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A multilevel analysis of what matters in the training of pre-service teacher's ICT competencies

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Abstract

Few empirical studies investigate the impact of pre-service teachers' background and ICT profile in combination with the support they receive from their teacher training institution on their ICT competencies. Moreover, research focusing on preparing future teachers for ICT integration is generally limited to the impact of one single strategy. Therefore, the aim of this study was to test a model to explain pre-service teachers' perceived ICT competencies that integrates pre-service teachers' background characteristics (age and gender), their ICT profile (e.g., attitudes towards ICT) and the multiple strategies pre-service teachers experience in their teacher training institution: 1) using teacher educators as role models, 2) reflecting on the role of technology in education, 3) learning how to use technology by design, 4) collaboration with peers, 5) scaffolding authentic technology experiences, and 6) continuous feedback. Based on a survey among 931 final-year pre-service teachers in Flanders (Belgium), the multilevel analyses indicated a positive association between the strategies and pre-service teachers' ICT competencies. The more pre-service teachers perceive the occurrences of the strategies during their teacher education, the higher their perceived competence to use ICT for learning processes and to strengthen their instructional practice. Gender and age did not affect pre-service teachers' ICT competence for educational practice. Furthermore, the results revealed a positive impact of pre-service teachers' attitudes towards ICT (in education) and ease of use, on their ICT competence for educational practice. These

results can provide guidance for the preparation of pre-service teachers for the 21st century learning environments with new technologies.

1. Introduction

Teacher training institutions (TTI) are expected to prepare future teachers to integrate technology in their classrooms. The need to integrate technology, pedagogical and content knowledge has been noted by many researchers (Romeo, Lloyd & Downes, 2013; Sweeney & Drummond, 2013; Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013; Voogt, Schols, Bottema, van Bergen, van der Stap, et al., 2014). This has resulted in the adoption of various strategies by TTIs in order to develop pre-service teachers' competencies to use technology and harness its potential to enhance teaching and learning. Promoting pre-service teachers' competencies for educational technology use in an integrated manner is a complex process that demands specific strategies in order to be successful (Agyei & Voogt, 2014; Mims, Shepherd, & Inan, 2010). These strategies were identified through an extensive literature review by Tondeur, van Braak, Sang, Voogt, Fisser, and Ottenbreit-Leftwich (2012) and conceptualized in an overarching SQD-model (Synthesis of Qualitative Evidence) which presents six effective strategies at the micro level (Fig. 1): 1) using teacher educators as role models, 2) reflecting on the role of technology in education, 3) learning how to use technology by design, 4) collaboration with peers, 5) scaffolding authentic technology experiences, and 6) continuous feedback.

Figure 1. SQD-model to prepare pre-service teachers for technology use (Tondeur et al., 2012)

However, there are still questions remaining in this area. These inquire into whether or not the strategies of this theoretical model are actually implemented by TTIs and to what extent these strategies have an actual impact on pre-service teachers' ICT-competencies. Research focusing on preparing future teachers for ICT integration is generally limited to the study of one single strategy (e.g. Valtonen, Kukkonen, Kontkanen, Sormunen, Dillon, & Sointu, 2015). Also, empirical evidence is missing about the impact of the support pre-service teachers receive in combination with their individual background and ICT profile, such as attitudes towards ICT or ICT experience. This relationship is particularly important as it has been found that pre-service teacher's individual ICT characteristics (attitudes, ease of use, innovativeness) have a great effect on their use of educational technologies (Kavanoz, Yusel, & Ozcan, 2015; Teo, Milutinovic & Zhou, 2016; Teo & Milutinovic, 2015; Zogheib, 2014). Anderson and Maninger (2007) stress that pre-service teachers' ICT-related characteristics

need to be developed during teacher preparation programs.

Many studies have centred on pre-service teachers' characteristics associated with their ICT competencies, such as their ICT attitudes (e.g., Holland & Piper, 2016) or "ease of use" (e.g., Teo & Milutinovic, 2015). Nonetheless, the focus on pre-service teachers' characteristics could lead to individual blame rather than system blame when explaining ICT competencies. Research should also stress the role of training institution. Therefore, the main aim of this study was to explore the impact of pre-service teachers' background (age and gender) and ICT characteristics (e.g., attitudes towards ICT) in combination with the support they receive from their teacher training institution on their ICT competencies. In particular, we focused on the strategies included in the inner circle of the SQD-model (see Fig. 1) followed by an examination of the influence of these strategies in relation to pre-service teachers' background and ICT characteristics on their competencies to use technology in education.

2. Theoretical background

2.1 Competencies needed to integrate ICT in education

Competencies to integrate ICT in education can be defined in different ways. Many organizations have provided frameworks with ICT competencies for (pre-service) teachers. In different ICT frameworks, different terms are used, such as digital literacy, ICT literacy and ICT competence (Markauskaite, 2007). ICT skills refer to the technical use of ICT; ICT competencies are conceptualized as the integrated and functional use of digital knowledge, skills, and attitudes (Ananiadou & Claro, 2009). Digital skills are, thus, part of digital competencies (Erstad, 2013; Tondeur, Aesaert, Pynoo, Braak, Fraeyman, & Erstad, 2017a). The definition of ICT competency has moved from a narrow technical skills-based focus to a broader and more holistic concept of building pedagogical knowledge about technology

including both instructional tools and cognitive tools to foster student learning (Margaryan, Littlejohn & Vojt, 2011; Niess, 2008; Tondeur, van Braak, & Valcke, 2007).

Several frameworks adopt a broad definition. In the United States, for example, the International Society for Technology in Education (ISTE) standards and performance indicators (2008) have been applied as important guidelines for teachers on integrating ICT in the teaching and learning processes. In Australia, over the last 20 years, there has been a movement within the Department of Education, from identifying what was termed 'Minimum Standards' which referred to ICT skills, to the more current identification of ICT as implicit within pedagogy. The Australian Professional Standards for Teachers (2016) uses three domains within their guiding framework: Professional Knowledge, Professional Practice and Professional Engagement. In each of these domains ICT is both overt and implicit, with respective examples as: 'Implement teaching strategies for using ICT to expand curriculum learning opportunities for students'; 'Demonstrate knowledge of a range of resources, including ICT, that engage students in their learning'; 'Understand the relevant and appropriate sources of professional learning for teachers'. Internationally, therefore, ICT is conceptualized as a pedagogical tool rather than a skill-based competency.

In Flanders (Belgium) and the Netherlands, ICT competencies are also represented in empirical typologies developed by, for instance, Kennisnet (2012) and ENW AUGent (2013). On the base of previous studies (Tondeur, van Braak, & Valcke, 2007, Tondeur, Aesaert, Pynoo, Braak, Fraeyman, & Erstad, 2017a), the current study distinguished between two different types of ICT competencies: Type 1: competencies to help pupils to ICT use in class and Type 2: competencies teachers need to design an ICT-rich learning environment. The items on 'pupil use' (Type 1) were designed to measure the extent to which pre-service teachers feel competent to educate pupils in the use of ICT for learning processes, such as the support pupils need in processing and managing information by means of ICT.

The items on instructional design (Type 2) measure the degree to which pre-service teachers feel competent to design an ICT-rich learning environment with the available infrastructure. More specifically, these competencies are related to the ability to manage ICT for their own classroom practice. As directed by the concept of Technological Pedagogical Content Knowledge (TPACK), Koehler and Mishra (2009) have suggested that pre-service teacher education should not only focus on how to use technology but that it should also examine how technology intersects with pedagogical and content knowledge in order to design an ICT-rich learning environment. Their concept of TPACK stems from Shulman's (1987) notion about pedagogical content knowledge and his belief that teaching boils down to understanding the relationship between what is to be learned and how it is to be taught.

Tondeur, Siddiq, Scherer and van Braak (2016) highlight the importance of distinguishing between competencies required to design an ICT-rich learning environment and those to support pupils in the use of ICT in the classroom but at the same time, a reasonable positive correlation is found between both types of ICT competencies ($d = 0.66$, $p > 0.1$). This relationship is in line with the findings of Sang et al. (2010) indicating that the supportive use of ICT as tool to organize your educational practice is the most significant predictor of classroom ICT use to develop the ICT competencies of the pupils. Identification of specific competencies used in the current study is presented in the method section.

2.2 Strategies to develop future teachers' ICT competence

There are different strategies to develop pre-service teachers' ICT competence. Such strategies can include educational technology courses, method courses and field experience (Mouza et al., 2014). Still, the question remains how TTIs can get a comprehensive overview of effective strategies to support pre-service teachers to integration new technologies in a meaningful way in their educational practice. In this respect, Tondeur et al. (2012) reviewed

19 qualitative studies in order to develop an SQD-model on content and delivery methods that best prepare pre-service teachers to use technology into their future classrooms (see Fig. 1). According to the findings of this review, twelve key themes need to be in place in the teachers' education programs to develop future teachers for ICT competence. The two outward circles in the SQD-model include the conditions necessary at the institutional level such as technology planning and leadership, training staff, access to resources, cooperation within and between the institutions. The two inner circles include micro level strategies such as using teacher educators as role models, and scaffolding authentic technology experiences. The six strategies at the micro level were examined in this study: role models; reflection; instructional design; collaboration; authentic experience; feedback.

The first strategy involves teacher educators acting as role models. Laronde and MacLeod (2012) found that pre-service teachers preferred strategies in which academics modelled various technologically supported teaching methodologies specifically related to curriculum domains. The authors believed this modelling to be important as pre-service teachers tend to adopt the teaching styles they were exposed to during teacher education. The demonstration of technology appropriation has clear benefits but it is not sufficient in ensuring pre-service teachers will apply these examples in their own classrooms (Tondeur, Pareja Roblin, van Braak, Voogt, & Prestridge, 2017b). Importantly, pre-service teachers should be able to transfer these examples into specific educational contexts. Therefore, the second strategy consists of discussing and reflecting upon successful uses of technology in practice. Dorner and Kumar (2016) described the use of an online community where pre-service teachers had the opportunity to share, develop and critique learning resources to help them integrate technology in their lessons. This may help them see the utility, value and feasibility of using a particular technology and/or teaching strategy (cf. Laronde & MacLeod,

2012; Mouza et al., 2014) hence furthering their ability to differentiate between model and appropriation, enabling deeper more critical thought about technology integration.

Research also suggests that providing pre-service teachers the opportunity to learn about technology integration by (re-)designing curriculum materials (Strategy 3) can also be a promising strategy (Lee & Lee, 2014). In several studies, pre-service teachers stated that technology integration required additional planning and preparation because they had no prior knowledge about or experience with the design of ICT-supported learning activities (e.g., Polly et al., 2010). Many studies have demonstrated that group work (Strategy 4) might mitigate these feelings of insecurity when teachers need to design technology-related curriculum materials (Tearle & Golder, 2008). As a fifth strategy, pre-service teachers may also apply their knowledge of educational technology in authentic settings (Sang et al., 2010; Valtonen et al., 2015). These types of engaging experiences lead pre-service teachers to a better understanding of the link between theories and teaching practices (Sang et al., 2010). Finally, the sixth strategy involves on-going and process-oriented feedback, which has been proven to be beneficial for pre-service teachers' abilities to use technology in the classroom (Banas & York, 2014). These strategies need to be infused as a systemic aspect throughout the entire program rather than presented in separate "stand-alone" courses (Polly et al., 2010; Strudler et al., 2003) so that pre-service teachers can understand the reasons behind using technology (Tondeur et al., 2012).

2.3 Pre-service teachers' background and ICT profile

This final section considers the generality of being a pre-service teacher embarking on 21st century teaching. As much has been written about our technology infused lives being shaped by and even 'empowered' through digital devices and spaces (Taylor & Keeters, 2010), pre-service teachers are positioned as the pedagogues who prepare our future students

for the challenges of living, working and learning in an online socially networked world (Chubb, 2015). Thus, our current 21st Century pre-service teachers should have an affinity with and for technology as part of their own learning, and therefore seek this within and for their potential students through pedagogical applications.

Current research has found that pre-service teachers have a high level of web based instructional knowledge and their competencies for ICT knowledge and pedagogy increase over a teacher education program supporting a developing perception of the use of ICT (Cakir & Yildirim, 2015). They hold different attitudes associated to subject domains, in that pre-service teachers with a Maths or Science background are more positive about ICT than Social or Language studies students (Padmavathi, 2016). Additionally, pre-service teachers identify difficulties with differentiating and assessment of student learning with and about ICT (Cakir & Yildirim, 2015). As a whole, pre-service teachers are both skilled to use technology and have a positive attitude to using ICT, however, they still lack the ability to meaningfully appropriate ICT in the practical context (Aslan & Zhu, 2016; Liu, 2012; Tondeur et al., 2012).

The disparity between pre-service teachers' attitudes and actual practice with regard to ICT teaching and learning maybe a response to teacher preparation programs. In the current study the focus is on pre-service teachers' attitudes towards technology (in education). Several authors found that among the factors affecting (pre-service) teachers' competencies for technology use in education, attitudes towards ICT play a key role (see e.g., Sang et al., 2012). Tondeur, Van Keer, van Braak, & Valcke (2008) argued that ICT competencies can be strongly affected by specific attitudes, such as "attitudes toward ICT in education" and "usefulness". Therefore, a scale is used in this study that includes dimensions such as "usefulness", "interest", and "pleasure". It is a complex situation, which further validates the need for an in-depth investigation into the relationships between pre-service teacher ICT

attitudes, ICT competencies and institutional strategies within teacher education programs. This brings us to the purpose of this study.

2.4 Purpose of the study

Some researchers make a case for a more holistic approach to study the development of future teachers' ICT competence to integrate technology into teaching and learning in a meaningful way. They assume an integral, multidimensional relationship between individual ICT competencies and a set of personal and institutional characteristics. In this respect, researchers are faced with the challenge of investigating the many influencing characteristics in conjunction with each other. In the introduction section, we reviewed the empirical literature grounding the importance of the variables and processes. Yet this list of factors cannot reflect the full complexity of ICT integration. Understanding one element leads to the necessity to understanding the foundation on which that element rests, which in turn can lead to the discovery of other significant elements (Beach & Lindahl, 2004). The main objective of this study is to determine the impact of pre-service teachers' background (age and gender) and ICT characteristics (e.g., attitudes towards ICT) in combination with the support they receive from their teacher training institution on their ICT competencies.

A multivariate hierarchical regression analysis with a two-level design was used because the pre-service teachers of the current study are not considered as completely independent, due to the shared institutional context. Tondeur, Siddiq, Scherer, & van Braak, 2016) conducted a longitudinal multiple case study to examine the ways in which the strategies included in the SQD-scale were promoted in different teacher training institutions. The findings indicate that they adopted different strategies to prepare pre-service teachers for ICT integration. The findings also suggest that these efforts remain insufficient in some of the institutions (cf. Valtonen, Kukkonen, Kontkanen, Sormunen, Dillon, & Sointu, 2015). To

illustrate, the last year pre-service teachers in two institutions of the Tondeur, Siddiq, Scherer, and van Braak (2016) study felt that their pre-service education did not give them sufficient opportunities to engage in authentic tasks wherein they could apply their knowledge about technology to the design of concrete ICT-related activities that could be useful in their later practice (see also Lee & Lee, 2014).

3. Research method

3.1 Context and sample

931 final-year pre-service teachers from 20 teacher training institutions in Flanders (the Dutch speaking part of Belgium) participated in this study. All respondents received an email invitation to fill in the survey. Participation was completely voluntary. 72.4% of the respondents were females, a representative gender distribution of the pre-service teachers in Flanders (see Tondeur, Siddiq, Scherer, & van Braak, 2016). The average age was 24.7 years (SD = 7.02 years). 57.8% of the pre-service teachers had obtained a Bachelor's degree in higher education and 42.2% had obtained a specific teacher training degree from universities, colleges, or centres for adult learning.

3.2 Instruments

A survey was developed to explore the relationship between two types of ICT competencies (dependent variables) and different types of independent variables: pre-service teachers' background and ICT-related characteristics (e.g., attitudes and ease of use) and their perceived support by the TTI (the six strategies included in the inner circle of the SQD-model).

3.2.1 Dependent variable: two types of ICT competencies

The two dependent variables that were investigated are: competencies to educate pupils in the use of ICT for learning processes (Type 1) and competencies to appropriately integrate ICT in the (electronic) learning environment (Type 2). The 11 items on Type 1: ICTC PU (pupil use) (Cronbach's α=.94, M=70.87, SD= 14.84) were designed to measure the extent to which pre-service teachers are competent to help pupils in the use of ICT for learning processes, for instance "offer pupils opportunities to express ideas in a creative way by means of ICT", "support pupils to communicate with ICT in a safe, responsible and effective way", or "stimulate pupils to use ICT in a critical manner".

The eight items on instructional design Type 2: ICTC ID (Cronbach's α=.89, M=67.37, SD=15.26) measure the degree to which pre-service teachers are competent to use ICT to design their instructional practice. Sample items of the ICTC ID scale are: "select ICT-applications in view of a specific educational setting" or "design a learning environment with the available infrastructure". Respondents were asked to rate each statement on a five-point Likert scale, anchored between (0) *strongly disagree* and (4) *strongly agree* (see Tondeur, Aesaert, Pynoo, Braak, Fraeyman, & Erstad (2017a) for more information about the development of the two scales).

3.2.2 Independent variables

A first set of instruments is related to pre-service teachers' ICT profile. The "General Attitudes toward ICT Scale" (Cronbach's α = .83) is a five-item scale (0 = strongly disagree, 4 = strongly agree) developed by Evers et al. (2009). It includes items associated to interest (e.g., "I want to know more about computers"), pleasure (e.g., "I like to talk about computers to others"), and usefulness (e.g., "The use of a computer is useful to me"). The "Ease of Use Scale" (Cronbach's α = .88; 0 = strongly disagree, 4 = strongly agree) contains three items (e.g., "I feel comfortable when I use computers"). The "Attitudes toward ICT in Education

Scale" (Evers et al., 2009) measures students' attitudes toward the effects of adopting computers in education including the same spectrum of dimensions: "interest", "pleasure" and "usefulness" (Cronbach's α = .78; 0 = strongly disagree, 4 = strongly agree). The questionnaire also included information about a number of background characteristics (age, gender, teaching grade) and two types of intensity of ICT use: level of ICT use at home and for educational purposes (hours a week).

3.2.3 Independent variables: SQD-scale

The SQD-scale used in this study was constructed around the six significant domains of the inner circle (the micro-level) of the SQD-model (), a model based on the synthesis of qualitative evidence (for the development of this scale see Tondeur, Siddiq, Scherer, & van Braak, 2016; Figure 1). The SQD-scale is a uni-dimensional scale including six effective strategies for the content and delivery methods to prepare pre-service teachers for technology use (1) using teacher educators as role models, (2) reflecting on the role of technology in education, (3) learning how to use technology by design, (4) collaboration with peers, (5) scaffolding authentic technology experiences, and (6) providing continuous feedback (22 items, Cronbach's α = .97). Respondents were asked to rate each statement of all on a five-point Likert scale, anchored between (0) strongly disagree and (4) strongly agree. A table of the mean values and standard deviations of the six strategies of the inner circle of the SQD-scale can be found in Appendix A. The results show a high scores on the items related to "role models". In contrast the data shows a lower score on the items related to "learning by design" and "feedback".

3.3. Analyses

The participants of the current study are not considered as completely independent, due to the institutional context shared by the pre-service teachers. Taking into account the hierarchical structure of pre-service teachers (level 1) nested within teacher training institutions (level 2), we opted for a two-level design, since these models are specifically geared to the statistical analysis of data with a clustered structure (Goldstein, 1995).

A multivariate hierarchical regression analysis with a two-level design (pre-service teachers clustered into teacher training institutions) was used to investigate the effects of both preservice teachers' ICT related characteristics and the SQD-strategies on future teachers' competence in educating pupils in the use of ICT for learning processes (ICTC PU) and on their competence to use ICT to support and strengthen their instructional practice (ICTC ID). In total, four models were tested. First, a fully unconditional model (null model) was estimated, in order to investigate whether differences in pre-service teachers' ICT competences could be found at the student level and at the institutional level. In the subsequent three models, teachers background characteristics (model 1), ICT related teacher characteristics (model 2) and the SQD-strategies (model 3) were added as explanatory variables to the model. The difference in deviance between models, a test statistic with a chi-squared distribution, was used to investigate whether each model significantly fitted the data better than the previous models.

4. Results

The main aim of this study was to investigate the impact of pre-service teachers' background (age and gender), their ICT characteristics (e.g., attitudes towards ICT), in combination with the support they receive from their teacher training institution on two types of ICT competencies (ICTC PU and ICTC ID). Although four models were tested, only the results of the null model and the final model (model 3) are presented. As the analysis is

multivariate, the null model and final model are presented for both ICT competence for learning processes (ICTC PU) and ICT competence to strengthen instructional practice (ICTC ID).

4.1 Null model

The first step in the analysis was to explore whether the variance in pre-service teachers' ICT competences at the student level and at the institutional level. With regard to the first dependent variable of the multivariate analysis, i.e., pre-service teachers' competence in the use of ICT for learning processes (ICTC PU), the results in Table 1 indicate that the within-institution variance (student level: σ^2_{u0}= 207.321, χ^2=86.919, p<.001) differs significantly from zero, whereas the between-institution variance (institutional level: σ^2_{v0}= 2.053, χ^2=0.902, p>.05) does not. Moreover, the results indicate that only 0.9% of the variance in preservice teachers' competence in the use of ICT for learning processes is attributed to differences between teacher training institutions (ICC=$\sigma^2_{v0}/(\sigma^2_{u0}+\sigma^2_{v0})$= 2.053/(2.053+207.321)= .009), whereas 99.1% of the variance is due to differences at the student level.

With regard to pre-service teachers' competence to use ICT to support and strengthen their instructional practice (ICTC ID), the analysis provided similar results. More specifically, the variance at the student level (σ^2_{u1}= 229.769, χ^2=64.586, p<.001) significantly differs from zero, whereas the variance at the institutional level (σ^2_{v1}= 5.117, χ^2=1.821 , p>.05) does not. Moreover, only 2.2% of the variance in pre-service teachers' ICT competence for instructional practice can be attributed to differences between teacher training institution (ICC=$\sigma^2_{v1}/(\sigma^2_{u1}+\sigma^2_{v1})$= 5.117/(5.117+229.769)= .022).

4.2. Final model

In the next step of model specification, teachers background characteristics (model 1), ICT related teacher characteristics (model 2) and the SQD-strategies (model 3) were added to the subsequent models respectively. For convenience, only model 3 is presented (see Table 1). The intercept of 70.171 represents the overall mean competence to use ICT for learning processes across male pre-service teachers with an average age and average score on ICT private use, ICT educational use, general ICT attitude, educational ICT attitude, ICT ease of use and the SQD-scale. Similarly, the intercept of 67.980 represents the overall mean competence to use ICT to support and strengthen one's instructional practice across male pre-service teachers with an average age and average score on ICT private use, ICT educational use, general ICT attitude, educational ICT attitude, ICT ease of use and the SQD-scale.

Table 1. Model estimates for the two-level analysis of two types of ICT competencies

		ICTC PU		**ICTC ID**
	Null model	**Model 3**	**Null model**	**Model 3**
Fixed				
Intercept (cons)	71.464 (0.644)**	70.171 (0.953)**	67.980 (0.836)**	67.186 (1.128)**
Gender (ref: male)		1.778(1.048)		0.883 (1.131)
Age		-0.075 (0.062)		-0.078 (0.069)
ICT Private use		-0.041 (0.039)		0.050 (0.043)
ICT Educational use		-0.057 (0.031)		0.018 (0.035)
ICT attitude general		0.226 (0.040)***		0.091 (0.043)
ICT attitude education		0.137 (0.035)***		0.085 (0.038)
ICT ease of use		0.163 (0.030)***		0.217 (0.032)***
SQD		0.141 (0.023)***		0.258 (0.025)***
Random				
lnstitutional level				
Intercept (σ^2_{v0} and σ^2_{v1})	2.053 (2.161)	1.480 (1.554)	5.117 (3.792)	4.457 (3.027)
ICT PU/ICT ID (σ_{v01})	3.507 (2.674)	2.419 (1.879)	3.507 (2.674)	2.419 (1.879)
Student level				
Intercept (σ^2_{u0} and σ^2_{u1})	207.321 (10.540)	126.973 (6.909)*	229.769 (12.033)	146.169 (7.968)
ICT PU/ICT ID (σ_{u01})	140.682 (9.479)*	62.481 (5.774)**	140.682 (9.479)*	62.481 (5.774)**
Model Fit				
Deviance (2-log)[a]	12118.898	10518.021	12118.898	10518.021
χ^2	5.704	1600.877	5.704	1600.877

d*f*	3	19	3	19
p	>.05	<.001	>.05	<.001
Reference	Single level model	Null model	Single level model	Null model

Note: Estimates & standard errors from the Multivariate random intercept model (dependent variables: ICT PU and ICT ID * significant at the .05 level; ** significant at the .01 level; *** significant at the .001 level

With regard to *background characteristics*, the results indicate that both pre-service teachers' gender (B=1.778 χ^2= 2.878 d*f*= 2, p>.05) and age (B=-0.075 χ^2= 1,468 d*f*= 2, p>.05) are not related to their ability to use ICT for learning processes. Similarly, both gender (B=0.883, χ^2= 0.609, d*f*= 2, p>.05) and age (B=-0.078, χ^2= 1.260 d*f*= 2, p>.05) do not affect pre-service teachers' ICT competence for instructional practice.

Taking a closer look at the *ICT related pre-service teacher characteristics,* the estimates reveal that the degree to which pre-service teachers use ICT for private and educational purposes does not seem to be related to their competence to use ICT for learning processes or to strengthen their instructional practice. However, the results also indicate that general ICT attitude (χ^2= 32.116 d*f*= 2, p<.001) and educational ICT attitude (χ^2= 15.047 d*f*= 2, p<.001) make a significant contribution to the ICTC PU model (competence for ICT Pupil Use). The positive slopes indicate that for every increase with one unit, the score on the ICTC PU scale increases by 0.226 and 0.137 respectively. This means that the more pre-service teachers are convinced of the general benefits of ICT and the benefits that the use of ICT has for the education of their students, the more competent they perceive themselves in using ICT for teaching and learning processes. At the same time, the results indicate that pre-service teachers who believe that learning to use ICT is generally useful (B=0.091, χ^2= 4.444, df= 2, p<.05) and educationally beneficial (B=0.085, χ^2= 4.889, df= 2, p<.05) for their students, do not have a higher mean (perceived) competence in using ICT to strengthen their instructional practice.

Finally, the addition of the variable 'ICT ease of use' made a significant contribution to both the ICTC PU model and the ICTC ID model (ICT competencies for Instructional Design). The results indicate that the easier pre-service teachers perceive the integration of ICT into the classroom, the higher their mean level of ICT competence for learning processes (mean=70.171+0.163=70.334, χ^2= 29.428 d*f*= 1, p<.001) and the higher their mean level of ICT competence for strengthening their instructional practice (mean=67.186+0.217=67.403, χ^2= 44.723 d*f*= 1, p<.001).

Interestingly, the results show that the SQD strategies make a significant contribution to the ICTC PU model and the ICTC ID model. The positive slopes indicate that for every increase with one unit on the SQD-strategies scale, pre-service teachers' score on the ICTC PU scale and the ICTC ID scale increases by 0.141 (χ^2= 38.154 d*f*= 1, p<.001) and 0.258 (χ^2= 4.822 d*f*= 1, p<.001), respectively. In other words, the more pre-service teachers perceive the occurrences of the SQD-strategies during their teacher education, the higher their competence to use ICT for learning processes and to strengthen their instructional practice.

4. Discussion and conclusion

According to educational authorities worldwide, digital technologies are expected to be widely deployed for teaching and learning in primary and secondary schools. Therefore, frameworks on ICT competence were implemented for students in schools, and have only recently started targeting (pre-service) teachers (see e.g., Kennisnet, 2012; Norwegian Centre for ICT in Education, 2015). To illustrate, in Flanders a framework for pre-service teachers (ENW AUGent, 2013) has been developed to describe a) which competencies teachers need to integrate ICT in such a way that their pupils can achieve the ICT attainment targets and b)

to design a powerful learning environment: the two output variables in the current study (For an overview see Tondeur, Aesaert, Pynoo, Braak, Fraeyman, & Erstad, 2017).

But promoting these ICT competencies is a challenge for most teacher education institutions (e.g., Gao, Wong, Choy, & Wu, 2011; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010) because it demands multiple strategies in order to be successful, as illustrated in the SQD-model (Fig. 1, Tondeur, van Braak, Sang, Voogt, Fisser, and Ottenbreit-Leftwich, 2012). The aim of this study was to instigate the impact of pre-service teachers' background (age and gender) and ICT characteristics (e.g., attitudes towards ICT) in combination with the support they receive from their teacher training institution on two types of ICT competencies. In this section, we relate the main findings to the existing literature. In addition, we extrapolate the limitations of the study, directions for future research and practical implications for supporting future teachers for technology integration in education.

4.1 Impact of pre-service teachers' characteristics

The results of the multilevel analysis indicate that pre-service teachers with higher scores on their perceived ICT-profile report higher self-perceived ICT competencies. Specifically, "ease of use" has a positive impact on both types of ICT competencies: 1) competencies to develop pupils' ability to use digital technologies (ICTC PU) and 2) pre-service competencies to design an ICT-rich learning environment (ICTC ID). Attitudes towards ICT (in education) also have a significant impact on pre-service teachers' competencies to develop pupils' ICT use. From the introduction section it seemed that an important characteristic of pre-service teachers adopting technology includes their interest, pleasure, and ease of use in exploring the opportunities of technology for teaching and learning (e.g., Sang et al., 2012).

ICT attitudes have no impact on pre-service teachers competencies to design a learning environment with ICT (ICTC ID). This is in line with the findings of van Braak, Tondeur, &

Valcke, 2004). Similarly, they delineated two main categories in a study among in-service teachers in Flanders: a) competencies to use ICT to support their educational practice and b) competencies to develop pupils' ability to use ICT. Also in their study, attitudes towards ICT in education only influence the teachers' competencies to support pupils' ICT use. Clearly, these results highlight the importance of distinguishing between types of competencies. At the same time, a reasonable positive correlation is found between ICTC-PU and ICTC-ID. This relationship between both types of ICT competencies can also be found in the study of Sang et al. (2010), who contend that the supportive use of ICT is the most significant predictor of classroom ICT use. In future studies, researchers might wish to collect in depth information to investigate different types of ICT competencies.

Surprisingly, intensity of ICT use however has no impact on pre-service teachers' ICT competencies. A possible reason is that the measure used in this study (the time pre-service teachers spend working with ICT) does not provide an in-depth picture of ICT use for personal compared to educational use. We were not able to differentiate between different types of ICT use and not all types of use may have a similar impact on ICT competencies or instructional design. In general, research has identified 'more' time as an affordance for ICT use in education (Hsu, 2016; Mirzajani, Mahmud, Ahmad Fauzi & Wong, 2015) with regard to both competency and pedagogical application, with positive relationships found between personal computer use and classroom use (Rakes, Fields & Cox, 2006; Sipilä, (2010); Wozney, Venkatesh & Abrami, 2006).

No impact was found of the two socio demographic variables age and gender. The latter is in line with the Tondeur, Van de Velde, Vermeersch and Van Houtte (2016) study suggesting that being female is negatively related to ICT use for leisure activities, but no relationship was found between gender and study-related ICT use (cf. Vekiri & Chronaki, 2008). Based on these studies, it could be argued that female pre-service teachers are not likely to be

disadvantaged in teacher training institution regarding ICT instruction. Also Abbiss (2008) describes females as task-oriented users who focus on utilitarian functions of ICT and on the end product, such as the use of ICT for teaching and learning purposes. A possible reason why age has no impact on ICT competencies can be due to the fact that most pre-service teachers start their training after secondary education or after their Master degree resulting in a small variance in age.

4.2 Impact of pre-service training

The final multilevel model revealed that the more pre-service teachers perceive the occurrences of the SQD-strategies during their pre-service training, the higher their self-reported competencies to use ICT for learning processes and to strengthen their instructional practice. This finding should not be perceived simplistically as the 'more the better' but rather as acknowledging the intricacies of ICT as a general capability across subject domains and pedagogical approaches. The use of ICT for teaching and learning needs to be embedded fluidly, consciously and effectively throughout a teacher education program using multiple strategies as found in other studies (e.g. Angeli & Valanides, 2009).

The results show a high scores on the items related to "role models" but lower scores on the items related to feedback. This is in line with the results in the Tondeur, Pareja Roblin, van Braak, Voogt and Prestridge (2017b) study suggesting that assessment and feedback with respect to educational technology use is one of the main problems TTIs experience (cf. Mouza et al., 2014). Nevertheless, empirical evidence indicates that on-going feedback is beneficial to build pre-service teachers' competencies to use technology in the classroom (Boulton, 2014). Moreover, items related to the design of technology-rich lessons seem to be challenging for TTIs. Empirical evidence shows that additional support for pre-service teachers is needed to prepare and implement lessons incorporating technology (e.g., Sadaf,

Newby, & Ertmer, 2012). Lee and Lee (2014) argue that TTIs and schools could form partnerships to collaboratively work toward identifying the best methods to support pre-service in designing their lessons and practice related to technology integration.

In a qualitative study (Tondeur et al., 2017b), the strategies of the SQD-scale were used to collect in-depth interviews with beginning teachers. It appeared that teacher educators modelling ICT use was an important motivator for beginning teachers to use technology in their own teaching, but field experiences seemed to be the most critical factor influencing their ICT competencies (Tondeur et al., 2017b). Linking theory developed in coursework with practical experience in classrooms has been established as a highly effective strategy to develop pre-service teacher competencies (Brouwer & Korthagen, 2005; Darling-Hammond, 2006). In sum, the results revealed that all beginning teachers acknowledged the importance of the six strategies but not all of them where addressed during their pre-service learning experiences. The overall comments emerging from the interviews indicated that feedback with respect to lesson design was one of the main problems in TTIs. This is in line with the finding from the current study (see Appendix 1). The survey data show low(er) scores on items related to feedback. Nevertheless, previous research indicates that on-going and process-oriented feedback is beneficial to build pre-service teachers' abilities to use technology in the classroom (Boulton, 2014).

Findings of the current study did not show differential effects for the two types of ICT competencies: competence to use ICT for learning processes and to strengthen their instructional practice. Possibly, the distinction between the two types of ICT competencies can be blurred because of the reasonable positive correlation between the two outcome variables. In educational practice, it is often less easy to differentiate between different types of ICT competencies. This complicates the problem of evaluating ICT competencies.

Nevertheless, the overall results in the Tondeur, Aesaert, Pynoo, Braak, Fraeyman and Erstad (2017a) study emphasise the need to be specific as to the type of ICT competencies.

From a methodological perspective, the multilevel approach allowed for identifying the impact of pre-service teacher characteristics in conjunction with differences at the level of the TTIs. Interestingly, the results demonstrate almost no variance at the institutional level. There is still much to learn with respect to the differential impact of teacher training institutions, the variations of strategies at various institutions as well as the quality of the strategies. This study for instance focused on the strategies of the inner circle of the SQD-model and student teachers' perceptions of these SQD-strategies. Future research should also explore the key themes at the outer circle, such as "collaboration within and between institutions" or "the development of a shared vision" and triangulate by using different kind of measures (e.g. observation). Further development of the model is needed when setting up future research. This brings us to the next section.

4.3 Limitations of the study and recommendations for future research

The results presented in this study demonstrate that the SQD-scale allows researchers to evaluate the development of future teachers' ICT competencies. However, the results of the current study should be considered in light of some limitations. First, the results cannot simply be generalized to other educational context, for instance in-service training. Additionally, some themes were specifically connected to the context of pre-service training in Flanders. In other parts of the world, technology might be used in different ways. Apart from the evaluation of technology use outside the Flemish context, a crucial limitation of the present study concerns the quantitative nature of our survey. It has to be stressed that ICT integration in education is a complex phenomenon with perceptions as the main form of data that can be gathered in a survey.

ICT does not exist in isolation; it is interwoven with the rest of the environment (Lim, 2002). Therefore, research studies in ICT need to shift their attention towards the whole configuration of events, activities, contents and interpersonal processes taking place in the context in which ICT is used (Salomon, 1993). In this respect, researchers are faced with the challenge of investigating the many influencing characteristics of ICT integration in conjunction with each other. Our results provide a basis for the statement that the influencing factors must be studied from a system of variables that interact in determining the success or failure of ICT in education; the status of one factor is continuously affected by the status of many others. Therefore, future studies need to undertake qualitative interpretative research.

Also the perspective of teacher educators should be taken into account. Teacher educators are expected to model effective ICT integration and provide future teachers with the necessary ICT entry qualifications. Professional development and support are therefore needed to prepare teacher educators for this task (cf. Goktas et al., 2009). Furthermore, longitudinal research could be interesting to investigate to what degree pre-service and beginning teachers integrate ICT into teaching and learning activities once they enter the profession and assume full responsibility of a group of students. Clearly, the SQD-scale provides an instrument TTIs could use to measure pre-service teachers' perceptions of the extent to which they experience the support and training needed to integrate technology in their educational practice (cf. Chien et al., 2012; Goktas et al., 2008; Kaufman, 2015).

4.4 Conclusion

Despite the limitations, the study contributes to the literature on pre-service teachers' readiness for educational technology use in different ways. The current study shows that the more pre-service teachers perceive the occurrences of the SQD-strategies during their pre-service training, the higher their self-reported competencies to use ICT for learning processes

and to strengthen their instructional practice. To illustrate the relevance of these strategies, the findings of the multilevel analysis emphasise the impact on two types of ICT competencies. By implementing these strategies pre-service teachers' ICT related characteristics should be taken into account. As technology continues to drive changes in education, teacher training institutions should develop a supportive environment that facilitates reflection about the role of new technologies in education and provides opportunities to experiment with new practice in order to further integrate technology in teaching and learning processes.

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Appendix A

Correlation coefficients among the six (theoretical) SQD strategies

SQD-strategy	M	SD	Pearson correlation					
			1.	2.	3.	4.	5.	6.
1. role models	56.73	21.68	1					
2. reflecting	54.03	21.86	.79	1				
3. learning by design	52.83	22.22	.83	.80	1			
4. collaboration	54.87	20.98	.77	.79	.83	1		
5. authentic experiences	56.46	20.41	.81	.80	.86	.80	1	
6. feedback	49.18	23.15	.79	.80	.86	.80	.82	1