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Adapting to online teaching during COVID-19 school closure: teacher education and teacher competence effects among early career teachers in Germany

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ABSTRACT

As in many countries worldwide, as part of the consequences of the COVID-19 pandemic lockdown schools in Germany closed in March 2020 and only partially re-opened in May. Teachers were confronted with the need to adapt to online teaching. This paper presents the results of a survey of early career teachers conducted in May and June 2020. First, we analysed the extent to which they maintained social contact with students and mastered core teaching challenges. Second, we analysed potential factors (school computer technology, teacher competence such as their technological pedagogical knowledge, and teacher education learning opportunities pertaining to digital teaching and learning). Findings from regression analyses show that information and communication technologies (ICT) tools, particularly digital teacher competence and teacher education opportunities to learn digital competence, are instrumental in adapting to online teaching during COVID-19 school closures. Implications are discussed for the field of teacher education and the adoption of ICT by teachers.

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COVID-19; ICT; teacher competence; technological pedagogical knowledge; teacher education

Introduction

As in many countries worldwide, as part of the consequences of the COVID-19 pandemic lockdown, tens of thousands of schools in Germany were closed in March 2020. Although schools began partially re-opening two months later in May, far-reaching restrictions remain in place, and any prediction as to when closures will end completely seems to be hardly possible at the moment. Consequently, teachers face significant challenges in adapting to online teaching, and maintaining at least a minimum of communication with students and supporting students' learning and development. However, the extent to which teachers have successfully mastered these challenges and which factors are most relevant remain unknown.

The extensive school closures occurred during an era that has generally been shaped by rapid transformation in technological innovations and digitalisation, not least in educational contexts (e.g., Selwyn 2012; McFarlane 2019). Consequently, 'digitalisation in schools' has become a prominent issue, independently of and before the COVID-19

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pandemic (GEW (Gewerkschaft Erziehung und Wissenschaft) 2020). However, in Germany – as in other European countries, such as France or Italy – many schools lag behind with respect to the expected information and communication technologies (ICT) transformation progress (Fraillon et al. 2019; Autorengruppe Bildungsberichterstattung 2020; GEW (Gewerkschaft Erziehung und Wissenschaft) 2020). Therefore, not only does the question arise as to whether the lockdown may be compensated for through teachers' and students' use of digital tools in online teaching, but the question of how teachers' competence and teacher education opportunities to learn digital competence contribute to teachers' mastery of the challenges of the specific situation also comes to the fore.

Against this background, the present paper reports on a survey of early career teachers, i.e., teachers who have entered the teaching profession within the past two years. They worked at different types of schools (primary schools, lower secondary schools, comprehensive schools, upper secondary schools or special needs schools). Belonging to the 'digital native' generation (Prensky 2001), it is expected that this target group should be able to quickly adapt to the online teaching challenges posed by the current situation. Having recently graduated from initial teacher education and having had specific and innovative opportunities to develop digital competence (Jäger-Biela, Kaspar, and König 2020), they are expected to be relatively competent in using online teaching applications. We will address the following research questions:

- (1) To what extent do early career teachers maintain social contact with students and parents in addition to mastering the core challenges of teaching (providing online lessons, introducing new learning content, providing task differentiation, providing feedback, conducting online assessments) through online environments?
- (2) How do school computer technology (e.g., ICT tools available), teachers' professional competence (e.g., technological pedagogical knowledge, TPK), and opportunities for developing digital competence to which the teachers were exposed during training affect their successful mastery of such challenges?

Data collection took place through an online teacher survey in the federal state of North Rhine-Westphalia (NRW), Germany during May and June 2020, at which time schools were completely or partially closed then. Specific measurement instruments were newly developed to contextualise the survey to the COVID-19 pandemic. Our objective was to analyse and discuss the role of digitalisation in education during the COVID-19 situation. We will discuss implications for teacher competence facets and the design of suitable learning opportunities for pre-service teachers who will enter the profession in the near future.

Online teaching during COVID-19 school closure

The COVID-19 pandemic situation has posed unprecedented challenges requiring teachers to adapt to teaching online. Until March 2020, the typical teaching situation at school was characterised by students who convened in classrooms according to their timetables and teachers who covered their subjects' standard content, frequently through formal lecturing. Students were required to listen to their teachers, work individually or in groups, and predominantly reproduce knowledge in assessments (e.g., Lipowsky 2015). By contrast, ICT use was limited (Fraillon et al. 2014, 2019; GEW

(Gewerkschaft Erziehung und Wissenschaft) 2020). The school lockdown confronted teachers, students, and parents with an entirely new situation (Huber and Helm 2020). Continued teaching and learning was only possible through alternative means of schooling. Teachers had to change to online teaching, requiring them to use various digital tools and resources to solve problems and implement new approaches to teaching and learning (Eickelmann and Gerick 2020). Beyond instructional goals, teachers were also required to maintain contact with their students to account for the social integration of their learning groups.

ICT transformation process in educational systems

Although the transition to online teaching was unexpected and rapid due to COVID-19, it took place amid a wider ICT transformation process in educational systems (Selwyn 2012; McFarlane 2019). Digitalisation in schools has recently attained prominence. A key argument relates to closing the 'gap' between students' conventional learning and development at school and 'the experiences and skills that our youth need to enter the information economy' (Kozma 2011, 106): the school curriculum should increasingly be interwoven with ICT, and students should be given opportunities to use advanced technological tools and digital resources for creative and innovative problem solving (Kozma 2011, 115).

In Germany, the country of the present study, the need to prepare students for a society in which digital literacy plays an important role has been acknowledged as well. The Standing Conference of the Ministers of Education and Cultural Affairs of the Länder (KMK [Standing Conference of the (State) Ministers for Education and Culture] 2017) recently published its strategy paper on 'education in the digital world', requiring schools to foster digital competences in their students across all subjects. Student competences are classified into areas that correspond with the European Digital Competence Framework (DigComp, Ferrari 2013). Despite these goals (and the provision of structural funding to equip schools, such as the so-called 'Digital Pact' of the Federal Government and the Länder in Germany in 2020; GEW (Gewerkschaft Erziehung und Wissenschaft) 2020), critical discussion has emerged in relation to how digital technologies improve student learning in the classroom (e.g., Buabeng-Andoh 2012; Autorengruppe Bildungsberichterstattung 2020).

Evidence suggests that digital technologies may enable new opportunities for teaching and learning (for a meta-analysis, see Chauhan 2017), and the use of ICT has become increasingly popular in elementary and secondary schools in recent decades. However, in spite of its potential influence on teaching and learning, the mere presence of computer technology hardware does not necessarily lead to student progress (Li and Ma 2010). Although technical infrastructure is required to implement ICT in instructional contexts, teachers and students must also be encouraged and supported in using digital tools. Therefore, far-reaching added value, for example, in terms of increased digital literacy competences among students, may not yet be guaranteed. Findings from the International Computer and Information Literacy Study (ICILS), in which one third of eighth-grade students did not reach proficiency level 2, which indicates 'underachievement in digital competence' (European Commission 2019, 11), gave rise to concerns in Germany.

Research desiderata appear to be related to pedagogical concepts that could be used to apply ICT effectively in addition to how teachers can be trained to use technology in ways that are pedagogically adequate. It is important to examine deeper principles of teaching and learning and how teachers integrate technology in pedagogical contexts (e.g., Baker et al. 2018). Regarding teacher education, the question of how opportunities to learn digital competence should be implemented (Jäger-Biela, Kaspar, and König 2020) with the aim of fostering pre-service teachers' competences so that they are better prepared for digitalisation in schools remains open.

Teacher competence

In current empirical educational research, teacher competences are understood as 'context-specific, cognitive performance dispositions that are functionally responsive to situations and demands in certain domains' (Kaiser and König 2019, 599). Several studies relate to generic models of professional competence, comprising both cognitive and affective-motivational areas (e.g., Blömeke 2017). Regarding the cognitive area, based on Shulman's classification of teacher knowledge (1987), researchers today usually differentiate between teachers' content knowledge (CK), pedagogical content knowledge (PCK), and general pedagogical knowledge (GPK) (Guerriero 2017). Teachers must draw on this range of professional knowledge and weave it into coherent understandings and skills to master the core challenges of teaching (Shulman 1987).

In response to the increasing significance of the ICT transformation process in educational systems (Selwyn 2012), these teacher knowledge categories have been extended to incorporate the knowledge required to master the challenges associated with using ICT in teaching and learning at school. The best-known approach was developed by Mishra and Koehler (2006), who defined teachers' technological knowledge (TK) in addition to CK, PCK, and GPK. Their so-called TPACK-model specifies various intersections of TK with CK and GPK, often illustrated by a Venn diagram (Mishra and Koehler 2006, 1025). For example, the intersection of TK and GPK is called 'technological pedagogical knowledge' (TPK). TPK comprises teachers' professional knowledge about technologies for application in teaching and learning situations that are not bound to a specific subject. This means that, independent of their specific subjects, teachers should be generally capable of applying technologies to pedagogical concepts and teaching practice. TPACK is the overall intersection of teacher knowledge categories (CK, GPK, and TK, including PCK). It is called 'technological pedagogical content knowledge' and constitutes the core of the model developed by Mishra and Koehler (2006). However, in the present study, we will focus on teachers' TPK, since we surveyed teachers of various subjects, necessitating a general perspective on teacher knowledge.

The COVID-19 situation requires not only knowledge and skills but also confidence regarding success in online teaching. Regarding the affective-motivational area, we therefore focus on teachers' self-efficacy as one of the most important constructs in teacher competence (Lauermaann and König 2016). Based on Bandura's (1997) work, teachers' self-efficacy denotes teachers' beliefs about their abilities to succeed in specific situations. The extent to which teachers perceive such efficacy may influence whether or not they take action, invest effort in an action, and how long they may sustain possible challenges (Tschannen-Moran and Hoy 2001). We therefore consider teachers' self-efficacy as a decisive resource for teachers obliged to adapt to online teaching during COVID-19 school closures.

Teacher education: opportunities to learn digital competence

Discussion of teacher competences is closely related to the design and quality of learning opportunities to which pre-service teachers are exposed during their teacher education programmes (European Commission 2013). The opportunities to learn (OTL) concept is used in empirical educational research to investigate the curricula of programmes that frame the learning and development of pre-service teachers (e.g., König et al. 2017; Kaiser and König 2019).

ICT curriculum integration is an important issue, reflected by many teacher education programmes worldwide (e.g., Russell and Finger 2007; Buabeng-Andoh 2012). In Europe, teacher competence related to ICT challenges has been described in the European Digital Competence Framework for Educators (DigComEdu, Caena and Redecker 2019). In Germany, nationwide teacher education standards from 2004 were updated in 2019 (KMK [Standing Conference of the (State) Ministers for Education and Culture] 2019) accordingly. In the federal state of North Rhine-Westphalia (NRW), Germany, where the present study was conducted, the so-called Media Competence Framework NRW was developed on the basis of the DigComEdu (Medienberatung 2019). Schools as well as teachers and universities are expected to adopt this framework for ICT integration into the curriculum. However, these competence frameworks (i.e., the transformation into learning opportunities) have begun to develop, their systematic implementation remains at an early stage (Bertelsmann Stiftung 2018).

Furthermore, few empirical studies have specifically examined the use of learning opportunities and provided insights into the status quo of the implementation process (see, e.g., for Norway, Gudmundsdottir and Hatlevik 2018). In Germany, a study was conducted by Jäger-Biela, Kaspar, and König (2020) in 2019, using a standardised scale inventory to survey pre-service teachers' use of opportunities to develop their digital competence during teacher education. The inventory relates to the Media Competence Framework NRW and defines six content areas (see, for further detail, Table 1), ranging from the operation of programmes for text creation to the handling of algorithms. Pre-service teachers were asked to indicate the breadth and depth of ICT content in their teacher education programmes' learning opportunities. As this survey's findings show,

Table 1. Scale inventory measuring opportunities to learn digital competence during teacher education (Jäger-Biela, Kaspar, and König 2020).

Subscale	Item example	Number of Items	α
Operate and apply	Organising, structuring, and securing digital information and data (teaching materials, teaching results, and project data)	4	.62
Inform and research	Conducting targeted information research on the Internet and digital databases (documents, information, literature)	4	.80
Communicate and cooperate	Rules for appropriate digital communication and cooperation as well as strategies for dealing with media-related behavioural problems (bullying on the Internet, Internet addiction)	4	.68
Production and presentation	Planning, design and presentation of media products in a manner appropriate to the addressee (students) and their appropriate provision	4	.72
Analyse and reflect	Reflecting on media actors and their respective positions and influences on media education (business enterprises, interest groups, parties, governments, private individuals, mass media)	4	.82
Problem solving and modelling	Knowledge of algorithmic patterns and structures for different usage contexts (e.g., search engines, switching systems, human-machine interfaces)	4	.71

especially the topic 'inform and research', but also the topics 'operate and apply' and 'production and presentation' were most often perceived. By contrast, higher-order topics, such as 'problem solving and modelling', which relate to the use of algorithms, played a minor role in teacher education. As the pre-service teacher survey indicated, most of the content was covered but was not dealt with in depth. This prompts the question as to whether early career teachers are sufficiently prepared for online teaching and learning environments through their teacher education programmes' learning opportunities.

Research questions

In this article, we investigate how early career teachers have adapted to online teaching during COVID-19 school closures. We focus on two major research questions:

- (1) To what extent do early career teachers maintain social contact with students and parents in addition to mastering the core challenges of teaching (providing online lessons, introducing new learning content, providing task differentiation, providing feedback, conducting online assessments) through online environments?
- (2) How do school computer technology (e.g., ICT tools available), teachers' professional competence (e.g., technological pedagogical knowledge, TPK), and opportunities for developing digital competence to which the teachers were exposed during training affect their successful mastery of such challenges?

Method

Sample

Data collection began in May and concluded with the end of the school year in June. We recruited a targeted population of 165 early career teachers in the greater Cologne area. With 89 participants, the response rate was acceptable (54%). On average, they were 32 years old (69% female). They worked at primary schools (27%), lower secondary schools (12%), comprehensive schools (29%), upper secondary schools (24%) or special needs schools (8%).

Instruments

Core challenges of teaching through COVID-19 online environments

As earlier teacher surveys have shown (e.g., Eickelmann and Drossel 2020), one of the major concerns that teachers encounter is the maintenance of social contact with students and their parents. Further concerns relate to the core challenges of teaching through online environments during the COVID-19 pandemic. The delivery of online lessons (e.g., through video conference systems) served as a general premise for online teaching and learning interaction, particularly to facilitate whole-class assignments during COVID-19 closures. As teachers were concerned about enabling students to access a substantial part of the school year's curriculum content from home, the introduction of (new) learning content to stimulate students' cognitive activation emerged as another challenge. The provision of task differentiation for home schooling offered a means of

reaching all students during distance learning through adaptive teaching (König et al. 2020). Since student learning involves bridging the gap between desired and actual performance, teachers’ feedback to students about their learning progress was essential (Boud 2015). Finally, teachers expressed concerns regarding how assessment could be conducted when teacher-student interaction was absent or significantly reduced; therefore, online assessment became a necessity.

In response one of the teachers’ major concerns – the maintenance of social contact with students and their parents – for our survey, we developed Likert-scale items to measure social contact as a scale (2 items, see Figure 1, $\alpha = .57$). Core challenges related to online teaching were measured using single items as follows: providing online lessons, introducing new learning content, providing task differentiation, providing feedback, and conducting online assessments. Teachers were asked to report on the frequency of their activities during lockdown (see Figure 2).

School computer technology: digital instruments for teaching

Even before pandemic-induced school closures, numerous digital instruments were available to support teaching. To ensure clarification in our study design, we followed Li and Ma (2010, 218) computer technology classification of software using a differentiation into two categories: tutorial (programmes for direct teaching, e.g., drill and practice software, computer-assisted instruction, learning games) and communication media

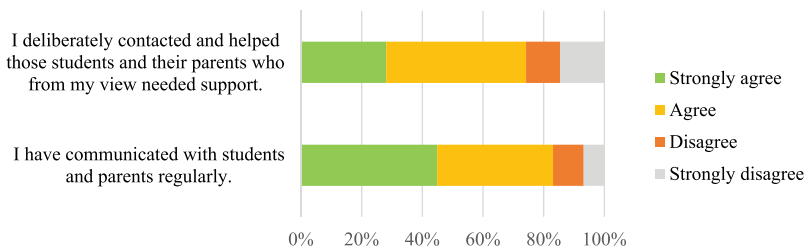


Figure 1. Percentage of teacher agreement on items related to maintain social contact.

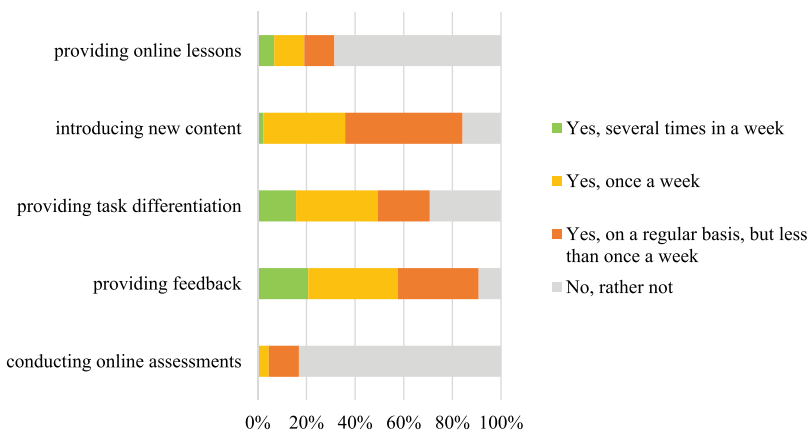


Figure 2. Percentage of teacher agreement on items related to core challenges of teaching.

(e.g., email, videoconferencing, computer supported collaborative learning systems and platforms). We asked teachers to indicate in a list which digital instruments they had been using for teaching. These instruments relate to tutorial (3 items, $\alpha = .64$, e.g., 'online learning software to individually foster specific competencies') and communication media (4 items, $\alpha = .47$, e.g., 'virtual classroom').

Teachers' competence

We assessed teachers' conceptual and situational TPK using an existing standardised test (Lachner, Bachner, and Stürmer 2019). The test consists of two scales, one related to the conceptual TPK (i.e., TPK about facts, concepts, and principles) and another related to situational TPK (i.e., TPK about situations, practical contexts, and typical problems). The scales include 18 closed items, all of which are provided by Lachner, Backfisch, and Stürmer (2019). As a central affective-motivational measure, we included the revised teacher self-efficacy scale (Pfitzner-Eden, Thiel, and Horsley 2014) to assess teachers' self-efficacy regarding instructional strategies (four items, e.g., 'How certain are you that you can gauge students' comprehension of what has been taught?'), to be rated on a 9-point Likert-scale (varying from 'not at all certain' to 'absolutely certain').

Opportunities to learn digital competence during teacher education

The instrument developed by Jäger-Biela, Kaspar, and König (2020) was used to retrospectively measure early career teachers' opportunities to develop the digital competence during teacher education (Table 1). The following introductory question was used: 'When you now recall your teacher education, was the following content covered in your programme?' Pre-service teachers were asked to indicate content coverage through 24 items, each with three categories ('Yes, the content was covered and it was covered in depth', 'Yes, the content was covered, but was not dealt with in depth', 'No, the content was not covered'). Four items per content area were combined into a subscale of the instrument. Each scale's reliability was in an acceptable range.

Control variables

Due to differences in familiarity with the use of digital devices according to gender and age, we will control for both dimensions.

Results

Descriptive findings

To investigate RQ 1, descriptive findings on the teacher survey items related to their mastering of core challenges are provided. As can be seen in Figure 1, about 90% of teachers reported they managed to communicate with students and parents on a regular basis. However, teachers also reported having contacted and helped students who needed extra support.

Figure 2 provides descriptive findings on the items related to the core challenges of teaching. Only 20% of the teachers reported having provided online lessons at least once a week, whereas nearly 70% did not use digital instruments to provide online lessons at all. Nonetheless, the majority of teachers introduced new content (more than 80% at least on a regular basis), provided tasks in a differentiated way (70% at least on a regular basis),

and gave feedback (90% at least on a regular basis). By contrast, teachers conducted little online assessment (less than 20% at least on a regular basis).

Findings from regression analyses

Since RQ 2 relates to the analysis of potential factors influencing teachers' mastery of core challenges during COVID-19 school closures, we specified separate models using regression analysis with each of the six challenges as a dependent variable (due to low correlations and low average correlation of these six variables, $r < .30$; $\bar{r} = .08$). We used several variables as predictors. The two subscales of the TPK test (conceptual and situational TPK) and teachers' self-efficacy regarding instructional strategies were used as indicators for teacher competence. Digital instruments (tutorial, communication media) were used as indicators for school computer technology. The six scales that retrospectively measure early career teachers' OTL digital competence during teacher education were included first, but only the scale 'inform and research' turned out as significant predictor in preliminary analyses.

As the findings of final analyses show (Table 2), the variation in the dependant variable measuring the extent to which teachers maintain social contact with students and their parents can be explained to a large degree ($R^2 = .39$). All three areas (teacher competence, school computer technology, and teacher education) include significant predictors (conceptual TPK, using tutorials, and OTL digital competence). Conceptual TPK also significantly predicts whether or not a teacher will master the challenges of task differentiation. Teachers' self-efficacy is key in providing tasks to students in a differentiated way and in providing feedback. Among the digital instruments, particularly tutorials emerged as significant predictor for two further challenges (providing online lessons and task differentiation). Communication media significantly predicts providing online lessons and introducing new learning content. Unexpectedly, it was a negative predictor for providing task differentiation, though. OTL digital competence in teacher education also significantly predicts the introduction of new learning content and task differentiation. The core challenge of conducting online assessments can hardly be explained ($R^2 = .05$) without

Table 2. Findings from regression analyses on factors influencing the mastering of core challenges, controlled for age and gender.

	SC	OL	NC	TD	FB	OA
<i>Teacher Competence</i>						
TPK (conceptual)	.27**	.15	-.01	.19*	.15	-.04
TPK (situational)	.15	.05	-.08	.01	.05	-.06
Self-Efficacy (instructional)	.12	.02	-.09	.30**	.36***	.05
<i>School Computer Technology</i>						
Tutorial	.31***	.35***	-.15	.21*	-.01	-.10
Communication Media	-.01	.23**	.20*	-.24*	-.04	.12
<i>Teacher Education</i>						
OTL digital competence (Inform and Research)	.25**	-.02	.22*	.20*	.12	.08
R^2	.39	.29	.18	.28	.25	.05

Note. SC – maintain social contact, OL – providing online lessons, NC – introducing new learning content, TD – providing task differentiation, FB – providing feedback, OA – conducting online assessments.

*** $p \leq .001$

** $p \leq .01$

* $p \leq .05$

any significant predictor, which may be due to reduced variation in the dependant variable (see [Figure 2](#)).

Discussion and conclusion

As the COVID-19 pandemic lockdown affected almost all aspects of society and everyday life, people had to learn to organise communication and interaction in a new way. We investigated how early career teachers adapted to online teaching during COVID-19 school closures. Our research questions concerned how they mastered challenges in this unknown situation and what factors could account for their successful mastery of such challenges.

Almost all teachers reported having maintained communication with students and their parents. The majority of teachers reported having introduced new learning content in addition to assigning tasks and providing feedback to their students. However, challenges that clearly necessitate ICT integration, such as online teaching and online assessment, were mastered to a lesser extent. When analysing the potential factors accounting for mastery in such challenges, certain factors emerged as significant predictors in regression analyses. Regarding teachers' competence, their conceptual TPK as measured via a standardised online test was significant in predicting maintaining social contact and providing task differentiation. This means that teachers who performed better in the test also reported having maintained communication and delivered online adaptive teaching more frequently during school closure. Particularly, adaptive teaching is considered a decisive feature of high quality instruction (König et al. 2020). Teachers' self-efficacy was significant for providing task differentiation as well, but also for providing feedback to students. These findings correspond with research that emphasises the importance of teacher competence in successfully attaining relevant educational goals (Kaiser and König 2019). This demonstrates the predictive validity of TPK and self-efficacy as relevant facets of teacher competence as a 'multi-dimensional construct' (Blömeke 2017).

The computer technology available at school also played a role. Tutorials (programmes for direct teaching) significantly predicted maintenance of social contact, provision of online lessons and task differentiation. As ICILS 2018 demonstrated, schools' access to software resources in Germany lag behind, on average, compared with other European countries (Fraillon et al. 2019, 40). Moreover, whereas in ICILS 2018, nearly half of all teachers (48%) reported using ICT every day at school in their teaching, this was reported by only 23% of teachers in Germany (Fraillon et al. 2019, 179). That means that those teachers who had already software resources at their disposal and were familiar with their use in teaching were clearly advantaged when school closures began.

Although previous research has shown that communication media are relevant, as they enable effective communication and information sharing (e.g., Li and Ma 2010), in our study they did predict teachers' mastery of core challenges to a lesser degree. The minimal systematic variation in using communication applications may be one explanation for this. A nationwide teacher survey by the German Education Union (GEW (Gewerkschaft Erziehung und Wissenschaft) 2020, 26) conducted just before lockdown in Germany showed that virtually all teachers (98%) used digital communication media for their work outside teaching (e.g., email, platforms, messenger services, social networks). This means that as long as digital devices such as mobile phones were available to students and their

parents, communication was generally possible. Another survey in Germany showed that among teachers who digitally disseminate learning materials and tasks to their students, email is the most frequently used medium (63%, Eickelmann and Drossel 2020, 14).

Teacher education OTL with respect to digital competence significantly predicted teachers' maintenance of social contact, introduction of new learning content, and task differentiation. However, only the subscale 'inform and research' emerged as significant predictor. One explanation could be that as teachers had limited access to conventional teaching materials during lockdown, those who had been trained during teacher education in searching for and selecting online teaching materials may have better opportunities to provide support to their students. Besides, as our pre-service teacher survey 2019 had indicated, especially the topic 'inform and research' was most often perceived by pre-service teachers (Jäger-Biela, Kaspar, and König 2020, 70). This mirrors specific priority given by the initial teacher education curriculum in Germany.

As other teacher surveys have shown, conducting high-stakes examinations was limited during school closure, not least because of the lack of agreement by the ministry. If final exams were conducted, they took place in smaller groups at school. However, formative assessments, such as online quizzes, may have been possible, at least on a voluntary basis. Nonetheless, the question arises as to why so few teachers applied such approaches. This corroborates findings from ICILS 2018, where on average 78% of teachers reported knowing how to assess student learning using ICT; this was reported by only 49% of teachers in Germany (Fraillon et al. 2019, 180). It is possible that few teachers had OTL in this area of digital competence or in the area of assessment in general during their teacher education (König et al. 2017). In any case, as long as teachers do not conduct online formative assessments, it will be difficult for them to diagnose student needs regarding distance learning and to construct adequate lesson plans in the long run. Diagnosing student needs and aptitudes is necessary to make appropriate pre-instructional decisions (König et al. 2020) and, as a consequence, to prevent social inequality among students (Eickelmann and Gerick 2020).

Contrary to our expectations, early career teachers' status as belonging to the generation of 'digital natives' (Prensky 2001) does not guarantee that they have developed sophisticated digital skills in general. One reason for this may be that, as ICILS 2018 and other surveys conducted in Germany have shown (Fraillon et al. 2019; Autorengruppe Bildungsberichterstattung 2020; GEW (Gewerkschaft Erziehung und Wissenschaft) 2020), many schools lag behind the expected ICT transformation process in educational systems. Digital instruments must first be systematically introduced to students – and perhaps even to their parents – and implemented into everyday teaching and learning processes. The COVID-19 pandemic situation has just made visible what the consequences will be if schools fail to catch up with the fundamental ICT transformation process. Therefore, it will be crucial to provide learning opportunities in professional development for teachers and in training for future teachers.

While teachers may learn from reports on good practice for distance learning (e.g., Krommer et al. 2020), school remains the obligatory environment for student learning with teachers responsible for providing structured learning opportunities (Lipowsky 2015). Distance learning of any nature cannot therefore be regarded as an adequate measure to deal with the pandemic situation in a serious way,

particularly in the event of further lockdown measures or prolonged partial school closure. Rather, schools should develop their concepts towards blended learning, that is, a strategic combination of presence at school and structured approaches to student learning at home (Klieme 2020). Moreover, school is a place for social learning among students. Many students go to school to meet their friends as part of their social development and to master important age-specific developmental tasks (König, Wagner, and Valtin 2011).

Further impulses are provided by an expert commission for the school year 2020/2021 (Expert Commission Friedrich-Ebert Foundation 2020). Against this background, objectives related to student learning with digital media should be clarified, and teachers should account for relevant teacher competences needed for effective use of ICT during the further partial school closure. The present article has demonstrated the specific factors in the area of teacher competence and teacher education that impact teachers' successful mastery of new challenges. It emphasises the need to foster the development of teacher competence in ICT-related teaching and learning both in initial teacher education and teacher professional development. In particular, future teachers should be supported in their acquisition of TPK and corresponding cognitive skills during their teacher education. Preparing teachers for the digitalisation in schools can be regarded as a chance that teacher education should not miss.

Despite promising findings of our study, limitations should be discussed as well. First, generalisability of results are limited due to teachers' response rate of 54% and a relatively small teacher sample. Second, some of the survey instruments had to be timely adopted from existing ones or developed completely anew, which may have limited their reliability. Third, our study was carried out in Germany, therefore generalisation of results to other countries and their educational contexts is hardly possible. However, we assume that other countries in Europe and maybe worldwide are confronted with similar challenges during COVID-19 pandemic, since teachers' adapting to online teaching during complete or partial school lockdown is not a challenge that is restricted to Germany. That teacher education and teacher competence is relevant in mastering specific challenges caused by the pandemic is an issue that generally might open up further relevant research in various teacher education systems – at least as long as the pandemic lasts and teacher education and schools are detained from return to normal.

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References

- Autorengruppe Bildungsberichterstattung. 2020. *Bildung in Deutschland 2020 [Education in Germany 2020]*. Bielefeld: wbv.
- Baker, J. P., A. K. Goodboy, N. D. Bowman, and A. A. Wright. 2018. "Does Teaching with PowerPoint Increase Students' Learning? A Meta-analysis." *Computers & Education* 126: 376–387. doi:10.1016/j.compedu.2018.08.003.
- Bandura, A. 1997. *Self Efficacy: The Exercise of Control*. New York: Freeman.
- Blömeke, S. 2017. "Modelling Teachers' Professional Competence as a Multi-dimensional Construct." In *Pedagogical Knowledge and the Changing Nature of the Teaching Profession*, edited by S. Guerriero, 119–135. Paris: OECD.
- Boud, D. 2015. "Feedback: Ensuring It Leads to Enhanced Learning." *The Clinical Teacher* 12: 3–7. doi:10.1111/tct.12345.
- Buabeng-Andoh, C. 2012. "Factors Influencing Teachers' Adoption and Integration of Information and Communication Technology into Teaching: A Review of the Literature." *International Journal of Education and Development Using ICT* 8 (1): 79–105. doi:10.1080/09523987.2018.1439712.
- Caena, F., and C. Redecker. 2019. "Aligning Teacher Competence Frameworks to 21st Century Challenges: The Case for the European Digital Competence Framework for Educators (Digcompedu)." *European Journal of Education* 54 (3): 356–369. doi:10.1111/ejed.12345.
- Chauhan, S. 2017. "A Meta-analysis of the Impact of Technology on Learning Effectiveness of Elementary Students." *Computers & Education* 105: 14–30. doi:10.1016/j.compedu.2016.11.005.
- Eickelmann, B., and J. Gerick. 2020. "Lernen Mit Digitalen Medien: Zielsetzungen in Zeiten Von Corona Und Unter Besonderer Berücksichtigung Von Sozialen Ungleichheiten [Learning with Digital Media: Objectives in Times of Corona and under Special Consideration of Social Inequities]." *Die Deutsche Schule* 16: 153–162. doi:10.31244/9783830992318.09.
- Eickelmann, B., and K. Drossel. 2020. *Schule Auf Distanz [School at a Distance]*. Berlin: Vodafone Stiftung.
- European Commission. 2013. *Supporting Teacher Competence Development for Better Learning Outcomes*. Brussels: European Commission Education and Training UE.
- European Commission. 2019. *The 2018 International Computer and Information Literacy Study (ICILS). Main Findings and Implications for Education Policies in Europe*. Brussels, Brussels, European Commission.

- Expert Commission Friedrich-Ebert Foundation. 2020. *Schule in Zeiten Der Pandemie. Empfehlungen Für Die Gestaltung Des Schuljahres 2020/21. [Schools during Pandemia. Recommendations for the Design of School Year 2020/2021]*. Berlin: Friedrich-Ebert Foundation.
- Ferrari, A. 2013. *DIGCOMP: A Framework for Developing and Understanding Digital Competence in Europe*. Luxembourg: Publications Office of the European Union.
- Fraillon, J., J. Ainley, W. Schulz, T. Friedman, and D. Duckworth. 2019. *Preparing for Life in a Digital World: The IEA International Computer and Information Literacy Study 2018 International Report*. New York: Springer.
- Fraillon, J., J. Ainley, W. Schulz, T. Friedman, and E. Gebhardt. 2014. *Preparing for Life in a Digital Age: The IEA International Computer and Information Literacy Study International Report*. New York: Springer Open. doi:10.1007/978-3-319-14222-7.
- GEW (Gewerkschaft Erziehung und Wissenschaft). 2020. *Digitalpakt Schule Und Digitalisierung an Schulen [Digital Pact for Schools and Digitalisation in Schools.]*. Frankfurt: GEW.
- Gudmundsdottir, G. B., and O. E. Hatlevik. 2018. "Newly Qualified Teachers' Professional Digital Competence: Implications for Teacher Education." *European Journal of Teacher Education* 41 (2): 21–231. doi:10.1080/02619768.2017.1416085.
- Guerriero, S., ed. 2017. *Pedagogical Knowledge and the Changing Nature of the Teaching Profession*. Paris: OECD.
- Huber, S. G., and C. Helm. 2020. "COVID-19 and Schooling: Evaluation, Assessment and Accountability in Times of Crises—reacting Quickly to Explore Key Issues for Policy, Practice and Research with the School Barometer." *Educational Assessment, Evaluation and Accountability* 1–34. doi:10.1007/s11092-020-09322-y.
- Jäger-Biela, D., K. Kaspar, and J. König. 2020. "Lerngelegenheiten Zum Erwerb Von Digitalisierungsbezogenen Medienkompetenzen. [Opportunities to Learn Digital Media Competences.]" In *Bildung, Schule, Digitalisierung [Education, School, Digitalisation]*, edited by K. Kaspar, M. Becker-Mrotzek, S. Hoffhues, J. König, and D. Schmeinc, 66–72. Münster: Waxmann.
- Kaiser, G., and J. König. 2019. "Competence Measurement in (Mathematics) Teacher Education and Beyond: Implications for Policy." *Higher Education Policy* 32: 597–615. doi:10.1057/s41307-019-00139-z.
- Klieme, E. 2020. "Guter Unterricht – Auch Und Besonders Unter Einschränkungen Der Pandemie? [Good Teaching – Also and Especially under Restrictions of the Pandemic?]." *Die Deutsche Schule* 16: 117–135. doi:10.31244/9783830992318.07.
- KMK [Standing Conference of the (State) Ministers for Education and Culture]. 2017. *Education in a Digital World. Strategy of the KMK*. Bonn: KMK.
- KMK [Standing Conference of the (State) Ministers for Education and Culture]. 2019. "Standards Für Die Lehrerbildung: Bildungswissenschaften. Beschluss Der Kultusministerkonferenz Vom 16.12.2004in Der Fassung Vom 16.05.2019 [Standards for Teacher Education: Education Sciences." Resolution of the Standing Conference, [16 December 2004, accessed 16 May 2019]. Bonn: KMK.
- König, J., A. Bremerich-Vos, C. Buchholtz, I. Fladung, and N. Glutsch. 2020. "Pre-service Teachers' Generic and Subject-specific Lesson-planning Skills: On Learning Adaptive Teaching during Initial Teacher Education." *European Journal of Teacher Education* 43 (2): 131–150. doi:10.1080/02619768.2019.1679115.
- König, J., A. Bremerich-Vos, C. Buchholtz, S. Lammerding, S. Strauß, I. Fladung, and C. Schleiffer. 2017. "Modelling and Validating the Learning Opportunities of Preservice Language Teachers: On the Key Components of the Curriculum for Teacher Education." *European Journal of Teacher Education* 40 (3): 394–412. doi:10.1080/02619768.2017.1315398.
- König, J., C. Wagner, and R. Valtin. 2011. *Jugend - Schule - Zukunft. Psychosoziale Bedingungen Der Persönlichkeitsentwicklung - Ergebnisse Der Längsschnittstudie AIDA. [Adolescence – School – Future. Psycho-social Factors of Personality Development.]*. Münster: Waxmann.
- Kozma, R. B. 2011. "ICT, Education Transformation, and Economic Development: An Analysis of the US National Educational Technology Plan." *E-Learning and Digital Media* 8 (2): 106–120. doi:10.2304/elea.2011.8.2.106.
- Krommer, A., Wampfler, P. and Klee, W. 2020. „Impulse für das Lernen auf Distanz [Impulses for distant learning.] Ministry of North-Rhine Westphalia, Düsseldorf, Germany.

- Lachner, A., I. Backfisch, and K. Stürmer. 2019. "A Test-based Approach of Modeling and Measuring Technological Pedagogical Knowledge." *Computers & Education* 142: 103645. doi:10.1016/j.compedu.2019.103645.
- Lauermaun, F., and J. König. 2016. "Teachers' Professional Competence and Wellbeing: Understanding the Links between General Pedagogical Knowledge, Self-efficacy, and Burnout." *Learning and Instruction* 45: 9–19. doi:10.1016/j.learninstruc.2016.06.006.
- Li, Q., and X. Ma. 2010. "A Meta-analysis of the Effects of Computer Technology on School Students' Mathematics Learning." *Educational Psychology Review* 22 (3): 215–243. doi:10.1007/s10648-010-9125-8.
- Lipowsky, F. 2015. "Unterricht. [Teaching]." In *Pädagogische Psychologie [Educational Psychology]*, edited by E. Wild and J. Möller, 69–105. Berlin, Heidelberg: Springer.
- McFarlane, A. E. 2019. "Devices and Desires: Competing Visions of a Good Education in the Digital Age." *British Journal of Educational Technology* 50 (3): 1125–1136. doi:10.1111/bjet.12764.
- Medienberatung, N. R. W. 2019. *Broschüre Medienkompetenzrahmen NRW [Leaflet Media Competence Framework North-Rhine Westphalia]*. Münster: Medienberatung NRW.
- Mishra, P., and M. J. Koehler. 2006. "Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge." *Teachers College Record* 108 (6): 1017–1054. doi:10.1111/j.1467-9620.2006.00684.x.
- Pfitzner-Eden, F., F. Thiel, and J. Horsley. 2014. "An Adapted Measure of Teacher Self-efficacy for Preservice Teachers: Exploring Its Validity across Two Countries." *Zeitschrift Für Pädagogische Psychologie* 28 (3): 83–92. doi:10.1024/1010-0652/a000125.
- Prensky, M. 2001. "Digital Natives, Digital Immigrants." *On the Horizon* 9 (5): 1–6. doi:10.1108/10748120110424816.
- Russell, G., and G. Finger. 2007. "ICTs and Tomorrow's Teachers: Informing and Improving the ICT Undergraduate Experience." In *Handbook of Teacher Education*, edited by T. Townsend and R. Bates, 625–640. Dordrecht: Springer.
- Selwyn, N. 2012. *Education in a Digital World: Global Perspectives on Technology and Education*. New York, London: Routledge.
- Shulman, L. S. 1987. "Knowledge and Teaching. Foundations of the New Reform." *Harvard Educational Review* 57: 1–22. doi:10.17763/haer.57.1.j463w79r56455411.
- Stiftung, B., ed. 2018. *Lehrstudsium in Der Digitalen Welt: Professionelle Vorbereitung Auf Den Unterricht Mit Digitalen Medien?! [Teacher Education Studies in a Digital World: Professional Preparation for Teaching with Digital Media?!]*. Gütersloh: Bertelsmann.
- Tschannen-Moran, M., and A. W. Hoy. 2001. "Teacher Efficacy: Capturing an Elusive Construct." *Teaching and Teacher Education* 17 (7): 783–805. doi:10.1016/S0742-051X(01)00036-1.