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"The whole is greater than the sum of its parts" – Exploring teachers' technology readiness profiles and its relation to their emotional state during COVID-19 emergency remote teaching

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With the rapid spread of the Coronavirus (COVID-19), schools around the world came to a shutdown. This resulted in an abrupt transition from face-to-face instruction to emergency remote teaching (ERT), resulting in numerous challenges that have greatly affected teachers. Even though research has identified key factors for teachers to effectively implement ERT in the context of the COVID-19 school shutdown, there is still little research on the factors (and their interrelations) that account for the differences between teachers' experiences. Following a theoretical model of technology readiness, this study aimed to investigate teacher profiles based on domains of technology acceptance, technology competence and technology control. In addition, this study seeks to explore whether teachers' emotional state during ERT varies between the teacher technology readiness profiles. A total of 124 teachers participated voluntarily in an online survey stemming from the research project "*Students-Parents-Teachers in Homeschooling*" in Germany. Results from a two-step cluster analysis revealed three distinct teacher technology readiness profiles. Moreover, the findings also revealed gender differences between the three technology readiness profiles. Lastly, an analysis of variance indicated that teachers' positive emotional state during ERT varied significantly across the clusters. Implications of the results for teacher education and teacher professional development, as well as further lines of research are discussed.

KEYWORDS

teacher technology readiness, teacher profiles, positive state, negative state, emergency remote teaching

Introduction

Teaching has been considered as one of the most stressful professions (MacIntyre et al., 2020; Ozamiz-Etxebarria et al., 2020), and mastering it during the school shutdown imposed by the COVID-19 pandemic has only placed even more challenges to a teacher's job (Klapproth et al., 2020). In order to hinder the rapid spread of COVID-19, schools worldwide were forced to implement ERT as a temporary solution [ERT is related to emergency remote education which is considered as a branch of online learning and homeschooling (Bozkurt and Sharma, 2020)], shifting face-to-face instruction to online learning (Bozkurt and Sharma, 2020; Seufert et al., 2021). Important to recall is that teaching in an online environment does not only require that teachers have the appropriate technological skills and competencies, but also it also implies that teachers must implement a completely different pedagogical approach than teaching face-to-face (Gurley, 2018). Recent research within the context of ERT during COVID-19 has pointed out at the fact that besides teachers' digital competencies (König et al., 2020; Sá and Serpa, 2020) and previous experiences with ICT (van der Spoel et al., 2020), technology readiness was strongly related to how educators mastered and coped with the challenges during ERT (Adov and Mäeots, 2021). According to van der Spoel et al. (2020), technology readiness is a key teacher professionalization factor when it comes to educational technology integration. However, teachers' technology readiness does not only support the successful and meaningful integration of technology into their teaching practice, but it can also impact their emotional state or experiences (Kim et al., 2019). Several international studies have indicated that teachers who were not familiar with online teaching formats experienced more challenges and worries, and in consequence, a significant negative impact in their emotional state (Sahu, 2020; Sokal et al., 2020; Baker et al., 2021). Thus, it is not surprising that multiple studies have also indicated that teachers report an increase of stress, anxiety, and exhaustion (Al Lily et al., 2020; Li et al., 2020; Prado-Gascó et al., 2020; Zhou and Yao, 2020; Karakose et al., 2021). Bearing in mind the decisive role that the variable of teacher technology readiness has not only on their use of technology for instructional purposes, but as well on their emotional experiences, the current study seeks to contribute to the research field by exploring profiles of teachers' technology readiness. Furthermore, the present study will explore potential differences on teachers' emotional state across the identified profiles. Understanding the relation between teachers' technology readiness and their emotional state gives us the opportunity to acquire a deeper knowledge of which aspects should be addressed to support teachers' development of digital competencies, motivation, and readiness in order to foster their purposeful and effective integration of technology not only during the pandemic but as well after it (Adov and Mäeots, 2021). The following section will introduce the factor of technology readiness, followed by a brief discussion on the relevant research and findings on teachers' emotional state during ERT in the COVID-19 pandemic.

Technology readiness

Different theoretical models on technology integration, such as the technology acceptance model (TAM; Venkatesh and Bala, 2008), theory of reasoned action (Ajzen, 1991), or the "Will, Skill, Tool" model (Knezek et al., 2003), have highlighted people's technology readiness as a crucial factor for the successful use of technology (Petko et al., 2018; Howard et al., 2021). Moreover, such theoretical considerations have also been empirically supported by findings from multiple educational research studies (Petko et al., 2018). The construct of technology readiness originates from the TAM (Venkatesh and Bala, 2008), which explains the use of technology through the concept of technology acceptance, and theorizes that perceived usefulness and simplicity of technology influence both attitudes and beliefs toward technology usage (Venkatesh and Bala, 2008). Neyer et al. (2012), proposed a model of technology readiness in terms of three dimensions: technology acceptance (attitude reflecting the subjective appraisal of technological progress/perceived value), technology competence (assessment of one's own technology-relevant abilities), and technology control (subjective expectation of the results of technology-relevant actions). Technology readiness differences at the individual level based on these three facets should not only substantially associated with variables such as self-efficacy and emotional stability, but also with an individual's actual technology use (Neyer et al., 2012). Thus, based on such theoretical and empirical considerations, it can be assumed that teachers who are successful and effective in using technology are convinced that technology is beneficial for both instructional purposes and students learning, recognize the added value of technology, consider themselves competent to use digital technology (Woltran et al., 2022), as well as have positive control beliefs and experiences in technology-relevant situations (i.e., user friendliness; Amhag et al., 2019; Adov and Mäeots, 2021).

Previous research on teachers' technology readiness has shown that teachers hold a moderate level (Summak et al., 2010; Badri et al., 2014). In detail, Badri et al. (2014) reported that teachers scored relatively high in optimism and innovativeness. According to the authors, such factors are related to positive views about technology and an increase of control using new technologies. Additionally, findings by Summak et al. (2010) revealed significant differences between technology readiness and gender, indicating that male teachers demonstrated a higher technology readiness level than their female counterparts. A recent qualitative study by Adov and Mäeots (2021) in Estonia conducted during the COVID-19 pandemic lockdown, revealed that teachers varied in their levels of technology readiness, ranging from a low willingness to use technology in their teaching to a more open and positive view of the possibilities that technology provided. Further in-depth analyses indicated a relation between teachers' technology readiness level and their technology integration during ERT. Similarly, a study by Howard et al. (2021) which explored teacher data from 20 countries, also indicated that teachers have different levels of technology readiness, ranging

from low to high readiness. Interestingly, results from their study also indicated that most teachers had a medium level of technology readiness.

Stephan et al. (2019) argue that technology readiness is not only associated to the frequency of technology use, but also, to the user's affective experience. With this background, a recent study by Händel et al. (2020) explored higher education students' technology readiness and emotional experiences during emergency remote education in the COVID-19 pandemic. Findings from this study revealed a correlation between students' technology readiness and their self-reported emotional state, where students who held higher levels of technology readiness reported less tension, worries, and stress. Likewise, a study by Schneider et al. (2021) found an effect of pre-service (student) teachers' technology readiness on their emotional state during COVID-19; however, this effect was smaller when compared to the results by Händel et al. (2020). Taken together, it may be assumed that teachers' technology readiness could be a crucial condition of their emotional experience and adaptive technology use.

Emotional state

The construct of emotion refers to a "multifaceted experience in which affective, cognitive, physiological, motivational, and expressive processes combine into an emotional episode" (Knörzer et al., 2016, p. 97). In this sense, an emotion is characterized by an intense but rather short affective state (Shuman and Scherer, 2014). Thus, the short duration of emotion can in return lead to short-term changes of emotional states (D'Mello and Graesser, 2012). Watson and Tellegen's (1985) proposed two general activation systems of affect, with positive and negative affect as two unipolar dimensions. Such theoretical framework was based on the Circumplex Model of Affect developed by Russell (1980) who conceptualized two orthogonal dimensions. Tellegen et al. (1999) further modified Russell's model by differentiating between positive (PA) and negative (NA) activation. In this sense, PA and NA represent unipolar states of activation, "where high PA comprises positively valued states with a high degree of activation (e.g., enthusiastic); at the low end are negatively valued states characterized by low PA (e.g., dull). Analogously, high NA comprises negatively valued states with a high degree of activation (e.g., distressed); at the low end are positively valued stated characterized by low NA (e.g., relaxed)" (Schreiber and Jenny, 2020, p. 2). At the behavioral level, PA is associated with approaching behavior, while NA is related to avoidance (Watson et al., 1999).

With regard to teachers' emotional state during ERT in the COVID-19 context, findings from a study by Schwab and Lindner (2020) revealed that Austrian teachers reported feeling far more stressed when compared to before the pandemic. Similarly, a study conducted during the first school shutdown in Germany, Eickelmann and Drossel (2020) reported that 34% of the teachers surveyed indicated that they experienced ERT as a burden. Additionally, findings from Portillo et al. (2020) indicate that teachers perceived a higher workload during the lockdown which had made them experience negative emotions. When exploring teachers' PA and NA, results from Letzel et al. (2020) study revealed a significant increase in teachers' NA during ERT. Although such research has investigated teachers' emotional state during ERT, there is still however, a lack of information when it comes to understanding the factors that account for such impact. For instance, it is unclear why some teachers experienced more stress, strain and worries, whether others were able to manage ERT in a more successful manner. In light of the aforementioned theoretical background and outcomes of previous studies described in the precedent sections, it can therefore be assumed that teachers' technology readiness might play a role in teachers' emotional state.

The present study

The immediate health measures imposed to reduce the spread of COVID-19 forced educational institutions to implement ERT. As a result, a teachers' job was drastically changed from face-to-face instruction, to having to set up online instruction using the resources at hand. Unsurprisingly, teachers have experienced adverse consequences that have had a significant negative impact on their emotional state (Sahu, 2020; Sokal et al., 2020; Baker et al., 2021). Even though there are multiple studies describing teachers' emotional experiences and challenges during ERT in the context of the COVID-19 school shutdown (Huber and Helm, 2020; Klapproth et al., 2020), there is still a lack of research on how teachers' technology readiness contributed to the impact on teachers' emotional state. Against this background, the present study sought to investigate potential teacher profiles based on the different technology readiness domains (Neyer et al., 2012). Furthermore, since technology readiness could be assumed to play a role in teachers' emotional experiences during ERT, this study attempts to explore whether teachers' emotional state varies between the teacher technology readiness profiles. The research questions guiding the study were:

- Can teacher groups be identified differing from one another in terms of technology readiness?
- Do teachers' emotional state during emergency remote teaching (in the context of COVID-19) differ among the teacher groups?

Materials and methods

Participants and procedure

This study uses data from 124 teachers (78% female) who participated in an online survey stemming from the research project *Student-Parents-Teachers* in Homeschooling (abbreviated as SCHELLE following its German title ***Sch****üler-****El****tern-****Le****hrer* for a detailed overview of the SCHELLE project and its design please refer

to Letzel et al., 2020) conducted in the first COVID-19 school shutdown between May and June 2020. The teachers had a mean value of 38.02 years and an average of 10.81 years of teaching experience (SD = 7.37). The sample covered teachers from all school tracks and stages prevalent in the German school system: advanced (academic track) secondary school ($N = 32$), intermediate secondary schools ($N = 28$), comprehensive schools ($N = 26$), primary school ($N = 21$), special school ($N = 4$) and other school forms (i.e., vocational education school) or missing ($N = 13$).

Instruments

Technology readiness

Teachers' technology readiness was measured using the Technology Readiness Questionnaire from Neyer et al. (2012). The scale is composed of three sub-scales underlying the following constructs: technology acceptance (*I am very curious when it comes to new technology developments*; $\alpha = 0.83$), technology competence (*I have often fear to fail when dealing with modern technology*; $\alpha = 0.85$), and technology control (*It depends essentially on me whether I am successful using modern technology*; $\alpha = 0.72$). All sub-scales are based on a 5-point Likert scale ranging from 1 = *strongly disagree* to 5 = *strongly agree*.

Emotional state

To assess teachers' emotional state during emergency remote teaching, the Positive and Negative Activation and Valence (PANAVA) short-form scales from Schallberger (2005) were applied. The PANAVA consists of two scales: positive activation (PA; $\alpha = 0.76$) and negative activation (PA; $\alpha = 0.65$). The PA and NA comprise four bipolar items, respectively, rated on a 6-point Likert scale. To this end, participants received the instruction, "*How do you experience your day to day teaching work since homeschooling started because of COVID-19? Since homeschooling I feel…*," and were asked to rate accordingly their emotional states.

Data analysis

Statistical analyses were conducted in IBM SPSS Statistics 27. First to examine teachers' technology readiness and emotional state, descriptive analyses and *t*-tests were performed. Furthermore, to explore the first research question, a two-step cluster analysis was conducted (Field, 2013). As a first step, a hierarchical cluster analysis using Ward's method and squared Euclidean distance was performed to identify the number of possible profiles of teachers (Hair, 2010; Yim and Ramdeen, 2015). The clustering variables were the three scales stemming from the Technology Readiness (Neyer et al., 2012) instrument: technology acceptance, technology competence, and technology control. The second step consisted of a *k*-means procedure to assign pre-service teachers to their profile and was followed up by an additional discriminant analysis in order to validate the number of clusters. Further analyses included the examination of the relationship between the affiliation with the particular cluster and teachers' sociodemographic variables (i.e., age, gender, teaching experience, and school track). Finally, to explore group difference in emotional state variables relative to cluster membership, mean differences between the groups on the PA and NA scales were analyzed using one-way variance analyses (ANOVA; Rutherford, 2011).

Results

Teachers' technology readiness and emotional state

Mean and standard deviation scores were calculated to determine teachers' technology readiness. As shown in Table 1, the values for teachers' technology acceptance, competence, and control were between 3.66 and 4.16. As the theoretical mean of the scales was 3, the results from the one sample *t*-tests indicate that teachers accept technology, feel competent, and perceive a significantly positive control expectation of technological instruments and process. Finally, *t*-tests assessing differences in gender for the variables under study revealed that, in comparison to male participants, female teachers are less acceptant of technology ($M = 3.54$; SD = 0.85), $t(121) = -2.91$, $p < 0.01$, perceive themselves less competent, ($M = 4.06$; SD = 0.80), $t(121) = -2.82$, $p < 0.01$, and consider to have less control of technological instruments and processes, ($M = 3.70$; SD = 0.66), $t(121) = -2.55$, $p < 0.05$. With regard to teachers' emotional state during emergency remote teaching, no significant difference to the theoretical mean was found for teachers' PA or NA.

Teacher technology readiness profiles: Cluster analysis

In order to identify teacher groups, a hierarchical cluster analysis was performed to identify the clusters related to the dimensions of technology readiness. The dendrogram suggested a two- or three-cluster solution. Second, in order to assign the teachers into their readiness profile, a *k*-means cluster analysis was conducted. Based on the variation between the clusters, on the one hand, and the theoretical framework, on the other hand, a

TABLE 1 Means, standard deviations, one sample *t*-statistics and effect size ($N = 124$).

Variables	*M*	SD	*t*(122)	*p*	Cohen's *d*
1. Technology acceptance	3.66	0.87	8.39	<0.001	0.87
2. Technology competence	4.16	0.79	16.27	<0.001	0.79
3. Technology control	3.78	0.67	12.81	<0.001	0.67
4. PA	3.63	0.94	1.48	n.s.	–
5. NA	3.60	0.95	1.14	n.s.	–

three-cluster solution was identified and chosen. Finally, a discriminant analysis was performed where two discriminant functions were identified. The first function showed a canonical correlation of $R = 0.92$ (eigenvalue = 5.78; Wilks Lambda = 0.12; $p < 0.001$; explained variation 95.7%), the second function showed $R = 0.45$ (eigenvalue = 0.26; Wilks Lambda = 0.80; $p < 0.001$; explained variation 4.3%). In total, 96.7% of the cases grouped by the cluster analysis were correctly classified; accordingly, 3.3% cases were reassigned. The final clusters are composed as follows: cluster 1, the smallest, included 28 teachers (23%), cluster 2, the largest, included 65 teachers (52%), and cluster 3 included 31 teachers (25%). As shown in Table 1, one-way ANOVA with post-hoc analyses indicated that the three technology readiness scales significantly varied within clusters, and therefore, these profiles were valid.

The following section offers a description of the three clusters, while Figure 1 visually presents the teacher profiles:

- Cluster 1: teachers in the first cluster were characterized by the lowest mean scores for all technology readiness scales. In particular, technology acceptance was marked by a low value that differed strongly from the other teacher groups. However, teacher scores for the technology competence and control scales were about the average scale value. Thus, it can be assumed that teachers in this profile perceive themselves moderately competent and with control of technological process, nevertheless, are less acceptant of technology and do not fully recognize its importance, usefulness, and added value.
- Cluster 2: In general, teachers in this cluster indicated high mean values in the three technology readiness scales; however, their mean score values were lower than cluster 3. A particular distinctive characteristic from this cluster is, that in comparison to their mean scores on the technology acceptance and control scales, teachers here reported a considerably higher mean value for their technology competence.
- Cluster 3: teachers in the third cluster were characterized by the highest attribute level, exhibited equally for all technology readiness scales. This indicates that such teachers perceived themselves to be acceptant of

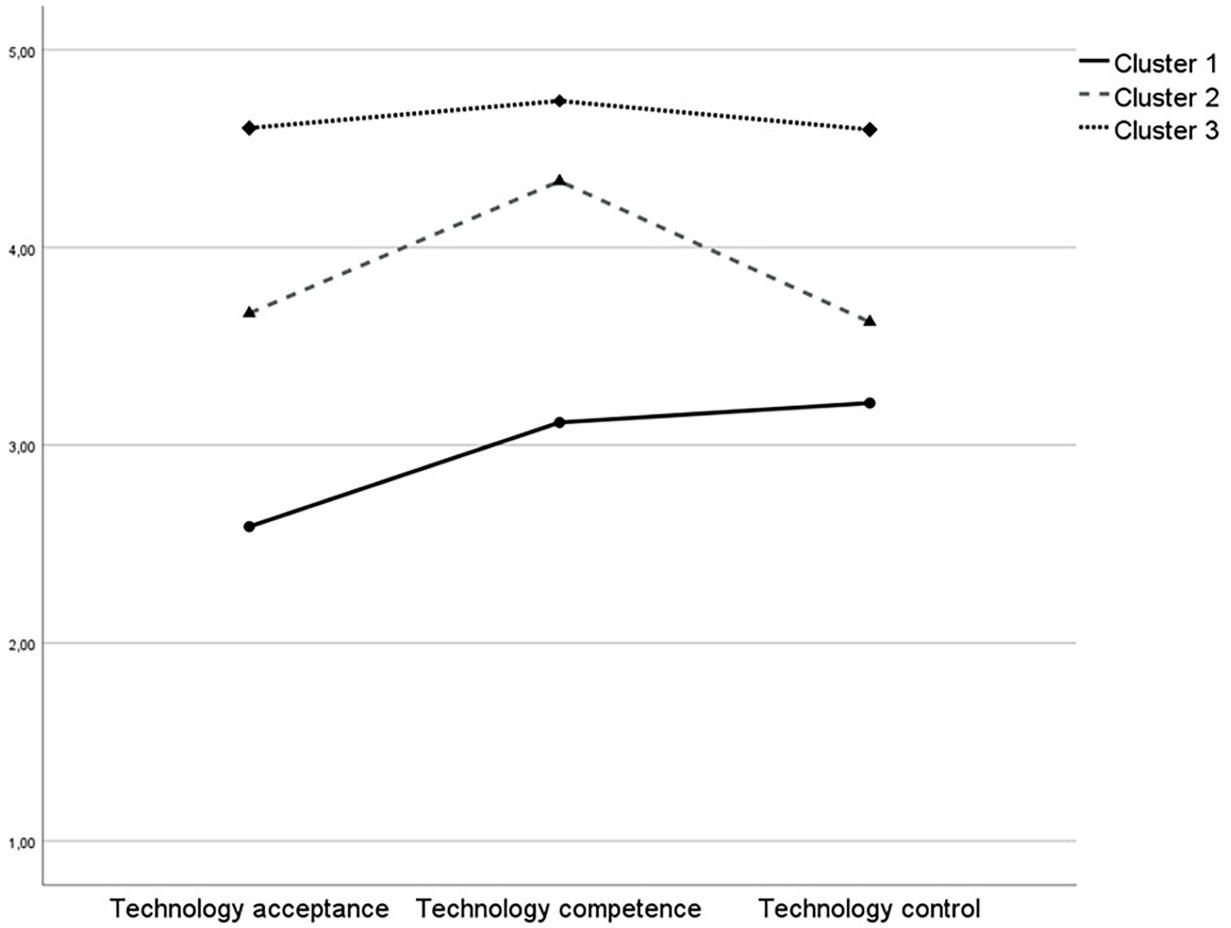

FIGURE 1
Technology readiness teacher clusters.

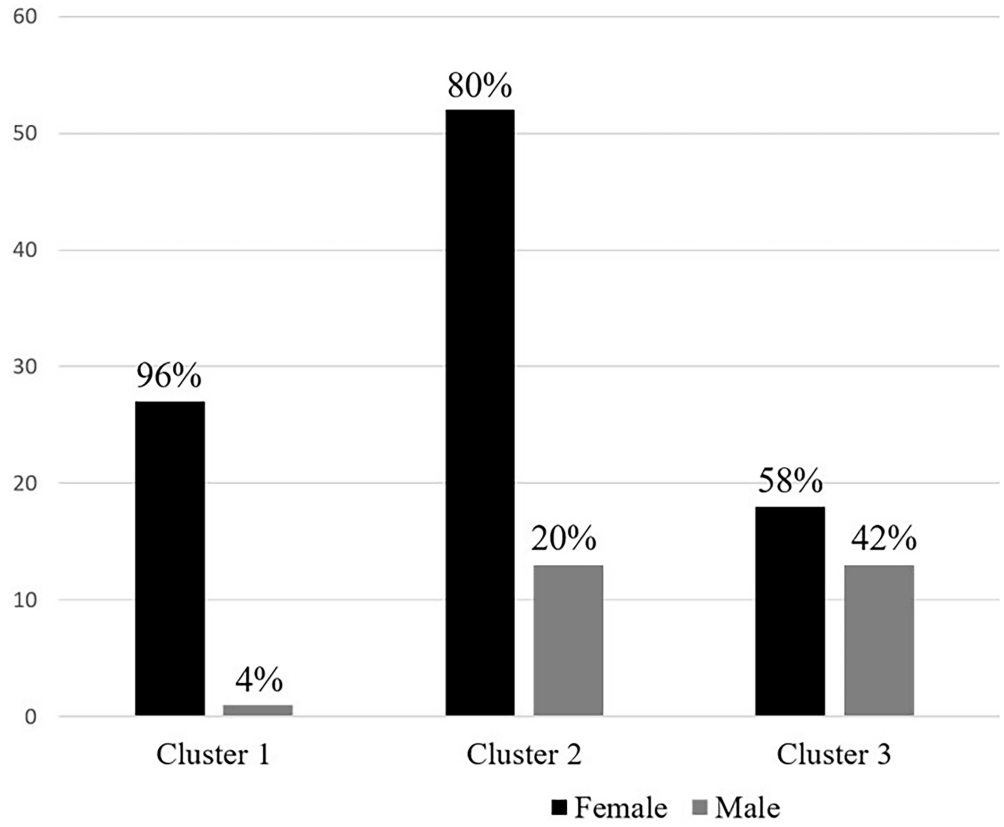

FIGURE 2
Distribution of teachers over the different technology readiness clusters.

technology as they recognize the importance and necessity of technological instruments and process, consider highly competent and in control of technological tools and devices.

Subsequently, a multivariate analysis of variance (MANOVA) was conducted to explore whether the scores of the separate variables in each of the profiles differed between the clusters. MANOVA has been selected instead of running multiple ANOVAs as a means to prevent the risk of making a Type 1 error and maintain the relationship between the variables (Field, 2013). The Wilks' Lambda was revealed to be significant highlighting the differences between the clusters, [$F(2,119) = 19.54$, $p < 0.001$, partial $\eta^2 = 0.25$]. Finally, chi-square tests of association were used to examined whether there was a relationship between the profiles and the demographic variables. Such analyses showed no significant association between teacher profile, age, and teaching experience. However, the analyses did reveal significant results for the relationship between profile and gender, χ^2 (2) = 12.97, $p < 0.01$. When observing in detail the distribution of teachers across the profiles (Figure 2), it is possible to observe that both clusters 1 and 2 are mainly represented by female teachers, whereas profile 2 appears to be balanced.

Comparison of the teacher technology readiness profiles and their emotional state

In order to investigate whether teachers' emotional state during ERT (in the context of COVID-19) differs among the groups, two one-way ANOVAs with cluster membership as the independent variable and PA and NA as dependent variables were performed. Table 2 shows the ANOVA results. With respect to teachers' NA, no significant differences between the clusters were revealed. However, significant differences were found for teachers' PA, [$F(2,121) = 10.65$, $p < 0.001$, $\eta^2 = 0.15$]. In detail, *post hoc* tests showed that cluster 3 ($M = 4.21$; SD = 0.90) varies significantly different to cluster 1 ($M = 3.20$; SD = 0.81) and 2 ($M = 3.52$; SD = 0.88) with regards to their PA during emergency remote teaching ($p < 0.01$). In contrast, cluster 1 and 2 did not varied significantly among each other. Considering the distinctive characteristics and features of each cluster (please refer to the previous section for a detailed description of the teacher clusters), it can be assumed that a positive emotional state does not solely rely on teachers perceiving themselves either technologically competent, acceptant of technology, or having higher technology control beliefs; but rather a meaningful interdependent balance

TABLE 2 One-way ANOVA of the technology readiness scales between profiles.

Domain	Cluster 1		Cluster 2		Cluster 3			
	M	SD	*M*	SD	*M*	SD	*F(2,431)*	η^2
Technology acceptance	2.59	0.57	3.67	0.54	4.61	0.43	110.50**	0.65
Technology competence	3.12	0.7	4.34	0.51	4.74	0.36	77.24**	0.56
Technology control	3.21	0.46	3.63	0.48	4.6	0.33	78.58**	0.57

**$p < 0.01$.

between all three technology readiness variables, that is: teachers who are strongly acceptant of technology, considered themselves highly competent and in control of technology, experienced a far more positive emotional state during ERT.

Discussion

The COVID-19 pandemic forced teachers to rapidly shift from regular face-to-face teaching to ERT. With this unprecedent context, teachers were left to prepare teaching remotely within a short time span and with few supports. As a result, teachers faced multiple challenges leading them to experience a heavy burden, high workload, stress, and negative emotions (Klapproth et al., 2020; Portillo et al., 2020). There have been multiple studies exploring teachers' challenges and teaching practices during ERT as well as their technology competencies, readiness, and emotional states, however, there is still little research on the factors (and their interrelations) that account for the differences between teachers' experiences of ERT (Helm et al., 2021). In other words, it is still unclear how and why such shift into remote teaching was simpler for some teachers than others (Adov and Mäeots, 2021), or why some teachers were able to master the faced challenges (Klapproth et al., 2020). Against this background, the present study aimed to explore teacher profiles based on the different technology readiness domains (Neyer et al., 2012). Identifying teacher technology readiness profiles provides the opportunity to analyze in-depth the professional development and training needs that teachers require for an effective and adaptive technology use in their teaching practice. Additionally, this study sought to investigate whether teachers' emotional state varied between the teacher technology readiness profiles.

Descriptive results revealed that overall teachers perceived themselves highly acceptable, competent, and in control of technology. Such results appear to be contradictory to previous research that indicates that teachers in general feel not sufficiently competent to use technology for teaching and learning (Helm et al., 2021). However, it is important to highlight that Neyer et al.'s (2012) technology readiness scale measures an individual's general willingness and commitment toward every day technology devices, media, and tools. Thus, the results from this study indicate that teachers feel acceptant, competent and in control of regular digital situation or tools (email, PowerPoint, videoconference tools, etc.). In this context, our results are in line with the findings from Portillo et al. (2020) who reported that teachers perceived significantly competent and acceptant of common technological devices. Taken together, such findings are of importance given that they serve as a foundation for the development of digital teaching methods that are related to positive students' outcomes (Cabero-Almenara et al., 2020).

For gender, findings indicated significant differences in teachers' technology readiness, in which female participants reported lower levels of all three domains. Previous research has demonstrated considerable differences between the genders, providing evidence for example, that male teachers hold a higher technology readiness level than their female counterparts (Summak et al., 2010). Overall, empirical research in the field of ICT suggests that female participants are falling behind in terms of a wide range of variables (e.g., attitudes, self-confidence, interest, readiness and digital skills; Tømte, 2008; Ferreira, 2017). However, it is argued that such an argument can only be considered valid if male participants' ratings are used as the norm and, thus, as representative of the "expected" standard (Drent and Meelissen, 2008). In this sense, Ferreira (2017) discusses that these differences might stem from deep-rooted gender stereotypes and preconceived ideas of how women and men use (or should use) technology. Consequently, the statistically significant gender differences within this study does not automatically imply that female participants are falling behind the male sample. When taking a closer look at the study's results, it can be observed that the total mean score for the sample's technology readiness was significantly higher than the mean (c.f. Section "Teachers' technology readiness and emotional state"), indicating that in general both male and female participants hold higher levels of technology readiness. More specifically, in this sample, only 2% of the female participants can be considered to be at risk (given their extremely low ratings regarding their technology readiness). Taken altogether, this study calls for critical reflection on gender differences and technology readiness as well as on the evaluation of such differences.

Three distinctly characterized teacher technology readiness profiles were found. The first profile was represented by teachers scoring particularly low in technology acceptance and in average on both technology competence and control. Based on the theoretical assumptions and research on technology readiness (Neyer et al., 2012), it can be assumed although these teachers feel skillful and positive toward technology-relevant actions, they do not fully seem acceptant and willing to use technology nor consider it valuable for

everyday life. The second profile was represented by teachers scoring significantly higher in all three domains, however with a predominant higher rating for competence. For this profile it is possible to assume that teachers do perceive themselves competent in common digital instruments, devices, and actions, however do not fully consider the added-value of technology neither consider themselves to be strongly under control of their technology use outcomes. Lastly, the third profile was mainly represented by teachers scoring equivalently among the three technology readiness domains. Based on the empirical evidence (Neyer et al., 2012; Petko et al., 2018; Amhag et al., 2019; Adov and Mäeots, 2021; Woltran et al., 2022), it can be assumed that such teachers are convinced that technology is beneficial, recognize the added value of technology, consider themselves competent to use digital technology, as well as have positive control beliefs and experiences in technology-relevant situations. When comparing the three profiles based on their demographic variables of gender, teaching experience, and school track, only a significant association between technology readiness profile and gender was found. Both cluster one and two, in which teachers rated their technology acceptance, competence, and/or control significantly lower than cluster 3, were mainly characterized by a higher distribution of female teachers. Thus, clustering results from this study appears to be consistent with previous research that has reported that female teachers have lower technology competence mean values (Portillo et al., 2020), are less acceptant and hold less positive attitudes toward ICT than their male counterparts (Tondeur et al., 2016; Cain et al., 2017). Although gender differences were discussed in the earlier paragraph, it is still important to emphasize the need to actively support female teachers as well as to reflex on the fact that "the transmission of social gender roles is maintained" (Portillo et al., 2020, p. 9).

When comparing teachers' emotional states across three teacher technology readiness profiles, surprisingly, there were no differences across their negative emotional states. Thus, it can be said that the technology readiness domains did not have positively or negatively impact teachers' negative emotional state during ERT. This is an important finding because even if teachers reported significantly lower levels of technology acceptance, as in the case of cluster one, there was no association to more negative emotional experiences. On the other hand, results did indicated differences in teachers' positive emotional state when comparing the three clusters. In detail, it was revealed that teachers in cluster three had a significantly higher positive emotional state when compared to their teacher counterparts belonging to cluster one and two. In contrast, and important to emphasize is, that teachers within cluster one and two did not significantly vary among each other in terms of their positive emotional state. When comparing our results with previous research on technology readiness and emotional state (Händel et al., 2020), it seems that they draw a similar pattern. Thus, teachers who are technologically ready and willingly (cluster three) experienced a higher positive emotional state. In contrast, teachers who lack the technology acceptance, competence and control might experience less motivation, enthusiasm and calm. Taken together, the findings highlight the importance for all three technology readiness levels to be both equally high for teachers to able to experience a positive emotional state when working with technology. In other words, the sum of each of the individual technology readiness domains might not be supportive for teachers' positive emotional experiences during ERT, but rather a meaningful balance between the three domains.

Taking the findings from this study together, it is possible to identify specific areas that should be targeted in teacher development programs. First, regardless of gender, technology readiness plays an important role not only adaptive technology use, but also on their emotional experiences resulting from technology integration. Thus, teacher professional development programs should foster not only educators' technology competence, but also their acceptance and control for technology by promoting and providing them means to learn how to meaningfully and productively make use of technology and digital instruments. Second, teacher professional development can strategically target the needs of the specific clusters. For instance, cluster one and two should have a special focus on fostering and developing their attitudes and control beliefs through action-oriented courses that would allow them to test technology in their teaching situations. Such experiences would also provide them the opportunities to reflect and evaluate whether and how technology benefitted or improved their teaching practice. On the other hand, teachers in cluster three, could be provided with advanced and specialized courses on new technology innovations for schools. They could also serve as mentors and role models for their colleagues in cluster one and two, and can be also given the opportunity of working together to develop new technology enhanced formats with their teacher colleagues and school staff.

Additionally, the findings from this study also point out at the important role that teacher education has on pre-service teachers' future performance and successful mastery of new challenges. In particular, results emphasis the need to foster the development of pre-service teachers' technology-related competencies, attitudes, and beliefs. This can be done by allowing pre-service teachers they to observe technology integration during their teaching internships and collaborate with their peers in authentic scenarios (Tondeur et al., 2012). Moreover, pre-service teachers should also be encouraged to design lesson plans incorporating technology as a teaching instrument, to pilot such lesson plans, and to implement them in the classroom. Lastly, schools and universities should partner up to enable pre-service teachers to work together with in-service teachers in real "teaching" situations (Hobbs, 2011; Tondeur et al., 2018).

Limitations and further research

It is necessary to acknowledge several limitations. First, the present study used convenient sampling, which is a common research strategy that possesses great advantages (e.g., least time-intensive and simple to conduct). However, it also carries important disadvantages. One of these is that the results obtained from such samples have generality only to the sample under study (Bornstein

et al., 2013). Additionally, teachers in special education and vocational schools, as well as other school tracks are underrepresented. Thus, there might be a limitation regarding the representativeness of the sample to the population. Therefore, the findings from this study must be considered with caution. In this sense, future research should not only include a larger sample but aim for a balance between school track teacher samples in order to improve the generality and transferability of the findings. A second limitation is that the present study uses teachers' self-reports. Hence, such responses can inherently be sensitive to overestimation, underestimation, or socially desired answers. A study by Desimone and Long (2010), however, revealed that teachers' self-reports regarding their teaching practices are highly correlated to classroom observations. Nonetheless, future research should not only make use of self-reports but integrate classroom observations as well.

A third important limitation is that this study holds a cross-sectional design as it only explores data from the first school shutdown. Thus, further longitudinal studies must be designed to identify how teachers' technology readiness and emotional state have evolved throughout the COVID-19 pandemic and school closures. This is in particular important given current studies indicate that due to the transition to ERT, teachers report that they have reflected in their teaching methods, are more motivated to integrate technology in their teaching (van der Spoel et al., 2020), and believe that their digital competencies have improved (Portillo et al., 2020; Adov and Mäeots, 2021). Furthermore, given that different methods of clustering analysis could yield different results (Field, 2013), it would be important for further research to test such structure in other German teachers as well as conduct qualitative interviews with participants to confirm the link between the respondents and the cluster they were ascribed to (Vanslambrouck et al., 2018). Finally, the present study did not included measures of technology use during ERT, therefore, it is not possible to explain or assume whether, for instance, teachers' technology readiness profile is associated to their technology integration (and frequency) during ERT, or whether there is any link between technology use and emotional state. Thus, future research should focus on analyzing the relations between such three factors.

Conclusion

The COVID-19 pandemic has imposed unprecedented challenges to teachers across schools worldwide, yet: "This substantial change provided us with an extraordinary opportunity to learn about the role of technology […] in a situation where teachers did not have any other option" (Adov and Mäeots, 2021, p. 1). Teachers have a key role in the effective delivery of ERT, but research has shown that there are teachers that have struggled mastering remote teaching. Consequently, teachers are suffering from stress and negative emotional experiences during the current situation. Although studies have pointed out at important factors that have helped teachers master ERT, research still the needs to fully explore how these account for the differences between teachers' experiences. The study's results should contribute to a better understanding of teachers' experiences during ERT and lead to conclusions for teacher training and professional development. However, this study also highlights the urgency for further research, as the full impact of ERT is still not fully examined.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Inspectorate and Service Directorate (Audsichts- und Diensteistungsdirektion) of state of Rhineland-Palatinate. The patients/participants provided their written informed consent to participate in this study.

Author contributions

MP and VL-A conceived the original idea as well as planned, and carried the research project and data collection process. MP took the lead in writing the manuscript with the support from VL-A and CS who contributed to the interpretation of the results and shaped manuscript. All authors provided critical feedback to the final version of the manuscript.

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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.

Publisher's note

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