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TPACK in teacher education: are we preparing teachers to use technology for early literacy?

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This study examines if and how five teacher education institutes are helping students to develop the technological pedagogical content knowledge needed to effectively use technology for early literacy. Focus group discussions were held with teacher educators in which their responses to expert recommendations were probed. Findings indicate that, currently, very little attention is specifically given to the knowledge that teachers need to foster early literacy through the use of technology. This is due to multiple factors, including the conviction that many new technologies (e.g. tablets) are not used much in schools. Additionally, teacher educators themselves struggle with effective use of technology in their own courses. And although technological and early literacy specialists are available in teacher training colleges, pre-service educators note a distinct lack of integrated expertise in their institutions. Based on these findings, recommendations are given for research, policy and practice.

Keywords: TPACK; pre-service education; early literacy

Introduction

Many studies show that the integration of technology in educational practice is a complex innovation for teachers (e.g., Mumtaz, 2000; Webb & Cox, 2004; Voogt, Tilya, & van den Akker, 2009). Teachers have difficulty in integrating technology in their instructional processes. Therefore even when the information and communications technology (ICT) applications have proven to be effective in isolation, this does not always imply that the same effects are also realised in natural educational settings. Olson (2000) argued that technology often does not fit into the existing teaching culture and that it may even undermine the teacher's sense of efficacy. Teachers using technology therefore tend to domesticate the application in such a way that it becomes congruent with their prevalent teaching practices while ignoring the affordances the technology offers (Higgins, Beauchamp, & Miller, 2007). In addition, technology use by young children in the kindergarten classroom should be embedded in (appropriate) pedagogical models (Plowman & Stephen, 2005). An assumption of such models is that ordinary classroom practice and technology use

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are well aligned (Van Scoter, 2008). To integrate technology in educational practice, empowering teachers to appropriately use technology is of paramount importance.

Based on Shulman's (1987) conception of pedagogical content knowledge (PCK – a term introduced to conceptualise teacher knowledge underpinning teaching expertise), Mishra and Koehler (2006) introduced technological pedagogical content knowledge (TPACK) as a framework for conceptualising teacher knowledge needed for appropriately teaching with ICT. While PCK integrates domain knowledge and pedagogical knowledge into an understanding of how particular aspects of subject matter can be organised, adapted and represented for instruction, the conception of TPACK adds technological knowledge as a new component which has to blend in with domain and pedagogical knowledge in order to effectively integrate ICT in instructional practices. We see TPACK as a useful conceptual framework to explicate the kind of knowledge teachers need to integrate technology in their teaching practices. Empowering teachers for effective technology integration does not mean that they need to know the TPACK framework as such, but implies that teachers need to understand how to shape instructional practices in which technological, content and pedagogical knowledge are embedded.

Early literacy has three main strands (McKenney & Bradley, 2015): (1) the (de)coding strand (linguistic consciousness, alphabetic principle and the phoneme–grapheme connection); (2) the text comprehension strand (book orientation, story understanding and reading/listening enjoyment); and (3) the functional strand (the relationship between spoken and written words, the communicative purposes of written products, understanding that symbols represent ideas/words). Recently, several studies (e.g. McKenney & Voogt, 2009; Takacs, Swart, & Bus, 2015; Van de Sande, Segers, & Verhoeven, in press) have shown that technology has potential to foster these early literacy strands, providing that the specific software applications meet certain features and that teachers know how to embed the technology in their classroom practice. This was an important reason to study if and how pre-service programmes are working to develop teacher TPACK in the domain of early literacy.

Theoretical framework

About TPACK

Both the discrete and integrated (technological pedagogical content) knowledge inform teacher decisions when selecting and using curricular resources, including ICT-rich ones (Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013). Specifically, the process of choosing and using resources requires: knowledge of relevant resources; knowledge of the features of relevant resources; and knowledge of how to use the resources effectively in practice. Knowledge of *specific hardware and software* is needed to enable teachers to understand the options from which they may select, and to operate them efficiently (technological knowledge) for specific domains in the curriculum (technological content knowledge). Knowledge of the *features* of technology-rich learning resources is important because it allows teachers to distinguish the qualities and affordances of specific tools in light of pedagogical (technological pedagogical) and domain-specific learning (technological content) goals. Knowledge of *how to use* technology-rich curricular resources is necessary for teachers to be able to employ ICT in pedagogically meaningful ways to achieve

learning in specific content areas (technological pedagogical content knowledge). Harris and Hofer (2011) and Jimoyiannis (2010) advocated explicitly relating TPACK development to subject domains. However, in their systematic review of research on TPACK, Voogt et al. (2013) found a severe lack of research related to TPACK that makes close connections to specific subject domains.

TPACK and early literacy

In light of the aforementioned need, this study examines TPACK development in relation to the domain of early literacy. Review studies have begun to describe and typify the kinds of *hardware and software* that can foster the development of early literacy (Belo, McKenney, & Voogt, 2016; Lankshear & Knoebel, 2003). For example, electronic storybooks and software for learning letter sounds and vocabulary have been found to be effective in early childhood classrooms. Both research and policy experts have articulated guidelines for the *features* of hardware and software that can serve early literacy development. These relate not only to how literacy content should be addressed (e.g. through authentic texts used in meaningful ways (McKenney & Voogt, 2009), but also to interface structures that are ergonomically sound for the age group (Segers & Verhoeven, 2002), promote on-task attention focusing (Takacs et al., 2015; Trushell & Maitland, 2005), and elicit active engagement (National Association for the Education of Young Chidren, 1996; Van Scoter, 2008). When it comes to knowledge about how to *use* hardware and software to effectively promote early literacy, research has pointed to the importance of teacher skills for assessing curricular compatibility and aligning the tool use accordingly (Bauserman, Cassady, Smith, & Stroud, 2005; Cassady & Smith, 2004). Thus, existing research has the potential to help inform and articulate the kinds of knowledge teachers need to integrate ICT in the teaching of early literacy. Yet the kindergarten teacher who feels confident and competent in this area is still rare, and research on teachers' TPACK development for early literacy is quite limited.

TPACK and the pre-service curriculum

Research has shown that beginning teachers do not feel sufficiently prepared to use ICT in their classrooms (Enochsson & Rizza, 2009; Sang, Valcke, van Braak, & Tondeur, 2010). While this may have several causes, it is known that the quality and quantity of pre-service exposure to the use of ICT for learning strongly shape the ways teachers view and use technology once they become practising teachers (Agyei & Voogt, 2011; Drent & Meelissen, 2008). In so doing, the need for ICT experiences to be integrated with subject matter content in pre-service education has been clearly identified (Brush et al., 2003; Kay, 2006). To explore how teacher education institutes (TEIs) promote the development of TPACK, Tondeur, Pareja Roblin, van Braak, Fisser, and Voogt (2013) conducted a multiple case study. They found that TEIs were struggling with integrating TPACK in the curriculum. Relating TPACK to subject domains, although favoured by all, resulted in a decreased attention to ICT in the teacher education curriculum. Tondeur et al. (2013) concluded that: 'ICT should be infused into the entire curriculum so that pre-service teachers have the opportunity to (a) understand the educational reasons for using ICT and (b) experience how ICT can support teaching and learning across different subject domains' (p. 242).

For over a decade, the need to bolster pre-service teacher knowledge about using ICT in the classroom has been recognised in both research and policy agendas (e.g. as discussed throughout the 2003 special issue of *Technology, Pedagogy and Education* [Volume 12, Issue 1]). But the barriers to change have been substantial. These include a lack of supportive values and beliefs (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010), infrastructure (Goktas, Yildirim, & Yildirim, 2009) and models to guide the development of expertise (Koh & Divaharan, 2011).

Aim of the study

As previously noted, TPACK is essential to enabling teachers to implement ICT in their teaching, as it enables teachers to select and use hardware and software, identify the affordances (or lack thereof) of specific features and use the tools in pedagogically appropriate and effective ways. Yet, despite its central connection to subject content, few studies (e.g. Agyei & Voogt, 2014; Hutchinson & Woodward, 2014; Jimoyiannis, 2010) have examined how TPACK can be elaborated for specific learning domains. At the same time, we know that the pre-service experiences of teachers are crucial for shaping ICT attitudes, skills and habits in new teachers. We also recognise that TEIs struggle to provide student teachers with the kinds of learning opportunities that will develop the TPACK needed to optimally serve learners (Tondeur et al., 2013).

Therefore, the goal of this study was to explore whether and how pre-service teachers are being prepared for effectively using technology for fostering early literacy. In accordance with the theoretical framing presented above, the study sought to understand:

(1) According to teacher educators, what is the relevance of teaching specific software *applications and/or hardware* with added value for developing early literacy in pre-service teacher education?
(2) Toward developing early literacy, which *effective technology features and effective use guidelines* are considered worth teaching in pre-service teacher education?
(3) Which *barriers and opportunities* do teacher educators see in the implementation of technology for early literacy in the curriculum of TEIs?

Methods

Respondents

Five TEIs preparing primary school teachers distributed across the Netherlands were asked to contribute to the study. At each TEI we requested the presence of two or three teacher educators with different expertise: a teacher educator with expertise in the domain of early literacy/young children, a teacher educator responsible for technology in the curriculum and, if possible, a teacher educator with an overview of the curriculum as a whole. In total, 12 teacher educators were involved in the study. Table 1 provides an overview of the TEIs and the respondents. Respondents were encouraged to reflect on and discuss the questions posed in the focus group from the situation in their TEI. The different respondents provided complementary information, which resulted in an image of the situation at the TEI concerning technology

Table 1. TEIs and respondents.

TEIs	TEI-1	TEI-2	TEI-3	TEI-4	TEI-5
Geographic region	East	North	Middle	West	Middle
Expertise	literacy (2), curriculum (1)	literacy (1), technology (1), curriculum (1)	literacy (1), technology (1), young children (1)	young children/ literacy (1), technology (1)	literacy (1), technology (1)

and early literacy. The focus groups provided representative samples of the relevant expertise in typical TEIs.

Instrumentation

The focus group interview consisted of three parts. In the first part the current early literacy and technology curriculum was discussed based on information sent to the researchers before the interview took place. This part of the interview served as background information for the study (see curriculum context). In the second part the focus group was asked to reflect on an overview of effective uses of ICT for developing early literacy. The overview was sent to the focus group members before the interview took place. In the third part the interviewees were asked to reflect on the opportunities and barriers they see for the integration of technology for fostering early literacy in their teacher education curriculum. Each interview lasted 60–90 minutes.

The overview that guided the second part of the study was based on the interim results of a Delphi study that aimed to identify and articulate the knowledge base pre-service teachers need in order to effectively use technology to help foster early literacy (McKenney & Voogt, under review). The overview was guided by three questions:

(1) For pre-service teachers, knowledge about which *software applications and/or hardware* with added value for developing early literacy is essential? (Examples include software: electronic books, commercial apps, electronic testing and learner tracking systems, digital portfolios, educational websites, educative television programmes; hardware: tablets, projectors, interactive whiteboard, multi-touch tables, printers.)
(2) For pre-service teachers, knowledge about which *effective characteristics of technology* with added value for developing early literacy is essential? (Examples include: general features of software, i.e. interface, content, curriculum fit, ease of use, adaptivity; features of specific applications of early literacy software, i.e. electronic books, letter sounds, applications for 'reading and writing' by kindergartners, serious games, educative websites and educative television programmes.)
(3) For pre-service teachers, knowledge about which *effective use of technology* is essential for developing early literacy? (Examples include: general conditions, i.e. frequency and sequence of use, interaction, teacher role; conditions for using the specific applications mentioned above; conditions for the uses of hardware in the early literacy classroom, i.e. tablets, interactive whiteboards.)

Data analysis

Each focus group discussion was transcribed into separate documents whereby each new speaking turn formed a new line in the transcription. For the first (current curriculum) and second part of the interview, deductive coding was used. The codes for the first part of the interview (current curriculum) were early literacy compulsory part; early literacy optional part; technology curriculum compulsory part; technology curriculum optional part; integration of technology in the early literacy curriculum. The codes for the second part of the interview (overview of effective uses of technology for early literacy) were derived from the prompts provided in the overview (see section on instrumentation). For the third part of the interview (opportunities and barriers), inductive coding was used. The resulting codes referred to vision, teacher educator competencies, time, relationship with internship schools and collaboration among teacher educators. The coded parts of the interview were parsed into a spreadsheet resulting in a cross-case display (Miles & Huberman, 1994).

Findings

Curriculum context

The preparation of primary school teachers in the Netherlands is organised as a four-year bachelor programme (240 European credits). Primary schools in the Netherlands offer education to children between the ages of 4 and 12. The first two years of primary education are often known as kindergarten. Students at TEIs for primary education are prepared to teach children between the ages of 4 and 12. With the view that teaching is learned at the workplace, internships form an integrated part of the TEI curriculum from the first year onward. An important part of the curriculum of the first two years is that pre-service teachers acquire basic knowledge of the content and pedagogy of the primary school subjects, amongst them (early) literacy. In addition to TEI-based tests, the acquisition of this basic knowledge is also assessed through a national exam at the end of year 2. In their third and fourth years of study, pre-service teachers specialise either in the younger child (ages 4–7) or the older child (ages 8–12).

All TEIs in the present study report that the early literacy curriculum is a small but compulsory part of the literacy curriculum during the first two years. The content of the early literacy curriculum is based on the Dutch national early literacy interim goals (Verhoeven & Aarnoutse, 1999). The early literacy interim goals address the three strands mentioned earlier in this article. TEI students learn the key concepts of these strands and appropriate pedagogies in teaching these concepts. The early literacy curriculum is part of the basic knowledge being tested in the national assessment mentioned above. The time devoted to early literacy does not vary that much across the TEIs in the study, neither does the way the curriculum is offered to the students. For students who specialise in younger children, attention to early literacy may return in their third and fourth years of study. However, whether pre-service students further develop their early literacy knowledge is typically optional. The early literacy specialists in our study played a minor role in this phase of the pre-service teacher education curriculum.

In terms of how attention is given to technology in the curriculum of the TEIs in our study, the situation is quite different. Technology is not a compulsory subject in primary education and thus not part of the national assessment given in the

second year. All TEIs in our study pay attention to preparing pre-service students to use technology in their (prospective) educational practice, often as part of pre-service teachers' professional preparation. Specific technology-related content addressed differs across institutions, and this is also the case with the TEIs in the present study. For example, most TEIs in our study devoted attention to the use of interactive whiteboards (all but TEI-5) and to preparing lessons with technology applications (all TEIs). Specific themes are present in some TEIs, such as lessons about cyber-bullying and Internet safety (TEI-2) and the TPACK framework (TEI-3). In only one TEI is technology a compulsory course during the first two years of study (TEI-4). Next to this basic use, technology is offered as an optional subject in year 3 at TEI-1 and TEI-5 (each for 30 European credits). Some TEIs have the intention to integrate technology in subject domains (TEI-3 and TEI-4), but this is not yet realised because the subject domain teachers lack the knowledge and skills to integrate technology in their lessons. In TEI-3, the technology coordinator has started to offer specific help to subject domain teachers in order to foster the integration of technology with specific curricular content.

Relevance of teaching about specific software applications and/or hardware with added value for developing early literacy

All but one of the TEIs endorse the relevance of paying attention to software applications with added value for early literacy. Three of them welcome the overview of effective applications, which made them aware of potential applications for early literacy. They acknowledge that little time is spent on technology for early literacy in the curriculum, but they also explicitly state that developing a basic understanding of early literacy in pre-service students is their first priority. Only after students have developed basic knowledge of how early literacy can be fostered, should software for early literacy be considered (TEI-1, TEI-2, TEI-3). TEI-5 endorses the relevance of paying attention to technology for early literacy, but doesn't see any possibilities for integrating technology in the current curriculum. TEI-4 expresses more doubts about using technology in the kindergarten classroom, including the use of technology for fostering early literacy, because 'we find that teaching kindergarteners should be based on offering them concrete experiences … the word bicycle cannot be learned via a computer screen but by bringing a bicycle in the classroom' (TEI-4).

All TEIs were aware of the availability of electronic books. Only one of them, TEI-2, pays (some) attention to electronic books when children's literature is discussed and 'they [the students] become acquainted with it [electronic books], … we show an example and discuss the quality and they then have to find a book themselves which they have to assess…'. However, TEI-2 also realises that 'it is surprising that electronic books are not much used in the schools, while it is such a powerful means for repetition'. In TEI-4, no attention is paid to commercially available electronic books, but pre-service students are required to produce electronic books themselves, which are then discussed as part of their technology curriculum. TEI-4 students also have to put two electronic books on their reading list of children's literature. All TEIs see the potential of electronic books, but also emphasise that interacting with kindergarteners while reading out loud should not be replaced by electronic books; as expressed by TEI-5, 'electronic books are a useful addition to interactive reading aloud'.

The TEIs have much less clear opinions about the other software applications mentioned in the instrument (commercial apps, electronic testing and learner tracking systems, digital portfolios, educative television and educative websites). Concerning commercial apps, TEI-2 says 'we mention them', TEI-5 sees possibilities for learning letter sounds and TEI-1 says 'yes we should do something about it'. The reaction towards educative television programmes varied. Only TEI-2 discussed the use of educative television. TEI-1 discussed its use in the past, but not in the current curriculum. TEI-3 would be concerned if children only watch educative television without discussing the programme and TEI-4 argues that 'we don't have to pay attention to educative television programmes, because they [the pre-service students] easily find them; we have to limit their use, and make sure they develop lessons with concrete materials'. They observe the problem of overuse also with educative websites.

TEIs are aware of electronic testing and learner tracking systems, because students learn to use them during their internships (TEI-1). But if these applications are treated in the teacher education curriculum they are part of the general pedagogy courses and usually get attention in the specialisation part (years 3 and 4) of the programme. TEIs do not see the relevance of digital portfolios because they are not used in the kindergarten classroom.

All TEIs agree that pre-service students do not have to be taught about the use of data projectors and printers. The interactive whiteboard is commonly used in most primary schools and therefore receives attention in the technology preparation TEIs offer to their students. TEI-4 is quite critical towards its use because, according to them, the interactive whiteboard results in 'whole classroom teaching with all eyes fixed on the whiteboard', which does not fit with their vision of teaching in kindergarten. With respect to tablets and multi-touch tables, the TEIs contend that most schools do not have these and therefore there is not yet need to pay attention to such devices in the teacher education curriculum. Moreover, kindergarteners should never be behind the screen the whole day (TEI-1). Only TEI-2 was quite positive about the potential of tablets for early literacy: 'I have seen some fabulous applications for early writing, but when I tell them about it they [the pre-service students] do not see the relevance, because most schools do not have tablets.'

Effective technology features and effective use guidelines worth teaching for developing early literacy

From a general perspective, all five TEIs agree that pre-service students should be aware of their goals when preparing lessons, and only then decide whether or not they can use technology for reaching this goal. So, the pedagogical use of technology is considered more important than the features of the interface and the ease of use of technology, as expressed by TEI-4: 'ease of use and the interface … I find this less important'. Based on this the main condition for using technology is that pre-service students have a basic knowledge of appropriate pedagogy for teaching kindergarteners and early literacy, and develop a positive constructive attitude: 'when can technology strengthen my pedagogy' (TEI-4). But TEI-5 realises that the teacher educators themselves do not act as role models in this regard: 'I expect that the pre-service students do with kindergarteners what I do with them, but if I don't use technology in my teaching, I cannot expect that they use technology in their teaching.' The TEIs acknowledge that they do not spend much time in preparing

pre-service students for using technology in a pedagogically appropriate way. TEI-3 discusses the importance of paying more attention to technology in their curriculum: 'Yes, I think we need to pay more systematic attention to technology in the early literacy curriculum' and TEI-1 emphasises that 'it is important that they know what good software is and what the features are of good apps'. Not all TEIs see a need to pay attention to features of apps in the early literacy curriculum, some see it as part of the technology curriculum, as expressed by TEI-1: 'I think it is more useful to teach them what a good app is, than to teach them what is a good app for early literacy.'

TEIs notice that it is not easy to teach pre-service students the features of appropriate software. TEI-1 contends, '… but it is quite complicated because the apps we might offer can be outdated when the pre-service students enter practice'. Similarly TEI-2 explains that 'I looked into this [apps for letter sounds] and I was shocked that there are many apps … then you can only teach them what the main characteristics are of teaching letter sounds and then have them evaluate these apps on these characteristics'. TEI-2 goes on: 'For electronic books it is easier, because we know that the more extras there are, the less effective the book … and we pay attention to that by showing them examples of electronic books.' However, TEI-2 is the only TEI that has such specific considerations when discussing features of software for early literacy.

Concerning the features of hardware, the TEIs do not have many suggestions. TEI-3 mentions the possibility to slow down the speaking rate of adaptive feedback for kindergarteners with a language delay. TEI-2 mentions the availability of slightly bigger keyboards with appropriate letters for kindergarteners.[1]

Barriers and opportunities for the implementation of technology for early literacy in the TEI curriculum

The TEIs agree that the main barrier to utilising technology for early literacy is related to their own limited knowledge about technology for early literacy. On the one hand, teacher educators responsible for technology are able to teach technology use related to general pedagogical practice, but do not know the affordances of technology specifically for early literacy. On the other hand, early literacy experts have limited knowledge of available technology for early literacy. TEI-2 explains that 'if you don't know a lot about it yourself then it is difficult to think what the possibilities are of technology for language arts. So apart from being able to use the technology, you just don't think about it.' And although all TEIs are aware of electronic books, they do not know how electronic books can be used effectively, except for TEI-2. TEI-4 expresses the problem as follows: 'what mainly needs to change is the competencies of the teacher educators. I think that our students see too few good examples of technology use.' TEIs are not aware of research about the use of technology for early literacy and experience that as something they are lacking: 'it would help me if we have summaries of scientific articles about technology use for early literacy, because that is how we teach our students … based on evidence' (TEI-3).

Teacher educators also experience that they are short in time if they invest in the use of technology, as expressed by TEI-2: 'in reality … it is always in your own time', and this also holds when training is offered: 'we are offered nice workshops and apps … but you are so busy … that you don't have time to experiment with it yourself … and that is what we need to do' (TEI-5).

Another problem that all TEIs face is the limited time available in the curriculum, because of the need to prepare the pre-service students for the national assessment of basic knowledge during the first two years of the programme. In addition, TEIs do not feel the urgency to pay attention to technology for early literacy, as long as the schools where their students do their internships pay little attention to technology. In such situations, pre-service teachers do not see the relevance of using technology because it is not part of their practice (TEI-1, TEI-2, TEI 4). Only when students do their internships in schools with tablets do they see the relevance, which is increasingly the case (TEI-3). But also then some caution is appropriate, because in many of these schools tablets are not used as a means but as a goal in itself (TEI-4).

Except for TEI-5, which was recently merged, the other TEIs see opportunities for paying more attention to technology in the early literacy curriculum. Three TEIs expressed the need to develop a shared vision about using technology in early literacy (TEI-1, TEI-3, TEI-4). In this regard, TEI-1 also proposes considering the use of technology more explicitly in the (forthcoming) redesign of their curriculum. TEI-3 acknowledges that they can be more pro-active with the experiences from pre-service students who do their internship in technology-rich schools. Both TEI-2 and TEI-3 realised that they did not know what was done by the technology expert and proposed to collaborate more often, as phrased by TEI-3: 'in any case we need to seek more collaboration'.

Discussion and conclusions

Discussion

This study sought to understand if and how TEIs integrate technology for fostering early literacy in their curriculum in order to develop prospective students' TPACK in early literacy. The findings show that the TEIs in our study hardly spend time on teaching about technology with added value for early literacy in their current curriculum. Having said this, they did agree that paying attention to technology in the early literacy curriculum is relevant. In particular, they see the value of teaching about the potential of electronic books. All five TEIs find it essential that prospective teachers use technology – and thus learn about technology for early literacy – based on a basic understanding of what early literacy is and how it should be taught. From this perspective, they regard it as more important that prospective teachers are taught criteria to help them evaluate software for early literacy which fit the goals and pedagogy they have for their lessons and that they become aware of conditions for using technology effectively, than they are taught all kinds of specific applications. Teacher educators see their limited competencies, either in the domain of technology or in the domain of early literacy, as the main barrier to integrating technology in subject domains in the teacher education curriculum (cf. Tondeur et al., 2013). Both teacher educators in early literacy and in technology are not aware of the evidence available about software applications with an added value for early literacy. As a result, prospective teachers are not provided with models on how to use technology for early literacy, which, according to Tondeur et al. (2012), is a powerful means in preparing prospective teachers for using technology in the classroom. Next to lacking technology competencies, teacher educators see the limited room in the current early literacy curriculum for paying attention to technology as

an additional barrier. However, TEIs could cope with this problem if the technology curriculum was better integrated with the curricula of subject domains, such as (early) literacy.

Collaboration between teacher educators responsible for technology and teacher educators responsible for early literacy was seen as a potential solution to these problems. Such collaboration can take the form of a mentoring role of the teacher educators responsible for technology for their early literacy colleagues (Polly, Mims, Shepherd, & Inan, 2010). Cviko, McKenney, and Voogt (2014) showed the potential of teachers who collaboratively (re)designed their early literacy curriculum to enhance it with technology. A similar approach could also have potential for teacher educators (Polly et al., 2010).

Another outcome of this study was that TEIs did not yet feel the urgency of preparing prospective students to use technology. They do not view themselves to be at the forefront of developments in education. As long as the prospective students are not expected to use technology in their internship, the teacher educators find it difficult to raise interest in technology use in their students. However, since primary schools increasingly use technology in teaching, also in kindergarten, they expect that this will change rapidly. Next to preparing prospective students to appropriately use technology in their teaching, they also see a critical role for TEIs in the proper use of technology for teaching and learning, because – according to the teacher educators – too often primary schools use technology as a goal in itself instead of a means for teaching and learning.

These findings give pause for several considerations. First, the TEIs agree that a main barrier to utilising technology for early literacy is related to their own limited knowledge about and use of technology for early literacy. Teachers note the need to experiment with tools themselves, but lament the lack of time to do this. The lack of experimentation with technology in pre-service programmes is consistent with findings from previous research (Enochsson & Rizza, 2009). It also shows that, with the possible exception of one TEI that encourages students to design their own multimedia storybooks, the TEI staff involved in this study would most likely be considered pre-novices ('I am not aware of specific technologies for early literacy') or novices ('I have read or heard about technologies for early literacy') using the pre-service teacher technology competencies (Krueger, Hansen, & Smaldino, 2000) if structured for the domain of early literacy.[2] Very few participants appear to have been apprentices ('I have used and evaluated technologies for early literacy') or practitioners ('I have designed learning activities that integrate technology for early literacy'), though these are the levels experts recommend pre-service educators strive for (Kirschner & Selinger, 2003).

Second, it would seem that the current structures and habits in TEIs are not conducive to developing TPACK. This is because there is very limited *integrated* technological pedagogical content knowledge among the teaching faculty, and there are very few courses or learning opportunities through which pre-service teachers could develop integrated knowledge. This is not to say that there is no value in separate courses for technology, pedagogy and content. In fact, Luan, Bakar, and Tang (2006) found that involvement in discrete ICT courses did positively influence student teacher attitudes to technology. But if the technological, pedagogical and content knowledge and skills are not integrated during pre-service education, they are likely to remain isolated and unexploited (Polly et al., 2010).

Study limitations

As only five TEIs contributed to the study, we cannot generalise the findings of this study. The main purpose of our study was to develop a better understanding of teacher educators' considerations of the feasibility and relevance of teaching about technology for early literacy. Our study contributed to raised awareness among the focus group participants about the potential of technology for early literacy. This leads to a second limitation of this study, namely that only a limited number of teacher educators took part in the focus group discussion, which may have resulted in bias in the findings as probably teacher educators interested in the topic took part. To prevent such bias, we emphasised in the discussion reflecting on the situation in their TEI.

Future directions

Based on the findings of this study, future directions towards promoting the integration of technology in the teaching and learning of subject domains should be concerned with pre-service teacher educators, given that the TEI teachers themselves lament the lack of TPACK for early literacy in their organisations. Thus, the practical implications of this study are consistent with previous research (Kay, 2006; Polly et al., 2010; Tondeur et al., 2013) in the suggestion that professional development to foster TPACK growth among teacher educators is essential. Doing so requires TEI-level and possibly broader-level policies that facilitate teacher educators' experimentation with (domain-specific) technologies.

Research could contribute to this process by documenting effective and efficient scenarios for developing TPACK among pre-service teacher educators. Although research on the effectiveness of interventions for developing teacher TPACK is limited to date, helpful starting points could be gleaned from the longer-standing body of research on PCK. In a recent review study, Evens, Elen, and Depaepe (2015) found that effective interventions for developing teachers' PCK often feature the following components: reflection, PCK courses, contact with other teachers, and experiences in educational practice. Given that the pre-service teacher educators prioritised pre-service teacher learning about the pedagogical uses of technology, this may be the most appropriate focus for reflection and redesign of teacher education courses, at least with first- and second-year students. In so doing, it may be helpful to begin with technologies already deemed important (electronic storybooks) before introducing additional forms of technology that can serve early literacy.

Conclusion

This study set out to examine if and how TEIs are helping students to develop the TPACK needed to effectively use technology for early literacy. The findings suggest that TEIs are not currently preparing pre-service teachers to use technology for early literacy. A major reason for this is that pre-service teacher educators themselves consider their own level of knowledge and skills to be weak, and have limited opportunities for developing their integrated TPACK. To ultimately help prepare new teachers for using technology in the service of developing early literacy, investment in developing the TPACK of teacher educators is urgently needed.

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Notes

1. For example, http://clevy.com/.
2. http://www.intime.uni.edu/model/technology/comps3.html.

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