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ONLINE PROFESSIONAL LEARNING COMMUNITIES FOR DEVELOPING TEACHERS' DIGITAL COMPETENCES

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ABSTRACT

Digital transformation shapes the educational system in many ways. It has also far-reaching implications for teachers as their job description may fundamentally change in the future. In this light, it is important 1) to identify necessary digital competences of teachers and 2) to find ways to foster those competences in an efficient way. By means of a literature review and expert interviews, we developed a framework of teachers' digital competences. In line with Baumert and Kunter (2006) as well as Koehler and Mishra (2009), it comprises content knowledge, pedagogical content knowledge, and pedagogical knowledge. However, these facets have extended meaning in the context of digital transformation. Moreover, our framework considers the official EU competence framework (Carretero et al., 2017) and hence covers instrumental skills and knowledge in handling digital media. We successfully validated our framework by means of structural equation modelling with a sample of 215 Swiss teachers. Utilising an Importance Performance Map Analysis, we identified competence facets that show the highest effects on the (self-reported) use of digital media and content. For efficiently fostering those facets, we will establish online professional learning communities consisting of a communication platform, webinar series, and blended learning courses.

KEYWORDS

Digital Competence, Online Professional Learning Communities

1. INTRODUCTION

One would be hard pressed to find a topic of current debate in education policy and educational practice that is as exhaustively discussed as the (proper) handling of the digital transformation (e.g. 'standing conference of the ministers of education and cultural Affairs' [KMK], 2016). A widely shared perception is that a more intensive use of digital media in the classroom will improve learning effectiveness, facilitate greater orientation to the future needs of learners, and support accompanied personality development in a digital society. The sweeping pressure to make changes is marked with a high degree of uncertainty regarding the use and benefits of digital media in schools (Bach, 2016).

Teachers addressing digital skills, such as the competent handling of online information, are often entering uncharted territory in their respective fields (media education). In this context, teachers are increasingly asking for inclusion of media-specific qualification objectives. However, the kind of competences teachers need to acquire remains somewhat vague and is largely limited to the use and operation of computer applications and digital content media (Blömeke, 2003; Blömeke, 2005). Furthermore, it is obvious that formal seminars, such as one-day training workshops on how to use ICT, are neither sufficient nor effective for developing teachers' digital competences. On the contrary, successful support initiatives to develop teachers' competence will have to be rooted in their particular context and simultaneously embedded in innovation strategies and quality development processes in their respective schools (Schneider & Mahs, 2003). The conceptualisation and design of suitable training measures for teachers requires a systematic approach to the professional development of teachers at vocational schools. Developing professional communities among teachers to underpin the benefit of learning together and from each other is of central importance (Hord, 1997). Learning communities that make use of the potential of digital information and communication are becoming increasingly important as a means of continuously fostering teachers' digital

competences. However, there is a research gap in the promotion of digital competences for teachers (Büsser, 2017, p. 15). In this light, this paper focuses on two research questions:

1) How can digital competences of teachers be defined and measured?
2) How can measures and interventions to foster online professional learning communities (online PLCs) be designed and evaluated for a systematic development of teachers' digital competences?

The paper consists of three parts. In the first part, we consolidate relevant theoretical considerations. The second part outlines the research methodology and the results of the research conducted. The third and final section discusses the results of the study, implications for designing online PLCs and presents a perspective for further research.

2. REVIEW OF THE LITERATURE

2.1 Digital Competences of Teachers

Baumert and Kunter (2006) and Kunter et al. (2009, 2011) presented a highly regarded model of professional teaching competence, which comprises professional knowledge, convictions in the sense of personally biased basic orientations, values, motivational orientations, and self-regulation (for empirical findings on professional knowledge in the commercial sector, cf. Seifried and Wuttke [2015]). Professional knowledge consists of content knowledge, pedagogical content knowledge and pedagogical knowledge. This division can be traced back to Shulman (1986, 1987). Koehler and Mishra (2009) added technological aspects to these facets of professional knowledge. They include technological knowledge as a new, disparate type of knowledge.

Current technological developments, such as artificial intelligence and cognitive computing, are flanked by fundamental questions about which digital competences teachers need to possess.

Moreover, approaches for developing media skills (Tulodziecki, 1995; Baake, 1999; Aufenanger, 2008; Schorb, 2009; Mayrberger, 2012) might be taken into account. In this vein, Blömeke's (2003) model is an approach that refers to teacher training. It distinguishes five areas of competence: 'didactic media competence', 'educational media competence', 'socialisation-related competence', 'school development competence', and 'personal media competence'. The demands faced by a vocational school in the light of ever-increasing digitalisation cannot be tackled through the efforts of single individuals. In such a case, the individual teachers would quickly feel overworked (Seufert & Scheffler, 2016). In the light of digital transformation, appropriate advisory and organisational knowledge regarding cooperation in teams and networks can thus be regarded as a relevant facet of competence for the joint development of teaching and schools.

For vocational education and training, the official EU competence framework (Carretero et al., 2017) is leading the way because it defines cross-vocational digital competences (in the sense of "digital literacies"), which can be specified in the Europass European Skills Passport[1] in the form of self-evaluations. The KMK Strategy 2016 follows a similar path, identifying six areas of competence for education in the digital world – comparable to the EU competence framework (KMK, 2016). However, the implications for professional teaching skills have remained (as yet) ambiguous.

Empirical findings on technology-mediated learning (TML) indicate that affective-motivational characteristics of the instructor are a decisive factor influencing the educationally effective use of digital media in the classroom (Gupta & Bostorm, 2009). Teachers have widely divergent views regarding the extent to which the lessons themselves should undergo digital change (Schmid, Goetz, & Behrens, 2017).

In sum, professional competence can be conceptualised as a "bundle of occupation-related characteristics" (Voss et al., 2015, p. 4), which are central prerequisites for observable professional behaviour or ability (Shavelson, 2013; Blömeke et al., 2015). Professional knowledge is thereby acknowledged as a key aspect of professional competence (Baumert & Kunter, 2006; Voss et al., 2015). In addition, digital competences must encompass skills in the competent use of digital media and tools as well as attitudes toward digitalisation (fostering digital skills of students, digital content and use of digital media in education).

[1]The Europass aims to provide a way to present qualifications and competences in a way that is transparent and understandable throughout Europe, cf. https://europass.cedefop.europa.eu/de.

2.2 Online PLCs for the Professional Development of Teachers

Teacher training and its effectiveness is a field of research that has great untapped potential (Terhart et al., 2014; Garet et al., 2001). Currently, there are virtually no studies that demonstrate the effectiveness of measures for digital competence development (Lipowski, 2010; Lorenz et al., 2017, p. 228). According to Terhart et al. (2014, p. 517ff.), the efficacy of training measures must be considered on a case-by-case basis. Since this can be influenced by countless variables and contextual factors (class, teacher, setting, quality of training content, diverse and challenging learning opportunities for teachers, etc.), Terhart (2014) proposes that it is practically impossible to distinguish generally applicable quality standards.

Multiple studies have shown that teachers develop their skills mainly in the informal context of their professional practice, i.e. in exchange with colleagues or through individual, critical reflection (Hoekstra et al., 2009; Meirink, Meijer, Verloop, & Bergen, 2009; Jurasaite-Harbison, 2009). As a result, international research literature on teacher education and training is especially focused on "integrated learning at the workplace", which is increasingly aimed at informal learning and reflective dialogue among the teaching staff (Meirink et al., 2009). For this reason, strong learning environments are based on design principles from a socio-constructivist perspective in the context of informal learning theories. Team and community-based learning may be considered one of the most effective and predominant learning methods in this context and it is against this backdrop that the construct of the professional learning community (PLC) should be mentioned. According to Hord (1997), PLCs involve groups of teachers or the entire teaching staff at a school that are jointly and constantly seeking ways to increase the effectiveness of their teaching, sharing what they have learned, attempting to put new ideas into actual practice, systematically testing these ideas, and reflecting on them (Höfer, 2006). New competence requirements in the wake of increasing digitalisation necessitate ongoing (further) education that is marked by a high degree of speed and innovation dynamic. Teachers can no longer implement these changes individually and in isolation from one another in their day-to-day school routine. Bonsen and Rolff (2006, p. 170) therefore propose "the combination of community and professionalism" in times of turbulent change. In general, experimental testing of new approaches is risky. Hence, it requires continuity and a stable framework for developing common value patterns (Bonsen & Rolff, 2006, p. 170). Effectiveness studies on PLCs have produced key success factors: shared practice (Hord, 2004, p. 7), reflective dialogue, deprivatisation of teaching (teaching is a personal, but not a private matter), common focus on students' learning (shifting the focus from teaching to learning), and fundamentally reinforced cooperation (Newmann, 1994).

Learning communities that make use of the potential of digital information and communication media are becoming increasingly important as a means of fostering teachers' digital competences. In this regard, the relevance of virtual and online learning communities has become apparent. The conditions for their success (such as coherence, transparency, and quality of moderator performance) have been examined in numerous studies (particularly noteworthy is the meta study [comparison of 64 studies] by Wegener & Leimeister, 2012, cf. also Carlén, 2010, Hew, 2009; Carlén, 2007; Arnold, 2005; Dückert, 2003; Lazar & Preece, 2002; Seufert et al., 2002). Similar results have been obtained in studies that investigate professional learning community for the teaching profession supported by digital media (Huffman et al., 2003). The advantages of online support are clear, especially in terms of time and location flexibility for cooperation as well as the availability of knowledge gained through specific experience.

3. METHOD

3.1 Design

First, it is necessary to delineate professional competences of teachers in the context of the digital transformation. The resulting framework concept must then be systematically differentiated. For the subsequent test development phase, it is imperative to take into account the purpose of the measurement and the intended use of the results (AERA, APA, & NCME, 2014, p. 75f.). The purpose of the measurement is to assess teachers' digital skills for formative purposes. The results should serve to identify potential for improvements and to design appropriate support measures. With this in mind, we have designed a self-assessment tool that has been validated using confirmatory factor analyses. Since the aim of our research

is to identify adequate professional development measures, which is within teachers' own interest, we regard a self-assessment instrument as suitable.

In collaboration with five partner schools from German-speaking Switzerland, we have developed items that capture the constructs described in section 2.1, cf. table 1. The items are measured on a 7-point rating scale. We have validated the instrument by means of 12 expert interviews. The experts show a diverse background: training representatives of companies, researcher in the field of digitalization, school principals, educational policy makers, and federation representatives. Moreover, we carried out five focus group discussions with teachers at every partner school.

We utilised an importance-performance map analysis (IPMA) (Ringle & Sarstedt, 2016) to assess teachers' competences and promising fields for improvement. This method, though not yet widely used in the PLS-SEM context, enables a clear and theoretically justified presentation of the results for a baseline evaluation. The first dimension (Importance [I]) of the importance-performance map depicts for each construct, cf. table 1, or item its impact on a previously specified construct. In our case, we utilize frequency of use (measured on a 5-point rating scale) as the target construct, cf. table 2. For instance, a value of 0.1 for "pedagogical knowledge" would indicate that an increase in this construct by one unit on the rating scale increases the expected frequency of digital media use by 0.1 units. IPMA also considers indirect effects. This enables us to identify measures that are potentially most beneficial in terms of increasing the frequency of use of digital media. The second dimension (Performance [P]) places each construct or item on a scale from 1 to 100, indicating how pronounced the construct or item is among the teachers studied. A value that is low compared to other constructs or in absolute terms may indicate a potential for improvement. When selecting interventions, the focus should be on constructs that have a comparatively strong impact on the target construct and are not (yet) close to the maximum. We discuss IPMA-results in focus group interviews with school administrations and specialist representatives from pilot schools, and focal points for fostering digital competences within the framework of an online PLC.

3.2 Instruments and Data Analysis

The final instrument for capturing teachers' digital competence consists of 86 items covering 11 constructs (10 facets of digital competences, cf. table 1 and frequency of use, cf. table 2). 215 teachers at nine Swiss vocational schools act as a sample. 50 % of them are female. On average, they are aged 45 (SD = 6) and have 18 (SD = 10) years of teaching experience. The lack of normal distribution for all items is noteworthy (Shapiro-Wilk test: $p < .05$). Overall, 3.9% missing values occurred. The absence of values does not follow any specific pattern. A Little's MCAR test performed taking into account all context variables was not significant ($\chi^2 = 3616$, df = 3297, $p = 1$). We also checked for outliers using Mahalanobis distances. However, we did not exclude any observation.

Table 1 provides an overview of the 10 competence facets measured by a seven-point rating scale: from "very low" to "very high" (content knowledge, pedagogical content knowledge) and from "does not apply at all" to "applies very strongly" for all other facets (see table 1):

Table 1. Facets of teachers' digital competences including sample questions

Professional knowledge (classroom level, school level) with respect to digitalisation	Instrumental skills and knowledge in handling digital media	Affective-motivational characteristics related to digitalisation
<u>Classroom-oriented professional knowledge</u> *Content knowledge:* 1) General knowledge about digitalisation (e.g. "My basic knowledge about decisive principles of digitalization is…") 2) Business knowledge about digitalisation (e.g. "My knowledge about digital value chains is…")	8) Digital skills: - handling digital information (e.g. "I can efficiently use search strategies to find online information"); - creating digital content (e.g. "I can create learning videos"); digital collaboration (e.g. "I can efficiently use digital communication tools"); - ensuring digital security (e.g. "I regularly check my	9) Positive attitudes (e.g. "I like using digital media/tools in my instruction") 10) Negative attitudes (e.g. "I am afraid of making mistakes when using digital media/ tools in my instruction")

Pedagogical Content knowledge: 3) Knowledge about digitalisation as a school subject (e.g. "My knowledge about teaching digital value chains is…") *Pedagogical knowledge:* 4) General knowledge of digital media (e.g. "I am able to use digital assessment tools for students' summative assessment") 5) Promoting students' interdisciplinary digital skills (e.g. "I am able to foster my students' digital skills to use online information") 6) Media didactics (e.g. "I am able to select adequate learning videos for students' knowledge creation") <u>Professional knowledge at the school level:</u> 7) advisory and organisational knowledge (e.g. "I am able to support my colleagues to improve professional practice in terms of digital content and digital media use")	security settings of my digital devices and/or applications"), - digital problem solving (e.g. "I can regularly keep up-to-date my skills in handling digital media/ tools); - specific applications (e.g. "I can use profession-specific applications (e.g. Office applications)"

Table 2. shows the three elements of the target construct "frequency of use". They are measured on a 5-point rating scale: never, infrequently (1-2 times per semester), occasionally (3-5 times per semester), frequently (every month), very frequently (every week).

Table 2. Target construct 'frequency of use' including sample items.

Frequency of use	Sample Items
digitalisation as a class subject (professional, interdisciplinary);	How often do you consider digital related topics in your instruction? How often do you foster students' competences when dealing with digital media (e.g. dealing with online information)?
Use of digital media for individualisation;	How often do you practice individualisation of your teaching according to the learning progress supported by digital media?
General use of digital media	How often do you practice individualisation of your teaching according to learning preferences supported by digital media? How often do you use blended learning scenarios (e.g. flipped classroom)? How often do you use digital learning arrangements in your instruction?

Overall, we consider our instrument suitable for a comprehensive and valid formative assessment of digital competences as well as for competence development among teachers.

4. RESULTS

4.1 Instruments and Data Analysis

Test validations by means of confirmatory factor analyses generally yielded good values for all eleven constructs (CFI > .980, TLI > .969, RMSEA < .093, SRMR < .036). Moreover, the measures are reliable, indicated by Cronbach's alpha and composite reliability above .80. Convergent validity is established as all standardized factor loadings exceed .7. Hence, for every construct, the average variance extracted (AVE) is

greater than .5, which indicates convergent validity. Discriminant validity is ensured because the square roots of AVE are always higher than the correlations among the constructs (Fornell-Larcker criterion). Measurement invariance analyses demonstrate the instrument's suitability for assessing competence development as well as group comparisons in terms of gender, age, and teaching expertise. The findings on the prognostic validity of the instrument are positive: Frequency of use can be adequately explained using the facets of digital competence (.36 > R2 > .26).

The results of the structural equation models show that, in general, all competence facets are important for the use of digitalisation and digital media in teaching. "Negative attitudes" are the exception. This may indicate that it is not necessary to address "negative attitudes". Rather, the affective aspect of "positive attitudes" may be put into focus.

It is important to view the facets of competence in context, and to systematically foster all of them. However, developing all facets of competence at the same time would likely overtax the teaching personnel. Therefore, the next step will be to concentrate on selected competence facets within the framework of an online PLC. In line with the IPMA (baseline evaluation), these would primarily encompass the following:

- Media didactics: This facet of competence exhibits both a low self-assessment and a high level of effect on the frequency of use of digitalisation and on teaching with digital media; the findings show that digital media is primarily used for instructional knowledge acquisition (e.g. use of learning videos), but less for constructivist and cognitive processes, such as for discussion, reflection, or for forms of action-oriented teaching and learning (e.g. simulations, multimedia applications).
- Pedagogical knowledge: General, interdisciplinary knowledge of digital media also shows a rather high importance and a moderate performance. In this area, competence diagnostics with digital media in particular constitutes a knowledge gap for many teachers (this is accompanied by the relatively low values for formative and summative self-assessments in the competence facet of media didactics, which basically represents the concrete implementation level);
- Fostering students' digital skills: Teachers give the lowest rating to their ability to promote their students' knowledge acquisition of digital media. Against the requirements in vocational education and training, this finding is alarming and illustrates how pressing the need for action to develop the skills of teachers in this area is.
- Instrumental skills and knowledge in handling digital media: This competence facet also has a relatively strong effect on the use of digital content and digital media. The importance of the inclusion of digitalisation related topics in the classroom is even higher than that of the use of digital media in the classroom. A teacher who seems to be more active in the 'digital world' is more likely to recognise the necessity and become familiar with concrete application possibilities in order to integrate digitalisation topics into the classroom in a didactic manner.

In sum, media didactics has a particularly positive influence on the use of digital learning arrangements. There is potential for improvement, particularly in the digital assessment of learners' competences (summative and formative).

4.2 Developing Teachers' Digital Competences in Online PLCs

The results of the study were discussed with the school administrators of the nine schools in the sample. In this process, we addressed focal points for the ongoing promotion of digital competences within the framework of cross-school online PLCs. The design of the online PLC as a social construct for a continuous set of measures was conceptually established and access to the technological platform was regulated. Table 3 describes the online PLCs.

Table 3. Interventions for developing digital competences within online PLCs

Online PLC	Objectives	Implementation
Communication platform (continuously expanded)	Theme-based channel for digitalisation (blog with comment functionality);	Portal structure with access to online PLC
	Collection of good practices (webinar recordings, teaching materials)	Wordpress platform
"Good Practices" webinar series, approx. 2 hours per session	Moderated good practice sessions in an online setting: 5 webinars within one year; each participating school hosts one webinar	Teacher input, moderated reflection; virtual classroom (with ZOOM software)
Blended learning courses over 8 weeks	One blended learning course in one year (per intervention study), with three course components:	Three-phase concept:
	Learning with digital media (subject area "Interdisciplinary Competences")	Preparation phase (building on existing experience, providing new impetus);
	Testing with digital media (subject areas "Economy and Society", "Consolidating and Networking")	Presence phase (experimenting) and;
	Digital school development (everyday school life: joint cooperation among different places of learning)	Transfer phase with learning assignment Moodle platform (access via portal website)

5. CONCLUSION AND OUTLOOK

Our research project has produced a framework for the conceptualisation of digital competences of VET teachers in the field of business. In terms of professional knowledge, there are two building blocks of digital competences: 1) Instructional level: designing classroom situations, and 2) School level: shaping school development. Drawing on this framework model, we were able to operationalise the ten facets of digital competence in an instrument that we tested empirically in a pilot study with 215 teachers. The quality criteria of the instrument are high, allowing the results of the pilot study to be used as a baseline evaluation for subsequent research projects.

Furthermore, it was possible to acquire insight into how these digital competences can be continuously and effectively fostered among teachers by means of online PLCs. The aim is not only to examine the effectiveness of the support models, but also to explore which factors influence teachers' use of digital learning opportunities. In this way, it will also be possible to ascertain potential ways to increase the effectiveness of the support models.

For one thing, the significance of reflected documentation of effective learning episodes in the form of interactive knowledge among the faculty became evident (in which the descriptions of knowledge are differentiated into the dimensions of content knowledge, pedagogical content knowledge, and media didactics) (Mishra & Koehler, 2005; Fried, 2003). This interactive knowledge seems to be of particular relevance for restructuring and innovating teaching development in terms of self-produced knowledge coupling in the area of practice (Fried, 2003). Since the questionnaire for the framework model of digital competences of teachers in the field of business is already very extensive, the open questions for the qualitative survey of interactive knowledge in the following three contexts were not yet included: 1) Any teacher in any subject, 2) A colleague teaching the same subject and 3) An individual learning episode. These areas of knowledge are to be included in a follow-up project as a further facet of competence based on a qualitative research design. This also offers the advantage that institutional framework conditions (e.g. support structures, cultural development at schools) can be analysed using a qualitative evaluation design.

The main limitation of our study is the reliance on self-assessments. This could result in two different types of bias: Teachers deliberately give inaccurate answers or are not able to make a valid assessment. We

regard the first bias as unlikely because the survey was voluntary and anonymous. Irrespective of this, based on the impressions gained during the qualitative phase of the research project, we can attest that the teachers are highly self-reflective. This indicates that the second type of bias may also be inapplicable.

The results of the empirically validated instrument for assessing the digital competences of VET teachers and the baseline evaluation involving 215 teachers provide a very good basis for the follow-up project. In this context, we intend to assess the online PLGs in a longitudinal study.

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