition for success in incorporating innovations into the classroom is emphasized by several studies (Borko, 2004; Fussangel, 2008; Krebs, 2008). Therefore, it is a desirable goal to initiate a professional cooperation of teachers in vocational education for the implementation of technological and didactical innovations beyond teacher training and to systematically involve further stakeholders in the development of school and teaching, e.g., school management, educational administration, school functionaries with expertise related to the innovation (e.g., the person responsible for IT), in order to meet the changing and increased requirements in the vocational education system.

If there is a large physical distance between members of a PLC, the usage of digital media can be a solution (Kansteiner, 2019). Individual sessions can be organised as online-only, but also as hybrid sessions. A VET teacher needs to have knowledge about suitable collaboration tools, thus needs to have Networking and Collaborative Technological Pedagogical Knowledge (NTPK). Digital technologies and media can also support and improve (time and location independent) cooperation within and between the learning venues (Euler & Severing, 2019), as well as with other relevant actors for the VET system (e.g., social services, universities, etc.). Digital labour and learning platforms can offer the possibility of improved coordination and exchange of experience as well as work resources, documents, materials and data (Euler & Severing, 2019). A VET teacher needs to know how to use them to best connect and engage networking as well as collaboration with the various actors.

If necessary, a teacher in Germany can seek support from the school's media education consultants *(medienpädagogische Berater:innen digitaler Bildung, mBdB)* or information technology (IT) consultants *(informationstechnische Berater:innen digitaler Bildung [iBdB])*, who represent an important link between the various school and non-school stakeholders. They support teachers in shaping the digital transformation as well as in relation to media education and IT issues. Media education consultants focus on the challenges of the modern media world and digitalisation as a whole and give support in the development of schools and teaching regarding questions of school media education. However, media education consultants have also specific expertise as trainers within learning communities/collaboration.

3.3 Networking and Collaborative Content Knowledge (NCK) and Networking and Collaborative Technological Content Knowledge (NTCK)

One of the most important characteristics of the subject area of nutrition and home economics is its considerable range of training occupations, as it includes 29 different occupations with an industrial-technical or craft character (e.g., occupations in food production), with an economic administrative or commercial character (e.g., occupations in food retailing), as well as with a person-related service character (e.g., occupation in hospitality and home

economics) (Brutzer & Küster, 2015; Kastrup & Brutzer, 2019; Kettschau, 2013; Terrasi-Haufe & Miesera, 2018). Furthermore, some are designed as dual training occupations and others as full-time school-based vocational training programmes (Kastrup & Brutzer, 2019). The heterogeneity of the subject area makes the importance and necessity of networking and cooperation with the various actors of the VET system as well as within the school's subject group *(Fachgruppe)* all the more obvious. A vocational school teacher for NaH should place special emphasis on close cooperation within the subject group by regularly making more precise arrangements regarding the specifications of the curricula and the content knowledge to be taught. Whenever networking and cooperation with the various actors of the VET system as well as within the subject group for this purpose takes place successfully with help of digital cooperation tools (such as Zoom, Teams, Adobe Connect, Padlet etc.) or digital working and learning platforms (such as Moodle, SharePoint etc.), we speak of Networking and Collaborative Technological Content Knowledge (NTCK).

3.4   Networking and Collaborative Pedagogical Content Knowledge (NPCK)

The in section 3.2 mentioned learning venue cooperation can take place by involving companies in the design of learning situations, by exchanging information on the implementation of the learning field concept or by planning training courses together. Moreover, a VET teacher for NaH could carry out a practical training or a visit within a company, in order to align learning situations as closely as possible to real work and business processes of the occupational field. Learning venue cooperation ultimately pursues the mutual goal of enabling the trainees to achieve a vocational action competence (Helm et al., 2017; KMK, 2021).

As a VET teacher for NaH or as a member of a team that collaborates with the university, it is also of great importance to be in close exchange with the subject didactic of NaH located at the university. This way, an optimal networking of study and vocational school, of theory and practice, can be achieved. Furthermore, this way of networking supports a future-oriented VET. Networking and collaboration with federal working groups *(Bundesarbeitsgemeinschaften)* related to the vocational field *(e.g., Bundesarbeitsgemeinschaft für Berufsbildung in der Fachrichtung Ernährung und Hauswirtschaft [BAG E&H])* promotes this interlock of research and practice as well, and thus innovation in VET.

Furthermore, the learning field concept (introduced in 1996) has caused a didactic paradigm shift at vocational schools, requiring the cooperation between teachers. With the introduction of the learning field concept, separate school subjects were largely abolished. Instead, learning fields with an extensive time volume are now to be implemented; there is a dissolution and reorganisation of the planning and organisational structures, related to times, rooms and teachers - a learning field is not exclusively assigned to one teacher anymore, but entails the cooperation of several teachers (Kremer & Sloane, 2000; Tenberg, 2017). In order

to ensure the highest possible quality of vocational education within the learning field plans, a VET teacher needs to have the ability to optimally integrate his/her strengths within a team of teachers and to compensate for his/her weaknesses as much as possible (Tenberg, 2017).

3.5 Networking and Collaborative Technological Pedagogical and Content Knowledge (N-TPACK)

N-TPACK refers to knowledge that goes beyond the individual components of professional knowledge. It can be interpreted as knowledge and understanding related to the complex and required interaction of the different components. Supported by cooperation within networks (especially with the learning venue company), a VET teacher needs to know how to teach and convey subject content using appropriate subject didactic and pedagogical reflection as well as technologies. Based on learning field-related teaching, a VET teacher has the responsibility to identify relevant, vocational tasks and problems and prepare these didactically as action oriented learning situations. Considering the ongoing digitalisation characterising the World of Work 4.0 and the immediacy to the labour market, a VET teacher needs to recognize technologies and digital media with relevance for the corresponding occupational field and integrate them into the teaching-learning scenarios in a competency-oriented manner (Grundmann et al., 2019). According to the authors of this article, through networking and cooperation between the two learning venues as well as with other stakeholders of the VET system, company needs and on-going digital developments within the occupational field can be included in the best possible way in vocational school teaching (e.g., as learning situations based on current and future-oriented professional actions), and thus offering up to date teaching.

Furthermore, digital media and technologies, such as mobile devices and cloud-based learning management systems, offer new opportunities for the cooperative knowledge construction between the learning venues, e.g., for linking work and learning processes (Schmid et al., 2016)

In summary, a central prerequisite for the development and implementation of innovative training concepts is that a vocational school teacher has the necessary competencies to qualify trainees for the requirements of a World of Work 4.0. In addition to a VET teacher's technical know-how, up-to-date, practice-relevant knowledge on digitalisation, Industry 4.0 and the networking of operational processes is necessary (Blossfeld et al., 2018). In this respect, a vocational school teacher needs to be able to convey complex content regarding the subject of digitalisation and Industry 4.0 and, on the other hand, to combine traditional and digital forms of learning in a suitable manner (Blossfeld et al., 2018).

Because of changing requirements for VET and considering the demanded implementation of complex, future-oriented learning situations, according to the authors of this article,

besides learning venue cooperation, also cooperation and networking between teachers becomes more and more advantageous, if not necessary, with the final goal of ensuring school development as well as the improvement of the learners' professional action competence.

4   Discussion and Conclusion

The analysis and understanding of learning and interaction processes and their contextual adaptations are the prerequisite for the design of future VET. The impact of the digital transformation on learning and professional development needs to be taken into account by teacher education programs, teaching and learning processes as well as by inter-professional cooperation.

The specificity of the VET system and VET teachers' education in Germany, requires an adaptation of existing frameworks defining teachers' professional knowledge. The TPACK framework was used in several studies to define and capture teachers' professional knowledge, however primarily in the field of general school education. The TPACK framework captures the technology-related knowledge components of a teacher, which in this article refers primarily to technological knowledge in the context of a World of Work 4.0. Technological changes and an increasingly networked, digitalised world require an expansion of the professional understanding of teachers and thus a revision of existing competency frameworks - e.g., of the TPACK model. This article takes into account this desideratum by extending the TPACK to an N-TPACK framework, by including Networking and Collaborative Knowledge (NK) as a further knowledge facet. As an example, in this article this is done for teachers of the vocational subject area of nutrition and home economics. With regard to the learning venue cooperation in VET, there is a lack of research that systematically examines the influence on school and teaching development as well as the influence on students' learning outcomes in VET.

With a view to a future-oriented VET and VET teachers' training, there is a need for research that records the status quo of the various N-TPACK components among (prospective) VET teachers on the one hand, while on the other hand, it is necessary to enable and carry out corresponding offers further on - e.g., in the form of digital and networked Teaching and Learning Labs - that prepare (prospective) VET teachers for the challenges of a World of Work 4.0 and through which the implementation of their network related knowledge is promoted. Thus, it is essential to move from the level of knowledge to the level of practice, design and application.

Ethics Statement

The submitted article is a theoretical article for which no empirical data collection was carried out, thus no research ethics committee was consulted. The ethical principles in accordance with the IJRVET Ethics Statement were implemented.

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Biographical Notes

Carmen Torggler, M.Sc., is a vocational education teacher of nutrition and was a research assistant at the TUM School of Social Sciences and Technology (former TUM School of Education) at the Technical University of Munich, Germany. Her research focuses on digital transformation in the vocational field of nutrition and home economics.

Susanne Miesera, Dr phil., is the coordinator of didactics of nutrition and home economics for vocational school teacher education at the TUM School of Social Sciences and Technology at the Technical University of Munich, Germany. Her research focuses on the professionalization of teachers at vocational schools. Research topics are conditions for the implementation of inclusion as well as the design of teacher education with regard to the digital transformation in the vocational field of nutrition and home economics. The research activities are integrated into national and international networks (Austria, Switzerland, Canada). Based on the research results, she develops pre-service and in-service teacher training programs.

Claudia Nerdel, Dr rer. nat., is associate professor of life sciences education at the TUM School of Social Sciences and Technology at the Technical University of Munich, Germany. Her research focuses on teaching and learning with digital media as well as digital transformation in the context of biology as a subject and related STEM disciplines. Further research interests are teacher education and training on subject-related and didactic innovations and their implementation in the classroom as well as the cooperation of teachers and scientific staff in professional learning communities. The investigation of professional competencies of (prospective) teachers in dealing with technical language in science education as well as student research and cooperative networks with schools complete her research profile.