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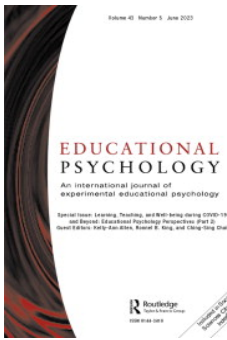
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Technology-supported teaching in times of COVID-19's first period of emergency remote teaching: an exploratory analysis of influencing factors

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ABSTRACT

In this exploratory study, we evaluated which factors are predictive of technology-supported teaching, conceptualised as Technological Pedagogical Content Knowledge (TPACK) competences and related professional development needs, and teachers' mental health in terms of job satisfaction, work-life balance, and teacher stress during COVID-19's first period of emergency remote teaching (ERT). In spring 2020, an online questionnaire was administered to gauge factors relevant to (1) shifting to ERT, (2) teachers' well-being, and (3) teacher characteristics. Data from 309 Dutch teachers across educational sectors were analysed using Structural Equation Modelling in two models. We further explored the results of the model predicting technology-supporting teaching as this showed the most optimal fit. Our analyses show that factors from all three categories contributed to technology-supported teaching during the first educational lockdown, but that competence-related aspects were the strongest predictors. Our results offer directions to strengthen the teaching context to support teachers navigating challenging ERT-periods.

Teaching practices and mental health in times of COVID-19

In the spring of 2020, educational institutions worldwide closed to prevent further spreading of COVID-19. Within a week, teachers had to radically redesign and shift traditional, face-to-face, educational activities to online instructional delivery modes facilitating *emergency remote teaching* (ERT; Hodges et al., 2020; Mishra et al., 2020). Prior to the COVID-19 crisis, educational technologies such as online learning

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platforms were often implemented slowly and reluctantly (König et al., 2020). Now these technologies had to be put into practice overnight, regardless of teachers' familiarity with these tools and the Technological Pedagogical Content Knowledge competences (TPACK; Mishra & Koehler, 2006) required to effectively instigate technology-enhanced teaching practices. At the same time, the pandemic also impacted teachers' personal lives and mental health. For example, because they simultaneously had to home-school their children or take care of vulnerable family members. This resulted in blurred boundaries between personal and work-related responsibilities (Kim & Asbury, 2020). The question is how teachers dealt with such a challenging situation that placed substantial demands on both their teaching competences and mental health.

The first scientific papers reporting on the COVID-instigated shift to ERT addressing this question, primarily described how teachers shaped and implemented ERT, teachers' perceptions of technology-supported remote learning practices, their experienced technological challenges, and how teachers felt overwhelmed by the vast amount of available online resources and tools (Kaden, 2020; Lemay et al., 2021; Mishra et al., 2020; Shamir-Inbal & Blau, 2021; Trust & Whalen, 2020). Less attention has been paid to teachers' proficiency in the technological-pedagogical competences as a prerequisite for ERT and a potential need to professionalise these competences, except for König et al. (2020) and Jimoyiannis et al. (2020). König et al. found that German early career teachers' technological competences were instrumental in adapting to ERT; Jimoyiannis and colleagues reported that most K-12 teachers in their sample felt confident and proficient in using online learning tools, but nevertheless felt a need to professionalise their skills to effectively design online technology-supported instruction.

Early published studies examining teachers' mental health and well-being during the COVID-19 pandemic are also mainly descriptive and have not examined how variation in teachers' well-being could both be explained by (changing) contextual factors in the workplace and home environment and by personal characteristics. Available studies documenting the first ERT-period (spring–summer 2020) do show that teachers experienced a variety of negative consequences of the pandemic. For example, teachers experienced more fatigue and anxiety, an increased workload, and worried about specific students (Alves et al., 2020; Kaden, 2020; Kim & Asbury, 2020), which presumably reduced teachers' mental health in terms of lower psychological well-being (such as job satisfaction and work-life balance) and/or increased their stress levels.

Hence, it is likely that the quality of ERT is not only dependent on teachers' previously acquired professional knowledge of, skills for, and experiences with technology-supported teaching situations, but also on teachers' mental health, personal resources, and living situations. Apart from Sokal et al. (2020a), who reported a relationship between teachers' (negative) attitudes towards technology and burnout during the initial stages of the COVID-19 pandemic, most of the early-published teaching-related studies have focussed *either* on ERT *or* on teachers' mental health. However, we posit that technology-supported teaching and teachers' mental health are likely connected as COVID-19 implicated sudden but drastic changes in both work-related and personal

aspects of life. Therefore, we set out to understand what influenced teachers' technology-supported (or online) teaching competences, professional development needs, and mental health when teaching in these challenging times.

Understanding technology-supported teaching and mental health

To understand which factors are predictive of teachers' experienced (1) technology-supported teaching (i.e. TPACK competences and professional development needs) and (2) mental health (i.e. job satisfaction, work-life balance, and teacher stress) in times of ERT, we integrated insights from different established educational and psychological theories that are suitable to examine and explain a variety of teacher outcomes. For example, components of the Unified Theory of Acceptance and Use of Technology model (UTAUT; Venkatesh et al., 2003), can give insight into potentially relevant factors related to the shift to ERT. Moreover, we included theories related to teachers' psychological well-being. For example, we used the Job Demand-Resources framework (Bakker et al., 2004; Schaufeli & Taris, 2014) as it can give insight into relevant *job-related* demands and resources experienced by teachers; the Self Determination Theory (Deci & Ryan, 2012) and psychological perspectives on resilience (Mansfield et al., 2016) can give insight into *personal* resources. This way, we captured a broad array of concepts that are potentially relevant to explain technology-supported teaching and mental health when teaching in times of COVID-19.

Technology-supported teaching: TPACK competences and professional development needs

To conceptualise technology-supported teaching practices, we adopted the Technological-Pedagogical Content Knowledge model (TPACK; Koehler et al., 2013; Mishra & Koehler, 2006). This framework describes how three core knowledge-based competences, namely Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), and Technological Pedagogical Knowledge (TPK) as well as the interactions between these three, shape the integration of educational technologies in teaching practices. The first competence, PCK, refers to a teacher's ability to apply general pedagogical knowledge to specific content or subjects and translate subject-specific content into effective teaching methods (Shulman, 1986). The second competence, TCK, entails knowing which technologies are best suited for teaching specific content. The third competence, TPK, represents teachers' understanding of how (using) specific learning technologies transforms teaching and learning processes. The overarching competence, TPACK, refers to teachers' understanding of the differential effect of a tech's pedagogical affordances and constraints *as a function of* specific content and context-related factors, and how this changes teaching and learning processes (Koehler et al., 2013; Mishra & Koehler, 2006).

Teachers need to develop TPACK competences and a thorough understanding of teaching with technology to effectively implement technology-enhanced teaching practices. This requires teachers to adequately prepare themselves and develop all TPACK-competences (Mishra & Koehler, 2006). However, developing TPACK is a

complex process and should be carefully trained based on gaps in teachers' TPACK skills and their individual, or so-called *professional development* needs (Koh, 2020). We expect that the ERT-period exposed large differences in teachers' perceived TPACK competences and that this resulted in a variety of TPACK-related professional development needs (Koh, 2020).

Teachers' mental health

Teachers' mental health can be conceptualised in terms of psychological well-being (i.e. being healthy mentally; Yildirim, 2015). In this exploratory study, we considered job satisfaction and work-life balance as indicators of *positive* mental well-being, and teacher stress as an indicator of *ill*-mental health. Job satisfaction refers to experiencing positive arousal or pleasant emotions ensuing from self-appraisal of job- or work-related achievements and experiences (Demirtas, 2010; Van der Boom & Stuivenberg, 2013). Work-life balance denotes the degree to which a teacher can maintain a balance between emotional, behavioural, and time demands of teaching and family responsibilities (e.g. time management, boundary setting; Bell et al., 2012). Teacher stress pertains to subjectively experienced mental or emotional tensions or strains resulting from demanding occupational (i.e. teaching-related) circumstances. Teacher stress can negatively impact mental well-being and social- and work-related functioning (e.g. De Bruin, 2006; Harmsen et al., 2018).

Factors related to emergency remote teaching

We expect that factors such as teachers' pre-ERT familiarity with different distance learning tools, teachers' perceptions of these tools' affordances for teaching and learning (based on the UTAUT model, Venkatesh et al., 2003; see also Trust & Whalen, 2020), preparation time, and school-facilitated ERT-support and can explain variance in both technology-supported teaching and mental health. These facilitating factors will likely not only determine the fluency of the implementation of technology-enhanced learning environments and the quality of teaching practices and learning processes (Mishra et al., 2020), but also teachers' perceived TPACK competences (i.e. technology-related teacher-efficacy beliefs), needs for professional development, and well-being (Lauermann & König, 2016). For example, having limited time to prepare for the shift to ERT, experiencing a lack of support in terms of assisting students working on new online learning platforms, or the (perceived) inability to maintain social contact with students or colleagues could result in lower job satisfaction, worrying, or elevated stress levels (König et al., 2020; Lauermann & König, 2016; Sokal et al., 2020b).

Factors related to well-being

One important framework that can be used to better understand mental health in terms of (work-related) well-being and stress is the Job Demands-Resources model (JD-R model; Bakker et al., 2004). The JD-R model has been used extensively to explain teacher mental health and describes how three parallel yet interacting processes can

lead to work-related well-being and stress. Job *demands*, such as high work pressure or dealing with disruptive student behaviours can lead to stress. The job demands implicated by the sudden shift to ERT during the first period of school closures such as or worrying about students or health and/or working overtime might have caused stress and possibly affected teachers' mental health and teaching practices. Job *resources* such as an autonomy-supportive working climate, collegial support, or experiencing positive effects of ERT for students' learning can lead to well-being, and simultaneously moderate the relation between job demands and stress (Bakker et al., 2004; Sokal et al., 2020b).

In its core, the JD-R model focuses on aspects of the working environment. However, as environmental aspects interact with and are interpreted from personal factors and experiences, more recent interpretations of this model include *personal* resources as a third process (Schaufeli & Taris, 2014). Personal resources can help explain how demands and resources in the work context lead to well-being and stress and can be defined as psychological characteristics correlated with one's (perceived) ability to successfully control and function in the working environment. As such, personal resources are assumed to foster the positive effects of experienced job resources and buffer the negative effects of job demands on mental health and well-being. A personal resource that potentially influenced teachers' mental health during ERT is *resilience*. Resilience is the ability to bounce back during/after stressful situations, adapt to stressful situations, and function regardless of experienced stress (Mansfield et al., 2016; Smith et al., 2008). The sudden shift to ERT and the perceived inability to facilitate technology-supported teaching might well have posed such a continued stressor.

Another set of personal resources stems from the self-determination theory (Deci & Ryan, 2012), which states that the work environment plays a vital role in the fulfilment of the basic psychological needs for autonomy (the need to experience agency and determination in one's work), competence (the need to experience effective enactment of behavior), and relatedness (the need to form meaningful relationships with others). Through the fulfilment of these basic psychological needs, job resources can increase teachers' sense of well-being, for example in terms of job satisfaction and vigour (Schaufeli & Taris, 2014; Van den Broeck et al., 2008). Satisfaction of basic psychological needs may have been at risk during the first ERT-period, for example, that of competence when teachers felt that their TPACK competences were not sufficiently developed. This potentially impacted teachers' sense of well-being, self-efficacy, and the quality of ERT.

Teacher characteristics

Teacher characteristics are personal and/or workplace-related factors such as age, household composition, caregiving tasks, teaching experience, and educational sector. These factors likely also shaped teachers' technology-supported teaching practices and mental health in times of COVID-19's first period of ERT. For example, having to home-school young children or being a prime caregiver during ERT likely brought additional challenges for some teachers, possibly as a function of age (Kupers et al., 2022; Power,

2020). Teaching experience and age could also be relevant in terms of competences needed for technology-supported teaching: As compared to beginning teachers, more experienced teachers perhaps found it less difficult to shift *PCK*-related aspects of instruction to online modes, whereas younger teachers possibly felt more proficient in technology-related aspects (i.e. TK, TPK, TCK) of ERT as compared to older teachers (e.g. Lee & Tsai, 2010). In addition, ERT-practices may largely vary across educational sectors as students in primary, secondary, and tertiary education differ in age, language and/or digital literacy proficiency, or parental support, which can result in a variety of teaching challenges. For example, teaching kindergartners online poses different challenges than creating an engaging social learning environment for adolescents. As educational sectors differ in formal requirements, a variety of issues related to adapted or discontinued achievement testing, national exams, internships, practical learning activities, and didactical approaches (e.g. teacher-centered versus student-centered learning; de Bruijn & Leeman, 2011) were elicited. Moreover, the quality of ERT depends on the availability of hardware (e.g. devices, stable internet connections), software, and educational tools suitable for specific age groups and learning goals (e.g. knowledge transfer in pre-university secondary education versus hands-on skills in vocational education).
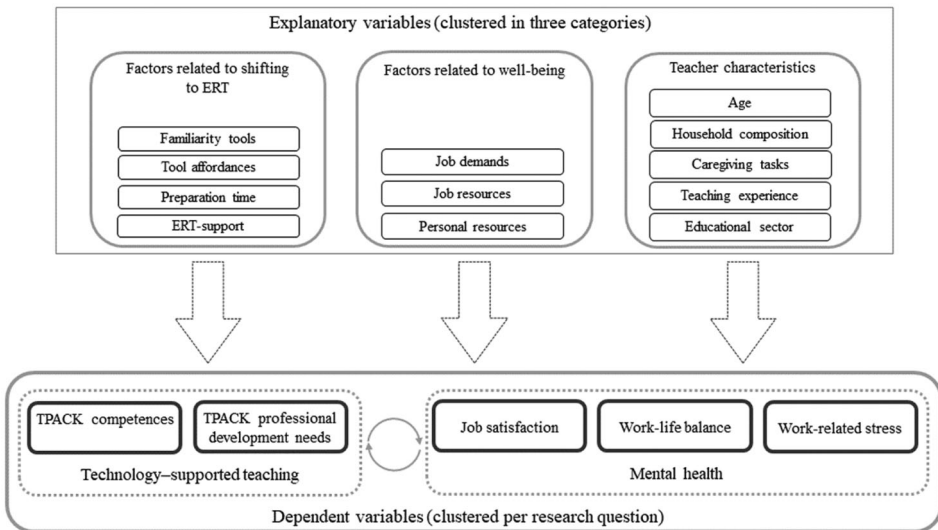
Figure 1. *Conceptual overview variables of interest.* The upper half schematises all theoretically derived variables (clustered in three categories) that are evaluated as predictors of the dependent variables (lower half). Indicators of technology-supported teaching (i.e. TPACK competences, TPACK professional development needs) and mental health (i.e. job satisfaction, work-life balance, stress) are considered as dependent variables. The circular arrows signal that indicators of mental health are also evaluated as predictors of technology-supported teaching, and vice versa.

The present study

To summarise: We wanted to better understand which factors made the shift to ERT a challenge (or a cinch) for teachers across educational sectors and aimed to evaluate which of the theoretically derived factors are predictive of teachers' (1) technology-supported teaching and (2) mental health during COVID-19's first educational lockdown. In this endeavour, we clustered the theoretically-derived and potentially predictive variables in three categories (see Figure 1): The first category includes factors related to shifting to ERT, the second category comprises factors related to psychological well-being, and the third category concerns teacher characteristics.

The research questions we wanted to answer were: 'Which ERT-related factors, well-being-related factors, and/or teacher characteristics are predictive of (1) teachers' perceived TPACK-competences and resulting professional development needs and (2) teachers' mental health in times of COVID-19's first period of ERT?'

While more studies in the past 2–3 years have focussed on teachers' technology-supported teaching and mental health during ERT, this study is one of the first to systematically evaluate factors potentially influencing teachers' technology-supported teaching practices and mental health based on theoretical models rooted in educational sciences and school/workplace psychology. By applying Structural Equation Modelling and exemplifying data from different educational sectors in the Netherlands, our exploratory study contributes to the growing body of research giving insight into factors potentially predictive of both teachers' technology-enhanced teaching and mental health during ERT.

Methodology

Participants and procedure

From April to June 2020, Dutch primary-, secondary-, special needs-, and vocational-education teachers were asked to fill out an online questionnaire (QualtricsXM platform), as approved by the ethics committee of the Department of Teacher Education at the University of Groningen (TED-1920-S-0014). This questionnaire comprising open-ended, rating, and multiple-choice questions took about 20 min to complete. Teachers were recruited through social media and the professional and personal networks of the researchers; 423 teachers opened the questionnaire and consented to participate. We report on the data of the 309 (265 women, two not specified) teachers who largely or completely filled out the questionnaire.

Measurement instruments

We used scales from different existing instruments to measure theoretically-derived variables of interest whenever possible (see Appendix A for a more detailed description of all included scales). To gauge background characteristics and situation-specific variables (such as time to prepare for ERT), we used categorical, open-ended, or slider-scale items. In Tables 1 and 2, the descriptive statistics are presented.

Table 1. Descriptive statistics continuous variables.

Variable	n	M (SD)	Range Min.	Range Max.	α
Technology-supported teaching					
TPACK competences[a]	305	3.47 (0.81)	1.00	5.00	0.85
TPACK professional development needs[a]	296	3.23 (0.99)	1.00	5.00	0.90
Mental health					
Job satisfaction[b]	305	4.12 (0.76)	1.60	5.00	0.78
Work-life balance[b]	305	3.45 (0.93)	1.00	5.00	0.85
Stress[b]	305	2.24 (0.92)	1.00	5.00	0.90
ERT-related					
Familiarity tools	309	2.58 (0.89)	1.00	4.00	NA
Tool affordances					
Whole class instruction	307	61.18 (28.54)	0.00	100.00	NA
Monitoring progress	306	56.91 (26.26)	0.00	100.00	NA
Differentiation	308	56.10 (27.06)	0.00	100.00	NA
Maintaining social climate	306	29.14 (22.35)	0.00	100.00	NA
Preparation time	309	2.40 (0.85)	1.00	4.00	NA
Well-being related					
Worrying about health	305	2.56 (0.99)	1.00	5.00	.82
Overtime	302	5.30 (10.15)	−35.00	48.00	NA
Autonomy-supportive working climate	300	3.71 (1.08)	1.00	5.00	.95
Collegial support	300	4.23 (0.80)	1.50	5.00	.75
Resilience	305	3.46 (0.77)	1.00	5.00	.79
Psychological Needs					
Autonomy	301	3.73 (0.90)	1.00	5.00	.78
Competence	300	3.99 (0.80)	1.75	5.00	.85
Relatedness	300	4.23 (0.75)	1.00	5.00	.87
Teacher characteristics					
Teaching experience	308	14.63 (10.02)	0.50	44.00	NA

[a]Dependent variable Research Question 1.
[b]Dependent variable Research Question 2. NA = reliability coefficient not available (single-item variable).

Technology-supported teaching

Technology-supported teaching was operationalised in terms of teachers' TPACK competences and TPACK professional development needs. Teachers first rated on a five-point Likert scale (1 = *completely disagree* to 5 = *completely agree*) to which extent they felt competent in the three technology-related TPACK competences. Our six researcher-constructed items tap into the TK, TCK, and TPK components of the TPACK-framework (e.g. Koehler et al., 2013), and include statements such as: '*I feel competent in understanding how the online tools and resources I use might affect my instruction*' (TPK). Subsequently, teachers rated the same six items, but now indicated the extent to which they experienced professional development needs (1 = *not at all* to 5 = *completely*).

Mental health

A five-point Likert-scale (1 = *completely disagree* to 5 = *completely agree*) was used to measure three distinct aspects of teachers' mental health during ERT: (1) *Job satisfaction* (five items; TALIS; Van der Boom & Stuivenberg, 2013), (2) *work-life balance* (six-item researcher-constructed scale measuring boundary setting, time-management, upholding non-job-related interests, and psychological detachment from work, similar to the Teacher Lifestyle Scale; Hlad'o et al., 2020), and (3) *work-related stress* (nine items; General Work Stress Questionnaire; De Bruin, 2006).

Table 2. Descriptive statistics dichotomous and categorical variables.

Variable	n	%
ERT-related		
Sufficient ERT-support		
Yes	192	62.1
No	117	39.9
Well-being related		
Worrying about students		
Yes	290	93.9
No	19	6.1
Positive effects ERT student learning		
Yes	235	76.1
No	73	23.6
Teacher characteristics		
Age		
20–29	54	17.5
30–39	79	25.6
40–49	78	25.2
50–59	73	23.6
60 years and older	24	7.8
Not specified	1	0.3
Household composition		
Alone	41	13.3
With partner	92	29.8
With children (single parent)	11	3.5
With partner and children	149	48.2
Other[a]	12	3.9
Not specified	1	0.3
Caregiver		
No	271	87.7
Yes	37	12.0
Not specified	1	0.3
Educational sector		
Primary education	94	30.4
Secondary education	123	39.8
Special needs education	47	15.2
Vocational education	44	14.2
Not specified	1	0.3

[a]For example, living with parents or sibling(s).

ERT-related factors

Teachers indicated on a four-point Likert scale (1 = *not familiar with any* to 4 = *familiar with all)* to what extent they were already familiar (e.g. before the first educational lockdown) with the online resources, distance learning tools, and/or digital platforms they used during ERT. To gauge perceptions of learning tools' affordances (i.e. perceived usefulness; Venkatesh et al., 2003), teachers indicated on four 100-point slider-scales to what extent the tools they used adequately enabled (a) whole-class instruction, (b) monitoring individual students' progress, (c) differentiation, and (d) maintaining a social climate. How much time teachers were given to prepare for ERT was again measured on a four-point scale (1 = *no preparation time* to 4 = *a week*). Last, teachers indicated whether they felt they were adequately supported by their schools in shifting to ERT (regarding redesign, troubleshooting, and learning to operate online platforms and tools) on a dichotomous (yes/no) scale.

Well-being-related factors

We measured well-being-related factors in terms of job demands, job resources, and personal resources. The first job *demand,* worrying about health, was measured on a five-point Likert scale ranging from *completely disagree* to *completely agree* (four items; Ultra-Brief Penn State Worry Questionnaire; Berle et al., 2011). Worrying about students was indicated on a dichotomous (yes/no) scale. Overtime was calculated by subtracting the number of hours a teacher is appointed from the number of hours worked during the first ERT-period. Job *resources* such as an autonomy-supportive working climate (seven items; Work Climate Questionnaire; Baard et al., 2000) and collegial support (two items) were also rated on a five-point Likert-scale (1= *completely disagree* to 5 = *completely agree*). Experiencing the positive effects of ERT on students' learning was measured by a dichotomous (yes/no) scale. *Personal* resources such as resilience (six items; Brief Resilience Scale; Smith et al., 2008) and fulfilment of basic psychological needs (i.e. autonomy, three items; competence, four items; relatedness, four items; BPNSFS; Chen et al., 2015) were also indicated on a five-point Likert-scale. An example item measuring competence is: '*In past weeks, I felt I could successfully complete difficult (work-related) tasks.*'

Teacher characteristics

Most teacher characteristics (i.e. personal and workplace-related factors) such as age, household composition, caregiving tasks, and educational sector were measured dichotomously or categorically (see Table 2). For teaching experience (in years), an open-ended textbox was used.

Data-analyses

We used Structural Equation Modelling (SEM; Mplus 7, Muthén & Muthén, 2010) for all analyses as it enables evaluating (cor)relations between latent and observed continuous and categorical variables and supports the inclusion of structural and measurement models, and as such, more adequately deals with measurement errors (Teo et al., 2013). A simultaneous evaluation of the structural and measurement models of all five dependent latent variables (e.g. TPACK competences, TPACK professional development needs, job satisfaction, work-life balance, and stress) in one model resulted in under-identification (i.e. negative *df* due to the ratio between observed and to-be-estimated parameters). Therefore, we ran two separate models that theoretically made the most sense: One to evaluate predictors of teachers' technology-supported teaching (i.e. TPACK-competences and professional development needs), and one to evaluate predictors of teachers' mental health (i.e. job satisfaction, work-life balance, and teacher stress). For both models, we used a robust WLSMV-estimator. Following Hooper et al. (2008), a variety of goodness-of-fit indices from different index-families were used: the Comparative Fit Index (CFI $\geq$ 0.90), Tucker-Lewis Index (TLI $\geq$ 0.90), Root Mean Square of Approximation (RMSEA $<$ 0.08), Weighted Root Mean Square Residual (WRMR $<$ 1.0), and normed Chi-square (χ^2/model *df* $<$ 2.0; Schreiber et al., 2006).

For the first model, with TPACK-competences and professional development needs (i.e. technology-supported teaching) as outcome variables, we ran a baseline model to

estimate regression paths of all potential predictors (CFI = 0.94; TLI = 0.92; RMSEA = 0.04; WRMR = 0.96; normed χ^2 = 1.51). Based on the modification indices, we first improved the model fit by adding theoretically justified inter-item correlations to the measurement model. Then, following the parsimony principle, a stepwise deletion of non-significant paths resulted in model improvement with acceptable model fit (CFI = 0.97; TLI = 0.96; RMSEA = 0.05; WRMR = 1.10; normed χ^2 = 1.74).

Similarly, for the second model with job satisfaction, work-life balance, and teacher stress (i.e. mental health) as outcome variables, we first estimated a baseline model with all potential predictors (CFI = 0.83; TLI = 0.79; RMSEA = 0.05; WRMR = 1.21; normed χ^2 = 1.69). Stepwise deletion of non-significant paths lead to model improvement but not to optimal model fit: CFI = 0.89; TLI = 0.88; RMSEA = 0.05; WRMR=

Table 3. Standardised parameter estimates of predictors TPACK-Competences and professional development needs.

Parameter	Estimate	SE	One-tailed p-value
Full model			
TPACK-competences			
Familiarity tools	0.269	0.055	.000
Tool affordance: Whole class instruction	0.131	0.062	.018
Tool affordance: Monitoring progress	0.183	0.055	.001
Preparation time	−0.113	0.056	.023
Psychological need: Competence	0.389	0.054	.000
Psychological need: Relatedness	−0.157	0.051	.007
Educational sector: Primary education[a]	−0.213	0.088	.008
Educational sector: Secondary education[a]	−0.349	0.096	.000
Educational sector: Vocational education[a]	−0.351	0.081	.000
TPACK professional development needs			
TPACK competences	−0.494	0.049	.000
Tool affordance: Differentiation	0.111	0.068	.050
Tool affordance: Maintaining social climate	−0.187	0.065	.002
Experienced ERT-support[b]	0.179	0.059	.001
Job satisfaction	−0.140	0.067	.019
Positive effects learning[c]	0.137	0.061	.012
Age 30–39[d]	−0.153	0.055	.003
Measurement model			
TPACK-competences			
1 General use tools	1.000	0.000	NA
2 Selecting subject-specific tools	1.329	0.103	.000
3 Applying subject-specific tools	1.232	0.095	.000
4 Handling students' technical difficulties	1.143	0.113	.000
5 Supporting students' learning processes	0.968	0.095	.000
6 Understanding effect instruction	0.933	0.096	.000
TPACK professional development needs			
1 General use tools	1.000	0.000	NA
2 Selecting subject-specific tools	1.060	0.064	.000
3 Applying subject-specific tools	1.091	0.064	.000
4 Handling students' technical difficulties	0.813	0.072	.000
5 Supporting students' learning processes	0.820	0.065	.000
6 Understanding effect instruction	0.791	0.066	.000
Correlations			
TPACK-competences 1 and 4	0.294	0.072	.000
TPACK-competences 3 and 4	−0.495	0.116	.000
TPACK-competences 5 and 6	0.296	0.061	.000
TPACK professional development needs 5 and 6	0.360	0.048	.000

[a]Baseline category: special needs education.
[b]0 = sufficient, 1 = insufficient.
[c]0 = no positive effects ERT on learning, 1 = positive effects ERT on learning.
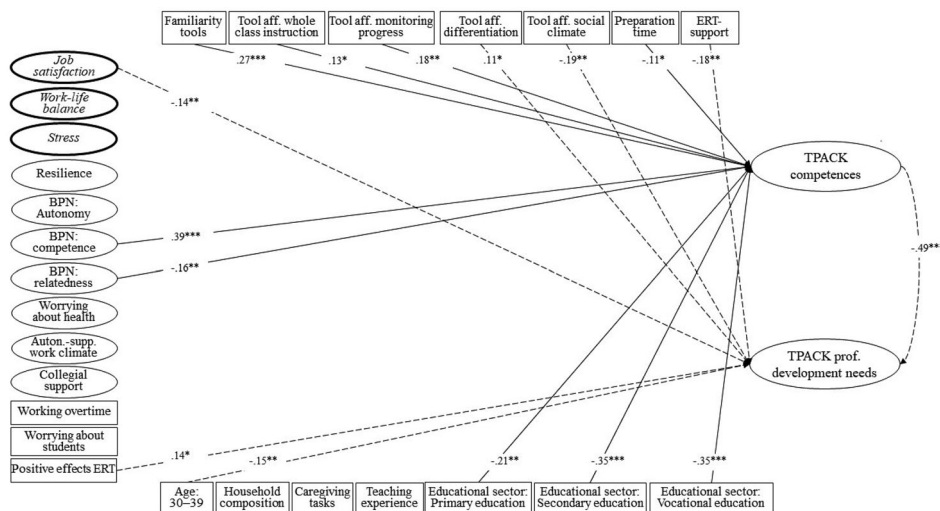[d]Baseline category: Age group 60 and older.

Figure 2. Structural model with standardized regression coefficients of significant paths. Continuous lines represent predictors of TPACK competences; dotted lines represent predictors of TPACK professional development needs. Latent factors are represented in ellipses; italicised latent factors are indicators of mental health. $*p < .05.$ $**p < .01.$ $***p \leq .001$

1.34; normed $\chi^2 = 1.81$. Because of the non-optimal fit of this second model, we consulted our statistical advisor and decided to present and interpret only the results of the first model. Suggestions to improve the measurement of the variables-of-interest and statistical evaluation of the second model are presented in the Discussion. A correlation table for all variables included in both models is available upon request from the corresponding author.

Results

Table 3 presents the parameters of the structural and measurement model with teachers' experienced TPACK competences and professional development needs as dependent variables (see also Figure 2). From the parameter estimates, we can infer that teachers rated their TPACK competences higher if they were already familiar with the tools and platforms used during ERT, hold more positive perceptions towards ERT-tools' affordances for whole-class instruction and monitoring individual students' progress, and experienced fulfilment of competence as a basic psychological need. Remarkably, fulfilment of relatedness as a basic psychological need and having had *more* time to prepare for ERT negatively predict teachers' TPACK competences. We also see that teachers in primary, secondary, and vocational education felt less proficient in their TPACK competences as compared to teachers in special needs education, with the largest standardised negative regression coefficient for vocational-education teachers.

Regarding TPACK professional development needs, we see that teachers who felt more competent in TPACK experienced fewer professional development needs. Teachers who rated ERT-tools' affordances for maintaining a social climate higher and those who were more satisfied with their job also reported fewer professional

development needs. Teachers aged 30–39 experienced fewer TPACK-related professional development needs as compared to teachers aged 60 (and older). Holding more positive perceptions towards ERT-tools' affordances for differentiation, experiencing insufficient ERT-support, and believing that ERT can be conducive to student learning increased teachers' need for TPACK-professionalisation.

Discussion

With this explorative study, we aimed to understand which factors made the sudden shift to ERT a challenge or a cinch for teachers across educational sectors. In specific, we used SEM to answer: *Which ERT-related factors, well-being-related factors, and/or teacher characteristics are predictive of teachers' (1) perceived TPACK-competences and professional development needs and (2) mental health in times of COVID-19's first-period of ERT?* The first model, in which we evaluated predictors of TPACK competences and professional development needs (i.e. technology-supported teaching), pinpointed a variety of influencing factors. The second model, in which potential predictors of three indicators of mental health were evaluated, did not result in an acceptable model fit. Therefore, we will only discuss findings related to technology-supported teaching. In this reflection, we will particularly focus on findings that are relevant for supporting ERT practices.

Factors influencing TPACK competences

Four *ERT-related factors* were predictive of teachers' perceived TPACK competences. The strongest predictor was teachers' familiarity with technology-supported tools: Teachers who indicated that they were already familiar with the tools and platforms that they used during ERT possibly experienced a greater sense of self-efficacy towards technology-enhanced teaching and encountered fewer difficulties while teaching remotely (e.g. Rabaglietti et al., 2021), which potentially contributed to their positive perceptions of their TPACK-competences. We also found that teachers generally rated their TPACK competences higher if they hold more positive perceptions of ERT-tools' affordances for whole-class instruction and for monitoring individual students' progress. Even in ERT situations, being able to do what you were trained for—albeit facilitated by online tools or learning platforms—possibly evoked positive feelings towards job-related functioning (Demirtas, 2010)

An unexpected finding worth discussing is the negative relation between preparation time and teachers' TPACK competences. Those who had more time to prepare for ERT rated their TPACK-competences lower. Generally, Dutch teachers value student-centered (interactive) learning approaches, and it could have been that teachers with more time for preparation discovered the complexity of shaping remote teaching practices that accords with their preferred and default teaching approaches. For example, the vast number of options to integrate interactive elements in ERT may have left teachers who had some time to delve into the technical possibilities baffled (e.g. Trust & Whalen, 2020), whereas teachers with little preparation time switched to

quick-fix solutions that presumably supported more teacher-centered learning approaches.

Of all *well-being-related factors*, we found that two *personal resources* are predictive of TPACK competences. Fulfilment of competence as a basic psychological need was in fact the strongest positive predictor of teachers' perceived TPACK competences when teaching in times of COVID-19. An unexpected finding is a negative relation between the fulfilment of relatedness as a basic psychological need and TPACK competences. Self-determination theory suggests that the need to belong precedes the desire for knowledge (e.g. Deci & Ryan, 2012), as it is seen as a basic and innate human psychological need. In regular situations, people tend to internalise and learn (new) values and practices from contexts in which they experience a sense of belonging (Niemiec & Ryan, 2009). This would favour a positive relation between the fulfilment of relatedness and experienced competence, but our results seem to suggest this is not evidently the case when teaching in times of COVID-19. One explanation could be that teachers who considered themselves as more competent felt confident enough to relatively individually explore how they could best shape their ERT-practices, whereas those who felt less competent may have more actively reached out to their colleagues for support and, consequently, experienced higher fulfilment of relatedness during ERT. Another explanation is that—in contrast to prior studies showing that negative perceptions of workplace factors (e.g. unfavourable working conditions instigated by the shift to ERT) are associated with decreased commitment (Borman & Dowling, 2008)—teachers possibly felt that they were all in this situation together and collectively (and temporarily) accepted lower teaching-quality standards as a result of this unique and unexpected teaching situation and their TPACK competences and that this collective somehow experience strengthened a sense of relatedness. To further examine this, longitudinal studies are needed to better understand the mechanisms underlying the negative relation between the fulfilment of the need for relatedness and teachers' experienced TPACK competences and to examine if and why this effect is typical for crisis situations.

Teacher characteristics were also predictive of teachers' experienced TPACK competences. Interestingly, we found variation across educational sectors: Teachers in special needs education held more positive perceptions towards their TPACK competences as compared to teachers in primary, secondary, and vocational education. There is no evidence that special-education teachers are more experienced in using technology per se, but it could be that these teachers are used to working more adaptively in general (Lübke et al., 2021). Given their students' special educational needs, they can rely less on teaching materials that work for 'most students' and, therefore, these teachers might feel more competent adapting their teaching to unexpected, changing circumstances.

Factors influencing TPACK professional development needs

Four *ERT-related factors* were predictive of teachers' experienced TPACK professional development needs. The strongest predictor was TPACK-competences: Teachers experienced fewer professionalisation needs if they felt more competent in TPACK.

Teachers who rated ERT-tools' affordances for maintaining a social climate higher and those who felt that they received sufficient support on average reported fewer needs for TPACK-related professional development, which underscores the importance of providing adequate teacher support during ERT, either in the form of online trouble-shooting FAQs, or scheduling fixed timeslots for collegial consultation (Kaden, 2020; Kupers et al., 2022;). Another ERT-related factor—holding positive perceptions towards ERT-tools' affordances for differentiation—*increased* teachers' experienced TPACK professionalisation needs.

Of all *well-being-related variables* that were evaluated, job satisfaction was the only significant predictor of teachers' experienced TPACK professional development needs. In specific, we found that that teachers who were more satisfied with their job reported lower levels of professionalisation needs. In 2018, McInerney and colleagues found that teachers desiring variety and innovations in their teaching tasks tend to show higher levels of psychological well-being. For some teachers, the shift to ERT potentially supported this desire for variation in and experimenting with new teaching approaches, and positively impacted job satisfaction.

Age was the only *teacher characteristic* predictive of teachers' needs to professionally develop their TPACK skills. In specific, we found that compared to teachers of 60 years and older, teachers aged 30–39 reported significantly lower needs for professional development of their TPACK competences. Possibly because these teachers are more used to the everyday integration of technologies as compared to their older colleagues, and at the same time can rely on more teaching experience as compared to younger teachers (e.g. Lee & Tsai, 2010).

Limitations and recommendations for future research

As in any study, there are some limitations. The first is that we set up this exploratory study while the COVID-19 crisis and ERT-practices were still evolving. That meant that we had little to no (theoretical) indication of which ERT-related aspects would prove to be most challenging or what would affect teachers' mental health most; nor was it possible to know which of a plethora of teaching and/or general tools would retrospectively prove to be most relevant. For example, we measured teachers' perceptions of four tool affordances that strongly related to teaching-as-normal practices (i.e. whole-class instruction, monitoring progress, differentiation, and maintaining a social climate), whereas the enormous variety of tools used during ERT probably also afforded other aspects of learning. Moreover, it could be that some tools more strongly called on TPACK competences as compared to others. Including information about the type of tools used in our analyses potentially would have allowed contextualising our findings.

In addition, even though our SEM-analysis seems to confirm several needs identified in the qualitative study of Klusmann et al. (2022), we need to stress the preliminary nature of our results given the exploratory set-up of our study and because our second model did not reach acceptable model fit due to a lack of power. However, to be able to fully understand the mechanisms underlying technology-supported teaching and mental health in times of ERT, an evaluation of the second model is still

needed. In addition, the starting point for this study was a *simultaneous* evaluation of ERT-, well-being, and teacher characteristics-related predictors of both technology-supported teaching and mental health in one model. Integrating all dependent variables in one model evaluated in a larger sample size could have led to more adequate model specification in terms of (in)direct effects mediating the interplay between technology-supported teaching practices and mental health, between-factor correlations, and possibly would have led to a more conclusive evaluation of the directionality of effects.

A larger sample size would also have allowed for testing measurement invariance across educational sectors, which would be a recommendation for future studies. In addition, as the pandemic prolonged and more educational lockdowns were needed, teachers' stress may have increased, or its sources changed. For example, over time teachers learned about learning delays caused by ERT (Onderwijsinspectie, 2021), which potentially impacted their workload on the long run as well. This underlines the importance of a longitudinal measurement of aspects of teacher well-being and mental health during and after ERT.

Final reflections

Even though the models we initially proposed warrant further parametrical and theoretical improvement and validation, especially with regard to the model predicting mental health, our findings provide insight into potential mechanisms underlying teachers' technology-supported teaching practices when teaching in times of COVID-19 (or other forced periods of ERT). The results of our study provide at least three directions for strengthening ERT-practices, which could potentially also positively impact teachers' mental health, in times of challenging situations. First, it was not surprising that all ERT-related factors were predictive of either teachers' TPACK competences required to effectively instigate technology-enhanced teaching practices or experienced professional development needs. These results emphasise the importance of providing ample just-in-time ERT-support and pro-actively professionalising teachers' TPACK competences (e.g. Koh, 2020) and allowing them to familiarise themselves with and understand the potential and affordances of a broad array of general digital or online communication tools and learning platforms that can be used for instructional purposes during and beyond ERT. Second, of all included mental health and well-being-related factors, we found that particularly variables that can be conceptualised as a job or personal *resources* are predictive of TPACK competences and professional development needs. This overall pattern suggests that *especially* in times of COVID-19, it is essential to provide a working context that allows to experience competence in teaching behaviours, social connections, and autonomy (Collie et al., 2016; McInerney et al., 2018). It emphasises the relevance of an autonomous supportive school climate that—strengthened by opportunities for collegial consultation—can help teachers to feel competent, which at longer turn might also boost job satisfaction. Third, teacher characteristics such as age and educational sector proved to be useful sources to explain variation between teachers. Based hereupon, we advise

schools to take into account teacher characteristics and tailor support and profession-alisation opportunities to different age groups and educational sectors.

All in all, when it comes to teaching practices and teachers' TPACK competences and related needs for professional development in times of COVID-19, our results stress the importance of providing teachers with a positive and stimulating work envir-onment *during and after* ERT that facilitates ongoing tailored professional develop-ment, offers adequate ERT-related support, and enables effective enactment of teaching behaviours. Our findings could be relevant for future crises, but even more importantly, for to-be-implemented blended curricula ensuring high-quality technol-ogy-supported education for all learners.

Authors contributions

Jolien Mouw: Conceptualisation, Research Design, Methodology, Data Collection, Analyses, Writing (Original Draft and Revision).

Marjon Fokkens-Bruinsma: Conceptualisation, Research Design, Methodology, Data Collection, Writing (Original Draft and Revision).

Elisa Kupers: Conceptualisation, Research Design, Methodology, Data Collection, Writing (Original Draft and Revision).

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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Appendix A. Overview of measurements

Table A1. Overview of scales and/or items.

Construct, subscale	No. items	Response type	Based on instrument
TPACK-competences	6	5-point Likert scale	Items measures aspects related to the technological-oriented competences/facets of the TPACK model: Technological Knowledge (2 items), Technological Content Knowledge (2 items), and Technological Pedagogical Knowledge (2 items). Based on Koehler et al. (2013); Mishra and Koehler (2006).
TPACK professional development needs	6	5-point Likert scale	Items measuring the same aspects as the TPACK competences-items, but the professional development needs items are reformulated. For example, the TPACK-competence item *'I feel competent in understanding how the online tools and resources I use might affect my instruction'* was changed into *'I experience a need for professionalisation to understand how the online tools and resources I use might affect my instruction'*
Familiarity tools	1	4-point Likert scale	NA.
Preparation time	1	4-point Likert scale	NA.
Tool affordances	4	Slider 1–100	Based on the perceived usefulness scale (aspect of the technology acceptance model; Venkatesh et al., 2003).
Sufficient ERT-support	1	Yes/no	NA.
Job satisfaction	5	5-point Likert scale	Teaching and learning international survey (Van der Boom & Stuivenberg, 2013)
Work-life balance	6	5-point Likert scale	Self-constructed scale measuring boundary setting, time-management, upholding non-job-related interests, and psychological detachment from work. Similar to the (later published) teacher lifestyle scale (Hlad'o et al., 2020).
Stress	9	5-point Likert scale	General Work Stress Questionnaire (De Bruin, 2006)
Resilience	6	5-point Likert scale	Brief Resilience Scale (Smith et al., 2008)
Psychological Needs			Basic psychological needs satisfaction and frustration scales (BPNSFS; Chen et al. 2015)
Autonomy	3	5-point Likert scale	BPNSFS: Autonomy scale (Chen et al., 2015)
Competence	4	5-point Likert scale	BPNSFS: Competence scale (Chen et al., 2015)
Relatedness	4	5-point Likert scale	BPNSFS: Relatedness scale (Chen et al., 2015)
Overtime	2	Text-box question	Calculated by subtracting reported appointment hours from the number of hours worked during the first ERT-period.
Worrying about health	4		Penn-state worry questionnaire (Berle et al., 2011)
Worrying about students	1	Yes/no	NA.
Positive effects ERT on student learning	1	Yes/no	NA.
Autonomy-supportive working climate	7	5-point Likert scale	Work climate questionnaire (Baard et al., 2000)
Collegial support	2	5-point Likert scale	Contact with colleagues scale (Kupers et al., 2022)
Household composition	1	Text-box question	NA.
Age	1	Categorical	NA.
Caregiver	1	Yes/no	NA.
Educational sector	1	Categorical	NA.