Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence

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ABSTRACT

This study reviewed qualitative studies that focused on strategies to prepare pre-service teachers to integrate technology into their lessons. A meta-ethnography approach was utilized to locate, critically appraise, and synthesize the results of these studies. Based on an extensive search in the Web of Science, 19 articles were included in this synthesis. The results were divided into two parts: (1) key themes explicitly related to the preparation of pre-service teachers (e.g., using teacher educators as role models, learning technology by design, scaffolding authentic technology experiences), and (2) conditions necessary at the institutional level (e.g., technology planning and leadership, co-operation within and between institutions, training staff). To present how these key themes related to each other, an over-arching model was developed. By interpreting the results of the review, recommendations were discussed for pre-service teacher technology training and future research.

1. Introduction

Research shows that a crucial factor influencing new teachers' adoption of technology is the quantity and quality of pre-service technology experiences included in their teacher education programmes (Agyei & Voogt, 2011; Drent & Meelissen, 2008). Unfortunately, research findings suggest that technology is significantly under-used by pre-service teachers and beginning teachers (Dawson, 2008; Kirschner & Selinger, 2003). According to researchers, a gap exists between what pre-service teachers are taught in their courses and how teachers use technology in a real classroom (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010; Pope, Hare, & Howard, 2002). Research continues to reveal that beginning teachers feel they are not well-prepared to effectively use technology in their classrooms (e.g., Sang, Valcke, van Braak, & Tondeur, 2010; Tearle & Golder, 2008).

A number of factors have been identified to explain why teachers do not feel prepared to use technology in their classrooms, including insufficient access to technology (e.g., Dawson, 2008), lack of time (e.g., Wepner, Ziomek, & Tao, 2003) and lack of technology skills (e.g., Teo, 2009). While there is no doubt that these factors contribute to a lack of technology integration, increasing access to technology, time, and technology skills training does not seem to be enough to adequately prepare pre-service teachers to successfully integrate technology into their future classrooms (Kirschner & Selinger, 2003). Recent calls have indicated that to prepare pre-service teachers for effective technology integration, teacher education programmes need to help them to build knowledge of good pedagogical practices, technical skills, and content knowledge, as well as how these concepts relate to one another (Koehler & Mishra, 2009).

Many teacher education programmes have recognized the challenges associated with developing teachers' abilities to use technology in the classroom and have proposed original, innovative strategies (e.g., Angeli & Valanides, 2009). Given the lack of a comprehensive review about these approaches, the purpose of this study was to reveal the most useful strategies for contemporary technology integration in pre-service teacher education programmes. More specifically, a synthesis of qualitative research was used to locate, critically appraise, and synthesize the evidence base for interventions to prepare pre-service teachers to integrate technology into classroom practices. Before

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describing this methodology in more detail, the next section examines recent approaches related to technology integration research in teacher education.

2. Background

Teacher education programmes have struggled with selecting and implementing the most effective strategies on how to prepare pre-service teachers to integrate technology in their future lessons (Goktas, Yıldırım, and Yıldırım, 2008). Many programmes have attempted to develop pre-service teachers' technology skills through an introductory educational technology course (Polly, Mims, Shepherd, & Inan, 2010). In one survey of 1439 institutions with teacher education programmes in the United States (Kleiner, Thomas, & Lewis, 2007), 85 percent of those programmes reported having an educational technology course ranging from one to four credits. By taking an educational technology course, pre-service teachers are expected to transfer knowledge and skills to their future classrooms (Brush et al., 2003). However, as stated before, the evidence suggests that pre-service teachers do not feel prepared to effectively use technology in their classrooms (e.g., Drent & Meelissen, 2008; Kay, 2006). These studies may indicate the importance of pre-service teachers' understanding with regards to technology: pre-service teacher education should not only focus on how to use technology, but also how technology can be used for teaching and learning.

Many researchers have suggested that technology skills should be integrated throughout the teacher education curriculum in order to provide pre-service teachers with the skills and experiences needed to apply technology to their specific content areas (e.g., Niess, 2005). These programmes emphasized technology training in authentic teaching situations. In this respect, pre-service teacher education programmes provide a wide range of approaches throughout their curriculum (based on Ottenbreit-Leftwich et al., 2010; Polly et al., 2010): information delivery of technology integration content (e.g., lectures, podcasts), hands-on technology skill building activities (e.g., workshops), practice with technology integration in the field (e.g., field experiences), and technology integration reflections (e.g., electronic portfolios). Recent studies have revealed that the best practices provided to pre-service teachers with regards to technology training include authentic experiences in real K-12 classrooms (e.g., Ottenbreit-Leftwich et al., 2010).

Based on the assumption that technology should be connected to specific content areas, Koehler and Mishra (2009) introduced the concept of Technological Pedagogical Content Knowledge (TPACK). TPACK encompasses an integrative knowledge base of technological knowledge and skills, as well as knowledge of learners, subject matter content, and pedagogy necessary for teachers to be competent to teach with technology in the classroom (Koehler & Mishra, 2009). TPACK is a framework that emphasizes the importance of preparing pre-service teachers to make sensible choices in their uses of technology when teaching specific content to a specific target group. According to this framework, technology integration does not require one single pedagogical orientation; it includes a spectrum of approaches to teaching and learning. Teachers select specific technological applications in line with their selections of other curricular variables and processes (e.g., instructional strategies) that fit into their existing educational beliefs (Tondeur, Hermans, van Braak, & Valcke, 2008). In this respect, many researchers believe that technology skills should be integrated throughout the teacher education curriculum, thus providing pre-service teachers with experience in applying technology to specific content areas and pedagogical approaches (Brush et al., 2003; Kay, 2006).

The need to better align pre-service teachers' preparation in the integration of technology with pedagogical issues and curriculum integration has been noted by many researchers recently (e.g., Agyei & Voogt, 2011; Ottenbreit-Leftwich et al., 2010; Sang et al., 2010). Moreover, extensive time and money has been spent developing strategies and programmes to help pre-service teachers use technology effectively. For instance, the U.S. Department of Education's "Preparing Tomorrow's Teachers to Use Technology" (PT3) programme provided funds to support the development of teacher technology learning experiences. From its genesis in 1999 until 2003, the PT3 programme dedicated more than $750 million to projects focusing on new methods for preparing future teachers to effectively integrate technology into their teaching (Lawless & Pellegrino, 2007). Based on evidence from these studies (e.g., Polly et al., 2010), it seems that pre-service teachers' development of technology is a complex process that requires teachers to develop various capabilities. In one review of quantitative studies of previous pre-service teacher technology training, Kay (2006) concluded that "The jury is still out on which strategies work best" (p. 395). Due to this uncertainty, the purpose of the current study was to review qualitative studies that focused on strategies to prepare pre-service teachers to integrate technology into their lessons in order to identify effective strategies.

3. Purpose of the study

While most researchers agree that technology needs to be incorporated in teacher education programmes, numerous suggestions exist regarding the content and delivery methods of that training (e.g., Angeli & Valanides, 2009; Niess, 2005). Therefore, it is of great importance to examine how teacher education programmes influence pre-service teachers to use technology in their future classrooms. As Kay (2006) pointed out, qualitative research studies have been used frequently to describe and examine the results of technology experiences included in pre-service teacher education programmes. According to Atkins et al. (2008), qualitative approaches may provide insights into the reasons why interventions or programmes succeed or fail. The increase in volume of available qualitative research lends itself to synthesis as one method for relating knowledge gathered from these individual studies (Atkins et al., 2008).

The aim of this study was to synthesize the available qualitative research regarding the training of pre-service teachers to integrate technology into their future classrooms. The advantage of such a systematic review is that it produces a holistic view of the situation. Systematic review can facilitate understanding of a topic, identify common threads across studies, and/or develop theory (Hammersley, 2002). More specifically, this review of qualitative research was used to synthesize the evidence regarding which content and delivery methods best prepare pre-service teachers to integrate technology into their future classrooms.

4. Research method

In this study, a systematic review method was used to locate, critically appraise, and synthesize qualitative studies that examined technology training for pre-service teachers. The study used a "meta-ethnography" approach, an interpretive strategy originally developed

by Noblit and Hare (1988) to Synthesize Qualitative Data (SQD) in the field of education. Unlike a meta-analysis of quantitative studies, meta-ethnography of qualitative studies is interpretative rather than aggregative. Through the process of meta-ethnography, the researchers compare and analyze studies while creating new interpretations across the multiple studies (Atkins et al., 2008). The main stages of the review are outlined in Table 1.

Phase one and two focused on (1) deciding on the targeted research focus of the study and (2) locating a sample. Initially, the articles were subject to two criteria for inclusion in the meta-synthesis: first, the research needed to focus on technology integration in teacher education, and second, the research design needed to be qualitative. The studies included in this meta-synthesis were located through an extensive search in the Web of Science. The search was based on the following key words: "teacher education," "pre-service education," "student teacher," "pre-service teacher," "prospective teacher," "trainee teacher," and "teacher educator" in combination with search filters to identify a variety of qualitative studies. The search also included the term "technology" that utilized several words including the following: "technology," "IT" (Information Technology), "ICT" (Information Communication Technology) or "Computers". Articles were restricted to papers written in English published between 2000 and 2011.

One hundred forty-four potentially relevant journal articles were identified by the review team. The review team consisted of the six authors of this article, all experienced in research on technology in teacher education. In an initial screening, the abstracts of the studies ($n = 144$) were examined by two researchers. Exclusions were made if studies were insufficiently focused on the topic or did not use qualitative methods. Based on this abstract screening, 23 studies were identified. Next, the 23 studies were evaluated using an adapted version of the CASP (Critical Appraisal Skills Programme, 1988). This step assisted in exploring the quality and any potential major gaps in the reported results of the 23 studies. Table 2 presents the evaluation criteria used by two independent reviewers on all research studies ($n = 23$). All disagreements between the reviewers were resolved through discussion.

Through the critical appraisal exercise, the reviewers identified several methodological aspects that were not included in some of the selected studies. For example, in seven of the 23 studies the research questions and/or purposes were not clearly stated. Studies that did not include some of the methodological aspects still provided contributions to the synthesis and were thus not excluded based on the quality assessment used in Table 2. After closer review, four papers were excluded due to an insufficient focus on the main purpose of the study: the potential of programmes used to prepare pre-service teachers in order to integrate technology into classroom practices.

In the next phase of meta-ethnography, "reading the studies" (Phase 4), the focus was to become as familiar as possible with the content and detail of the evidence with respect to strategies for technology training in pre-service teacher education programmes. In determining the relationships between the 19 studies (Phase 5), a list of themes were created and juxtaposed (Noblit & Hare, 1988). In this study, the translation (Phase 6) was approached by first arranging each paper chronologically, comparing the themes from paper one with paper two. The synthesis of the themes found in these two papers were then compared with paper three. This process was replicated until all 19 studies were compared. As we compared the selected studies, our initial broad grouping of themes was gradually refined by merging and collapsing themes. For example, "access to infrastructure" became a more encompassing theme of "access to resources". This process required repeatedly returning to the original data to verify, contradict, or enrich interpretations. The final key themes included some of the following: "Teacher educators as role models", "Collaboration with peers", and "Learning technology by design" (for an overview see Table 3). Each key

Table 1

The process of completing the meta-ethnography (based on Atkins et al., 2008; Noblit & Hare, 1988).

Phase	Steps for this study
(1) Aim	The area of interest is the potential of programs used to prepare pre-service teachers in order to integrate technology in classroom practice.
(2) Search strategy	The text words include the following: e.g. ICT, technology, teacher education, pre-service teachers, qualitative Literature databases: Web of Science.
(3) Quality assessment	We appraised studies using an adapted version of the CASP (1988) criteria (Atkins et al., 2008). Exclusions were also made if studies turned out to be insufficiently focused on the topic or not qualitative.
(4) Reading the studies	Reading the studies closely, we collected content issues, as expressed by the original authors.
(5) Determining how the studies are related	We determined how the studies in the same thematic group were related.
(6) Translation	Similarities, differences, and unusual information were combined across the studies.
(7) Synthesizing the translations	The commonalities of the themes were analyzed and synthesized.
(8) Expressing the synthesis	The results of the analysis were written: model for preparing pre-service teachers

Table 2

Quality criteria and results (Atkins et al., 2008; based on Programme CAS).

Question	Yes	No	Unclear
1. Is this study qualitative research?	23	0	0
2. Are the research questions clearly stated?	14	7	2
3. Is the qualitative approach clearly justified?	15	4	4
4. Is the approach appropriate for the research question?	21	2	0
5. Is the study context clearly described?	18	3	2
6. Is the role of the researcher clearly described?	4	16	3
7. Is the sampling method clearly described?	13	10	0
8. Is the sampling strategy appropriate for the research question?	10	0	13
9. Is the method of data collection clearly described?	20	2	1
10. Is the data-collection method appropriate to the question?	19	0	4
11. Is the method of analysis clearly described?	9	11	3
12. Is the analysis appropriate for the research question?	8	2	13
13. Are the claims made supported by sufficient evidence?	17	5	1

Table 3
Key themes in relation to each study.

Study	Key themes											
	Aligning theory and practice	Using teacher educators as role models	Reflecting on attitudes	Learning technology by design	Collaborating with peers	Scaffolding authentic technology experiences	From traditional assessment to continuous feedback	Technology planning and leadership	Co-operation within and between institutions	Staff development	Access to resources	Systematic and systemic change efforts
Angeli	x	x	x	x	x	x	x	x				x
Baron	x	x			x	x	x				x	
Brush	x	x	x		x	x						
Clift		x				x		x		x	x	
Cuckle		x	x			x					x	
Goktas'08	x			x		x					x	x
Goktas'09		x	x					x	x		x	
Haydn	x	x			x	x	x	x			x	
Jang (a)	x	x	x		x		x					
Jang (b)	x	x	x	x	x	x	x					
Lavonen	x						x	x	x	x	x	x
Niess	x	x	x	x							x	
O'Reilly		x				x	x				x	
Sahin	x		x	x	x		x				x	
Seels	x	x			x	x		x	x	x	x	x
Sime	x	x	x							x	x	
Strudler						x				x	x	x
Tearle	x	x	x			x					x	
Thomson	x	x	x	x	x	x	x	x	x	x	x	x

theme is described and examples are provided in the Results section below. The results of the analysis are presented in a model (Phase 8) depicted in Fig. 1.

5. Results

5.1. Sample characteristics

Nineteen articles from eight journals were included in the review and incorporated data from pre-service teachers, teacher educators, and other faculty members (e.g., project leader, head of the department). The studies included in the meta-ethnography were conducted in six different countries: six were from the United States, six from the United Kingdom, three from Turkey, two from Taiwan, one from Finland and one from Cyprus. An overview with detailed information regarding each of the selected studies is included in the Appendix.

5.2. Synthesis findings

Based on the synthesis, the results showed 12 key themes for content and delivery methods that prepare pre-service teachers to integrate technology into their future classrooms.

The synthesis findings are reported in three parts: (1) seven key themes explicitly related to the preparation of pre-service teachers (2) five key themes about conditions necessary to implement such programmes at institutional level, and (3) the overarching model. Table 3 presents the key themes in relation to each study.

5.2.1. Key themes related to the preparation of pre-service teachers

5.2.1.1. Key theme 1: aligning theory and practice. An overall theme in 14 out of 19 studies relates to how well the theory was embedded in practice. Rather than being presented as isolated content (e.g., how to use specific software), it seems that conceptual or theoretical information should be linked to practice so that pre-service teachers can understand the reasons behind using ICT (e.g., Brush et al., 2003; Jang, 2008a). In the study of Angeli and Valanides (2009), a pre-service teacher expressed his appreciation for the combination of theory and practice: "The combination of theory during lectures and practice during lab time was effective for me. From the one hand, I needed the theory, but from the other hand I also needed to see the application of this knowledge in real-world classroom examples" (p. 166). Goktas et al. (2008) found that pre-service teachers were not motivated by or interested in a technology course that was heavily focused on theoretical concepts: "Because of the vast amount of the course curriculum being theoretical, I won't be able to comment positively. (…) I think that the content of the course should be related to my future career" (p. 176). In other words, pre-service teachers were interested in being introduced to ways to use technology for educational purposes. Lavonen, Lattu, Juuti, and Meisalo (2006) suggested a mixture of short lectures or demonstrations and practical work. They found that "studying in one's own time and the combination of short demonstrations was a good solution" (p. 255). The importance of demonstrations leads to the second key theme.

5.2.1.2. Key theme 2: using teacher educators as role models. Thirteen studies mentioned the term "role model" and argued that modelling of technology use is vital. The results from these studies showed that most pre-service teachers had little specific knowledge or associated skills with respect to the use of technology for teaching and learning (e.g., Tearle & Golder, 2008). To illustrate, one pre-service teacher noted his lack of knowledge regarding how to use technology for educational purposes: "I felt immensely uncomfortable. (…) Gradually, through the instructor's lectures and practice during labs, things started to become clearer" (Angeli & Valanides, 2009, p. 166). Interestingly, in the study of Sime and Priestley (2005), the integration of technology into teaching situations was systematically observed by pre-service teachers during a placement in primary schools.

Based on the collected evidence, it seems that observing a teacher using technology proved to be an important motivator (e.g., Haydn & Barton, 2007). One mentor in the Haydn and Barton (2007) study cited a number of cases where pre-service teachers had watched him use presentation software and soon after were using this type of software within their own classes. Similarly, the results of the study of Brush et al. (2003) described how pre-service teachers adopted the strategies demonstrated during their pre-service trainings. However, interview data with project leaders indicated difficulty associated with finding technology-using teacher educators who are able to model technology use for pre-service teachers (Thompson, Schmidt, & Davis, 2003). Also Clift, Mullen, Levin, and Larson (2001) noted that there were insufficient examples and practices in the teacher education curriculum. They reported, for example, that pre-service teachers were encouraged to purchase a graphing calculator although the math teacher educator did not use it himself. Therefore, possible reasons for the lack of knowledge, skills, and resources with regards to technology may be due, in part, to a lack of teacher educators as role models using technology. This key theme was exemplified by comments of the school-based tutors in the study of Tearle and Golder (2008, p. 65): "Because ICT isn't modelled and resources are limited, pre-service teachers are unlikely to think about using it".

5.2.1.3. Key theme 3: reflecting on attitudes about the role of technology in education. A recurring theme in 13 sample studies was the importance of reflecting on the role of technology in education. One of the teacher educators indicated that "We need to change the attitude of students in order to benefit from ICT related courses. They have negative attitudes and complain (…). We should change these attitudes. This is the most important problem for me" (Goktas, Yildirim, & Yildirim, 2009, p. 198). In this respect, one of the challenges identified for a teacher education programme was engagement of pre-service teachers and teacher educators in conversations about their attitudes regarding the role technology should play in teaching and learning. According to Brush et al. (2003), this can be a difficult task: "If it [conversations about their attitudes regarding the role technology] can be accomplished, we have the potential to address two of the issues voiced by the pre-service teachers in this study—I don't really know what technology does to help students, and, I still don't know how to do anything" (p. 71).

Discussion groups, observation and writing seemed to help pre-service teachers reflect on the role of technology in education (e.g., O'Reilly, 2003; Tearle & Golder, 2008). One participant in the Jang (2008a) study expressed the importance of reflection on their attitudes: "Without thinking and discussing with other peers, the teaching method seen from the observation is just a common teaching method.

However, through writing the analyses and critiquing the teaching process, I finally realized that the theories of the teaching could be so effectively integrated into practice" (p. 860). The qualitative findings also showed a link between active learning (e.g., material development) and the development of pre-service students' positive attitudes towards technology. Some of the comments in the study of Sahin (2003) were: "(…) I used my skills. I used computer, video, etc. I enjoyed being active. We have to be active as the teachers of future" (p. 72) and "Being active is useful for positive attitudes" (p. 73).

5.2.1.4. Key theme 4: learning technology by design. Instructional design was a major theme in six of the selected studies. The pre-service teachers in the different interventions stated that they felt additional planning and preparation was needed to implement lessons incorporating technology because they had no prior knowledge relating to the design of such learning activities (e.g., Thompson et al., 2003). One student wrote: "At the beginning, I felt I needed to listen to my course instructor and learn about instructional design. My initial knowledge about the design of ICT-enhanced learning activities was zero, and I wanted to just hear about it and read about it" (Angeli & Valanides, 2009, p. 166). The preparation of materials was also seen as important in the study of Sahin (2003) who explored the pre-service teachers perceptions of the instructional development course. One future elementary teacher commented that "I made my material. I was an active learner. After I made my material, I presented it to my friends as an example elementary course. I learned the preparation of different materials with different technologies. Also, I observed my friends and evaluated their materials with my class and my lecturer" (p. 72). The role of their peers was also perceived as an important factor in the active production of materials (e.g., Jang, 2008b): "We could not make such a good lesson design and teaching practice if we worked separately" (p. 655).

5.2.1.5. Key theme 5: collaborating with peers. Based on the pre-service teachers' overall comments, discussing and sharing concerns with peers was very important (in nine out of 19 studies): "It was just an easy and relaxing, non-threatening way of picking things up, sharing expertise" (Barton & Haydn, 2006, p. 263). Many studies expressed strong support for working in groups when learning about the educational use of ICT. The following comments from pre-service teachers provide two examples of the positive facets of working in groups: "The most successful part of the lesson was students helping each other" (Brush et al., 2003, p. 66); "I think the quality of experiences we get is better because you are continually getting people's input on it" (Thompson et al., 2003, p. 83). According to Angeli and Valanides (2009), collaboration with peers appeared to provide a time effective, high-challenge, low threat learning environment for pre-service teachers, contrary to many technology learning experiences that can induce anxiety and failure avoidance: "You could make mistakes (…) and it didn't matter" (p. 166). It also made them aware of the fact that in order to evaluate others, they first had to reflect on their own performance and evaluate themselves (Tearle & Golder, 2008).

An online environment seemed to be useful in giving pre-service teachers a forum to discuss and exchange points of view with others. An online forum had no limitation in class time, and each person had chances and enough time to explain their opinions/thoughts (Jang, 2008b). However, the asynchronous online collaboration opportunities did not allow many chances to instantly interact with the instructor (Jang, 2008b). In addition, the composition of the group had an influence on how positive the experience was felt to be: "One of the problems was that the group I was in had someone who was really good at ICT, but they went too quickly, you just got lost" (Jang, 2008a, p. 263). The study suggests that there may be some benefits in changing the composition of working groups over the course.

5.2.1.6. Key theme 6: scaffolding authentic technology experiences. Pre-service teachers acknowledged the importance of applying their knowledge about educational technology in authentic technology experiences (in 13 out of 19 studies). To illustrate, Tearle and Golder (2008) stressed that "watching" technology being used could not substitute for "doing", with one trainee providing feedback on how to improve the training: "Actually letting us experience using more ICT, more hands-on experience" (p. 63). In addition, results from Barton and Haydn (2006) indicated pre-service teachers showed a strong sense of achievement by applying their knowledge, as indicated by the following comments: "I remember a physics lesson, I had a sound generator, and I was showing a video as well, and there was the data projector and a laptop with the oscilloscope on it, and I did all that and it worked really well. (…) I never expected to be doing this" (p. 262).

When discussing the factors pre-service teachers felt had impacted their progress, there was consensus about the importance of providing the necessary scaffolds, such as additional support during the planning and preparation (Brush et al., 2003). In this respect, Goktas et al. (2008) pointed out the importance of co-operation between teacher education programmes and the K-12 schools (see also Key theme 10): "what students produce in those courses can be linked to K-12 schools, and the prospective teachers can have the opportunity to link theoretical knowledge with practice in authentic environments" (p. 177).

5.2.1.7. Key theme 7: moving from traditional assessment to continuous feedback. Another issue emerging in nine of the selected studies was the lack of relationship between the content of traditional assessment to measure the pre-service teachers' ICT competencies and what is needed in order to make progress in using technology in the classroom (Lavonen et al., 2006; O'Reilly, 2003; Sahin, 2003). From these studies, it seemed that very few pre-service teachers felt that tests were helpful, and some felt that they took time away from worthwhile activities and prompted negative attitudes towards technology. The main issue to emerge is the lack of any relationship between the tests and what is needed in order to make progress in using ICT in the classroom. This is summed up by the comment of a pre-service teacher in the study of Barton and Haydn (2006): "[The online tests are] unrelated to subject or to common sense" (p. 262). In this respect, the results of the Lavonen et al. (2006) study showed that "evaluation data should be continually collected by discussions, questionnaires, interviews, and observations in order to follow how staff members have adopted ICT, how they use ICT and how their ICT competence has developed, and what kind of problems and visions they have had in ICT use" (p. 262).

Sahin (2003) implemented assessment based on the process (the efforts of the students, active participation and material development process, co-operation, etc) and pre-service teachers were evaluated by their peers and their instructors. One of the recommendations in the study of O'Reilly (2003) was to use an "ICT portfolio" to integrate assessment throughout the training process. In this study some of the fourth grade pre-service teachers commented about their portfolio uses: "The ICT portfolio gave us ideas in using ICT for our teaching"; "linking our own experiences to research was very useful", and "it provided motivation for the use of ICT in our school placement" (p. 436). Although time-consuming, it appeared that the final product provided a comprehensive folder full of ideas for technology use. According to Lavonen et al. (2006), the technology competence of staff should also be evaluated. This means that preparing pre-service teachers to use ICT

in teaching cannot be planned independently from the progressive evolution of practices belonging to the institutional level, as elaborated in the next section.

5.2.2. Key themes related to the institutional level

5.2.2.1. Key theme 8: technology planning and leadership. The synthesis revealed significant differences between training institutions regarding how pre-service teachers are prepared to integrate technology into their practices (in seven out of 19 studies). For example, Clift et al. (2001) stated that "In some schools, not using technology was simply not an option" (p. 47). In this respect, it is necessary for policy development at the institutional level to develop a shared vision on technology integration (see Thompson et al., 2003). The synthesis revealed significant differences between training institutions in the way pre-service teachers are currently prepared to integrate technology in their practices. Certain teacher education programmes required the use of technology, while others did not have this shared vision (Clift et al., 2001).

An important enabler seemed to be the development of a technology plan at the teacher education programme level. The results of the synthesis indicated that technology planning should be 1) developed together with all stakeholders, 2) supported by a task force for both technical and instructional purposes, 3) aimed at the empowerment of end users, and 4) updated on a regular basis (Goktas et al., 2009; Lavonen et al., 2006; Thompson et al., 2003). Consequently, teacher education programmes should organize co-operative technology strategy planning (Lavonen et al., 2006). In the study of Haydn and Barton (2007) for example, the head of the Department of Teacher Education, was leading the technology strategy planning and implementation work. Their empirical data offers support to the conclusion from several previous projects that the role of top management in planning, and especially implementation, is crucial. In some of the selected studies (e.g., Haydn & Barton, 2007), the technology coordinators were taking a leadership role to facilitate the planning activities. At the same time, evidence showed that wide staff participation in the planning phase was the key factor in facilitating the implementation of the strategy (Lavonen et al., 2006; Seels, Campbell, & Talsma, 2003). It seemed that staff participation in the planning phase facilitated the implementation of technology integration innovations.

5.2.2.2. Key theme 9: co-operation within and between institutions. Apart from the planning phase, six studies also provided evidence for the importance of co-operation in other phases. Thompson et al. (2003) found that co-operation at institutional level is needed: "Staff, teachers, and students spend more time helping each other with technology" (p. 83), which was found necessary to make technology integration successful. Members in the project reported by Seels et al. (2003) revealed that, as they met with their technology support person and project teams, the sense of community became a critical element in their PT3 experience. Based on the interviews with teacher educators, Goktas et al. (2008) conclude that also co-operation with the K-12 schools should be supported: "What students produce in those courses can be linked to K-12 schools, and the prospective teachers can have the opportunity to link theoretical knowledge with practice in authentic environments" (p. 177). Overall, evaluators of teacher education programmes seemed to express the importance of co-operation within and between institutions to result in successful technology integration trainings that would help pre-service teachers transfer knowledge gained to their future classrooms.

5.2.2.3. Key theme 10: staff development. Many studies indicated that the teacher educators lacked the knowledge, skills, and self-efficacy to teach or model technology integration to pre-service teachers. It is also clear from the evidence (in five of the sample studies), that teacher educators should be provided with training so they can design their courses based on how pre-service teachers can use the knowledge and skills they gained within their subject area. Based on their findings, Clift et al. (2001) stress the need of supporting teacher educators' use of technology through workshops, easily accessible consultants, and sharing of information. With respect to the latter, one of the deans in the Goktas et al. (2009) study suggested the following: "More competent staff should lead the less competent ones and transfer their experiences" (p. 199). This corroborates with the study of Thompson et al. (2003) who signal the importance of a three-way professional development for university faculty, in-service teachers, and pre-service teachers with emphasis on one-on-one support.

5.2.2.4. Key theme 11: access to resources. Access to resources was noted as a key theme in 15 studies. The evidence confirms what is general acknowledged: resources (hardware, software, learning material, documentation, etc.) are an important condition for technology integration. A more important result perhaps is the access to resources (Goktas et al., 2008; Seels et al., 2003), expressed by a strong preference for using technology as a component of lessons, rather than having "special occasions" in the ICT room: "access to computers was poor; computers needed to be booked in advance and there were few or no computers in subject classrooms" (Cuckle & Clarke, 2002, p. 336). There seem to be a number of reasons for this preference. Teacher educators often found ICT rooms "block-booked by the time they started their placement and were also deterred by the logistics of moving a whole class" (Haydn & Barton, 2007, p. 265). Rather than limiting resources to certain centres, they should be spread to the whole physical environment of an institution such as canteens, corridors, and particularly classrooms (Goktas et al., 2009). In the study of Thompson et al. (2003), one student remarked: "The laptop gives me more of a chance to play on the computer because I have it with me most of the time and I can use it when I have a few minutes free" (p. 87).

Another problem emerged in terms of other resources such as electronic educational portals that have been designed to support pre-service teachers' use of technology. According to Haydn and Barton (2007), pre-service teachers reported that they either did not have time to read through the range of CD-roms and technology support web site materials, or were unaware of their existence. They identified the need for specific practical guidance about how to find and how to use these resources. In contrast, the participants in the Lavonen et al. (2006) study mentioned the use of resources (online help, ICT use guides and Web pages) in a positive way. Some of the staff members explained in detail how the learning materials helped them to learn the use of software: "When I use the software at home I can recapitulate the use of it from the excellent learning material. It is also possible to learn more from the manual" (p. 255).

5.2.2.5. Key theme 12: systematic and systemic change efforts. The synthesis results illustrated the importance of preparing pre-service teachers as a *systemic* change process (in six out of 19 studies). The Thompson et al. study (2003) showcased the importance of the systemic change process in integrating technology into curricula: "Now the (technology) coordinator meets with grade level teachers to plan integrated projects. They come in and work together, rather than separate. It's not special, it's seen as a piece of their curriculum" (p.
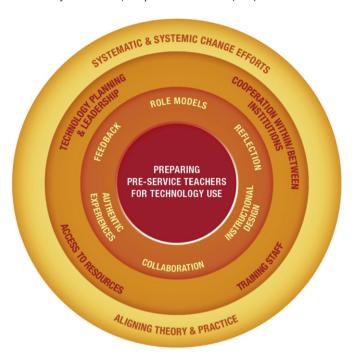
Fig. 1. SQD Model to prepare pre-service teachers for technology use.

85). In the same study a pre-service teacher stressed the importance of *systematic* change efforts: "You are introduced to technology little by little and yet it's gradual (…)" (p. 84). In this respect, a teacher educator recommended that "a computer course should be given in the first year so that the pre-service teachers can use technology in their courses in following years" (Goktas et al., 2009, p. 173). This aligns with the results of Seels et al. (2003) who concluded that it should take a long period with a constant reiterations to see substantial change in technology integration.

5.2.3. The overarching model

As a final step of the review procedure, the results of the analysis were presented in a model (see Fig. 1). The research findings were structured into two aggregation levels: key themes explicitly related to the preparation of pre-service teachers at the micro level and key themes about conditions necessary to implement such programmes at the institutional level. The two key themes "Aligning theory and practice" and "Systematic and systemic change efforts" were clustered together as overarching themes, identified as important at both micro and institutional levels.

From the evidence, it was clear that effective preparation of pre-service teachers for technology integration required attention to not only the separate key themes in the model, but the relationship between each of the key themes. The key themes were linked together in a way that made it difficult to address them separately. For example, the use of "role models" (Key theme 2) were often perceived as an important condition in the development of lessons with technology (Key theme 4). Based on these findings, it is important to note that learning to teach with technology is a constructive and iterative process. In other words, it seems that in order to successfully train pre-service teachers to use technology, teacher education programmes need to address all these key variables thoughtfully. The discussion section elaborates on this perspective and other consequences of the presented SQD model synthesized from the qualitative data.

6. Discussion

This review focused on how teacher education programmes work on preparing teachers to use technology in their (future) classrooms. The findings of the synthesis resulted in an overarching model that was developed to provide a holistic description of the key themes identified as important in the technology training of pre-service teachers (Fig. 1). In this section the results are discussed in three parts: 1) the critical factors included at the micro level to prepare future teachers to use technology in their future classrooms; 2) the role of the teacher training institutions as a unit of change, and; 3) the limitations of the study and directions for future research.

6.1. Critical factors included to prepare future teachers to use technology

The SQD model depicted in Fig. 1 highlights critical factors that need to be considered when designing pre-service technology training. The first issue at the micro level relates to how pre-service teachers within a programme observe appropriate models of technology use in the classroom (Goktas et al., 2009; Thompson et al., 2003). Based on the collected evidence, it seems that observing a teacher using technology was an important motivator for pre-service teachers to integrate technology into their own practices (e.g., Haydn & Barton, 2007). Given the lack of good role models that pre-service teachers encounter (Tearle & Golder, 2008), researchers have recommended that technology should be integrated throughout the curriculum in order to provide pre-service teachers with the experiences needed to apply technology to their specific content areas (e.g., Kirschner & Selinger, 2003; Ottenbreit-Leftwich et al., 2010). Rather than being

presented as isolated content, the results suggest that conceptual or theoretical information should be linked to practice so that pre-service teachers can understand the reasons behind using technology (Brush et al., 2003; Jang, 2008a).

In this respect, it seems to be important that pre-service teachers have the possibility to see and experience the pedagogical integration of technology in the classroom during their training experiences, by observing good examples and being able to implement such practices themselves (Enochson & Rizza, 2009). The ability to implement those practices reinforces the importance of instructional design as a major theme throughout the selected studies (see e.g., Angeli & Valanides, 2009; Niess, 2005). The pre-service teachers in these interventions indicated that they felt additional planning and preparation was needed to implement lessons incorporating technology. Also research on TPACK (e.g. Koehler & Mishra, 2009) suggests that the opportunity to (re-)design technology-enhanced curriculum materials was a promising strategy for pre-service teachers. As previously stated, TPACK is a framework that emphasizes the importance of preparing teachers to make rational choices in their uses of technology when teaching specific content to a specific target group.

Through collaboration experiences, pre-service teachers also acknowledged the importance of applying their knowledge about educational technology in authentic settings (e.g., Cuckle & Clarke, 2002; Tearle & Golder, 2008). According to Angeli and Valanides (2009), collaboration with peers appeared to provide a low threatening learning environment for pre-service teachers that can reduce anxiety and failure avoidance. In this respect, Clift et al. (2001) concluded that programme designers should deliberately create experiences in which pre-service teachers share their attitudes and abilities with one another. 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). At the same time, the pre-service teachers' qualitative comments indicate that on-going and process-oriented feedback of experts were beneficial to building their abilities to use technology in the classroom (Angeli & Valanides, 2009; O'Reilly, 2003).

6.2. Role of the teacher training institutions as a unit of change

The discussion about how to implement and sustain programmes to prepare pre-service teachers to integrate technology in classroom practice should be seen as part of the development of the entire teacher education programme (Polly et al., 2010). This leads to a focus on the institution as a unit of change and pays additional attention to the conditions at the institutional level. The institutional level factors, as expressed in the model, included "technology planning and leadership", "training staff", "access to resources" and "co-operation within and between institutions". These key themes emphasized that the effective integration of technology in teacher education was possible if future goals and strategies were set and implemented in a planned manner (Seels, 2003; Thompson et al., 2003). To implement such a plan, access to resources needs to be guided by the administrative, financial, and teaching needs. This may include the development of a technology plan that integrates the vision and strategic direction of the entire teacher education programme (Lavonen et al., 2006; Tondeur, Van Keer, van Braak, & Valcke, 2008).

Technology planning can be challenging because the qualitative evidence indicates that teacher educators do not have similar technology knowledge or skills (Goktas et al., 2008). As a result, teacher educators should be provided with training to become role models for their pre-service teachers (Barton & Haydn, 2006). Moreover, it seems to be important to organize co-operative and creative technology strategy planning sessions (see Vanderlinde, van Braak, & Tondeur, 2010) to increase the learning experience of both the pre-service teachers and teacher educators, while also serving as useful reference for collaboration with other education institutions.

This attention on the institution as a unit of change must recognize the importance that learning to teach with technology is a systematic process (Lim & Hang, 2003; Seels et al., 2003) that requires the engagement of pre-service teachers in investigating role models, designing lesson plans, practicing in authentic settings, and providing feedback. In this respect, effective preparation of pre-service teachers for technology integration requires attention to the separate key themes, but also demands similar attention toward the relationships between the themes (cf. Kay, 2006). Furthermore, technology integration needs to be infused as a *systemic* aspect throughout the entire programme rather than presented in separate "stand-alone" courses (Polly et al., 2010; Strudler, Archambault, Bendixen, Anderson, & Weiss, 2003). These findings support the guidelines of Thompson et al. (2003) indicating that technology should be infused into the entire teacher education programmes so that pre-service teachers can understand the reasons behind using technology. Otherwise, the knowledge and the skills pre-service teachers gained from a separate stand-alone course process are likely to remain isolated and unused (Goktas et al., 2008).

6.3. Limitations of the study and directions for future research

This study used a meta-ethnography approach to synthesis qualitative evidence about the preparation of pre-service teachers in using technology. Though time-consuming, meta-ethnography provided a method to re-interpret meaning across the selected studies in order to extend the level of interpretation based on the data from all 19 studies. The added value lies in the deeper, richer account and the broader context (Hammersley, 2002) than can be obtained by reviewing multiple studies as opposed to the limited view from individual studies, especially when looking for the influence of a specific strategy or a few characteristics in the process of technology integration in teacher education. For example, by reviewing multiple studies, most indicated that there are benefits to the provision of non-threatening environments where pre-service teachers can discuss their attitudes regarding the role of technology in teaching and learning (see e.g., Cuckle & Clarke, 2002; Niess, 2005).

Using a meta-ethnographic approach, an overarching model was developed based on the results of the synthesis of the selected qualitative studies. However, simplifying such a complex innovation was a difficult process that reduced the importance of the contextuality of the results. In this respect, the results of the review cannot simply be generalized to other teacher training institutions in different parts of the world. It is important to recognize that the SQD model presented in Fig. 1 is an initial projection of a theoretical explanation meant to describe the complex reality of preparing pre-service teachers to integrate technology. In addition, although the qualitative evidence presented supports the current model, it does not prove the model. Future research should use an iterative approach in developing the model. For instance, researchers may examine the macro-level factors that influence technology use and policies at the institutional level. At the national level, educational authorities heavily influence education, despite the importance of school autonomy. Therefore, it would be of interest to study how teacher education institutions respond to such national factors (e.g., technology standards for teachers).

Another issue that requires further study is the influence of cultural and contextual factors on the development of pre-service teachers' capacity to apply technology in daily classroom practices. The problem of how to retain the rich context of the data was also complicated due to the methodological problems in the selected studies. Therefore, future research on pre-service technology training should address the methodological concerns as noted in the evaluation tool (see Table 2) by following the recommendations made by Kay (2006): clear description of the sample (e.g., number of students, age, teaching level) and the educational programme (e.g., number of years of study and the organization of the programme), reliability and validity estimates of the data collection instruments used, and measures that look at attitude, ability and use in the same study. A mixed-method approach, using qualitative methods to support the quantitative survey data, addressing the methodological concerns mentioned above could also be a promising approach to help develop the theoretical understanding presented in this review.

7. Conclusion

In this meta-ethnography, published qualitative studies exploring the preparation of pre-service teachers in technology integration were screened, analyzed, coded, and interpreted. A variety of factors and interventions were explored to obtain a more complete understanding of the complex process of preparing pre-service teachers in the field of educational technology use. The results of the meta-ethnography yielded 12 themes: seven themes explicitly related to the preparation of pre-service teachers and five themes about conditions necessary to implement such programmes at the institutional level. To clarify how these key themes relate to each other, an overarching model was developed. The SQD model conveys the main findings of the review to policy makers, practitioners, and programme planners, hopefully using the findings to better prepare pre-service teachers to use technology in their teaching practices.

Appendix. Sampling frame of included articles.

First author	Year	Country of origin	Topic	Method	Respondents
Angeli	2009	Cyprus	Technology mapping: development of ICT-TPCK	Qualitative analysis of the design task and lesson activities	215 pre-service teachers
Barton	2006	UK	Training to use ICT in subject teaching	Focus group interviews	27 pre-service teachers
Brush	2003	USA	Field-Based training to use ICT in teaching and learning	Postunit reflections and interviews	57 pre-service teachers
Clift	2001	USA	Interaction between school context, instruction and ICT	Case study: survey with open-ended questions, interviews, analysis of e-mails	4 pre-service teachers
Cuckle	2002	UK	Mentoring pre-service teachers to use ICT in schools	Case study	13 pairs of pre-service teachers and mentors
Goktas	2009	Turkey	Main barriers and possible enablers of ICT integration in teacher education	Open-ended questions/interviews	111/6 teacher educators, 1330/6 pre-service teachers, 53 deans
Goktas	2008	Turkey	Effectiveness of ICT related courses	Open-ended questions/interviews	1429/6 K-12 teachers, 1111/6 teacher educators, 1330/6 pre-service teachers, Trainees and mentors
Haydn	2007	UK	Pre-service teachers views on strategies to use ICT in teaching	Interviews and focus group discussions	
Jang	2008a	Taiwan	Integrating technology with teaching strategies on observation and writing	Field observation and writing (online discussion reports)	134 pre-service teachers
Jang	2008b	Taiwan	Integrating technology and team-teaching strategies	Interviews	42 pre-service teachers, 1 instructor
Lavonen	2006	Finland	Development of an ICT strategy plan for teacher education	Documentation, interviews, observations, etc.	75 staff members
Niess	2005	USA	Preparing teachers to teach science/math with ICT	Case study: observations and interviews	22 pre-service teachers
O'Reilly	2003	UK	Portfolio as means of implementing ICT	Portfolio, audits, comments	18 pre-service teachers
Sahin	2003	Turkey	Student teachers' perceptions on instructional technology: developing materials	Open-ended questions	80 pre-service teachers
Seels	2003	USA	Communities of learners to support technology integration	Case studies, observations, evaluation of materials, etc.	Student teachers, university faculty, K-12 teachers, school administrators
Strudler	2003	USA	Project THREAD: Project to prepare teachers to use technology in teaching	Interviews, observations, analysis of documents	153 students teachers, faculty
Thomson	2003	USA	Technology Collaboratives: systematic approach to using ICT in schools	Focus group, interviews	Project leaders, in-service and pre-service teachers, school leaders
Tearle	2008	UK	Evaluation of a program to support pre-service teachers' use of ICT	Case studies, interviews, group discussions, observation,	36 trainees, 3 tutors
Sime	2005	UK	Pre-service teachers' first reflections on ICT	Discussion forums	82 pre-service teachers

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