UNIVERSITY OF AMSTERDAM

UvA-DARE (Digital Academic Repository)

Teacher educators' competences in fostering student teachers' proficiency in teaching and learning with technology: An overview of relevant research literature

Uerz, D.; Volman, M.; Kral, M.

[Link to publication](#)

Teacher educators' competences in fostering student teachers' proficiency in teaching and learning with technology: An overview of relevant research literature

Dana Uerz [a, *], Monique Volman [b], Marijke Kral [a]

[a] HAN University of Applied Sciences, iXperium/Centre of Expertise Teaching and Learning with ICT, P.O. Box 30011, 6503 HN, Nijmegen, The Netherlands
[b] University of Amsterdam, Research Institute of Child Development and Education, P.O. Box 15780, 1001 NG, Amsterdam, The Netherlands

HIGHLIGHTS

- Literature on teacher educators' competences as role models is scarce.
- Four domains of competence for teacher educators can be identified.
- Most research focuses on competences to teach with technology.
- Research on teacher educators' level of competences is limited.

ARTICLE INFO

ABSTRACT

Teacher educators play an important role in preparing student teachers to integrate technology into their classrooms. This article presents an overview of research literature on teacher educators' competences in preparing their students to teach with technology. A literature search yielded 26 relevant research articles. Four domains of competence were identified: technology competences, competences for pedagogical and educational technology use, beliefs about teaching and learning and competences in professional learning. The literature focuses on teacher educators' competences in using technology for teaching. Research on the competences that teacher educators need and have as second-order teachers is lacking. Recommendations for future research are discussed.

© 2017 Elsevier Ltd. All rights reserved.

Contents

* Corresponding author.
  E-mail addresses: dana.uerz@han.nl (D. Uerz), M.L.L.Volman@uva.nl (M. Volman), marijke.kral@han.nl (M. Kral).

1. Introduction

Technological developments are changing what is required of teachers in several ways. Firstly, it is increasingly expected that teachers use technology to support new ways of teaching and learning (Drent & Meelissen, 2008). Secondly, they are supposed to develop their students' technological literacy in order to prepare them for working and learning in twenty-first-century society (International Society for Technology in Education [ISTE], 2008; United Nations Educational, Scientific and Cultural Organization [UNESCO], 2011; Voogt & Pareja Roblin, 2010). New requirements for (student) teachers also make demands on teacher education. Student teachers and in-service teachers in primary and secondary education need to be educated to use technology as a tool for teaching and to support students' technological literacy (Agyei & Voogt, 2011; Drent & Meelissen, 2008; Sang, Valcke, Van Braak, & Tondeur, 2010; Tondeur et al., 2012). These demands are reflected in diverse international frameworks of professional standards (e.g. ISTE, 2008). In recent years research on teacher educators' use of technology and their competences in this area has also been emerging. No overview of this literature exists, however. Therefore, this study investigates what competences teacher educators need both to teach and learn with technology and to foster student teachers' technological literacy, based on an overview of the existing research literature.

2. Theoretical framework

Both current and future teachers have to deal with the requirements that technological developments make of them. Teachers are expected to develop innovative ways to use technology as a *tool* to enhance the learning environment and to effectively support their teaching and students' learning with technology (Drent & Meelissen, 2008; ISTE, 2008; UNESCO, 2011). At the same time, technology is a *goal* of learning; teachers need to encourage students' technological literacy in order to prepare them for working and learning in 'twenty-first-century' society and to help them develop the necessary skills for cooperation, communication, problem solving and lifelong learning (ISTE, 2008; UNESCO, 2011; Voogt & Pareja Roblin, 2010).

The innovative use of technology in education lags behind expectations. Many teachers are only beginning to integrate technology into their classes, though the level of use varies widely within and between schools (Tondeur, Kershaw, Vanderlinde, & Van Braak, 2013). Mioduser, Nachmias, Tubin, and Forkosh-Baruch (2003) along with Tondeur et al. (2013) argue that technology is predominantly used to support existing practices and not so much as a means to transform pedagogical practices. Tondeur et al. (2012) state that the use of technology for changing pedagogical practices is still limited among in-service teachers, as well as among student teachers and beginning teachers. Teachers and student teachers often feel that they are not sufficiently well equipped for teaching and learning with technology in their classrooms (Houston & Pierson, 2008; Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010; Sang et al., 2010; Tondeur et al., 2012).

New requirements for (student) teachers also make demands on teacher education. Student teachers and in-service teachers in primary and secondary education need to be educated to use technology as a tool for teaching and to support students' technological literacy (Agyei & Voogt, 2011; Drent & Meelissen, 2008; Sang et al., 2010; Tondeur et al., 2012). These demands are also reflected in diverse international frameworks of professional standards (e.g. ISTE, 2008).

The question then arises of how teacher education institutions can meet these demands, and especially what is required of teacher educators within this context.

To answer this question, the unique character of the profession of teacher educators (Lunenberg, Korthagen, & Swennen, 2007) should be taken into account. Teacher educators are not just teachers. In fact, they are second-order teachers (Murray & Male, 2005): they educate student teachers who will be working with pupils, as opposed to first-order teachers who work directly with pupils. In addition to being teachers themselves, teacher educators serve as role models for their students in teaching with technology as well as in fostering students' technological literacy. Acting as a role model in teaching means that teacher educators' pedagogical behaviour is congruent with the pedagogical behaviour they want to promote in their students (Lunenberg et al., 2007; Wright & Wilson, 2007). Teacher educators not only deliver the content of their courses, they also teach and model technology use, pedagogical beliefs and instructional strategies (Bai & Ertmer, 2008; Garcia & Rose, 2007). Modelling is an effective technique to help student teachers learn to use technology (Garcia & Rose, 2007; Groth, Dunlap, & Kidd, 2007; Matthew, Stephens, Callaway, Letendre, & Kimbell-Lopez, 2002). To prepare student teachers to integrate technology as a tool and as a goal in their future practices, teacher educators need to do more than just model technology use; they have to justify the modelled behaviour, substantiate the underlying pedagogical and educational choices and explicitly connect aspects of technology, pedagogy and content and the underlying relationships (Koehler, Mishra, Hershey, & Peruski, 2004; Lunenberg, Dengerink, & Korthagen, 2013).

Teacher educators are therefore faced with an even more complex task than first-order teachers concerning the use of technology in education. Research on teacher educators' teaching with technology in pre-service teacher education is expanding, but is still far less voluminous than research on teaching and learning with technology by teachers in primary or secondary schools. Several studies describe how teacher education institutes are searching to integrate new professional standards for their students in their curriculum and are starting to reshape their curriculum with technology (e.g. Ottenbreit-Leftwich et al., 2010; Tømte, Enochsson, Buskqvist, & Kårstein, 2015). And although the importance of fostering student teachers' competences in teaching with technology has been stressed in recent frameworks of professional standards (e.g.; ISTE, 2008), it is not always reflected in the teacher education classrooms.

Some studies suggest that teacher education institutes are struggling to provide student teachers with sufficient inspiring role models as there are not enough teacher educators that use technology effectively themselves (e.g. Gronseth et al., 2010; Tondeur

et al., 2012). Other studies emphasize that even if more teacher educators used technology, the quantity of technology use in itself would not be enough to prepare student teachers to teach and learn with technology (e.g. Kaufman, 2015; Lei & Zhao, 2007). Teacher educators also need to support student teachers' ability — and their knowledge in this regard — to choose optimal technologies to reach specific pedagogical goals with specific groups of students (e.g. Chien, Chang, Yeh, & Chang, 2012; Mishra & Koehler, 2006). A comprehensive review on what is required of teacher educators to become the role models student teachers need, taking into account the unique character of their profession, is lacking.

3. The present study

The purpose of this study is to investigate what competences teacher educators need to teach and learn with technology and, as second-order teachers, to foster both student teachers' competences in using technology as a tool for teaching and their competences in enhancing pupils' technological literacy, based on an overview of the existing research literature. Competences are defined as the range of knowledge, abilities and commitment needed to do something well and efficiently or to achieve professional goals (American Heritage, 2011; Teodorescu, 2006). According to definition, competences encompass skills and knowledge as well as attitudes and beliefs.

Technological literacy is broadly defined as the entirety of knowledge, skills and attitudes related to the use of technology in everyday life, connecting instrumental skills, media literacy and information skills as well as computational thinking (Barr & Stephenson, 2011; Voogt, Fisser, Good, Mishra, & Yadav, 2015; Voogt & Pareja Roblin, 2010). Instrumental skills concern the ability to use current technologies and to keep these skills up to date. Media literacy is defined as the ability to efficiently and effectively retrieve, select and evaluate information (information skills) as well as the ability to consciously and strategically use media and to critically evaluate different aspects of media and their content (e.g. European Commission, 2007; Koltay, 2011; Van Deursen & van Dijk, 2012). Computational thinking is the thought process of (re) formulating problems and solutions in such a way that solutions are represented in a form that can be carried out by an information-processing agent (Wing, 2008).

Based on this theoretical framework, which distinguishes (preparing students for) using technology as a tool for teaching and developing technological literacy, and which approaches teacher educators as second-order teachers, a literature review was conducted. The following research questions led the review:

1. What competences have been identified in previous research that teacher educators need in order to integrate technology into their classes as second-order teachers, in particular:
   A. to use technology as a tool to enhance their own teaching and to reach learning goals;
   B. to prepare student teachers to effectively use technology in their future practices by modelling the required behaviour, and;
   C. to prepare student teachers to support their students' technological literacy?
2. What is known through previous research about the extent to which teacher educators have these identified competences for teaching and learning with technology?
3. What key characteristics of professional development are identified to support teacher educators in the acquisition or development of these competences for teaching and learning with technology?

4. Methods

4.1. Search and selection criteria

The literature search for the review was conducted in February 2015. The following scientific databases were searched: Education Resources Information Centre (ERIC), Social Sciences Citation Index (SSCI), Science Citation Index (SCI) and Picarta (which provides access to the Dutch Central Catalogue (NCC) and Online Contents (OLC). In the search query, three sets of search terms covering the main concepts of the study's focus (identifying competences that teacher educators need to integrate technology in their teaching) were combined:

1. *Technology* (technology integration, technology uses in education, educational technology, ICT integration) AND;
2. *Teacher educators* (teacher educators, teacher educator, identity, role model, pre-service teacher education, student teacher) AND;
3. *Competences* (teaching skills, teacher skills, teacher competen*, computer attitudes, technological literacy, computer literacy, computational thinking, professional development.

The set of search terms for competences was broadly defined and included a range of competences, skills and attitudes concerning teaching in general and teaching with technology in particular. The search was limited to peer-reviewed articles written in English and published between January 2005 and December 2014. The literature search did not focus exclusively on empirical studies, but also included theoretical and philosophical publications that discuss what competences teacher educators need for teaching and learning with technology. In total, 217 articles were found that covered the three sets of search terms and met the aforementioned inclusion criteria (see Fig. 1).

The abstracts of the 217 articles were screened to assess their relevance. Articles that did not focus on teacher educators' competences in teaching and learning with technology were excluded. A randomly chosen set of 30 abstracts was screened by the three authors of this paper. Because there were very few disagreements on the rating of relevance, the other abstracts were evaluated by the first author only. Based on the screening of the abstracts, 176 articles were excluded from further analysis. Most of these excluded articles focused on (student) teachers' qualifications or technology use in primary or secondary education and merely mentioned teacher educators and teacher education as contributors. Other studies did describe technology use in teacher education, but did not relate the use of technology in any way to teacher educators' competences, either in the results or in the discussion. After the screening of the abstracts, 32 articles turned out to be relevant for further analysis. In nine cases, the relevance was difficult to assess based solely on the abstract. These articles were also kept for full-text screening. Through 'snowballing' (scanning references from the full-text articles and selecting relevant publications), four additional titles that combined all sets of search terms were included in the next stage of the review, regardless of the year of publication. Two articles were published before 2005. Thus a total of 45 articles were selected.

During the first stage of the full-text reading, 19 articles proved to be irrelevant to the review after all and were excluded. Each decision to exclude an article was discussed by the research team. Most of these articles focused on student teachers' qualifications to teach and learn with technology, without discussing the consequences for teacher educators. Other articles focused on the use of technology in teacher education, but again did not address underlying teacher educators' competences or professional development.
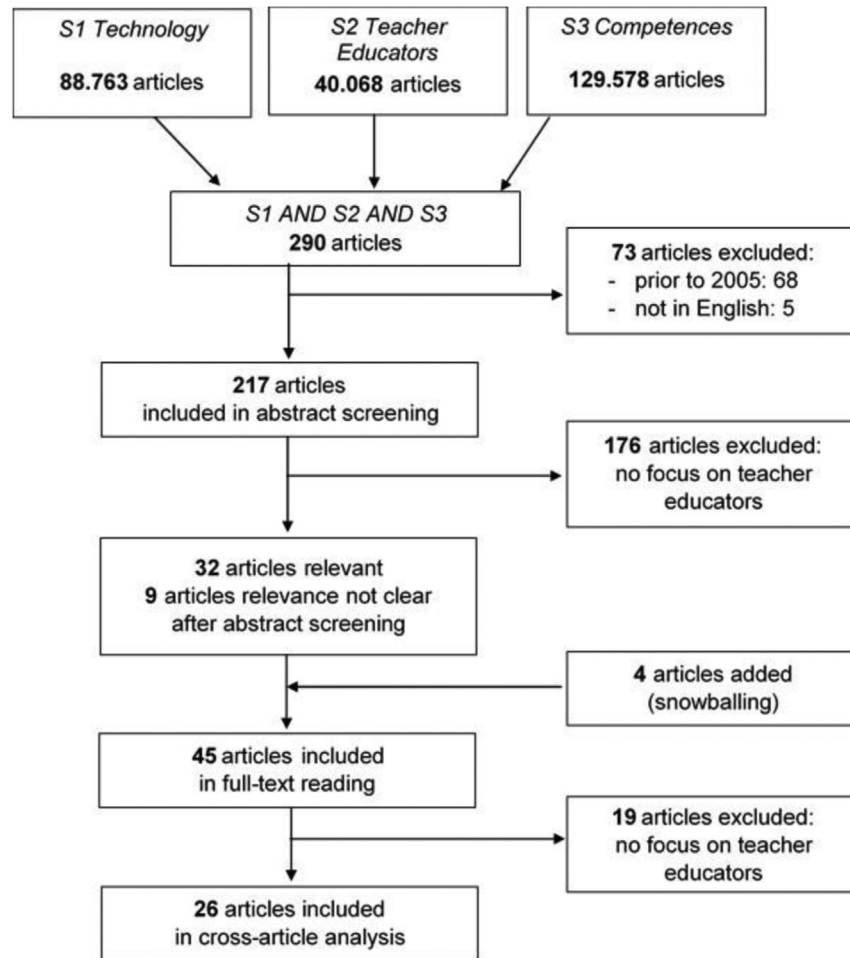
Fig. 1. Article search and selection process.

A total of 26 articles were kept for in-depth analysis.

4.2. Summarizing articles and analysis

A spreadsheet was used to summarise the articles (Petticrew & Roberts, 2006). This summary included bibliographical and methodological characteristics of the studies, theoretical frameworks and core constructs, main results and conclusions. Also, data related to the three research questions were extracted from the articles: 1) definitions and descriptions of teacher educators' competences in integrating technology into their classes as second-order teachers; 2) results on the actual level of these competences; and 3) descriptions of characteristics of professional development aimed at improving teacher educators' competences in using technology for teaching and learning. The summaries were made by the first author of this paper. The second and third author served as a review board that critically discussed the spreadsheet displaying the data that were extracted from the articles by the first author. As a result, ambiguities regarding the quality and methodology of the studies and the exact meaning of concepts and definitions used in the articles were clarified by the research team.

Next, in order to answer the first research question, overarching domains of competence for teacher educators were identified by connecting and contrasting commonalities and differences in the described competences in the different articles (cross-article analysis). These domains of competence were used for structuring the results section. In order to answer research question 2, the results on actual proficiency levels of teacher educators were summarized for each domain of competence and discussed by the research team. In order to answer research question 3, characteristics of professional development aimed specifically at developing the required competences were distinguished.

During this phase of cross-article analysis, 1) the identification of the domains of competence, 2) conclusions about the level of competence of teacher educators for the identified competences and 3) relevant characteristics of professional development were discussed by the research team, until a consensus was established. All the results in the spreadsheet were read again and assigned to the domains.

Table 1 describes the articles included in the review, the study designs, the educational contexts and the domains of competence for teacher educators and characteristics of professional development that were identified in the respective articles. The competences will be introduced and explained in the next section. Nineteen studies in the review are descriptive, qualitative studies, such as case studies, theoretical studies or evaluation studies. Seven studies are non-experimental, quantitative studies, describing teacher educators' competences in teaching and learning with technology (Ajjan & Hartshorne, 2008; Carroll & Morrell, 2006; Chapman & Gaytan, 2009; Drent & Meelissen, 2008; Georgina & Olson, 2008; Javeri & Persichitte, 2010; Murdock, 2006).

Table 1
Key information on, and domains of, competence identified in articles discussed in the review.

Authors	Study design	Sample (n)	Educational context	Technology competences	Competences in pedagogical and educational use of technology	Beliefs about teaching and learning	Competences in innovation and professional learning	Characteristics of professional development
Ajjan & Hartshorne, 2008 (USA)	Non-experimental (survey/path analysis)	135	Higher Education	X		X		X
Amburgey, 2006 (USA)	Evaluation study (qualitative)	23	University College of Education		X			X
Archambault et al., 2010 (USA)	Evaluation study (qualitative)	20	University College of Teacher Education and Leadership			X		
Boling & Adams, 2008 (USA)	Review (multiple case studies)	—	Teacher Education (English literacy education)	X	X	X		
Capobianco & Lehman, 2006 (USA)	Single case study	1	Science Teacher Education	X			X	X
Carroll & Morrell, 2006 (USA)	Non-experimental (survey)	51	Teacher Education (liberal arts colleges)	X	X			
Chapman & Gaytan, 2009 (USA)	Non-experimental (survey)	46	Business Teacher Education	X				X

Authors	Study design	Sample (n)	Domain	Technology competences	Competences in pedagogical and educational use of technology	Beliefs about teaching and learning	Competences in innovation and professional learning	Characteristics of professional development
Drent & Meelissen, 2008 (Netherlands)	Non-experimental (mixed methods)	210	Teacher Education (for primary education)	X	X	X	X	X
Friel et al., 2009 (USA)	Evaluation study (survey)	55	University		X	X		X
Garcia & Rose, 2007 (USA)	Intervention research (qualitative)	12	Teacher Education (faculty and students)		X			
Georgina & Olson, 2008 (USA)	Non-experimental (survey)	237	Higher Education (colleges of education)	X	X			X
Groth, Dunlap, & Kidd, 2007 (USA)	Multiple cases (mixed methods)	3	Graduate School of Education (literacy faculty)		X			X
Heck & Sweeney, 2013 (Australia)	Evaluation study (qualitative)	41	Teacher Education	X				
Houston & Pierson, 2008 (USA)	Discussion/Opinion	—	Teacher Education	X				

Authors	Study design	Sample (n)	Domain	Technology competences	Competences in pedagogical and educational use of technology	Beliefs about teaching and learning	Competences in innovation and professional learning	Characteristics of professional development
Howland & Wedman, 2004 (USA)	Evaluation study (survey)	21	Teacher Education (teaching content methods course)	X		X		X
Javeri & Persichitte, 2010 (USA)	Non-experimental (survey)	208	Schools, Colleges and Department of Education (faculty engaged in research)	X				
Koehler et al., 2004 (USA)	Multiple cases (mixed methods)	6	College of Education	X	X	X	X	X
Lim et al., 2011 (Asia Pacific Region)	Theoretical study	—	Teacher Education Institutions (TEI)	X	X			X
Matthew et al., 2002 (USA)	Evaluation study (mixed methods)	33	Teacher Education Tech University	X				X
Murdock, 2006 (USA)	Non-experimental (survey)	105	Technical Teacher Education (TTE)	X		X		X
O'Brien et al., 2011 (USA)	Review (overview)	—	Distance Education and Preparation of Special Educators	X				

Authors	Study design	Sample (n)	Domain	Technology competences	Competences in pedagogical and educational use of technology	Beliefs about teaching and learning	Competences in innovation and professional learning	Characteristics of professional development
Peeraer & Van Petegem, 2012 (Vietnam)	Evaluation study (mixed methods)	899	Teacher Education		X		X	
Reading & Doyle, 2013 (Australia)	Evaluation study (qualitative)	7	Teacher Education (English, Mathematics, Science and History)					X
Rodesiler & Tripp, 2012 (USA)	Discussion/ Opinion	—	English Teacher Education				X	
Teclehaimanot & Lamb, 2005 (USA)	Evaluation study (mixed methods)	91	Teacher Education (Colleges of Education and Arts & Sciences)		X	X		
Wepner et al., 2005 (USA)	Evaluation study (mixed methods)	7	University College of Education (methodology teachers and supervisors)	X				X

5. Results

The reviewed articles describe a wide range of projects, interventions and research regarding teacher educators' use of technology and the competences and/or professional development identified to realise the integration of technology in teaching and learning. Exploration of the findings in the reviewed articles (cross-article analysis) resulted in the identification of four domains of competence for teacher educators for teaching and learning with technology (see Table 1). The following domains of competence were identified:

1. Technology competences — the ability to use technology in general (not specifically related to teaching and learning);
2. Competences for pedagogical and educational use of technology — teacher educators' competences in using technology for teaching and learning;
3. Beliefs about teaching and learning — teacher educators' beliefs about education;
4. Competences for innovation and professional learning — competences related to changing pedagogical practices and to professional development.

Only one study includes all of the domains of competence (Drent & Meelissen, 2008). The other studies describe three or less of the domains of competence (see Table 1).

The domains of competence for teacher educators for teaching and learning with technology are similar to those found in research on teachers' competences for technology use in primary and secondary education (e.g. Ertmer, 2005; Hargreaves & Fullan, 2012; Hermans, Tondeur, Van Braak, & Valcke, 2008; Vanderlinde, 2011; Voogt, Fisser, Pareja Roblin, Tondeur, & Van Braak, 2013).

This section describes what is known from previous research about each of the domains of competence within the specific context of teacher education and what is said about the extent to which teacher educators have these identified competences. The literature findings (concerning research questions 1 and 2) are organized along the lines of the four domains of competence.

5.1. Technology competences

Seventeen of the 26 reviewed studies describe the relevance of teacher educators' personal technological skills as a competence for teaching and learning with technology (see Table 1). These technological skills concern the use of technology in everyday life, i.e.

instrumental and information skills. The studies assert that in order to integrate technology into education, teacher educators first need to be able to use technologies themselves and understand how they work.

Nine studies define technology competences as proficiency in using technology in general, or as proficiency in using specific kinds of technologies (Carroll & Morrell, 2006; Chapman & Gaytan, 2009; Drent & Meelissen, 2008; Georgina & Olson, 2008; Howland & Wedman, 2004; Lim, Chai, & Churchill, 2011; Murdock, 2006; O'Brien, Aguinaga, Hines, & Hartshorne, 2011; Wepner, Bowes, & Serotkin, 2005). Some studies focus on teacher educators' proficiency with common technologies such as the use of email, online searches, text processing, presentation software or maintaining a website (Howland & Wedman, 2004; Murdock, 2006; Wepner et al., 2005), or even proficiency in using computers in general (Drent & Meelissen, 2008). Other studies differentiate between experience with commonly used hard- and software (such as email, online searches, text processing or presentation software) and less common and often subject-specific technologies (Carroll & Morrell, 2006; Georgina & Olson, 2008).

All of the nine studies assume that teacher educators lack the necessary technological experience, especially with emerging or more complicated technologies. Murdock (2006), for instance, concludes in his survey (n = 105) of online course development in teacher education that teacher educators in technical teacher education lack experience with technology. Experience with technology is defined as the extent to which educators maintain a personal or private website. The majority (64%) of teacher educators do not maintain such websites. Georgina and Olson (2008) conducted a survey (n = 237) on technology integration in colleges of education. They conclude that teacher educators have limited experience, especially with more complicated and less common technologies, such as web page creation, blogging and using software like Movie Maker, Publisher or Access, whereas they report high levels of experience with commonly used hard- and software (e.g. the use of laptops, digital cameras, web browsers, email or Word). Carroll and Morrell (2006) reach a similar conclusion in their survey of teacher educators (n = 51) as they describe how teacher educators report relatively high skill levels for a number of basic tools (such as presentation software and spreadsheets), but consider themselves to be less experienced with regard to programs that are less commonly used. In 2006, this referred to technologies like online communication. Qualitative and theoretical studies (Howland & Wedman, 2004; Lim et al., 2011; Wepner et al., 2005) also state that teacher educators lack

the necessary technological experience, but do not elaborate on their actual levels of experience.

O'Brien et al. (2011) present an overview of technology tools and their usefulness for teacher educators preparing students to teach in special education, especially when serving students at a distance in rural areas. Their overview adds a new aspect to the description of technology competences. According to the authors, proficiency in using a wide variety of technologies is particularly relevant for the integration of technology in teacher education. They consider it to be more important than teacher educators' being very competent in a limited range of technologies. Chapman and Gaytan (2009) emphasize the importance of the swiftness with which teacher educators adopt emerging technologies, using Rogers' Rate of Adoption theory (1995), and differentiating between innovators early adopters and laggards. They found that older, more experienced teacher educators (15 or more years of teaching experience) had lower technology adoption rates and integrated technology less often as a pedagogical tool than their less experienced and younger colleagues.

Five other studies in the review focus less on the proficiency in using technology and define technological competence in terms of the *level of comfort with technology* use or self-efficacy (Ajjan & Hartshorne, 2008; Capobianco & Lehman, 2006; Houston & Pierson, 2008; Javeri & Persichitte, 2010; Matthew et al., 2002). Ajjan and Hartshorne (2008) conducted a survey (n = 135) among higher education faculties, including teacher education faculties, about their decisions to adopt Web 2.0 technologies. They conclude that higher education faculties in general are not familiar with the use of Web 2.0 technologies and are uncertain or even negative about their own abilities in this area. The lack of comfort with these kinds of technologies is considered to be a barrier to the actual use of technology for teaching and learning. The other studies confirm teacher educators' lack of comfort with the use of technology, but do not further describe actual levels of comfort or specific definitions of comfort or self-efficacy.

Three qualitative case studies focus on acquired *knowledge about (the impact of) technology* − either knowledge needed to solve technological problems or knowledge related to understanding the impact, affordances and constraints of technology in everyday life (Boling & Adams, 2008; Heck & Sweeney, 2013; Koehler et al., 2004). These studies describe the relevance of knowledge about technology as an aspect of technological proficiency, but do not elaborate on the extent to which teacher educators actually possess this knowledge.

In summary, 17 studies identify technology competences as key to teacher educators' teaching and learning with technology. How 'technology competences' are defined in the reviewed articles varies from being able to use certain technologies, to feeling comfortable in using technology, to being proficient in a wide variety of technologies, to swiftly adopting emerging technologies and being knowledgeable about (the impact of) technology in general. The extent to which teacher educators have these technological competences is less often researched. The studies do indicate that teacher educators do have experience with basic technologies, but are less competent in the use of less common software and hardware or in adopting emerging technologies.

5.2. Competences in pedagogical and educational use of technology

In 12 of the 26 reviewed articles it is argued that the use of technology for teaching and learning not only requires technology competences on the part of teacher educators, but also imposes demands on specific competences for pedagogical and educational use of technology. Much like previous research on teachers' technology use in education, the reviewed articles emphasize that technological proficiency in itself is no guarantee of pedagogical proficiency in educational technology. The competences needed to use technology for pedagogical and educational purposes are considered to be relevant for the actual use of technology in education.

Most studies (8 out of 12) emphasize that teacher educators first need to learn to *use (educational) technologies within the context of their classroom* (Amburgey, 2006; Boling & Adams, 2008; Carroll & Morrell, 2006; Drent & Meelissen, 2008; Friel et al., 2009; Garcia & Rose, 2007; Georgina & Olson, 2008; Teclehaimanot & Lamb, 2005). Drent and Meelissen's (2008) path analysis (n = 210) showed that teacher educators' experience in using educational technologies has a significant direct effect on the innovative use of technology for teaching and learning (0.23), whereas general technological competence only has a small indirect effect (0.05). Even if teacher educators are proficient with technology in general, they still need support to learn how to use this technology in the classroom. Boling and Adams (2008) describe in their review of multiple case studies that teacher educators' familiarity with online discussions and experience with video-based programs influences the use of hypermedia video-based programs to assist teacher candidates in understanding the complexities of teaching. Based on an evaluation of a collaborative training model aimed at improving technology integration in higher education (n = 55), Friel et al. (2009) conclude that teacher educators need to be supported in the use of technologies in their classrooms. Teacher educators that were helped by technology trainers to use interactive and presentation technologies in their own pedagogical context felt more comfortable in using these for future teaching. Amburgey (2006) and Teclehaimanot and Lamb (2005) report similar findings in their evaluation of professional development programmes aimed at improving educators' technology use in university colleges of education. They argue that professional development should focus on helping educators to use different technologies (e.g. Internet, email, digital audio and video programs) to increase their confidence level in utilizing technology in their classes and to help them understand the unique ways in which technology can enhance their teaching and assessment.

Georgina and Olson (2008) confirm in their survey (n = 237) that technological competence is no guarantee of being able to use technology in an educational context. They found that teacher educators' proficiency in more commonly used hard- and software is high, but drops significantly where teaching with educational (subject)-specific technologies is concerned. Carroll and Morrell (2006) find similar results in their survey in which they compare teacher educators' (n = 51) and student teachers' knowledge and use of technology in education. They find that even though students and teacher educators differ in technological experience (students are more experienced in the use of online communication tools and teacher educators in the use of familiar office applications such as word processing and email), they are both equally uncertain about their ability to use educational technology.

Five qualitative studies specifically stress the importance of making a meaningful connection between technology, pedagogy and content. The ability and knowledge to choose optimal technologies to reach specific pedagogical goals with specific groups of students (*pedagogical reasoning*) is essential for pedagogically meaningful use of technology (Garcia & Rose, 2007; Groth et al., 2007; Koehler et al., 2004; Lim et al., 2011; Teclehaimanot & Lamb, 2005). Koehler et al. (2004) describe a transactional relationship between technology, pedagogy and content: a change in any one of these factors influences the other factors and sets changes in motion for all aspects. Knowledge of all three factors − technology, pedagogy and content − and the underlying relationships is necessary to make informed decisions regarding the use of

technology for teaching and learning (Koehler et al., 2004). This so-called TPACK model is frequently used to describe teachers' use of technology in primary or secondary education (e.g. Koehler, Mishra, & Cain, 2013; Voogt et al., 2013), and is also adopted in the literature on teacher educators' use of technology in education. The extent to which teacher educators are able to meaningfully connect technology, pedagogy and content is not described in the five qualitative and evaluative studies.

In summary, competences in pedagogical and educational use of technology are identified as the second domain of competence for teacher educators to integrate technology into their classes. Twelve studies indicate that technological competences are not enough for teacher educators to be able to use technology for pedagogical and educational purposes. Teacher educators also need to be proficient in the use of educational hardware and software in the classroom and be sufficiently able and knowledgeable to effectively connect technology, pedagogy and content in relation to specific teaching goals for specific groups of students. The studies indicate that many teacher educators are uncertain about their ability to use educational technology. Research on the extent to which teacher educators are experienced in connecting technology, pedagogy and content is not yet available.

5.3. Beliefs about teaching and learning

In the research on teacher educators' use of technology for teaching and learning, teachers' beliefs about teaching and learning and the ability to question or change these beliefs are also identified as a relevant domain of competence, although less frequently than technology competences and competences for pedagogical and educational use of technology (9 of the 26 articles). Three of the studies focus on teacher educators' beliefs concerning the advantages of using technology in reaching their teaching and learning goals (Ajjan & Hartshorne, 2008; Murdock, 2006; Teclehaimanot & Lamb, 2005). Murdock (2006) argues, based on his survey (n = 105), that in order to improve technology-enhanced course development, educators in technical teacher education first need to be made aware of the benefits of technology-enhanced learning for student learning. During their evaluation of a professional development programme for teacher educators (n = 91), Teclehaimanot and Lamb (2005) noted that if teacher educators recognize the effect of technology on the teaching and learning process, they are more likely to start using technology in their classrooms. Ajjan and Hartshorne (2008), however, show that positive beliefs about teaching and learning with technology in themselves do not automatically lead to (innovative) technology use in education. They analysed teacher educators' decisions to use Web 2.0 applications (n = 135) and found that even though many teacher educators acknowledge the pedagogical benefits of these applications, the majority do not actually use them. Other factors, such as ease of use, usefulness and the compatibility of technologies, are at least equally important for teacher educators' willingness to use Web 2.0 technology.

Six of the nine studies relate the use of technology for teaching and learning in teacher education to educational reform and changing pedagogical practices (Archambault, Wetzel, Foulger, & Williams, 2010; Boling & Adams, 2008; Drent & Meelissen, 2008; Friel et al., 2009; Howland & Wedman, 2004; Koehler et al., 2004). They describe how the use of technology for teaching and learning in teacher education coincides with changes towards a new, more student-centred learning pedagogy. The integration of technology offers teacher educators an opportunity to experience active and student-centred ways of teaching and learning. Drent and Meelissen (2008), however, describe a more reciprocal relationship. In the case studies that were a part of their quantitative

analysis they found that teacher educators' innovative use of technology and changes towards a more student-oriented pedagogical approach take place simultaneously and influence each other. Koehler et al. (2004) conclude in their study on the development of an online curriculum that changing pedagogical practices always requires a redefinition of the relationship between content, pedagogy and technology. Teacher educators' beliefs about teaching and learning, as well as their perception of the benefits of technology use, influence the definition of this relationship.

In summary, teacher educators' beliefs about teaching and learning are identified as a domain of competence for the use of technology for teaching in teacher education in nine of the 26 articles. Beliefs about both the added value of technology for teaching and learning in general, and the added value for changing pedagogical practices, are considered to be relevant. Some of these studies place teacher educators' use of technology for teaching and learning within the framework of educational reform, and typically describe a change from instructor-led education to more student-centred teaching and learning activities with technology. Most of the research in this domain is exploratory and qualitative. Furthermore, most studies do not elaborate on the actual beliefs held by teacher educators.

5.4. Competences for innovation and professional learning

As described in the previous section, the use of technology in education is often set within the framework of educational reform and changing pedagogical practices. Integrating technology into education with the aim of innovating pedagogical practices is seen as a complex and multidimensional innovation process that makes demands on teachers' competences in innovation and professional learning (Vanderlinde, 2011). These competences in innovation and professional learning encompass three characteristics of educational professionals besides their general pedagogical skills: being able to collaborate and share with colleagues, being able to reflect on and change their own professional behaviour and having a research-oriented attitude (Fullan, 1992). The ability to be an innovative, collaborative and researching professional is seen as especially important within the context of the fast-changing possibilities of technology for teaching and learning (Vanderlinde, 2011). In the reviewed literature on teacher educators' use of technology, competences in innovation and professional learning are also identified as a relevant domain of competence for teacher educators teaching and learning with technology (5 of the 26 articles).

In their path analysis (n = 210), Drent and Meelissen (2008) found personal entrepreneurship to be the key factor in the integration of innovative technology use for teaching and learning (β = 0.33). Personal entrepreneurship is defined as the number of contacts teacher educators have with colleagues or experts within and outside their institution regarding their professional development in the use of technology. In the case studies that were part of this study, Drent and Meelissen (2008) found indications that personal entrepreneurship is strongly related to teacher educators' willingness to reflect upon and change their teaching and learning. Rodesiler and Tripp (2012) also discuss the importance of teacher educators collaborating with colleagues. They stress the opportunities for teacher educators to actively participate in teaching-focused online networks in order to model networked learning to their students, but also to develop their own network of mentors. In their research on the development of online courses, Koehler et al. (2004) state that the development of a new teaching environment forces teacher educators to question their beliefs about teaching and learning (see previous section), but also to actively find new forms of support and collaboration to sustain these changes.

Peeraer and Van Petegem (2012) emphasize the relevance of both collaboration with colleagues and of teacher educators having a research-oriented attitude. In their evaluation of a professional development trajectory for teacher educators in the use of technology for teaching, they found that conducting research on the topic as well as participating in an online community of practice had a positive influence on teacher educators' technology use. Finally, Capobianco and Lehman (2006) describe how in their action research they found that reflecting on and actively changing their own practice helped them to overcome internal and fundamental beliefs and established practices that limit innovation (second-order barriers), and to find innovative ways to integrate technology into their elementary science methods course.

In summary, five studies in the review show that teacher educators need to be able to be innovative, collaborative and researching professionals in order to enhance their own teaching with technology and to stimulate and sustain educational change. The extent to which teacher educators actually have these competences in innovation and professional learning is not described.

5.5. Key characteristics of professional development

In this section we focus on how teacher educators can be supported in the acquisition or development of the previously identified competences in teaching and learning with technology according to the reviewed literature (research question 3).

In 15 of the 26 reviewed articles, characteristics of professional development aimed at improving teacher educators' competences in using technology for teaching and learning are discussed. In these articles, professional development of individual teacher educators is seen as key to the (innovative) use of technology for teaching and learning. Improving access to technology and support helps to overcome first-order barriers to technology innovation. In order to overcome second-order barriers, related to beliefs and routines, professional development is essential (Ajjan & Hartshorne, 2008; Ertmer, 1999). The reviewed articles describe four key characteristics for professional development aimed at improving teacher educators' use of technology for teaching and learning. First of all, it is emphasized that professional development activities should be relevant and closely *related to* a teacher educator's own *pedagogical context* (Chapman & Gaytan, 2009; Koehler et al., 2004; Lim et al., 2011). Koehler et al. (2004) argue that a new balance in the relationship between technology, pedagogy and content is essential for genuine technology integration in education. They evaluated a 'learning-by-design' approach in which six teams of teacher educators and students worked collaboratively to design online courses that would be taught by the teacher educators the following year. The approach was aimed at helping teacher educators understand the complex relationship between technology, pedagogy and content, and at using this understanding to develop appropriate, context-specific strategies for the use of technology for teaching and learning. They conclude that good online teaching can only be realized when all three components of pedagogy, content and technology are considered in interrelation with one another. Amburgey's (2006) evaluation study describes how teacher educators valued the combination of formal technology training and the opportunity to practise what they had learned while redesigning their own course curriculum. Teacher educators indicated that this combination improved their level of confidence in using technology and led to new ideas regarding how to use technology for teaching and learning.

Seven other articles endorse the importance of professional development being related to the pedagogical context, but add *inter- or multidisciplinary collaboration* as an essential characteristic of learning to teach and learn with technology (Ajjan & Hartshorne,

2008; Friel et al., 2009; Groth et al., 2007; Howland & Wedman, 2004; Matthew et al., 2002; Reading & Doyle, 2013; Wepner et al., 2005). Collaboration with colleagues and experts within and outside the individual teacher education institution is considered to be helpful and supportive in processes of pedagogical change (Fullan, 1992). This is the case even more when these processes include the use of rapidly changing technologies (Vanderlinde, 2011). Friel et al. (2009) describe an interdisciplinary, collaborative training model in which the professional development programme is conducted by a multidisciplinary faculty group and an information technology specialist within the pedagogical context. Evaluation of this model (n = 55) showed that training increased faculties' technology skills and encouraged them to use a more constructivist approach to teaching in a technology-rich learning environment. Reading and Doyle (2013) studied (n = 7) which aspects of the TTF (Teaching Teachers for the Future) project were identified by teacher educators as enablers for the development of their Technological Pedagogical Content Knowledge (TPACK). They found that factors associated with supportive action in the workplace and with collaboration nurtured teacher educators' learning about using technology for teaching and learning the most. Howland and Wedman (2004) describe a tailor-made professional development programme in which faculties worked together with educational technology specialists and students with technology experience on developing a technology integration plan. This collaboration helped improve teacher educators' efficacy in using technology for teaching and learning (n = 55). Other studies also show the importance of interdisciplinary collaboration in teacher educators' professional development in which either students, practising teachers, or other faculty or technology specialists function as role models for teacher educators (Ajjan & Hartshorne, 2008; Groth et al., 2007; Matthew et al., 2002; Wepner et al., 2005).

A third key characteristic of professional development in using technology in education is *tailoring* professional development programmes *to* individual *teacher educators' needs and interests* as much as possible. Teacher educators should, according to the reviewed studies, be able to choose between different forms of professional development activities (Georgina & Olson, 2008; Howland & Wedman, 2004; Lim et al., 2011) and these activities should substantively be tailored to the specific courses that teacher educators teach (Chapman & Gaytan, 2009). Finally, the inclusion of *reflective learning* in professional development is advised. The reviewed studies show that teacher educators should have the opportunity to reflect on existing and new practices and thus generate and share information to inform future practices (Lim et al., 2011; Murdock, 2006; Reading & Doyle, 2013). Peeraer and Van Petegem (2012) build on these findings as they describe their professional development programme to improve Vietnamese teacher educators' use of technology and thus help expose student teachers to effective uses of technology for teaching and learning. They stress the need for a step-by-step trajectory in which teacher educators consecutively (1) receive information about the interplay between technology, content and pedagogy (TPACK) in workshops; (2) engage in a real-world authentic task of designing a technology-enhanced lesson; (3) share, discuss and reflect on these lessons with peers and technology experts; and finally (4), are encouraged to become involved in continued professional development through participation in online communities of practice, in extra training and through researching the topic of technology integration in their teaching and learning. The majority of the participants included in the evaluation study (n = 392) found the step-by-step programme very inspiring as it gave them ideas about how to apply technology in their teaching.

Summarizing the 15 reviewed studies on professional

development, they provide evidence of four key characteristics of professional development aimed at improving teacher educators' competences in using technology for teaching and learning. These key characteristics are: a relatedness to teacher educators' specific pedagogical contexts, inter- or multidisciplinary collaboration, tailor-made to teacher educators' needs and interests, and stimulation of reflective learning.

6. Conclusion and discussion

The purpose of this study is to investigate what competences teacher educators need to teach and learn with technology and to foster student teachers' technological literacy as second-order teachers, based on an overview of the existing research literature. The review aims to answer the question of what competences teacher educators need, how competent they are and how the required competences can effectively be developed.

Research on teacher educators' teaching with technology is expanding, but remains less voluminous than research on teaching and learning with technology by teachers in primary and secondary education. Furthermore, many of the studies on technology use in teacher education focus primarily on student teachers' needs and qualifications and not on their educators. An extensive literature search revealed 26 studies explicitly dealing with teacher educators' competences in teaching and learning with technology. The novelty and significance of this review is that its results provide a unique overview on what is known from previous research on the specific competences teacher educators need to fulfil their task to foster student teachers' proficiency in teaching and learning with technology.

Four domains of competence for teacher educators for teaching and learning with technology are identified based on the review of the 26 research articles (research question 1): technology competences, competences in pedagogical and educational use of technology, beliefs about teaching and learning, and competences in innovation and professional learning. The definition of technology competences surpasses the ability to use specific technologies or to feel comfortable in using them. Metacognitive competences, such as the aptitude to swiftly adopt emerging technologies or being knowledgeable about (the impact of) technology in general, are considered to be at least equally important. Within the domain of competences in pedagogical and educational use of technology, a similar distinction between instrumental skills and metacognitive abilities is made. Teacher educators need to be proficient in the use of educational hardware and software in the classroom, but they also need to be able — and knowledgeable in this regard — to effectively connect technology, pedagogy and content in relationship to specific teaching goals for specific groups of students. The third domain of competence, concerning beliefs about teaching and learning, includes both beliefs about the added value of technology for teaching and learning in general and beliefs about the added value of technology for changing pedagogical practices. Teachers need to be aware of their beliefs, to be willing and able to articulate, discuss and change their beliefs. Finally, the ability to be an innovative, collaborative and researching professional is seen as important for teacher educators to teach and learn with technology. Competences in innovation and professional learning entail the ability to collaborate and share with colleagues, the ability to reflect on and change their own professional behaviour and having a research-oriented attitude.

The number of studies that describe the extent to which teacher educators have the identified competences (answering research question 2) is limited. Those studies that do quantify the actual level of competence mostly focus on instrumental skills or the ability to use technologies (basic, common or educational). Studies

on the extent to which teacher educators have competences on a metacognitive level, such as the ability to swiftly adopt emerging technologies or the proficiency to relate technology to pedagogy and content, are lacking. Results on teacher educators' actual beliefs and competences in innovation and professional learning are also scarce. Current research on the extent to which teacher educators have specific competences is limited and is at risk of rapidly becoming outdated as a result of its restriction to the ability to use specific time-bound technologies. This kind of research is likely to fall behind with technological developments. Research on metacognitive competences or beliefs seems to be more in line with the fast-changing possibilities of technology for teaching and learning (Vanderlinde, 2011).

The domains of competence for teacher educators in teaching and learning with technology that are identified in the review are much the same as the competences that were found relevant or even conditional in research on teachers' technology use in primary and secondary education (e.g. Ertmer, 2005; Hargreaves & Fullan, 2012; Hermans et al., 2008; Knezek & Christensen, 2008; Mishra & Koehler, 2006; Sang et al., 2010; UNESCO, 2011; Voogt et al., 2013). In the reviewed articles, the nature of the relationship between teacher educators' beliefs and the use of technology for teaching remains ambiguous. Some authors argue that changes in beliefs about what constitutes good teaching lead to changes in the use of technology for teaching. Others state that the integration of technology offers teacher educators and teachers an opportunity to experience innovative ways of teaching and learning, thereby influencing their beliefs on education and the added value of technology. Some research describes a more reciprocal relationship, where innovative use of technology and changes in beliefs on education take place simultaneously and influence each other. In order to determine the exact relationship between beliefs about education and the use of technology for teaching, further research is needed.

The review offers a first overview of relevant domains of competence that are defined in previous research and describes the extent to which teacher educators have at least some of these competences. Most of the results are related to teacher educators' use of technology for teaching and seem to focus on the teacher educator's role as a first-order teacher. The studies hardly elaborate at all on competences related to the specific requirements of being a second-order teacher (research questions 1B and 1C), such as the ability to justify the modelled behaviour and explain underlying pedagogical choices (Bai & Ertmer, 2008; Lunenberg et al., 2013; Murray & Male, 2005; Wright & Wilson, 2007). Moreover, the competences that teacher educators need to prepare student teachers to support their future students' technological literacy are not discussed. More research on these topics is clearly needed.

The review shows that the specific role of teacher educators in the integration of technology in education has not been an important research theme in the last few decades, when compared to the body of research on the role of teachers. Not only is the amount of research relatively limited, but the nature of the research is merely qualitative. Quantitative studies on the actual practices and competences of teacher educators and the relations of these practices with the competences and practices of student teachers and starting teachers are lacking. The review also shows that, when studying teacher educators (in higher education) in their role as teachers, similar competence domains are found to be relevant for the use of technology as for teachers in primary and secondary education. That in itself is interesting in terms of the teacher educator as a role model: next to modelling the use of technology, the teacher educator might also be modelling his own competency development. This could be a topic for further research.

Teacher education institutions are searching for effective

strategies to professionalize their teacher educators (Tondeur et al., 2012). The reviewed studies provide evidence of four key characteristics of effective professional development aimed at improving teacher educators' competences in using technology for teaching and learning (research question 3). According to the reviewed studies, professional development programmes for teacher educators regarding the use of technology in education should be related to teacher educators' specific pedagogical contexts, should include inter- or multidisciplinary collaboration, should be tailored to teacher educators' needs and interests, and should stimulate reflective learning. These characteristics are very similar to previous research findings on effective professional development programmes aimed at helping teachers to improve their competences in teaching and learning with technology (e.g. Hargreaves & Fullan, 2012; Voogt et al., 2013). Literature on how professional development programmes can support teacher educators explicitly in their role as second-order teachers in the domain of teaching with technology is not yet available. Based on the findings of this review, it can be argued that professional development of teacher educators for teaching and learning with technology should address at least four competence domains (the 'what') − technological competences, pedagogical competences related to technology, beliefs about teaching and learning, and professional competences for innovation − and should be (the 'how') context-specific, tailor-made, collaborative and reflective. The research literature gives no directions on what elements should be added or integrated to address the level of the teacher educator as a second-order teacher. Future research could focus on this question. More research is also needed on both the 'what' and 'how' question regarding the professional development of teacher educators to prepare student teachers to support their future students' technological literacy.

The review reveals an increasing interest in research literature in teacher educators' competences in teaching and learning with technology, but research that explicitly takes into account the specific requirements for teacher educators as second-order teachers is seriously lacking. The framework of competences in teaching with technology, as described in this article, needs to be extended to encompass specific sets of competences in order to do justice to the specific character of the teacher educators' profession. Future research also needs to answer the question concerning the extent to which teacher educators actually have these competences, and to describe how the different domains of competence interact and influence teacher educators' actual use of technology as second-order teachers. Most of the studies in the review (19 out of 26 studies) are exploratory, descriptive and qualitative studies such as case studies, theoretical studies or evaluation studies. In order to specify what competences teacher educators have, and to establish direct and indirect relationships between the domains of competence and technology use in teacher education, more quantitative, experimental research is needed.

The fact that most studies were conducted at least ten years ago (20 out of 26 articles were published prior to 2011) represents a limitation to the results of the review. Some of the results might be outdated. However, it is unlikely that the relevance of the four domains of competence has changed significantly over the last ten years, especially considering the fact that these domains are still very similar to those identified in previous and recent research on teachers' technology use in education. Results on the extent to which teacher educators have the required competences are more prone to becoming outdated. This rings especially true for results on the ability to use specific technologies either in private life or in education. Technologies that were described as emerging or less common five years ago might be widespread today. Research that includes metacognitive competences, beliefs and competences in innovation and professional learning seem to be more in line with

the swiftness of technological changes. To overcome the risk of research results becoming rapidly outdated in future research, the focus should be on these metacognitive competences and beliefs instead of solely referring to competences in using specific current or emerging technologies. By including metacognitive competences, beliefs and competences in innovation and professional learning in future research, results will be more in line with the swiftness of technological changes. And it will also provide teacher education institutes with the specific information they need regarding how and what teacher educators need to learn to support their teaching and learning with technology.

As previously mentioned, further research is required on the specific competences teacher educators need to use technology for teaching and learning as second-order teachers as well as on the extent to which teacher educators have these required competences. Quantitative research is needed to describe the present situation and to analyse the relationships between the different domains of competence and the use of technology in education to boost effective professional development. Research on teacher educators' actual competences is often dependent on self-reports of teacher educators' own competences, and is therefore at risk of representing a distorted view of the reality with teacher educators over- or underestimating their own competences. To assess the validity and reliability of teacher educators' description of their own competences we would recommend having quantitative studies accompanied by research from a different perspective (triangulation): for example, by research focused on student teachers' perspectives on the use of technology for teaching in teacher education and on the extent to which teacher educators act as role models in this regard.

References

Agyei, D. D., & Voogt, J. (2011). Exploring the potential of the will, skill, tool model in Ghana: Predicting prospective and practicing teachers' use of technology. *Computers & Education, 56*(1), 91—100. https://doi.org/10.1016/j.compedu.2010.08.017.

Ajjan, H., & Hartshorne, R. (2008). Investigating faculty decisions to adopt Web 2.0 technologies: Theory and empirical tests. *Internet and Higher Education, 11*(2), 71—80. https://doi.org/10.1016/j.iheduc.2008.05.002.

Amburgey, V. (2006). One model of professional development. *Computers in the Schools: Interdisciplinary Journal of Practice, Theory, and Applied Research, 23*(3—4), 105—113. https://doi.org/10.1300/J025v23n03_07.

American Heritage. (2011). *The american heritage dictionary of the english language* (5th ed.) Retrieved from http://www.yourdictionary.com/competence#americanheritage.

Archambault, L., Wetzel, K., Foulger, T. S., & Williams, M. K. (2010). Professional development 2.0: Transforming teacher education pedagogy with 21st-century tools. *Journal of Digital Learning in Teacher Education, 27*(1), 4—11. https://doi.org/10.1080/21532974.2010.10784651.

Bai, H., & Ertmer, P. A. (2008). Teacher educators' beliefs and technology uses as predictors of preservice teachers' beliefs and technology attitudes. *Journal of Technology and Teacher Education, 16*(1), 93—112.

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12:What is involved and what is the role of the computer science education community? *ACM Inroads, 2*(1), 48—54.

Boling, E., & Adams, S. S. (2008). Supporting teacher educators' use of hypermedia video-based programs. *English Education, 40*(4), 314—339.

Capobianco, B., & Lehman, J. (2006). Integrating technology to foster inquiry in an elementary science methods course: An action research study of one teacher educators' initiatives in a PT3 project. *Journal of Computers in Mathematics and Science Teaching, 25*(2), 123—146.

Carroll, J., & Morrell, P. D. (2006). A comparison of teacher education faculty and preservice teacher technology competence. *Journal of Computing in Teacher Education, 23*(1), 5—10.

Chapman, B. F., & Gaytan, J. A. (2009). Impact of post-secondary business teacher educators' employment characteristics and innovation factors on their adoption of current computer technologies as a pedagogical tool. *Delta Pi Epsilon Journal, 51*(3), 137—151.

Chien, Y., Chang, C., Yeh, T., & Chang, K. (2012). Engaging pre-service science teachers to act as active designers of technology. *Teaching and Teacher Education, 28*, 578—588. https://doi.org/10.1016/j.tate.2011.12.005.

Drent, M., & Meelissen, M. (2008). Which factors obstruct or stimulate teacher educators to use ICT innovatively? *Computers & Education, 51*(1), 187—199. https://doi.org/10.1016/j.compedu.2007.05.001.

Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development, 47*(4), 47–61. https://doi.org/10.1007/BF02299597.

Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *Educational Technology Research and Development, 53*(4), 25–39. https://doi.org/10.1007/BF02504683.

European Commission. (2007). *A european approach to media literacy in the digital environment*.

Friel, T., Britten, J., Compton, B., Peak, A., Schoch, K., & VanTyle, W. K. (2009). Using pedagogical dialogue as a vehicle to encourage faculty technology use. *Computers & Education, 53*(2), 300–307. https://doi.org/10.1016/j.compedu.2009.02.002.

Fullan, M. G. (1992). *Successful school improvement: The implementation perspective and beyond. Modern educational thought*. Bristol: Open University Press.

Garcia, P., & Rose, S. (2007). The influence of technocentric collaboration on pre-service teachers' attitudes about technology's role in powerful learning and teaching. *Journal of Technology and Teacher Education, 15*(2), 247–266.

Georgina, D. A., & Olson, M. R. (2008). Integration of technology in higher education: A review of faculty self-perceptions. *The Internet and Higher Education, 11*(1), 1–8. https://doi.org/10.1016/j.iheduc.2007.11.002.

Gronseth, S., Brush, T., Ottenbreit-Leftwich, A., Strycker, J., Abaci, S., Easterling, W., et al. (2010). Equipping the next generation of Teachers: Technology preparation and practice. *Journal of Digital Learning in Teacher Education, 27*(1), 30–36. https://doi.org/10.1080/21532974.2010.10784654.

Groth, L. A., Dunlap, K. L., & Kidd, J. K. (2007). Becoming technologically literate through technology integration in PK-12 preservice literacy courses: Three case studies. *Reading Research and Instruction, 46*(4), 363–386. https://doi.org/10.1080/19388070709558476.

Hargreaves, A., & Fullan, M. (2012). *Professional capital: Transforming teaching in every school*. New York: Teachers College Press.

Heck, D., & Sweeney, T. (2013). Using most significant change stories to document the impact of the teaching teachers for the future project: An Australian teacher education story. *Australian Educational Computing, 27*(3), 36–47.

Hermans, R., Tondeur, J., Van Braak, J., & Valcke, M. (2008). The impact of primary school teachers' educational beliefs on the classroom use of computers. *Computers & Education, 51*(4), 1499–1509. https://doi.org/10.1016/j.compedu.2008.02.001.

Houston, W. R., & Pierson, M. E. (2008). Preparing teachers for a global society that is yet unknown to teacher educators. *Teacher Education and Practice, 21*(4), 479–481.

Howland, J., & Wedman, J. (2004). A process model for faculty development: Individualizing technology with technology during field experiences. *Journal of Technology and Teacher Education, 12*(2), 239–263.

International Society for Technology in Education [ISTE]. (2008). *ISTE Standards for teachers*. Retrieved from http://www.iste.org/standards/iste-standards/standards-for-teachers.

Javeri, M., & Persichitte, K. (2010). Use of innovation component configuration map (ICCM) to measure technology integration practices of higher education faculty. *Journal of Technology and Teacher Education, 18*(4), 607–643.

Kaufman, K. (2015). Information communication. *Mid-Atlantic Education Review, 2*, 1–11.

Knezek, G., & Christensen, R. (2008). The importance of information technology attitudes and competences in primary and secondary education. In J. Voogt, & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 321–331). New York: Springer.

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is technological pedagogical content knowledge (TPACK)? *Journal of Education, 193*(3), 13–19.

Koehler, M. J., Mishra, P., Hershey, R., & Peruski, L. (2004). With a little help from your students: A new model for faculty development and online course design. *Journal of Technology and Teacher Education, 12*(1), 25–55.

Koltay, T. (2011). The media and the literacies: Media literacy, information. *Media, Culture & Society, 33*(2), 211–221. https://doi.org/10.1177/0163443710393382.

Lei, J., & Zhao, Y. (2007). Technology uses and student achievement. *Computers & Education, 49*, 284–296. https://doi.org/10.1016/j.compedu.2005.06.013.

Lim, C. P., Chai, C. S., & Churchill, D. (2011). A framework for developing pre-service teachers' competences in using technologies to enhance teaching and learning. *Educational Media International, 48*(2), 69–83. https://doi.org/10.1080/09523987.2011.576512.

Lunenberg, M., Dengerink, J., & Korthagen, F. (2013). *Het beroep van lerarenopleider. Professionele rollen, professioneel handelen en professionele ontwikkeling van lerarenopleiders*. Amsterdam: Vrije Universiteit Amsterdam.

Lunenberg, M., Korthagen, F., & Swennen, A. (2007). The teacher educator as a role model. *Teaching and Teacher Education, 23*, 586–601.

Matthew, K., Stephens, E., Callaway, R., Letendre, C., & Kimbell-Lopez, K. (2002). Adoption of information communication technology by teacher educators: One-on-one coaching. *Journal of Information Technology for Teacher Education, 11*(1), 45–62. https://doi.org/10.1080/14759390200200122.

Mioduser, D., Nachmias, R., Tubin, D., & Forkosh-Baruch, A. (2003). Analysis schema for the study of domains. *Education and Information Technologies, 8*(1), 23–36.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teacher College Record, 108*, 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x.

Murdock, A. K. (2006). Online course development in technical teacher education programs. *Journal of Industrial Teacher Education, 43*(1), 74–90.

Murray, J., & Male, T. (2005). Becoming a teacher educator: Evidence from the field. *Teaching and Teacher Education, 21*(2), 125–142. https://doi.org/10.1016/j.tate.2004.12.006.

O'Brien, C., Aguinaga, N. J., Hines, R., & Hartshorne, R. (2011). Using contemporary technology tools to improve the effectiveness of teacher educators in special education. *Rural Special Education Quarterly, 30*(3), 33–40.

Ottenbreit-Leftwich, A. T., Glazewski, K. D., Newby, T. J., & Ertmer, P. A. (2010). Teacher value beliefs associated with using technology: Addressing professional and student needs. *Computers & Education, 55*(3), 1321–1335. https://doi.org/10.1016/j.compedu.2010.06.002.

Peeraer, J., & Van Petegem, P. (2012). The limits of programmed professional development on integration of information and communication technology in education. *Australasian Journal of Educational Technology, 28*(6), 1039–1056.

Petticrew, M., & Roberts, H. (2006). *Systematic reviews in the social sciences: A practical guide*. Oxford: Blackwell.

Reading, C., & Doyle, H. (2013). Teacher educators as learners: Enabling learning while developing innovative practice in ICT-rich education. *Australian Educational Computing, 27*(3), 109–116.

Rodesiler, L., & Tripp, L. (2012). Mentoring matters: Mentoring preservice and early-career English teachers in online environments. *English Journal, 102*(2), 134–137.

Rogers, E. M. (1995). *Diffusion of innovations* (5th ed.). New York: Free Press.

Sang, G., Valcke, M., Van Braak, J., & Tondeur, J. (2010). Student teachers' thinking processes and ICT integration: Predictors of prospective teaching behaviours with educational technology. *Computers & Education, 54*(1), 103–112. https://doi.org/10.1016/j.compedu.2009.07.010.

Teclehaimanot, B., & Lamb, A. (2005). Workshops that work!: Building an effective, technology-rich faculty development program. *Journal of Computing in Teacher Education, 21*(3), 109–115.

Teodorescu, T. (2006). Competence versus competency: What is the difference? *Performance Improvement, 45*(10), 27–30. https://doi.org/10.1002/pfi.027.

Tømte, C., Enochsson, A. B., Buskqvist, U., & Kårstein, A. (2015). Educating online student teachers to master professional digital competence: The TPACK-framework goes online. *Computers & Education, 84*, 26–35. https://doi.org/10.1016/j.compedu.2015.01.005.

Tondeur, J., Kershaw, L. H., Vanderlinde, R., & Van Braak, J. (2013). Getting inside the black box of technology integration in education: Teachers' stimulated recall of classroom observations. *Australasian Journal of Educational Technology, 29*(3), 434–449.

Tondeur, J., Van Braak, J., Guoyuan, S., Voogt, J., Fisser, P., & Ottenbreit-Leftwich, A. S. (2012). Preparing student teachers to integrate ICT in classroom practice: A synthesis of qualitative evidence. *Computers & Education, 59*(1), 134–144. https://doi.org/10.1016/j.compedu.2011.10.009.

United Nations Educational, Scientific and Cultural Organization [UNESCO]. (2011). *UNESCO ICT Competency framework for teachers*. Retrieved from http://unesdoc.unesco.org/images/0021/002134/213475E.pdf.

Vanderlinde, R. (2011). *School-based ICT policy planning in a context of curriculum reform [dissertation]*. Ghent, Belgium: Ghent University. Faculty of Psychology and Educational Sciences.

Van Deursen, A. J. A. M., & van Dijk, J. A. G. M. (2012). *Trendrapport internetgebruik 2012. Een Nederlands en Europees perspectief*. Enschede: Universiteit Twente.

Voogt, J. M., Fisser, P., Good, J., Mishra, P., & Yadav, A. (2015). Computational thinking in compulsory education: Towards an agenda for research and practice. *Education and Information Technologies, 20*(4), 715–728. https://doi.org/10.1007/s10639-015-9412-6.

Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & Van Braak, J. (2013). Technological pedagogical content knowledge: A review of the literature. *Journal of Computer Assisted Learning, 29*, 109–121. https://doi.org/10.1111/j.13652729.2012.00487.x.

Voogt, J., & Pareja Roblin, N. (2010). *21st-century skills. Discussion paper*. Enschede, Netherlands: University of Twente.

Wepner, S. B., Bowes, K. A., & Serotkin, R. (2005). Lessons learned from implementing technology in an undergraduate elementary education program. *Journal of Computing in Teacher Education, 21*(4), 111–119.

Wing, J. M. (2008). Computational Thinking and thinking about computing. *Philosophical Transactions of the Royal Society, 366*. https://doi.org/10.1098/rsta.2008.0118.

Wright, V. H., & Wilson, E. K. (2007). A partnership of educators to promote technology integration: Designing a master technology teacher program. *Education, 128*(1), 80–86.