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Differences in instructional quality during the Covid-19 pandemic between Oman and Germany and the role of teacher competences

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Introduction: School closures during the Covid-19 pandemic hit educational systems worldwide, forcing teachers to switch to digital learning settings. The presented study aims to (a) adapt and evaluate scales on instructional quality in digital settings, (b) describe instructional quality during the pandemic, and (c) to identify predictive teacher competences.

Method: Data was assessed in a cross-sectional design via an online questionnaire conducted in Oman and Germany simultaneously.

Results: Analyses of data from $N = 284$ teachers in Oman and Germany revealed mostly good psychometric parameters, differences in instructional quality between both countries, and positive relations between teachers' competences and instructional quality.

Conclusion: The present study contributes to instrument development and to the growing body of research, investigating teaching quality during the pandemic.

KEYWORDS

instructional quality, Covid-19 pandemic, teacher competences, digital teaching, country comparison

1. Introduction

The COVID-19 pandemic created one of the most extensive disruption in education systems in history (e.g., Reuge et al., 2021; Sing Yun, 2023). Teachers and students faced a set of barriers that presented them with challenges and led to difficulties in achieving educational equality. The transition from face-to-face learning to digital learning settings (in this paper synonymous for e-learning, remote learning, distance education, home schooling or home education) made it difficult for schools to reach all students. Asynchronous education in digital learning settings has become one of the main options for learning (Goodrich et al., 2022). The associated challenges and difficulties included technical challenges for teachers as well as students, didactical challenges in terms of providing adequate learning materials and to monitor students' learning processes and many more (Danjou, 2020; İnce et al., 2020; Shahat M. and Al-Amri, 2022; Shahat M. A. and Al-Amri, 2022).

As the pandemic spread, educational institutions in countries such as Oman and Germany, having different cultural, educational and economic backgrounds, tended to activate digital learning management systems, which allow for the management of all aspects of electronic courses and thus enable collaborative work between teachers and learners. Oman used Google

Classroom, a free open-source system, as its official platform, whereas programs as Zoom, a closed-source system, or Microsoft Teams were widely used in Germany for communicating with students. Neither of these platforms were initially developed for content creation. Furthermore, neither students nor teachers received adequate training on how to use e-learning platforms correctly to achieve their goals (Shahat M. and Al-Amri, 2022; Shahat et al., 2022). Comparing how two different educational systems dealt with the pandemic-induced challenges for instruction, contributes to better understand, how educational disparities developed. While more and more research is published on students' varying educational success during the pandemic within countries, yet little is known about differences in digital learning settings between countries. In light of this global shift to digital learning settings, it is necessary to better measure instructional quality in digital learning settings as a factor contributing to educational disparities during the pandemic. Following on from current discourses in teaching research about the theoretical and empirical structure of instructional quality and its relations to student achievement, instructional quality has common as well as subject-specific components (Schlesinger et al., 2018)—e.g., classroom management as a general dimension of instructional quality and cognitive activation as a more subject-specific dimension.

The present study meets this need by adapting existing instruments for assessing instructional quality—mainly scales from international large scale assessments (PIRLS), which were reliable in different educational contexts—for the context of digital learning setting and developing new scales, where needed. Furthermore, these scales were evaluated in two different educational settings—comparing instruction in Oman and Germany as examples of countries with different cultural and educational backgrounds. Additionally, the study takes into account subject-specificity of instruction, including teachers' focus domain (STEM and non-STEM subjects) in the analyses. Finally, teachers' competences were assessed and analyzed as prerequisites for instructional quality.

2. Theoretical background

2.1. Teaching and learning with digital media

In educational research, utilization-of-learning-opportunities models are widely used to describe teaching and learning processes in the classroom (e.g., Seidel, 2014). In these models (e.g., Lipowsky, 2006; Helmke, 2015), instruction is described as an interplay between teachers' learning offers and students' utilization of those offers, which are affected by individual characteristics—on both the student and teacher sides—as well as contextual factors such as culture, school or family. Relations between teachers, instruction, context and student outcomes have been empirically shown in diverse subject domains and school tracks (e.g., Holzberger et al., 2020). Hence, it seems reasonable to assume that such models can also be used to describe teaching and learning processes in digital learning settings, such as those that occurred during the Covid-19 pandemic, when schools were (partially) closed and students had to learn at home. Numerous studies analyzing the circumstances of home schooling showed that the situation was extremely stressful for teachers, students and parents, and there is substantial evidence that educational disparities widened during the pandemic (Hammerstein et al., 2021). The aforementioned models do not explicitly focus on the opportunities and challenges of digital learning settings and hence may not be sufficient to explain differences in teaching and learning processes during the pandemic. The model of quality dimensions of media education in school is an adaption of a general model for school effectiveness and school development that focuses on teaching and learning with digital media [Information and Communication Technologies (ICT)]. The model differentiates between the input, process, and output levels (Lorenz et al., 2019). Similar to utilization-of-learning-opportunities models, the model of quality dimensions of media education considers teachers as an important impact factor for teaching quality and student outcomes. Additionally, this model identifies ICT-specific context variables, such as technical infrastructure on the input level or technical support and staff development on the process level. Consequently, combining the teacher- and instruction-focused utilization-of-learning-opportunities models with the ICT-specific model of quality dimensions of media education could provide a useful framework for investigating instructional quality in digital learning settings and its predictors. In summary, we propose the model, displayed in Figure 1, as a framework for the presented study.

2.2. Instructional quality in digital teaching and learning settings

As displayed in Figure 1, instruction plays an essential role for educational outcomes in school. When describing and analyzing instruction and its effects on student outcomes, there is a distinction between the surface structure, the visible organization of a lesson, and the deep structure, the invisible interaction between teachers and students where learning processes take place (e.g., Oser and Baeriswyl, 2001). During the Covid-19 pandemic, instructional settings within the surface structure differed immensely between schools, regions, and countries. One major distinction is the teaching setting, whether instruction was held *synchronously*, for example via live video conferences; *asynchronously*, where the teacher provided the learning material and the students learned individually at home; or in a hybrid format, combining synchronous and asynchronous teaching (Sahin et al., 2020). As empirical studies in various domains and across school forms have shown, deep structure characteristics of instruction are associated with successful learning processes and student outcomes (Kyriakides et al., 2013; Khampirat, 2021). Widely established models describe three basic dimensions of instructional quality (Pianta and Hamre, 2009; operationalization for this paper: Klieme and Rakoczy, 2008): (1) Cognitive activation (e.g., elaborating thinking processes or providing tasks with multiple solutions; Chi and Wylie, 2014; Schmid et al., 2022), (2) classroom management and structure (e.g., establishing effective routines or providing a clear structure; Oser and Baeriswyl, 2001; Lester et al., 2017), and (3) a supportive learning climate (e.g., one that meets students' basic psychological needs – autonomy, competence, and relatedness; Griffin, 2016; Ryan and Deci, 2020). It seems reasonable that these deep-structure characteristics are also relevant for successful teaching and learning processes in digital settings. However, the questions of how to measure these characteristics in digital learning settings and of how these characteristics were realized in synchronous and asynchronous teaching settings during the Covid-19 pandemic in different countries

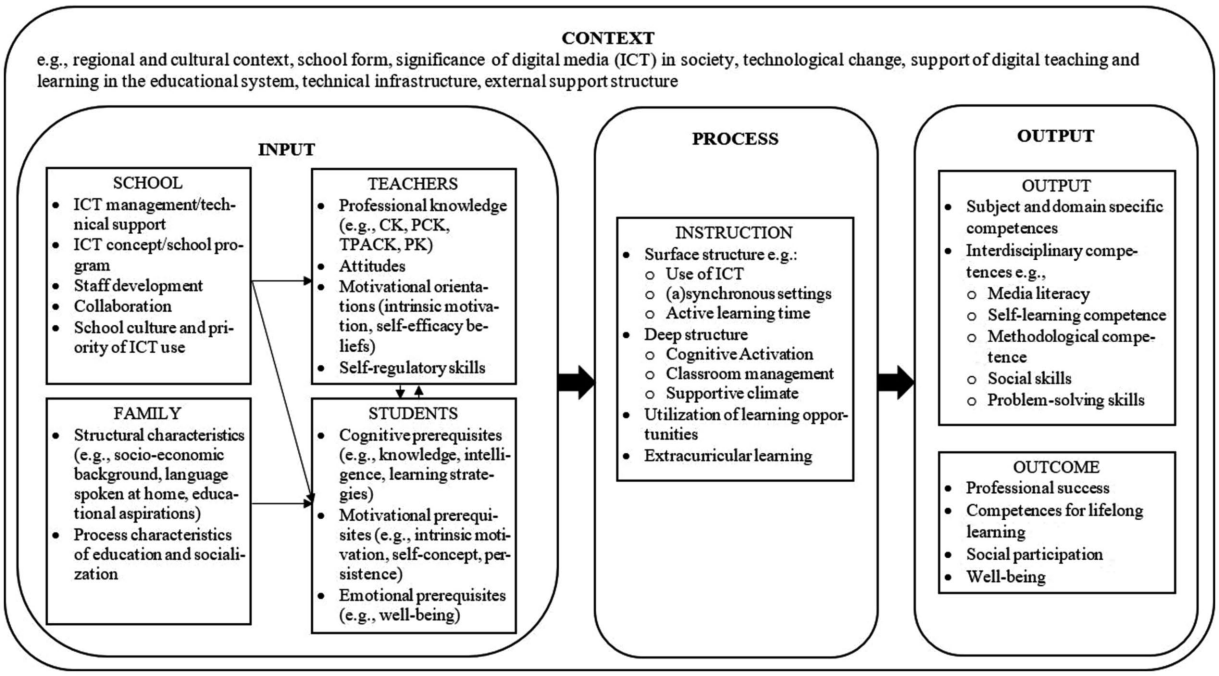

FIGURE 1
Model for teaching and learning in digital learning settings.

remain unanswered. As instructional research suggests, there are subject specific components of instructional quality. In the presented study, we differentiated between STEM and non-STEM domains, due to differences in instructional methods and subject-specific components of instructional quality.

2.3. General teaching conditions in Oman and Germany

Before addressing the question of how to measure instructional quality itself, the context of digital teaching processes need clarification, especially when comparing two countries with different educational systems. Besides teacher competences and their education, the general teaching conditions impact instructional practice. In Oman, teachers in elementary school (Cycle 1, Grades 1–4) specialize in teaching both science and mathematics subjects and are known as "teachers of a second field." Specialized teachers of Arabic, English and social studies are called "teachers of the first field." In schools, female teachers teach all students in cycle 1. However, beginning in Cycle 2, grades 5–10, male and female students are taught in separate schools, by teachers of both sexes in lower secondary school and by teachers of the same sex only in upper secondary school (Cycle 3, grades 11–12). In Cycle 2, science is taught as an integrated subject until eighth grade. From grades 9–12, science is separated into sub-disciplines (physics, chemistry, biology), which are taught only by teachers specializing in physics, chemistry or biology, respectively. The average class size in public lower secondary schools is 29 students, while the class size in upper secondary schools is 28 [Ministry of Education-Oman (MOE), 2021]. An Omani science teacher typically teaches 24 science lessons each week to different classes. The language of instruction for all public school classes is Arabic. Over the past few decades, the Omani education system has experienced significant reforms, at least partially because students have not demonstrated strong achievement on large-scale assessments such as TIMSS 2007–2019 (Mullis I. V. S. et al., 2020). A recent study in Oman identified one of the weaker aspects of students' performance in TIMSS to be their ability to apply their prior knowledge to new situations and relate science to everyday natural phenomena (Ohle-Peters et al., 2022). The proposed reforms included developing new science and mathematics curricula through an agreement with Cambridge University Press in 2017 [Ministry of Education-Oman (MoE), 2020]. The new Cambridge curricula, implemented in 2018, were designed to address concerns in four content areas: scientific inquiry, biology, chemistry, and physics (Shahat et al., 2022). These curricula differ from previous curricula in Oman by providing a structure for teaching and learning and offering ways to assess students' ability and understanding. Moreover, the curricula were adapted to Omani culture and its Islamic nature. The MOE supports teachers who teach the new curricula. The Specialist Centre for Professional Training of Teachers at the MOE teaches them instructional methods for content and assessment (Specialized Institute for Professional Training of Teachers, 2020). Hence, the presented study takes the potential special role of science and mathematics instruction with respect to teacher education programs into account.

In German schools, boys and girls are not separated at all, nor is there any specified gender division among teachers (Schulte, 2017). Furthermore, religion and education are considered separate; religion is taught as a school subject. In elementary school (grades 1–4, or 1–6 in two federal states), students have a class teacher who teaches most lessons (Porsch, 2016). Furthermore, science is taught as a comprehensive subject, combining different scientific perspectives in

a topic-focused way. In lower secondary school (grades 5 or 6 to 10) as well as upper secondary school (grades 11–13), each subject is taught by a specialized teacher and natural sciences are taught as distinctive subjects, all of which are considered "core subjects." In upper secondary school, students attend different subject courses and no longer spend the full day with the same group of students. The language of instruction for all classes in regular public schools in German. Due to differences in education systems, the science education context, and teacher preparation, a cross-cultural comparison could potentially contribute to better understanding the quality of digital science instruction during the Covid-19 pandemic (Shahat M. and Al-Amri, 2022). To our knowledge, there is no study comparing IQDLSs between Oman as an example of an Arab country and Germany as an example of a European country.

2.4. Teacher competences as prerequisites for instructional quality

An essential prerequisite for instructional quality is teacher competence (Kunter et al., 2013; Darling-Hammond, 2021; see model in Figure 1). As theories and empirical evidence from various domains show, teachers need cognitive as well as affective competences to provide adequate learning material and engage in adaptive teaching (e.g., Blömeke et al., 2016; Fauth et al., 2019; Voss et al., 2022). In the context of digital learning settings, teachers' technological pedagogical content knowledge (TPACK) is an essential aspect of teachers' professional knowledge (Mishra and Koehler, 2006; Scherer et al., 2017). TPACK includes knowledge about concepts concerning technology, about pedagogical techniques for using technologies, and about difficulties students might run into when learning with technology (Mishra and Koehler, 2006). Thus, TPACK is considered a "basis of good teaching with technology" (Mishra and Koehler, 2006, p. 1029). There is some, but still scarce, empirical evidence underpinning this assumption by demonstrating the relevance of teachers' TPACK for instruction and student outcomes (Harris et al., 2017; for TPK during the Covid-19 pandemic: König et al., 2020). Besides professional knowledge, teachers' attitudes are another vital component of teachers' competences (Baumert and Kunter, 2013). Attitudes (e.g., regarding the usefulness of digital teaching) are highly subjective implicit conceptions and part of teachers' value commitments (Pajares, 1992). Teachers' attitudes toward the usefulness of a teaching approach or a learning goal impact teachers' performance in the classroom in ways that are often unconscious; nevertheless, relations between teachers' attitudes and their instructional practice have been found in various empirical studies (Thibaut et al., 2018; for digital teaching: Skantz-Åberg et al., 2022). Another core dimension of teachers' professional competence is their intrinsic motivation, e.g., for (digital) teaching (Kunter et al., 2011). Intrinsically motivated persons act with high internal self-regulation and, e.g., teach for the joy of teaching and not just because they are paid to do so or for other external reasons (see Deci and Ryan, 2000). Teachers' intrinsic motivation for teaching is positively associated with their performance (Patrick et al., 2000) as well as student outcomes (Keller et al., 2017).

The question of whether these dimensions of teachers' professional competence were also related to instructional quality in digital learning settings during the Covid-19 pandemic remains unanswered.

3. Research questions and hypotheses

Consequently, the project aims were to (a) develop/adapt items to assess IQDLSs that are reliable in different educational and cultural contexts, (b) investigate differences in IQDLSs between different school forms, while including teacher demographics as control variables, (c) analyze differences in instructional quality between Oman and Germany, and (d) investigate the relations between teacher competences (TPACK, attitudes, and intrinsic motivation) and IQDLSs. Concretely, four research questions (RQ) and hypotheses (H) guided the present study:

> *RQ 1*: How good is the instruments' quality for assessing instructional quality in digital learning settings?
>
> *RQ 2*: Is there a relation between instructional quality and school form (a) and are the effects stable when teachers' demographics are considered as predictors as well (b)?
>
> *H2*: Against the background of high student heterogeneity in elementary school/Cycle 1 in both countries, we assume it is easier for secondary school teachers to adapt to their students' needs and hence provide better instructional quality. Empirical findings on the impact of teachers' demographics on instructional quality is heterogeneous we do not state directed hypotheses.
>
> *RQ 3*: What differences in IQDLSs can be found between Oman and Germany?
>
> *H3*: Due to the lack of empirical evidence and theories on pandemic-era instruction, we do not state a directional hypothesis on country-specific differences.
>
> *RQ 4*: How is IQDLSs associated with teachers' (a) technological pedagogical content knowledge, (b) attitudes toward the usefulness of digital teaching, and (c) intrinsic motivation for digital teaching?
>
> *H4*: Based on the model of teaching and learning in digital learning settings (Figure 1) and previous empirical findings, we expect positive relations between instructional quality measures and teachers' TPACK, attitudes toward the usefulness of digital teaching, and intrinsic motivation.

4. Methods

4.1. Design and sample

Data was assessed in a cross-sectional design between May and July 2021 via an online questionnaire conducted in Oman and Germany simultaneously. In Oman, the questionnaire was distributed to teachers via Google Forms after getting official permission from the Omani Ministry of Education. In Germany, the questionnaire link was distributed via the homepage of the Center for Research on Education and School Development (IFS) and social media (Facebook). Participation was voluntary and teachers could quit at any time.

TABLE 1 Sample.

	N	School form (% elementary/ lower secondary/ upper secondary)	Gender (% female teachers)	Teaching experience (in years, *M* [SD])	Focus Domain (% science or mathematics)
Oman	141	2.1/60.3/37.6	53.2	14.67 (6.99)	37.6
Germany	143	23.1/20.3/56.6	83.9	17.21 (10.57)	44.8

Significant differences between Omani and German sample in teachers' gender and teaching experience.

Personal data from this casualty sample was pseudonomised, reducing the risk of influencing teachers' answers by social desirability. A total of 290 teachers from the two countries filled out the questionnaire completely. Six German teachers from special needs schools were excluded from later analyses, since there were no counterparts in the Omani sample. Hence, the final sample included $N = 284$ elementary, lower secondary and upper secondary teachers. The sample statistics are displayed in Table 1.

At the time of data collection, 17% of schools in Oman were shut down, 67% were partially open, and 16% of schools were fully open. In Germany, 10% of schools were shut down, 37% were partially open, and 53% were fully open. 13% of Omani teachers reported that instruction during periods of pandemic-related school closures was mainly synchronous (20% in Germany), 14% mostly taught asynchronously (3% in Germany), and 73% reported a hybrid approach, combining synchronous and asynchronous teaching (77% in Germany). In order to control for potential differences between STEM teachers and other teachers (due to different teaching methods and curricular reforms in Oman), teachers had to choose one domain on which to focus when filling in the questionnaire.

4.2. Instruments

At the beginning of the questionnaire, teachers were asked about their demographic background, the conditions at their schools regarding digital learning, software use, and digital support and which domain they would like to refer to when answering the questions about instructional quality.

4.2.1. Instructional quality in digital learning settings

To assess IQDLSs, established instruments from previous studies were adapted to match the context and differentiate between asynchronous and synchronous instruction and new items were developed, where needed. In the prompt, teachers were asked to think about instruction in the focus domain they chose (science/ mathematics or other). Altogether, the questionnaire consisted of 10 scales measuring different aspects instructional quality. Table 2 provides an overview of the instructional quality scales.

4.2.2. Teacher competences

Similarly, established instruments using four-point Likert-scales from 1 "Applies not at all" to 4 "Applies completely" were used to measure teacher competences. Teachers' technological pedagogical content knowledge (TPACK) was assessed with five items (Schmidt et al., 2009; e.g., "I can teach lessons that appropriately combine literacy, digital media, and teaching approaches."; Cronbach's AlphaOman = 0.94; Cronbach's AlphaGermany = 0.90). The scale measuring teachers' attitudes toward the usefulness of digital teaching consisted of four items (Gebauer et al., 2013; e.g., "Students benefit from digital teaching and learning settings regarding their acquisition of general knowledge."; Cronbach's AlphaOman = 0.84; Cronbach's AlphaGermany = 0.84). Teachers' intrinsic motivation to teach in digital learning settings was assessed with four items (McElvany et al., 2012; Gebauer et al., 2013; e.g., "Teaching in digital teaching and learning settings is a positive challenge for me."; Cronbach's AlphaOman = 0.89; Cronbach's AlphaGermany = 0.94).

All items were translated from German into English and Arabic and back (see Kahveci et al., 2018). Researchers from both countries (Arabic and German native speakers) discussed the meaning of items in the original version and back translation to ensure comparability of the Arabic and German instruments.

4.3. Analyses

Sample statistics, reliability and descriptive results were computed in SPSS 28 (IBM Corp., 1989–2021), the analyses testing measurement invariance and answering the research questions were conducted in Mplus 8.6 (Muthén and Muthén, 1998–2021). For answering research question 1, first, the reliability of all instructional quality scales was tested for each country. In a second step, the measurement invariance was tested for a subsample of instructional quality scales, due to sample size and model complexity. In a semi-exploratory process, scales were selected to cover all three dimensions of instructional quality and to yield empirically distinguishable factors. Confirmatory factor analyses supported a five-factor model in both countries, including scales covering all three basic dimensions of instructional quality: (1) cognitive activation in synchronous settings, structure in (2) synchronous and (3) asynchronous settings, (4) routines, and (5) considering students' need for competence (see test for configural invariance in the results section). For testing measurement invariance of instructional quality as well as teacher competences, we used a sequential constraint imposition approach for CFA models (Dimitrov, 2010). After analyzing models for configural invariance for each country (pattern of model parameters are the same in both samples), a baseline model is specified using multi-group comparisons, with a fixed factorial structure and no parameter constrains. To test metric invariance (factor loadings are equivalent in both samples), the baseline model was compared to Model 1, where factor loadings were constrained to be equal between Oman and Germany. To test scalar invariance (factor loadings and indicator means are equivalent in both samples), Model 1 was compared to Model 2, where factor loadings and intercepts were constrained between groups. For teachers' competence, partial scalar invariance was reached as well by lifting the equality constraints for the factor loadings of two items.

TABLE 2 Scales for assessing IQDLS.

Scale	N_{items}	Example item	Source
Cognitive activation in synchronous settings[a]	4	Regarding synchronous teaching situations (e.g., via video conferences): I often ask students to explain their answers	Hußmann et al., 2017; Self-development
Cognitive activation in asynchronous settings[a]	5	Regarding asynchronous teaching situations (e.g., written assignments): I provide tasks, allowing for more than one solution	Hußmann et al., 2017; Self-development
Individualization in synchronous settings[b]	6	Regarding synchronous teaching situations (e.g., via video conferences): I allow fast-learning students to proceed to the next tasks, while slow-learning students still practice and recapitulate	Hußmann et al., 2017
Individualization in asynchronous settings[b]	4	Regarding asynchronous teaching situations (e.g., written assignments): I provide students with different tasks, according to their achievement level	Hußmann et al., 2017
Structure in synchronous settings[a]	3	Regarding synchronous teaching situations (e.g., via video conferences): In the beginning, I clarify the lessons topic	Hußmann et al., 2017
Structure in asynchronous settings[a]	3	Regarding asynchronous teaching situations (e.g., written assignments): I take care that students know, which tasks they should work on in a certain period of time	Self-development
Routines[a]	6	There are regular dates, when I provide students with new assignments	Self-development
Support for need for autonomy[a]	5	I provide students a choice between different meaningful tasks	Self-development
Support for need for competence[a]	4	While teaching in digital teaching and learning settings, I encourage students, when working on difficult tasks	Hußmann et al., 2017
Support for need for social relatedness[a]	5	While teaching in digital teaching and learning settings, I actively take care that every student feels related to the class group	BiSS-study (Ohle-Peters et al., 2021); self-development

[a]Four-point Likert-scale from 1 "Applies not at all" to 4 "Applies completely," prompt: "To what extend do you agree with the following statements about your teaching in digital teaching and learning settings?".
[b]Four-point Likert-scale from 1 "Never or almost never" to 4 "always or almost always," prompt: "How often do following aspects occur in your digital teaching and learning settings?".

TABLE 3 Model comparisons for testing measurement invariance for teacher competence scales.

	CFI	RMSEA	χ^2	df	$\Delta\chi^2$	Δdf	p
Teacher competences							
Configural Oman	0.969	0.07	106.40	62	–	–	–
Configural Germany	0.991	0.04	73.75	62	–	–	–
Baseline model	0.979	0.06	180.15	124	–	–	–
Model 1 (partial metric invariance)[a]	0.977	0.06	193.42	132	13.27	8	0.10
Model 2 (partial scalar invariance)[b]	0.975	0.06	208.46	140	15.04	8	0.06

[a]Intercorrelation between two items.
[b]Equality constraints lifted for two items.

Table 3 provides an overview of the model comparisons for teacher competences.

To answer Research Question 2, structural equation models (SEM) were specified with multiple latent dependent variables (instructional quality measures) and school type as a manifest predictor (Model 1), and then again including teacher demographics (Model 2) in order to test the stability of a potential school effect. In Model 3, country was added as a dummy variable (0 = Germany, 1 = Oman) to test whether additional variance is explained by the country context (Research Question 3). SEM were also specified to answer Research Question 4 separately for Oman and Germany. Due to model complexity and sample sizes, path coefficients reaching a 10% level of significance are reported as well as direct and indirect effects. As mentioned above, there were no missing values in the dataset.

5. Results

5.1. Descriptive results

Descriptive results showed that, in general, teachers in both countries report rather high instructional quality in the digital

TABLE 4 Means, standard deviations and bivariate correlations between instructional quality (1–5) and teacher competences (6–8) for Oman (above diagonal) and Germany (beneath diagonal).

	M (SD) Oman	*M* (SD) Germany	1	2	3	4	5	6	7	8
1. Cognitive activation in synchronous settings	2.69 (0.96)	3.19 (0.90)	–	0.47*	0.50*	0.41*	0.44*	0.28*	0.13	0.24*
2. Structure in synchronous settings[a]	3.44 (0.80)	3.41 (0.85)	0.67*	–	0.69*	0.66*	0.78*	0.33*	0.22*	0.22*
3. Structure in asynchronous settings[a]	3.11 (0.77)	3.06 (0.78)	0.15	0.09	–	0.62*	0.67*	0.33*	0.28*	0.26*
4. Routines[a]	3.02 (0.66)	3.47 (0.44)	0.24*	0.22*	0.28*	–	0.64*	0.33*	0.33*	0.21*
5. Support for need for competence[a]	3.25 (0.99)	3.66 (0.53)	0.21*	0.24*	0.21*	0.42*	–	0.33*	0.24*	0.20*
6. TPACK	2.89 (0.68)	2.88 (0.67)	0.30*	0.25	06	0.16	0.18*	–	0.34*	46*
7. Attitude toward usefulness of digital teaching	2.76 (0.64)	2.46 (0.65)	0.09	0.01	0.13	0.19*	0.30*	0.22*	–	0.57*
8. Intrinsic motivation for digital teaching	2.90 (0.71)	2.71 (0.82)	0.16	0.01	0.17*	0.19*	0.32*	0.42*	0.62*	–

*$p < 0.05$.

learning setting. All means except teacher attitudes toward the usefulness of digital teaching in Germany differed significantly from the theoretical scale mean of 2.50; Bonferroni correction for multiple *t*-tests taken into account. Table 4 displays descriptive results for Omani and German teachers.

Bivariate correlations between instructional quality and teacher competences were positive throughout, as expected, although the coefficients were lower and less often significant in the German compared to the Omani sample. Numerically, the results provided an initial indication of differences between the two countries and relations between instructional quality and teacher competences, which needed to be confirmed via SEM.

5.2. Quality of instruments (RQ 1)

The internal consistency of IQDLS scales was good in both countries, except for routines in the Omani sample and autonomy support in the German sample, as displayed in Table 5.

Measurement invariance was tested for (1) cognitive activation in synchronous settings, structure in (2) synchronous and (3) asynchronous settings, (4) routines, and (5) considering students' need for competence. Here, partial scalar invariance was reached by lifting the equality constraints for four items (based on CFI comparison; Cheung and Rensvold, 2002). This means that the relations between latent factors and external variables as well as factor means can be compared across countries (Dimitrov, 2010). Table 6 reports the results of model comparisons.

5.3. Differences in instructional quality between school forms (RQ 2)

SEM revealed that cognitive activation in synchronous learning settings was positively associated with school level. Teachers from secondary school reported a higher cognitive activation in their video meetings with students or other synchronous teaching formats, than teaches from elementary school. The effect was small, but stable even when teacher demographics were added as predictors. For structure in asynchronous settings, we found a negative relation with school form, indicating that teachers of younger students took more care to provide structure in tasks such as written assignments. When teachers' demographics were included as exogenous variables, the effect was smaller and no longer statistically significant. The results imply a gender effect; female teachers, who were more predominant in elementary schools, reported higher structure in asynchronous settings. Furthermore, teachers' gender was positively associated with routines in digital learning settings and with considering students' need for competence. Teaching experience was positively related only to routines in digital learning settings; more experienced teachers put more emphasis on routines in synchronous as well as asynchronous settings. Finally, teachers who reported on a science domain or mathematics reported higher cognitive activation in their digital teaching. All results are displayed in Table 7. Concluding, we could identify differences between school forms and its' directions depends on the aspects of instructional quality. Hence, the hypothesis that secondary school teachers provided better instruction in digital teaching (H2) could only be confirmed partially.

5.4. Country-specific differences in instructional quality (RQ3)

To answer Research Question 3, country was added as an additional predictor variable (model 3, Table 5). The results showed that additional variance could be explained by the country for all aspects of instructional quality except for structure in synchronous settings. Hence, we could identify country-specific differences. Compared to Omani teachers, German teachers reported higher cognitive activation in synchronous settings, provided more structure in asynchronous settings, and put more emphasis on routines and students' need for competence in digital learning settings. Nevertheless, the amount of explained variance for all five instructional quality measures was low, indicating the existence of stronger predictors, such as teacher competences, which was addressed in closing.

TABLE 5 Reliability of scales for assessing instructional quality (RQ 1).

Scale	N_{items}	Cronbach's Alpha Oman/Germany
Cognitive activation in synchronous settings[a]	4	0.82/0.92
Cognitive activation in asynchronous settings[a]	5	0.86/0.79
Individualization in synchronous settings[b]	6	0.78/0.74
Individualization in asynchronous settings[b]	4	0.85/0.81
Structure in synchronous settings[a]	3	0.95/0.88
Structure in asynchronous settings[a]	3	0.90/0.65
Routines[a]	6	0.59/0.87
Support for need for autonomy[a]	5	0.87/0.68
Support for need for competence[a]	4	0.94/0.87
Support for need for social relatedness[a]	5	0.94/0.88

[a]Four-point Likert-scale from 1 "Applies not at all" to 4 "Applies completely," prompt: "To what extend do you agree with the following statements about your teaching in digital teaching and learning settings?".
[b]Four-point Likert-scale from 1 "Never or almost never" to 4 "always or almost always," prompt: "How often do following aspects occur in your digital teaching and learning settings?".

5.5. Relations between teacher competences and instructional quality (RQ 4)

As shown in Figure 2, additional variance in instructional quality was explained by teachers' competences, mainly their technological pedagogical content knowledge, in both countries. The better teachers knew, how to use technology for their teaching, the better was their instructional quality. Furthermore, teachers' attitudes toward the usefulness of digital teaching were positively related to establishing routines in digital learning settings in the Omani sample. So, teachers, who value digital teaching put more emphasis on well structured interactions with students, than teachers, who find digital teaching less useful. In both countries, teachers' intrinsic motivation for digital teaching was positively associated with the consideration of students' need for competence in digital learning settings. The more teachers were motivated to teach in digital learning settings, the more they reported to invest in providing competence-oriented feedback to their students. The direct effects of school form, teachers' gender, teaching experience, and subject domain (STEM vs. non-STEM) differed between countries, but in general, teaching experience and subject domain tended to exhibit relations with instructional quality. The hypothesis, that teachers' competence is associated with their instructional quality was partially supported by our data (H4).

In the reported model, intercorrelations between latent instructional quality variables were allowed; correlation coefficients were $0.38 < \beta < 0.88$ (Oman) and $-0.06 < \beta < 0.70$ (Germany); due to space limitations, they are not displayed in this figure. For Oman, we found indirect effects of teachers' subject domain via teachers' TPACK on (a) cognitive activation ($\beta = 0.06$, $p < 0.10$), (b) structure in asynchronous settings ($\beta = 0.06$, $p < 0.10$), (c) structure in synchronous settings ($\beta = 0.08$, $p < 0.05$), (d) routines ($\beta = 0.08$, $p < 0.05$), and (e) consideration of students' need for competence ($\beta = 0.08$, $p < 0.05$). In the German sample, we found indirect effects of school form via teachers' TPACK on (a) cognitive activation ($\beta = 0.10$, $p < 0.05$), (b) structure in asynchronous settings ($\beta = 0.11$, $p < 0.10$), (c) structure in synchronous settings ($\beta = 0.08$, $p < 0.05$), and (d) routines ($\beta = 0.04$, $p < 0.10$).

TABLE 6 Model comparisons for testing measurement invariance for instructional quality scales (RQ 1).

	CFI	RMSEA	χ^2	df	$\Delta\chi^2$	Δdf	p
Instructional quality							
Configural Oman	0.932	0.09	271.93	124	–	–	–
Configural Germany	0.966	0.05	164.05	124	–	–	–
Baseline model	0.938	0.08	458.61	253	–	–	–
Model 1 (partial metric invariance)[a]	0.939	0.07	465.43	264	6.82	11	0.81
Model 2 (partial scalar invariance)[b]	0.935	0.08	487.86	270	22.43	6	0.00

[a]Intercorrelation between two items.
[b]Equality constraints lifted for four items.

TABLE 7 Instructional quality and relations to school form, teacher demographics (RQ 2) and country (RQ 3).

	Cognitive activation (synchronous)			Structure (synchronous)			Structure (asynchronous)			Routines			Support for need for competence		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
School form	0.13*	0.13*	0.12*	0.11	0.11	0.11	−0.19*	−0.02	0.02	0.10	0.13	0.12	−0.10	−0.07	−0.08
Teacher's gender	–	0.04	−0.02	–	−0.01	0.00	–	0.20*	0.09	–	0.19*	−0.09	–	0.19*	0.12
Teaching experience	–	0.00	−0.03	–	0.04	0.04	–	0.04	−0.02	–	0.16*	0.12	–	0.01	−0.02
Focus domain	–	0.14*	0.12*	–	0.08	0.09	–	0.04	0.00	–	0.02	0.00	–	0.04	0.02
Country	–	–	−0.19*	–	–	0.02	–	–	−0.28*	–	–	−0.28*	–	–	−0.22*
R^2	0.02	0.04	0.07	0.01	0.02	0.02	0.04	0.05	0.10	0.01	0.07	0.14	0.01	0.05	0.09

*$p < 0.05$; $N = 284$ teachers; school form: 1 = elementary school, 2 = lower secondary school, 3 = upper secondary school; teacher's gender: 1 = male, 2 = female; focus domain: 0 = other, 1 = science or mathematics; country: 0 = Germany, 1 = Oman; model 1: CFI = 0.93, RMSEA = 0.07, $\chi^2 = 344.36$, df = 138; model 2: CFI = 0.95, RMSEA = 0.05, $\chi^2 = 319.18$, df = 175; model 3: CFI = 0.93, RMSEA = 0.07, $\chi^2 = 433.70$, df = 188.

6. Discussion

The Covid-19 pandemic had a huge impact on school systems worldwide. All of a sudden, teachers and students were forced to adapt to digital teaching and learning settings as schools shut down. In the wake of this shift, more and more studies are emerging investigating the circumstances and consequences of digital teaching (or "home schooling" or "remote teaching"). The presented study focuses on quality of instruction during the Covid-19 pandemic using data from two countries with different educational and cultural backgrounds: Oman and Germany. The overarching research goal was to adapt and develop instruments to investigate instructional quality in digital learning settings and predictors, including school form, teacher demographics, country, and teacher competences. The first research question addressed the quality of instruments to assess IQDLS in both countries. Analyses, testing for internal consistency and measurement invariance, revealed that the adapted scales were suitable for assessing instructional quality in digital learning settings in Oman and Germany. Assuming that digital learning settings will become more relevant in the future, having reliable and invariant instruments for measuring instructional quality is a valuable contribution to research and evaluation of instruction. The second research question focused on the relation between teachers' self-reported instructional quality and school form. Results from structural equation models revealed small significant effects of school form on cognitive activation in synchronous learning settings and structure in asynchronous settings. When adding teachers' demographics as predictor variable, school form is only a significant predictor for cognitive activation in synchronous settings. Furthermore, the amount of explained variance was low; hence, there are stronger predictors of instructional quality in digital settings than school form, teachers' gender, teaching experience or subject domain (STEM vs. non-STEM). These heterogeneous results are not in line with our hypotheses. A possible explanation is potential variance in instructional practices during school closures, differences in further contextual conditions (e.g., ICT support) at school, and other factors that might influence teachers' ability to master teaching in digital settings (König et al., 2020). In Germany, teachers reported an increase of ICT support in schools (especially since the pandemic), but there is still room for improvement (Lorenz et al., 2022). In Oman, teachers also reported significant support for ICT at schools after the pandemic, especially in the fields of training, awareness, and utilization (Shahat M. A. and Al-Amri, 2022). Another contextual factor, contributing to instructional quality is teacher collaboration, which might be especially relevant in such an extreme situation as the pandemic. In Germany, empirical studies indicate, that teachers cooperate on rather low levels (e.g., just exchanging working materials) and they seldom work together in collaborative ways (e.g., working on common problems, such as dealing with digital teaching) (e.g., Ohle-Peters, 2020). In Oman, teachers demonstrated varying levels of cooperation, primarily limited to basic tasks like exchanging working materials. However, they occasionally engage in collaborative efforts, such as jointly planning instructional situations and exploring new styles of digital teaching (Shahat M. and Al-Amri, 2022). The third research question addressed country differences in instructional quality. The analyses showed differences in cognitive activation in synchronous settings, structure in asynchronous settings, routines and supporting students' need for competence in favor of the German sample. This is

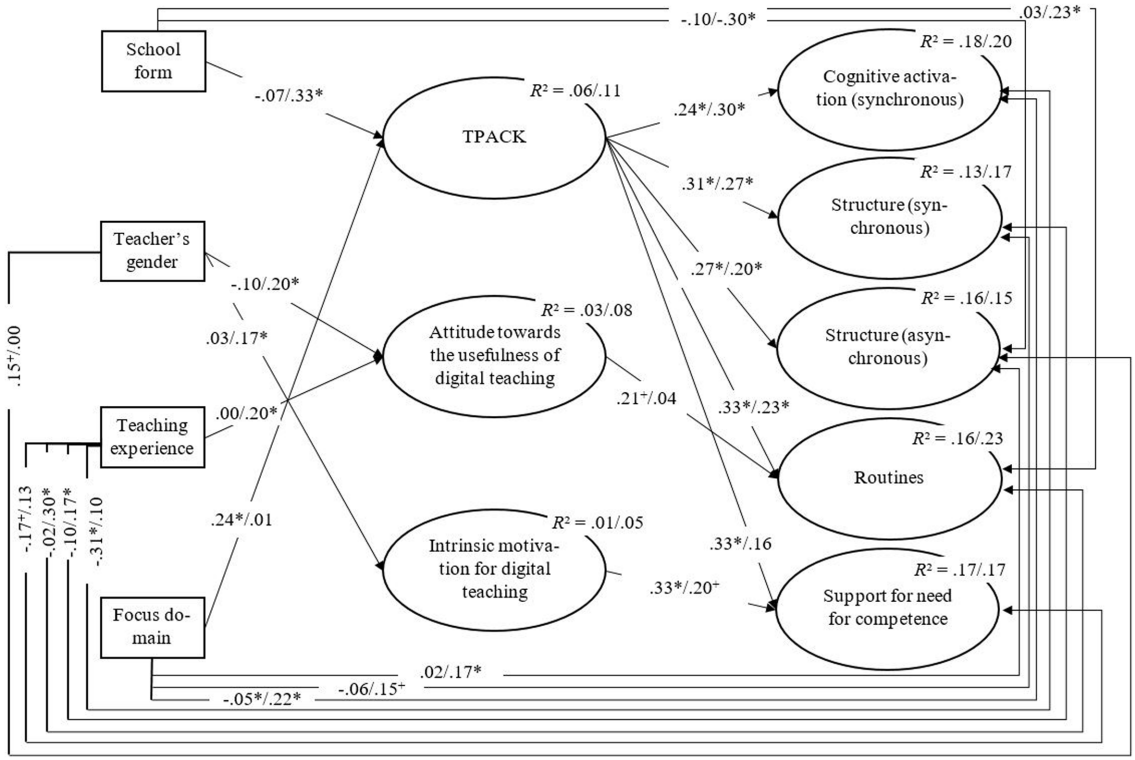

FIGURE 2
Structural equation model of teacher competences and instructional quality (RQ 3) in Oman/Germany.

contrary to results from the latest TIMSS study, where students from Oman reported that their mathematics and science lessons were more clear than students from Germany (Mullis I. et al., 2020). Of course, one has to keep in mind, that—in contrast to TIMSS 2019—the data in the presented study concerns teachers' self-reports with respect to digital learning settings during an exceptional educational situation. It would be beneficial to have student reports on how they perceived instructional quality during the pandemic, as they might differ from teachers' self-reported instruction. Another important factor influencing instructional quality is teacher competences. In line with other studies (e.g., Mayer and Girwidz, 2019; Li et al., 2021), the results for the fourth research question indicated that teachers' technical pedagogical content knowledge (TPACK) was positively related to instructional quality in both countries. Furthermore, teachers' attitudes toward the usefulness of digital teaching and their intrinsic motivation for digital teaching showed positive relations to instructional quality. Results from a recent study suggest that teachers' motivational beliefs play an important role for applying technologies in instruction (Backfisch et al., 2020).

6.1. Limitations

In the presented study, instructional quality and teacher competences were assessed using teachers' self-reports, which is common for TPACK (Greene and Jones, 2020), but it might be biased due to social desirability regarding the measurement of instructional quality. Furthermore, there might be a positive selection bias resulting from the recruitment procedures and voluntary participation of teachers (casualty sample). In future studies, the questionnaire could be further optimized, since the scales did not achieve full scalar invariance. Due to the given circumstances, data was only assessed once in a cross-sectional design, so with this data, it is not possible to describe any developments in digital teaching and learning during the pandemic. Although the models did converge, the sample size is rather small, so future studies should confirm the results with more participants.

6.2. Implications for practice

This study's principal contribution to the educational field is the detailed description of a five-factor model in Oman and Germany, including scales covering all three basic dimensions of instructional quality: (1) cognitive activation in synchronous settings, structure in (2) synchronous and (3) asynchronous settings, (4) routines, and (5) considering students' need for competence. These five dimensions could be used as part of a diagnostic measure to identify strengths and weaknesses related to digital learning settings. Such a measure might help education officials when conducting needs analyses and training teachers to teach in digital learning settings. Teachers could also use peer assessments to investigate the strengths and weaknesses of each other's performances when teaching in digital settings. These reports could then be used to document best practices for teaching science in general or during pandemics like Covid-19 or future forms of digital teaching in schools.

Another implication of this study is that teachers' curriculum guides may need to include teaching models for digital teaching. We recommend incorporating digital teaching in asynchronous and synchronous settings into the curriculum in all grades to encourage teachers to use these digital teaching skills effectively, not only in a pandemic situation. Teachers may also need more professional training regarding digital learning and may require additional in-service training to foster their motivation and attitudes toward digital teaching and to establish and enhance their capacity for digital teaching in asynchronous and synchronous settings. Designing workshops and/or training programs for teachers and their supervisors could help to improve their digital learning competences.

6.3. Implications for research

The principal implication of this study for research is the use of an instrument (IQDLSs), which partly consisted of established items as well as newly developed ones, that demonstrated good psychometric parameters in Oman and Germany and could be used in other countries to describe IQDLSs and identify predictive factors. We recommend replicating the study on a larger sample of teachers in various school levels in different countries. Furthermore, the impact of instruction and school-level specific teaching patterns on students' learning outcomes (Teig and Nilsen, 2022) in digital learning settings is yet to be investigated. Further research might involve a training intervention to assist teachers with digital teaching during pandemic-like conditions in order to improve their competence in the classroom. Furthermore, future studies should investigate further relevant input variables, such as ICT equipment and support in schools.

Data availability statement

The datasets presented in this article are not readily available because participants did not consent to publish data. Requests to access the datasets should be directed to annika.ohle-peters@tu-dortmund.de.

Ethics statement

Ethical approval was not required for the studies involving humans because not necessary according to current laws. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AO-P and MS: conception and design of the manuscript and drafting the manuscript. MS: data collection Oman. AO-P: data collection Germany and data analysis. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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