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Profiling teacher educators' strategies for professional digital competence development

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ABSTRACT

The present study investigates the variety among teacher educators (TEds) related to the use of digital resources in teaching as well as the strategies they use to develop digital competence. A person-centred approach was applied to identify meaningful patterns among TEds having different levels of self-reported digital expertise, at five teacher education institutions. Survey data from TEds (N = 389) was subjected to structural equation modelling. With latent class analysis, we identified three distinct profiles based on probability of engagement in different digital competence development (DCD) activities: 1) *The restrictive user*—characterised by sporadic and narrow use of DCD strategies, prefers peer-restricted collaboration, 2) *The moderate user*—regular user of DCD strategies, prefers peer-restricted collaboration, and 3) *The extensive user*—frequent and comprehensive user DCD strategies, engages in broad collaboration. *The extensive users* also use digital resources more frequently in their teaching compared to *the moderate* and especially *the restricted users*. This is the case for individual interactions with students, to make teaching more relevant and applicable, as well as to make teaching more student active. Based on the knowledge on TEds profiles emerging from this study, we propose recommendations for better tailoring of DCD initiatives.

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1. Introduction

An urgent challenge for teacher educators (TEds) today is implementing everchanging digital resources in ways that promote learning, while also modelling for student teachers how digital technologies can be used to enhance pupils' learning in school (Parrish & Sadera, 2019; Tondeur et al., 2019). TEds play a dual role when creating digitally rich

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learning environments that model the types of learning that they would like their student teachers to replicate in their schoolpractice. They teach, not only the subject matter, but also *how* to teach it, engaging students in reflecting on their teaching. This is why some scholars call them 'second-order teachers' (Uerz et al., 2018). To fulfil this complex role, they need digital competence development (DCD; Foulger et al., 2017; Lindfors et al., 2021; Nagel et al., 2023; Uerz et al., 2018). Developing digital competence for TEds encompasses technological proficiency, social awareness, and pedagogical understanding of how digital technologies can be utilised in teaching (Gondwe, 2021; Instefjord & Munthe, 2017). Therefore, DCD for TEds involves a broad range of purposes for using digital technologies (e.g., Røkenes & Krumsvik, 2014), such as facilitating student-active learning, making learning more relevant for the teaching profession, aa well as promoting communication and collaboration. Digital technologies can also pose downsides for learners, including digital distractions (e.g., Hatlevik & Bjarnø, 2021), cyber bullying (Evangelio et al., 2022), and distinguishing between facts and fake news (Musgrove et al., 2018). Consequently, knowledge of how TEds develop their own and student teachers' digital competence and the different purposes for using digital technologies is highly relevant to ensuring quality in teacher education (TE).

The overarching goal of the present study is to examine how TEds develop their competence in using digital resources, and the associations between DCD strategies and their purposes for using digital resources in TE. To reach the goal, we first explore whether there are various profiles of DCD strategies among Teds, based on the number, type, and frequency of DCD strategies in which they are typically engaged. Second, we assess how the profiles are related to TEds' use of digital resources in education as well as to individual characteristics. To do this, we adopt a person-centred approach using latent class analysis. Previous studies have demonstrated the usefulness of such an analysis in explaining heterogeneity among teachers, such as TEds' abilities to prepare student teachers for integrating technology into their teaching (Tondeur et al., 2019), as well as higher education teachers' levels of readiness for online teaching (Scherer et al., 2021).

The present study relates to the scope of the Special Issue by providing knowledge on how TEds engage with different DCD initiatives and how this is related to their perception of their digital competence and the ways they use digital resources with their students. Based on the findings, the study also recommends a research-based model for PDC development for TEds, thus contributing to this under-researched field (Ping et al., 2018; Tondeur et al., 2019). Moreover, the model provides knowledge for better tailoring of DCD initiatives to support TEds' professional learning during their careers.

1.1. Digital competence development for teds

Kirkwood and Price (2013) argued that TEds benefit from participating in various faculty development activities to foster their technology-specific competence and, hence, can increase their hands-on use of these technologies in the classroom. Other scholars have recommended engaging TEds in reflective learning and tailoring DCD to the pedagogical context and needs of the individual TEd (Parrish & Sadera, 2019; Uerz et al., 2018). TEds often prefer professional learning opportunities that facilitate the mutual sharing of expertise (Lindfors et al., 2021; Parrish & Sadera, 2019; Røkenes et al., 2022).

Additionally, interdisciplinary or multidisciplinary collaboration within and outside the teacher education institution is recommended (Reading & Doyle, 2012). Collaboration can also include partnerships with student teachers, practicing schoolteachers, other faculties, or technology specialists, as both formal and informal learning opportunities.

Although the above scholars provide insights into beneficial ways to support DCD for TEds, to the best of our knowledge, neither they nor other scholars have investigated *how* TEds develop their digital competence across teacher education institutions. To contribute to the limited research body on TEds' (Ping et al., 2018) and to provide practical insights that may contribute to and inspire future DCD approaches for TEds, in this study, we first explore whether there are various profiles of DCD strategies among TEDs.

1.2. Purposes for using digital resources in teacher education

Scholars (e.g., Basilotta-Gómez-Pablos et al., 2022; Røkenes & Krumsvik, 2014) have identified several purposes for using digital resources in higher education teaching, including (1) facilitating for more student-active learning, (2) professionally relevant learning, and (3) interaction and communication. However, we posit that TEds' use of different digital technologies is driven by how they approach teaching and operate in their specific contexts (e.g., subject discipline; Tondeur et al., 2019). In other words, digital technologies have the potential, but do not necessarily transform TEds' teaching practices.

First, *student-active learning* emphasises active involvement rather than passive teacher lecturing (Hackathorn et al., 2011), which implies shifting pedagogical control from teachers to learners, while actively supporting students. An example is engaging student teachers in creating digital timelines, which has been shown to increase motivation, engagement, and collaboration (DeCoito & Vacca, 2020). Furthermore, digital storytelling has been used to facilitate student teachers' shift from consumers to producers of knowledge (Røkenes, 2016). In the latter, TEds modelled for the student teachers how they could use digital stories to promote *student-active learning* in English and foreign language teaching.

Second, the educational use of digital resources is associated with *making learning more professionally relevant* by situating teaching and learning in the context of real-world or future situations (Herrington et al., 2014). For instance, several studies have addressed the use of technology as a resource for aligning theoretical and practical knowledge in teacher education (e.g., Røkenes & Krumsvik, 2016). Based on a review of the use of games and simulations in higher education, Vlachopoulos and Makri (2017) concluded that games and simulations have a positive impact on cognitive, behavioural, and affective learning goals. Furthermore, they called for playfulness and problem-based learning, which can promote content understanding, concept learning, self-assessment, and higher-order thinking skills. Other researchers have shown how student teachers learn classroom management through computer-based classroom simulations and have documented that self-efficacy can be promoted in such designs (Theelen et al., 2019).

Third, digital resources are used to promote *interaction and communication* in learning processes, both among students and between students and teachers. For instance, Major et al. (2018) showed how digital environments can be designed to

promote challenging dialogues and multiple perspectives, thereby engaging students in the co-construction of knowledge. Others have found that digital communication and interaction can enhance the quality of formative assessment and supervision. For instance, video annotation is used in peer feedback to promote students' communication and reflection on their practices (Nagel & Engeness, 2021). Video feedback has also been found to raise the quality of teachers' instruction, particularly if targeted towards domain-specific teaching behaviours (Brouwer et al., 2017).

Although national surveys have provided insights into digitalisation and the general use of digital technology in higher education, there is a lack of recent studies investigating TEds' actual use of digital technologies, especially quantitative investigations (Uerz et al., 2018). In the present study, we explore the associations between TEds' profiles of DCD strategies and the educational goals that guide their use of digital resources when interacting with student teachers.

1.3. The present study

In the present study, we use cross-sectional survey data to investigate DCD profiles among TEds to address the following research questions (RQ):

(1) What profiles exist among TEds regarding their strategies for developing their competence in using digital resources in teacher education?
(2) To what extent can profile membership be explained by the TEds' backgrounds, that is, gender, institutional affiliation, and self-assessed level of expertise with digital resources?
(3) To what extent are profile memberships associated with TEds' use of digital resources in their teaching?

The survey data analysed provide contemporary insights into the international relevance of TEds' profiles and how teacher education institutions can tailor DCD initiatives for TEds so that they are capable of executing their dual role as secondary order teachers and adequately preparing student teachers for teaching in digitally rich environments.

1.4. Research context

The Norwegian context of this study is of international interest for several reasons. First, Norway is one of the most digitalised nations in the world, with about 90% of schools providing a digital device to each student (The Norwegian Directorate for Education and Training, 2022). Second, Norwegian educational authorities have placed significant emphasis on the implementation of digital competence throughout school and teacher education for many years (Erstad et al., 2021; Lisborg et al., 2021). For instance, a national professional digital competence framework was established in 2017 (Kelentrić et al., 2017) to assist schools, programmes, and policymakers in addressing the competence requirements of current and future teachers.

Regarding higher education institutions, access to digital resources was provided already 15 years ago, with solid digital infrastructure and the provision of some technical support. However, the DCD of educators has long been left to individual enthusiasts

(Stensaker et al., 2007). In 2017, the Norwegian Ministry of Education granted €9 million to 5 of the 13teacher education institutions offering basic education teacher training in Norway. The funding was applied to develop R&D projects at each teacher education institution to enhance DCD among TEds and to prepare students for both the possibilities and challenges of teaching in digitally infused schools. Therefore, these teacher education institutions had financial means to be at the forefront of DCD in Norway (Amdam et al., 2022). The R&D projects lasted from 2018–2021.

The grants required TE institutions to support TEds' development of the competencies described in the national professional digital competence framework (Kelentrić et al., 2017). The projects were to include the main parts of the study programmes and all subject areas. They were to establish DCD arenas, courses, and support for TEds (Amdam et al., 2022). For instance, the institutions developed courses to explore and research how to integrate digital technologies in and across the TEds' subject disciplines, and they were sent to national network meetings to share their experiences with student-active learning in digital environments (e.g., Aagaard et al., 2022). Furthermore, all the institutions stimulated self-study and shared learning resources online. Technical support was also provided by teaching and learning support units and student assistants (e.g., Amdam et al., 2022). Moreover, arenas for collaboration and sharing expertise between university- and school-based TEds and teachers were established to strengthen the links between how digital technologies were used across schools and in TEs (e.g., Andreasen, 2023). Overall, the institutions followed an approach that stimulated collaboration with peers in and across subjects and institutions, with schools as well as external experts.

2. Methods

2.1. Instrument development process

This study's questionnaire originated as a project initiative to investigate how TEds across the five previously mentioned teacher education institutions (Daus et al., 2019; Hjukse et al., 2020) engaged in DCD and promoted student teachers' professional digital competence. Five of the co-authors of this article led the aforementioned R&D projects and co-created the questionnaire together with researchers from the Nordic Institute for Studies of Innovation, Research and Education (NIFU).

In the first phase, we considered the pros and cons of reusing questions from existing surveys on DCD and digital technology use in higher education, as well as in schools employed in research (e.g., Krumsvik et al., 2013; Røkenes & Krumsvik, 2016) or in policy initiatives (European Schoolnet, 2018; Guðmundsdóttir et al., 2014; Kofoed et al., 2019). For example, we drew on items from a survey on digital competence in Norwegian upper-secondary schools (Krumsvik et al., 2013), which had also been adapted and operationalised in a Norwegian teacher education context (Røkenes & Krumsvik, 2016). We also reused selected items from a more recent survey about digital competence, ICT use, and DCD initiatives in Norwegian higher education (Kofoed et al., 2019). However, we needed to align the list of DCD strategies with the strategies applied in the R&D projects. We also exploited our extensive and up-to-date thematic and methodological competence and insider experience from TE, when adding some

purposes for using digital technologies to those listed in Kofoed et al.'s (2019) survey. For instance, 'making the teaching more working life relevant' was important to include, as this is a continuous challenge in teacher education (Uerz et al., 2018).

2.2. Sample and instrument validation

Based on a survey pilot in 2019 with subsequent analyses, we identified areas in need of improvement in the adopted instruments (Daus et al., 2019; Hjukse et al., 2020), which preceded revisions and final administration in 2021 (Pedersen & Vika, 2022). A personal invitation to a web-based questionnaire was sent to 698 TEds at the five institutions in 2021, of which 389 responded ($n_1 = 34$, $n_2 = 37$, $n_3 = 136$, $n_4 = 75$, $n_5 = 107$) after four reminders and no incentives, resulting in a response rate of 55.7%. This finally resulted in 303 observations for the last analyses, where all background variables were included. The study was registered and approved by the Norwegian Centre for Research Data (project no: 609,036).

Below, we describe the analysed instruments. Item distributions for all instruments are displayed in Appendix Table A in supplementary material. The ordinal response options 1 ('Not at all'), 2 ('To a small extent'), 3 ('To some extent'), and 4 ('To a large extent') were used for all instruments.

2.2.1. Digital competence development strategies

The instrument consists of 11 items capturing frequency in the use of DCD activities to enhance personal competence in digital resource use. The instrument encompasses a variety of commonly used DCD strategies relevant to the professional development initiatives at the five TEds. The term 'digital resources' was defined in the survey as 'digital tools, services, and content', for instance, 'digital technologies (tablets, PCs, etc.) used in combination with digital learning resources, websites, learning platforms, interaction tools, co-writing technology, response technology, video, animations, and games.' The main prompt was, 'How do you usually develop your competence in using digital resources in education?' In our study, one item was discarded during the analyses due to a lack of variation.

We further measured three aspects of the learning-related purposes of digital resources. *Student-active learning* (SAL) consisted of four items capturing the extent to which TEds use digital resources to make teaching more student-active. *Communication with students* (COM) consisted of four items capturing the extent to which respondents use digital resources for various non-instructional purposes in TE, including tutoring, outside-class communication with students, assessment, and student–praxis cooperation. *Working-life relevance* (WLR) consisted of three items capturing the extent to which TEds use digital resources to make the lessons more relevant regarding the subject discipline, school praxis, and contemporary issues. In confirmatory factor analyses of unidimensionality, with observed variables as categorical with the means- and variance-adjusted weighted least squares estimator (WLSMV in Mplus), the data fit was excellent for both SAL ($\chi^2 = 2.89$, $df = 2$, $p = .235$, CFI = 1.00, TLI = 0.99, RMSEA = .04, SRMR = .02) and COM ($\chi^2 = 3.22$, $df = 2$, $p = .200$, CFI = .99, TLI = .98, RMSEA = .04, SRMR = .02). Due to the number of items being below 4, unidimensionality cannot be established directly using confirmatory factor analyses. However, exploratory factor analysis with SAL, COM,

and WLR resulted in an adequate fit to a three-factor solution (χ^2 = 84.9, *df* = 33, *p* = <.001, CFI = .98, TLI = .96, RMSEA = .07, SRMR = .05), with expected factor loadings. SAL and COM had adequate internal consistency (α_{SAL} = .74 and α_{COM} = .64). Regarding the confirmatory factor analyses, SAL was scalarly invariant, that is, equivalent in form and quality, hence permitting meaningful comparisons across genders but not across levels of expertise. *COM* was scalarly invariant across levels of expertise and gender. WLR was metrically (i.e. partially) invariant across levels of expertise, although not for gender. Invariance across organisations was not estimable for any of the three instruments, due to non-convergence. High correlations between SAL, WLR, and COM (.87.89.86) provided the evidence that each of the three reflected different aspects of the purposes of digital resources.

2.2.2. Background characteristics

Based on prior studies (Diery et al., 2020), we included the following explanatory observed variables: gender (binary, reference category: male), institution (reference category: largest institution), as well as level of expertise. The latter was derived from a question on the self-assessed level of expertise with digital resources in education (beginner, modest user, experienced user, and expert). Given that 91% had chosen the two mid-categories, the first two expertise levels were collapsed into 'low' (reference category), and the top two levels were collapsed into 'high'. Due to non-identification issues with our sample size, we could not include the following variables despite simplifications: years of experience teaching in school, age, and position.

2.3. Analytical approach

We modelled the profiles of DCD strategies as latent categorical variables using mixture structural equation modelling (Muthén, 2001). This involved investigating the optimal number of profiles represented by latent classes. To empirically determine the optimal number of profiles, we followed Masyn's (2013) recommendations. We assessed goodness of fit, primarily by identifying the model with the lowest Bayesian information criterion (BIC) and the sample-size adjusted BIC (SABIC), both of which have been shown to penalise complexity most appropriately (Henson et al., 2007; Marsh et al., 2009; Morgan, 2014; Schwarz, 1978). We also inspected these criteria using elbow plots and classification accuracy. Classification accuracy, as captured with the entropy index, is favourable when close to one and inaccurate when close to zero (Celeux & Soromenho, 1996). Finally, we used Lo-Mendell-Rubin and Vuong-Lo-Mendell-Rubin likelihood ratio tests (LMR-LRT and VLMR-LRT). Failure to reject the null hypothesis suggests no difference in the model fit between the two models: the *k* profile solution and the *k*-1 profile solution (Lo et al., 2001).

For graphically depicting the results in a meaningful and comprehensible way, we dichotomised the likely latent group membership for the item categories (thresholds), which we discuss in detail in Appendix G in supplementary material. Differences between latent classes for a given item were significance-tested with the concurrent model constraints estimation feature in Mplus.

We also introduced predictors using multinomial logistic regression. We estimated the logits (i.e. function of the probabilities) of being in a class (i.e. intercepts), and then,

for each predictor, a change in logits for a specific category relative to the reference group, all else being equal.

In contrast to the CFA, where we used WLSMV, a robust full-information maximum likelihood estimator (MLR) in Mplus 8.4 was used for all mixture models (Muthén & Muthén, 2022). Since essentially all missing observations arose from the same respondents, this implied listwise deletion.

3. Results

3.1. RQ1: investigating possible competence development profiles among teds

Models with up to five latent classes were compared to identify the optimal number of profiles of the TEds' reported use of DCD strategies (Table 1). The best log-likelihood was replicated across all models. Entropy (i.e. classification accuracy) and SABIC improved slightly with the number of classes. However, the BIC, the corrected AIC, the VLMR test, and the LMR test suggest that the 3-class model is the optimal solution. Furthermore, its smallest profile (no. 3, 25.4%) is large enough to represent an informative TEds group, and profiles 1 and 2 are of equal size (37%).

Table 1. Model fit for varying number of latent profiles.

#	LL	k_{par}	BIC	SABIC	AICC	Entropy	*p*(VLMR-LRT)	*p*(LMR-LRT)	% smallest
1	−3,862	33	7,913	7,809	7,799				100.0
2	−3,627	67	7,638	7,425	7,428	.83	.003	.003	43.9
*3	−3,519	101	7,616	7,295	7,343	.85	.002	.002	25.4
4	−3,463	135	7,698	7,270	7,416	.88	.762	.762	31.2
5	−3,419	169	7,803	7,267	7,608	.90	.769	.769	6.4

= number of profiles, LL = Loglikelihood, k_{par} = Number of parameters, BIC = Bayesian information criterion, SABIC = Sample-size adjusted BIC, AICc = Akaike information criterion, *p*(VLMR-LRT) = p-value of the Vuong-Lo-Mendell-Rubin likelihood ratio test, *p*(LMR-LRT) = p-value of the Lo-Mendell-Rubin likelihood ratio test. % smallest = Percentage of respondents being members of the smallest profile. * = Selected model.

3.1.1. Introducing a graphical depiction of the profiles

To distinguish the profiles, we present in Figure 1 the probability of responding to the upper two categories of an item (to some extent or to a large extent) for a DCD strategy, given that the respondent is a member of a profile. Hence, 48% in the first row below means that a Ted in Profile 1 had a 48% probability of responding 'to some/to a large extent' on the item 'By searching for pedagogical advice online'. Related strategies are clustered in five blocks for clarity. This clustering is based on an exploratory factor analysis available in Appendix Section C in supplementary material, which we consider instructive for our presentation. The open brackets indicate significant differences in probabilities between profiles for a given item. All but seven comparisons were significant. The legend at the bottom includes the size of the profile as the frequency and proportion of the total.

Profile 1 (black) is labelled *restrictive users of DCD strategies*. These respondents had a lower probability of using any of the listed DCD strategies, compared with members of Profiles 2 and 3. Profile 2 (dark green) is labelled *moderate users of DCD strategies*. The members of this profile had a lower probability of using any of the strategies than those of

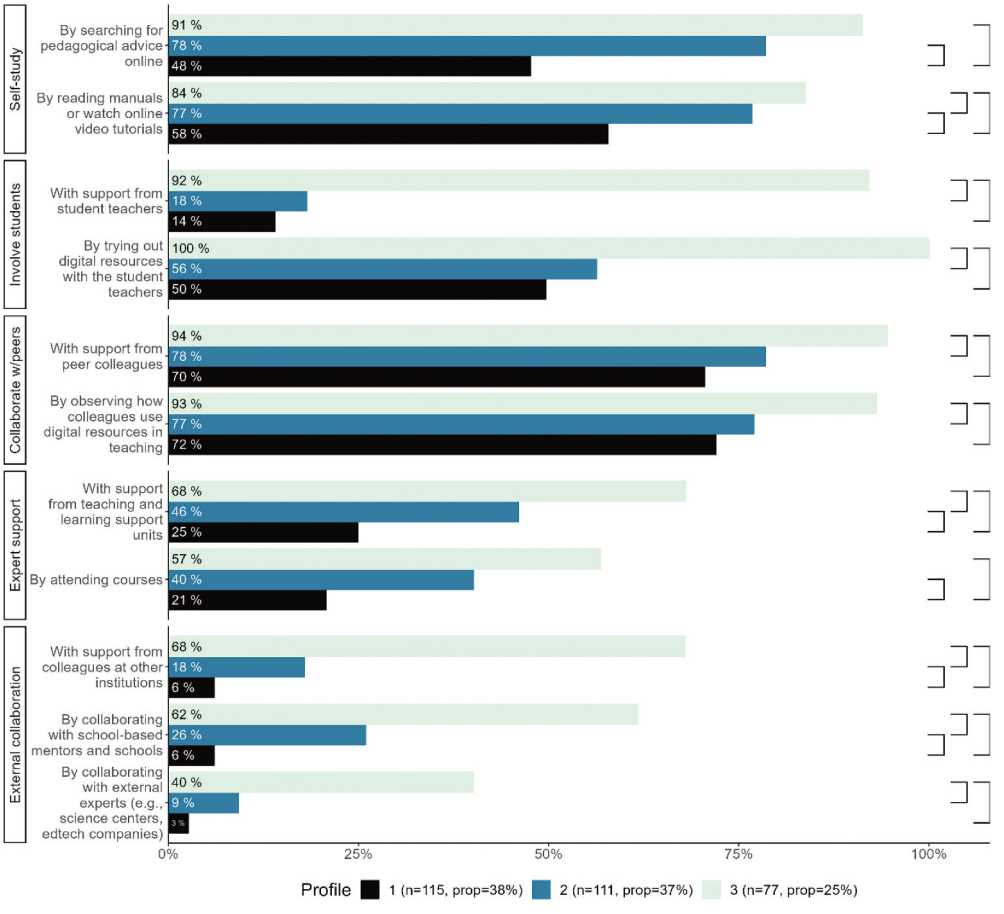

Figure 1. Probability of responding 'to some extent' or 'to a large extent' on the use of DCD strategies given profile membership Note. Main prompt: 'How do you usually develop your competence in using digital resources in education?' Only significant ($p < .05$) comparisons are shown on the right.

Profile 3 (turquoise), labelled *extensive users of DCD strategies*. Profile 3 is the profile with the fewest members, representing 25% of respondents who had a consistently higher probability of using a strategy than the two other profiles. Table 2 shows that the differences in latent means between Profiles 3 and 1 were statistically significant, although not for Profiles 1 and 2 or between Profiles 2 and 3. Thus, the general inclination to use DCD strategies differed across profiles and was greatest for Profile 3.

Table 2. Differences in latent means across profiles using profile 3 as reference group.

				95% CI		
Profile	Estimate	SE	*p*	*LL*	*UB*	% TEds
1	−0.40	0.19	.033	−0.77	−0.03	38%
2	−0.37	0.26	.159	−0.88	0.14	37%
3	0.00	–	–	–	–	25%

Estimate for profile 3 is fixed to 0 for identification, and hence lacks SE and CI.

3.1.2. Interpreting the Profile Strategies

However, the overall probabilities merely describe the quantitative aspects of the differences between profiles. To further describe the patterns that characterise profiles and distinguish between them, we investigated the composition of the most prominent DCD strategies in each profile, distinguishing between primary and secondary strategies. We define primary strategies as the highest probability items within a profile. However, the profiles sometimes share the same primary strategy. Hence, we define secondary strategies as any other item—not mentioned among the primary strategies—with a probability higher than about 50%. This second approach helps illuminate the complexities of TEds' preferences. We then applied the complementary representation of the profile differences for each item, as shown on the right side of Figure 1. In the following elaborations, we note the probabilities of responding to some or to a large extent to the strategies, given their profile membership.

Overall, *the restrictive user of DCD strategies* (Profile 1) infrequently uses the prompted DCD strategies. However, the profile characterises TEds who primarily collaborate with peers through direct support from or observation of colleagues (70–72%). The secondary strategies of this profile include reading manuals (58%), watching video clips online (48%), and trying out educational ideas and digital resources with the students (50%).

The *moderate users of DCD strategies* (Profile 2) extend Profile 1 with added attention to active self-study by searching for and watching instruction online (77–78%), in addition to collaborating with peers (77–78%). As a secondary preference, they seek to try out digital resources with students (56%). Profile 2 resembles Profile 1 with respect to the involvement of students and collaboration with peers.

Extensive users of DCD strategies (Profile 3) frequently use many strategies. However, these users involve students as a primary strategy (92–100%). The difference in DCD through student involvement is very large between Profile 3 and the other two profiles. These TEds also prefer collaboration with colleagues (93%) and self-study (84–91%). As secondary approaches, they also include educational technology courses (57%), local ICT staff (68%), and external collaboration (40–68%). Hence, Profile 3 extends the strategies of Profile 2 by further incorporating the strategies student involvement and attending courses, but resembles Profile 3 in the use of online searches.

The seemingly stepwise introduction of strategies for learning for each profile raises a hypothesis of developmental stages, which will be explored in the next section and elaborated upon in the discussion.

3.2. RQ2: gender, institution, and expertise as predictors of profile memberships

To further explore profile membership, we introduced teacher background predictors: gender, institution, and self-rated level of expertise with digital resources in education. The model fit to the data resembles that of the base model in Section 3.1, and the proportion of individuals in each profile remains similar, suggesting no need for direct effects between covariates and indicators. In using the smaller profile, *extensive users* of *DCD strategies*, as a reference group (the top two-thirds of Appendix Table E1 in supplementary material), we observed that being female, or having a higher level of expertise, reduces the odds of belonging to the *restrictive*

users of DCD strategies and *moderate users of DCD strategies*, everything else equal. No significant differences were found for covariates between *restrictive users* of *DCD strategies* and *moderate users of DCD strategies* (the bottom third of Appendix Table E1 in supplementary material) or institutions. In summary, female TEds, and TEds who were more experienced with the use of digital resources, tended to prefer student involvement and expertise support as DCD.

3.3. RQ3: association of profile memberships with teacher educators' purposes for using digital resources

Next, we supplemented the model above with three latent variables capturing the extent of one's purposes of using digital resources: (1) to make teaching relevant and practice-oriented (WLR), (2) to make teaching student-active (SAL), and (3) to communicate with students (COM) (see Appendix Table E2 in supplementary material). TEds with higher levels of WLR and SAL were less likely to be *restrictive* or *moderate users of DCD strategies* and more likely to be *extensive users of DCD strategies*, all other factors being equal. Furthermore, TEds with higher levels of WLR were less likely to be *restrictive* than *moderate users of DCD strategies* (b = −0.53, 95% CI [−0.91, −0.15]). We found no differences between *restrictive* and *moderate users of DCD strategies* regarding SAL and COM. Altogether, COM and the DCD strategy profiles were not significantly related. Although the estimates for the variables introduced in the first model resembled those of the second model, they cannot be directly compared (see e.g., Breen et al., 2018).

4. Discussion

Our main goal was to explore whether there were latent profiles among TEds regarding their strategies to enhance DCD. Further, we investigated the associations between profile membership and TEds' purposes when using digital resources in their teaching, in addition to background variables. As described above, a wide variety of DCD activities were made available to the TEds investigated in this study. The comprehensiveness of the R&D projects across the five institutions made it possible to include various commonly used strategies for DCD in our assessment. This allowed for a more in-depth understanding of the variety among TEds and their preferences for certain approaches, increasing the generalisability of the findings. Our analyses indicated that their DCD strategies can be categorised into five meaningful approaches: self-study, collaboration with peers, involving students, gaining expert support, and external collaboration. *Restrictive users of DCD strategies* engage sporadically in a narrow number of strategies, with a preference for peer-restricted collaboration and self-study. *Moderate users of DCD strategies* engage in DCD strategies regularly, but share the preference for collaboration with peers and, particularly, self-study. *Moderate users of DCD strategies* are also more inclined to seek expert support than the *restricted users*. Finally, *extensive users of DCD strategies* frequently engage in a comprehensive range of DCD strategies and collaborate broadly, including with peers, students, and to a larger extent, external partners and experts.

Our findings support studies that emphasise the importance of tailoring DCD initiatives to individual TEds to be effective (Parrish & Sadera, 2019; Tondeur et al., 2019). All

11 strategies in the survey were used at least occasionally by users of all profiles. The use of these strategies by all profiles suggests a need for a comprehensive and diverse repertoire of DCD strategies, if the intention is to reach all TEds and enable them to tailor the DCD to their competence level, preferences, and the pedagogical context they face. However, all profiles share a common preference for collaborative learning, especially with colleagues who face the same educational context and challenges.

Collaborative learning is the approach most frequently used across all profiles, and the differences between the *extensive users of DCD strategies* and the other profiles are modest, albeit statistically significant. The preference for collaborative learning might be understood in light of studies that have found that TEds often prefer professional learning that involves a mutual sharing of expertise (e.g., Lindfors et al., 2021; Parrish & Sadera, 2019; Røkenes et al., 2022). Furthermore, as facilitating collaborative learning was emphasised by all institutions as a core strategy, our findings indicate that this priority is accepted and welcomed by TEds as a community and is worth continuing with.

The fact that TEds vary in attitudes towards and use of digital resources, is a recurring finding in numerous studies (Baran, 2014; Burrows et al., 2021). Typically, previous studies have applied a qualitative or variable-centred quantitative analysis to better understand the factors influencing TEds' DCD. Our findings demonstrate the usefulness of a person-centred approach because it illuminates important differences available for interpretation (Morin & Marsh, 2015). For instance, all profiles reported frequently developing their DC by trying out digital resources when teaching. However, *extensive users of DCD strategies* stand out from the two other profiles when it comes to developing DC with student support. Engaging students in DCD implies sharing control with learners (Hackathorn et al., 2011) and providing them with active roles (Reading & Doyle, 2012). Nevertheless, we found that *moderate* and *restrictive users of DCD strategies* seldom utilised this opportunity for DCD.

In the present study, the most prominent predictor of profile membership was self-reported level of expertise. *Extensive users of DCD strategies* had the highest likelihood of containing TEds who regarded themselves as experienced in the use of digital resources as compared to *moderate* or *restricted users of DCD strategies*. A lack of technological competence is frequently identified as a barrier to integrating technology into teacher education (Ifinedo et al., 2020; Nelson et al., 2019; Uerz et al., 2018). In their study, Tondeur et al. (2019) found a strong correlation between TEds' self-efficacy, attitudes, and competence related to the pedagogical use of digital resources in teacher education (Tondeur et al., 2019). Moreover, those with high scores for these variables also reported higher levels of support for technology integration among student teachers.

Preparing student teachers for quality teaching in technology-enriched classrooms is a complex process (Uerz et al., 2018). In the present study, we explored the associations between TEds' use of DCD strategies, digital competence levels, and the educational goals that guide their use of digital resources when interacting with student teachers. *Extensive users of DCD strategies* also use digital resources more frequently to make their teaching student-active, relevant, and practice-oriented, compared to *moderate* or *restrictive users of DCD strategies*. As 'second-order teachers' (Uerz et al., 2018), TEds face the challenge of bridging the gap between campus and school practices, thereby promoting coherence in teacher education (Hammerness & Klette, 2015). Strategies to achieve more coherence may include using digital resources to make teaching more relevant and practice-

oriented (e.g., Røkenes & Krumsvik, 2014, 2016), as well as collaborating with schoolteachers and other external experts when developing educational practices and digital competence. However, we found that respondents rarely practiced these strategies, except for 25% of *extensive users of DCD strategies*. This group considered themselves experienced digital technology users and used digital resources more often than the other profiles for student-active learning, making learning relevant and communicating with students, including collaborating with those in the professional practice field. In future qualitative work in TE, these insights can be applied to discuss whether teacher educations could stimulate TEds to collaborate more systematically with schoolteachers and external partners on DCD, as well as make their teaching more relevant for the schools that their students will encounter after graduating.

4.1. Recommendations for systematic DCD initiatives in teacher education

Educational authorities and researchers have called for institution-level programmes to enhance DCD among TEds, both in Norway (e.g., Krumsvik & Jones, 2017) and internationally (e.g., Parrish & Sadera, 2019). However, teacher educations have struggled to identify the most fruitful strategies for developing TEds' DCD (Tondeur et al., 2012). A systematic and holistic approach to DCD has been called for, particularly one that incorporates both pedagogical aims and competence in integrating digital resources with pedagogical practice and subject-specific knowledge (Burrows et al., 2021; Tondeur et al., 2019). Further, Uerz et al. (2018) maintained that effective strategies are 'context-specific, tailor-made, collaborative and reflective' (Uerz et al., 2018, p. 22). The present study contributes to a relatively modest body of research on how DCD initiatives explicitly aimed at TEds can be designed to be both holistic and tailor-made.

On the basis of our analyses of the primary and secondary strategies, which constitute the three profiles, we propose that teacher education programmes could be organised as a sequence of DCD strategies where collaboration is the core. We found that TEds with less experience with digital resources tended to be among the *restrictive* and *moderate users of DCD strategies*. By contrast, *extensive users of DCD strategies* rated their expertise as high. These findings indicate that despite the variation between preferences among TEds, the profiles can be interpreted as reflecting steps towards expertise. In Figure 2, we illustrate this hypothesis as a staircase.

Figure 2 shows that for each step up from restrictive to extensive use of DCD strategies, an increasing number of strategies are being explored, and a wider variety of secondary strategies are introduced. In the right column, each profile's associated level of self-assessed expertise supports that the staircase starts with collaborative peer learning rather than coursework. The model illustrates that the differences between the profiles are not simply qualitative but represent various *levels* of preferences in professional DCD. Hence, DCD programmes aimed at TEds who are inexperienced with the use of digital resources should facilitate peer learning and self-study before they include the strategy of student involvement or try out pedagogical ideas and digital resources on their own. Experienced users of digital resources, however, could benefit from attending courses and receiving expert support.

Although our questionnaire admittedly did not distinguish between the levels of the courses attended (e.g., introductory or advanced), attending such courses might reflect a deeper involvement than what would typically be associated with a beginner. Moreover, we did not experimentally manipulate the conditions and, therefore, could not disentangle causal directions. Nevertheless, our analyses suggest that more experienced TEds use increasingly more varied strategies than novices do.

4.2. Limitations and future research

Our survey findings among TEds are not necessarily generalisable, as there is considerable uncertainty connected with the opinions and preferences of non-responders. The survey data used in our analysis suffers from a relatively low response rate of 55%, although this is not uncommon in cross-sectional studies in the field of education (Creswell & Guetterman, 2019). Non-responses and missing values in outcome variables are unlikely to be missing completely at random, meaning that those who did not complete the survey might have responded differently from those who completed the survey. Moreover, the variables included were measured with self-reported data from the perspective of the TEds. This is especially the case for the assessment of level of expertise, which is measured with one item. In addition, the item does not provide a detailed and theory-based operationalisation of how level of expertise should be interpreted to consider the quality of the competence. Another limitation is that the survey was originally designed to provide input to the R&D projects and not to answer the present research questions. It follows that variables that could be relevant for the analyses, such as sociocultural background, seniority, etc., are missing. Future studies should include other data sources that measure the predictors and outcomes of DCD strategies, especially the learning gains of student teachers (Archambault et al., 2010; Lawless & Pellegrino, 2007). However, given the generic nature of the items and the commonalities of the problems arising across institutions and countries, some generalisability across contexts seems reasonable. In the present study, the sample size did not allow for more sophisticated analyses of whether TEds' subject disciplinary background might predict their profile membership. Hjukse et al. (2020) found that TEds differed in their attention to professional digital competence based on the subject discipline they were teaching (Hjukse et al., 2020). Future studies should investigate whether profiles relate to and differ across various subject disciplines.

Profile #	Strategies for DCD				Self-assessed expertise
	Collaborate w/peers	*Self-study*	*Involve students*	*Expert support*	
3. Extensive user	Primary	Primary	Primary	Secondary	High
2. Moderate user	Primary	Primary	Secondary		Lower
1. Restrictive user	Primary	Secondary	Secondary		Lowest

Figure 2. Steps to expertise.

5. Conclusion

The present study provides an in-depth understanding of the patterns of DCD strategies among TEds. Further, the study relates these patterns of DCD strategies to the use of digital resources as well as contextual and individual characteristics. This knowledge is highly relevant to research on educational quality and is useful in teacher education when considering how to support the DCD of TEds and what to emphasise in such efforts. Additionally, by revealing what TEds today use digital resources for, the study offers a starting point for crucial discussions in teacher education. These findings pave the way for questioning whether this use promotes educational quality in line with the ambitions of teacher education institutions. Discussions like these, based on empirical findings, are important to ensure that the use of digital resources in teaching and learning contributes to students' learning.

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Data availability

Analysis scripts and anonymized data are available on: https://osf.io/8bvtf/

Ethics

Our study followed social research ethics standards in Norway.

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