Supporting pre-service teacher's Technological Pedagogical Knowledge integration through technology-enhanced lesson planning

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Abstract

This study examined the effect of providing pre-service teachers support based on the Technological Pedagogical And Content Knowledge (TPACK) Framework. The participants in this study were pre-service teachers who designed a technology-infused lesson plan, using the information that was provided in the support materials. The participants were assigned to one of two conditions, receiving support in the form of (1) *separate* technological, pedagogical and content information; (2) *integrated* Technological Pedagogical Knowledge (TPK) information and separate content information. The main research question was: Do pre-service teachers who received integrated support show more TPK in their lesson plans and reflections than pre-service teachers who received separate support? Results showed that participants who received the integrated support did not show significantly more TPK or TPCK use, than those who received the separate support. Furthermore, there was no difference in the quality of the integration of pedagogical knowledge and content knowledge. However, participants who received the integrated support showed significantly more high quality integration of technology in their reflections than participants who received the separate support.

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Computers and Information and Communication Technologies (ICT) play a significant role in our lives, and have a great impact on how people learn and behave (Martinovic & Zhang, 2012). Since the beginning of the millennium the usage of ICT has increased tremendously which has had significant impact on education (Xie & Reider, 2014). Consequently, teachers are faced with the challenge to consider the affordances of ICT in light of how students learn. Even though teachers might know how to use the ICT tools for personal use, this is an insufficient basis for the professional use of these technologies with students in the classroom (Krauskopf, Zahn, Hesse, & Pea, 2014; Russell, Bebell, O'Dwyer, & O'Connor, 2003). Moreover, when appropriately integrated, ICT has the potential to promote learning (Angeli & Valanides, 2009).

For this reason, educational researchers are increasingly interested in the essential roles and qualities of teacher knowledge bases necessary for successful technology integration. Moreover, teacher education programs are paying more attention to how they can best prepare teachers for teaching with technology. Russell et al. (2003) argued that one approach to preparing teachers to integrate ICT in their teaching, is to focus on teaching *with* technology, and rather than viewing technology as a tool, emphasize its potential to enhance teaching and learning beyond what the traditional methods allow. In order to do this, pre-service teachers are required to develop an understanding of how technology relates to pedagogy and content. These interactions are visualized in the Technological Pedagogical And Content Knowledge (TPACK) framework developed by Mishra and Koehler (2006), which builds on the concept of pedagogical content knowledge (Shulman, 1986).

As shown in Figure 1, the TPACK framework consists of seven knowledge elements (Mishra & Koehler, 2006). There are three key elements that form the basis of the framework: content knowledge (CK), pedagogical knowledge (PK) and technological knowledge (TK). CK is knowledge about the actual subject matter that will be taught in the lesson. PK is the teachers' knowledge about the methods and processes of teaching and learning. TK entails knowledge of technology, while understanding it broadly enough to apply it productively, to recognize when technology can assist or hinder the achievement of a goal, and to continually adapt to changes in technology. At the intersection of the key elements, three new integrated knowledge elements are formed. These are: pedagogical content knowledge (PCK), technological content knowledge (TCK) and technological pedagogical knowledge (TPK). PCK is knowledge of pedagogy that is applicable to the teaching of specific content. TCK is the understanding that technologies can constrain and afford a range of representations that can help make content more accessible to the learner. TPK entails knowledge of how different kinds of technologies can be applied in teaching. At the center of the framework, where all knowledge elements intersect, technological pedagogical content knowledge (TPCK) is placed. TPCK embodies pedagogical techniques that use technologies in constructive ways to teach content.

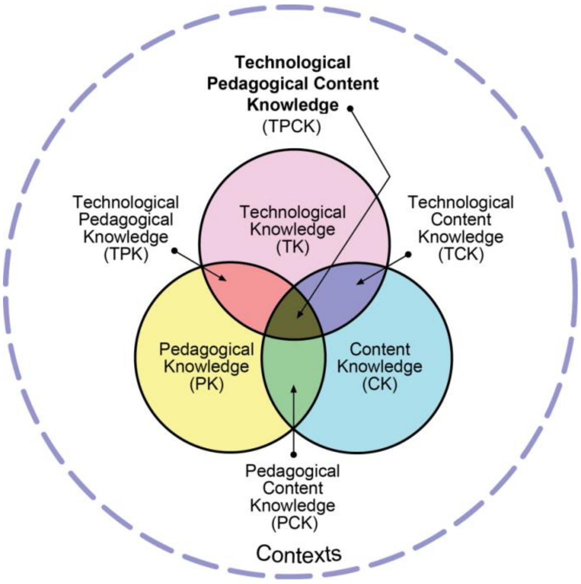

Figure 1. The TPACK framework and its knowledge elements.

Pre-service teachers may have difficulty developing TPACK, because it consists of a complex body of knowledge (Koehler & Mishra, 2009). Many studies have explored how pre-service teachers develop TPACK. Pre-service teachers are inexperienced, and need to be trained in teaching with technology. Design-based learning has proven to be a well suited approach (Lee & Breitenberg, 2010; Mishra & Koehler, 2006; Puente, van Eijck, & Jochems, 2013). Design based learning is an approach that is aimed at learning design skills in a way that fits the student's own preferences, learning styles, and various skills (Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008). Mishra and Koehler (2006) suggest that design-based activities provide a rich context for learning, inquiry and revision. Through the design of a technology-enhanced lesson, pre-service teachers are inclined to consider the interactions among CK, PK and TK (Angeli & Valanides, 2009; Cavin, 2008; Mishra & Koehler, 2006). Recent research has shown that providing pre-service teachers with TPACK-based support stimulates them to better integrate technology with pedagogy and content (Martinovic & Zhang, 2012; Mishra & Koehler, 2006).

Several studies have found positive results when looking at the development of TPACK through design-based learning. In these studies, the pre-service teachers receive various types of TPACK-based support. Knowing how certain types of support can affect TPACK development could help future research to identify the most effective approach. Therefore, it is important to look at what TPACK elements the support addresses, whether and how these elements are integrated, and what effect different presentation formats have on the development of the pre-service teachers' TPACK. The focus of the support can be divided into three categories: focus on all elements (CK, PK, TK, PCK, TCK, TPK and TPCK), focus on the key elements (CK, PK, and/or TK) and focus on integrated elements (PCK, TCK, TPK and/or TPCK). For example, Hofer and Grandgenett (2012) offered pre-service teachers various types of support during a three-semester long program that covered all TPACK elements. They concluded that the pre-service teachers had gained confidence in all TPACK elements, although reflection statements only showed a development of TPK. Chittleborough (2014) used an incremental approach by first providing support for the key elements (CK, PK, TK), after which all other elements were included. The pre-service teachers showed a positive development of all TPACK elements. Angeli and Valanides (2009) focused on all integrated TPACK elements (PCK, TCK, TPK, TPCK) in their support, resulting in a significant development of all TPACK elements. More studies are outlined in the literature study (Knoef, 2015). However, it is still unclear what kind of TPACK-based support is most effective. This study aims to build on the existing research by examining how different types of TPACK-based support affects pre-service teachers' integration of technology, pedagogy and content. It is difficult to make conclusions about the effect of the focus of the support, because the results are mixed. Furthermore, these studies included only one type of support. The present study aims to give new insights into the effects of a specific support focus.

According to Kramer, Walker, and Brill (2007) and Recker et al. (2005) there is a great variation in teachers' knowledge of technology integration, and in their competency to design pedagogically intact activities. Martinovic and Zhang (2012) examined pre-service teachers' attitudes towards the learning and integration of technology into their teaching and found that they are increasingly knowledgeable and skilled in the use of technology. However, they express that simply knowing how to use the technology is not enough. The technologies are often used superficially in teaching and pre-service teachers often have misconceptions around the educational use of technology. Fisher (1996) composed a list of the most important IT competencies required of pre-service teachers. In general, they concluded that there is a need for a better understanding of the utilization of technology for teaching and learning. These findings indicate that pre-service teachers are in need of a better understanding how technology interacts with pedagogy.

In the literature, several studies have given support that was focused on TPK (Koh & Divaharan, 2011; Walker et al., 2012). Although the results are varied, they are predominantly positive. However, because the participants in these studies all received the same support, it is hard to say whether a different type of support would have led to the same results. Walker et al. (2012) provided the only study that observed two groups who received the same support, but with a different TPACK focus; focus on TK, and focus on TPK. Both groups reported a positive development of PK, TK, PCK and TPCK. Besides that, no other differences between the two conditions were tested. Furthermore, it was not tested whether there were significant differences between the two groups' knowledge development. Because of that, it is difficult to say whether one of the two support types was more effective. However, the effect sizes for the pre- and post-tests were calculated for both groups. The participants that received the TPK support is higher on all effect sizes except on TK. The present study further looks into the effect of TPK support. The pre-service teachers are offered just in time support to examine the effect of the support on their TPACK use.

Research question and hypothesis

The participants of this study designed a technology-infused lesson plan, using the information that was provided in the TPACK-based support materials. The participants were assigned to one of two conditions, receiving support in the form of either (1) *separate* technological, pedagogical and content information; or (2) *integrated* TPK information and separate content information. The main research question for this study was: Do pre-service teachers who received integrated support show more integration of TPK in their lesson plans and reflections than pre-service teachers who received separate support? It was also examined whether there are any differences between the conditions regarding the quality of the integration of pedagogy, content and technology.

Based on previous studies, it seemed that the TPACK elements that receive attention in the support also develop more (Agyei & Keengwe, 2014; Çalik, Özsevgeç, Ebenezer, Artun, & Küçük, 2014; Chittleborough, 2014; Jang & Chen, 2010; Koh & Chai, 2014; Koh & Divaharan, 2011). Therefore, it was expected that pre-service teachers who received the integrated support would show more integration of TPK, and higher quality integration, in their lesson plans and reflections than pre-service teachers who received the separate support. The pre-service teachers who received the integrated support were also expected to show more integration of the other TPACK elements, because they had paid attention to the integration of two key knowledge elements. This might have made them more aware of the opportunities it created and integrate the content knowledge as well.

Method

Participants

The research sample comprised 32 pre-service elementary education teachers (7 males, 25 females; M_{age} = 19.8, SD_{age} = 1.5, range = 17 - 23). The pre-service teachers were enrolled in a teacher education program (PABO). Out of the pre-service teachers, 16 were first-year students and 16 were second-year students. Half of the students had a Higher General Secondary Education diploma, the other half had an intermediate vocational education diploma. The students had a varied amount of internship experience, rated in months ($M_{internship}$ = 13.6, $SD_{internship}$ = 5.8, range = 6 – 28) and classroom teaching experience ($M_{teaching}$ = 6.5, $SD_{teaching}$ = 12.1, range = 0 - 30). Almost half of the participants (47%) had experience with teaching in seventh grade, the class for which the lesson assignment was intended. Table 1 shows the participants´ experience, measured in the number of lessons taught, with the content, pedagogy and technology they had to apply in the assignment. There were no significant differences between the participants that receive the separate support and those who received the integrated support.

Table 1. Participants' practical experience

	Separate support (Mode)	Integrated support (Mode)	U	*z*	*p*
Subject matter (photosynthesis)	0.0	0.0	120.00	-0.59	0.55

Collaborative learning	1.0	1.0	113.50	-0.59	0.55
Bubble.us	1.0	1.0	109.00	-0.74	0.46
Padlet	0.0	0.0	124.50	-0.15	0.88
Socrative	0..0	0.5	107.00	-0.88	0.38
Film/animation	3.0	3.5	112.50	-0.62	0.53
Stoodle	0.0	0.0	118.50	-0.44	0.66

Instruments

Lesson plan. The participants designed a technology-enhanced lesson, by filling out a lesson plan template. The template matched the format the participants are used to working with in their program. It consisted of four sections: preparation, start of lesson, progress, and end of lesson. After completing the lesson plan, the participants wrote a reflection to justify the choices made regarding the content, pedagogy and technology.

Support materials. All participants received TPACK-based support materials they could use in designing their lesson plan. There were two sets of support materials: separate support and integrated support. The separate support contained three sections with information on the content, pedagogy, and technology that had to be incorporated in the lesson plan. The content information dealt with photosynthesis. The pedagogical information addressed the collaborative learning approach. The information about technology concerned five technological tools: bubbl.us, Padlet, Socrative, Stoodle and a film/animation.

The integrated support consisted of two sections: integrated technological and pedagogical information (TPK) and separate content information. The information itself was identical in both conditions, however, the information was presented differently. In the integrated support the technological and pedagogical information was integrated. For example, the pedagogical information in the separate support looked like this: 'for this lesson, the pupils have to make a functional drawing'. In the integrated support it looked like this: 'For this lesson, the pupils have to make a functional drawing. Stoodle only has basic drawing elements, which makes the software appropriate for this type of drawing.' The integrated support exemplified how the pedagogical and technological information can be integrated, as opposed to the separate support, where the participants had to determine these opportunities themselves.

Assignment. The previous instruments were accompanied by two assignments that explained the participants what to do. The first assignment was to design one elaborate lesson where the pupils would learn about photosynthesis. For each phase of the lesson plan the content, pedagogy and tools that would be used had to be described. The support materials were introduced as a resource that could be used for the lesson design. The participants were instructed to use at least two technological tools in their lesson design. The second assignment was to justify the choices the participants had made during the design of their lesson plan. They were instructed to answer the question: "why do you think the pupils will learn the most about the process of photosynthesis this way?". Each decision in every phase had to be justified, particularly with regard to the content, pedagogy and tools.

Background questionnaire. The participants filled out a background questionnaire, which aimed to assess their teaching experience as well as experience with technology. Six open-ended questions intended to clarify the demographics of the participants as well as their prior education. Ten rating questions measured how often the participants' had taught lessons with technology, collaborative learning and/or photosynthesis. The rating questions were answered on a 5-point Likert scale ranging from *never* to *ten lessons or more*.

Procedure

All participants attended a 75-minute session. First, the participants were shortly introduced to the purpose of the study. Next, the assignment was introduced and the technological tools were explained. The participants received the support materials and the lesson plan formats. The participants were instructed to design their lesson individually with the use of the support materials. After they were finished, they received another form on which they wrote their reflections. Finally, each participant filled out the background questionnaire.

Data-analysis

The goal of this study was to examine whether pre-service teachers who received integrated support would show more integration of TPK in their lesson plans and reflections than pre-service teachers who received separate support. Data analysis focused on the occurrence of the TPACK elements (i.e. either separate or integrated) in participants' lesson plans. Their reflections were coded separately, as these contain more elaborate information about the choices that the participants made.

First, the lesson plans were segmented such that each learning activity became a separate segment. In the second phase, these segments were coded using a coding scheme that was based on the TPACK elements. The same process was used for the analysis of the reflections. A second researcher independently segmented and coded 20% of the data. The first round lead to a high level of disagreement (κ = .43) due to the high interpretability of the data. Therefore, several coding rules were added to the coding scheme. A statement was coded as CK when it referred to the process of photosynthesis (the subject matter). As the participants were aspiring teachers with mediocre knowledge of biology, they were not expected to be very detailed in describing the content of the lesson. However, only when the process of photosynthesis was mentioned explicitly, the statement was coded as CK. Aspects like "the learning goal, assessing knowledge, and acquiring knowledge" are general didactics and were coded as PK. At several occasions the participants described a lesson activity where the pupils would make a drawing collaboratively, but they did not mention the use of the tool Stoodle explicitly. In such cases, it was assumed that the participant meant that the tool should be used and therefore was coded as TK. After the second round, an inter-rater agreement (Cohen's Kappa) of κ = .71 was reached for the segmentation, and κ = .88 for the coding of the data. Table 2 presents a definition of each TPACK code, based on the final coding scheme.

Table 2. Data analysis coding scheme

TPACK code	Definition
Content knowledge CK)	Knowledge about the actual subject matter that will be taught in the lesson
Pedagogical knowledge (PK)	Teachers' knowledge about the methods and processes of teaching and learning
Technological information (TK)	Knowledge of technology, understanding it broadly enough to apply it productively, to recognize when technology can assist or hinder the achievement of a goal, and to continually adapt to changes in technology
Pedagogical content knowledge (PCK)	Knowledge of pedagogy that is applicable to the teaching of specific content
Technological content knowledge (TCK)	The understanding that technologies can constrain and afford a range of representations that can help make content more accessible to the learner
Technological pedagogical knowledge (TPK)	Knowledge of how different kinds of technologies can be applied in teaching
Technological pedagogical content knowledge (TPCK)	Embodies pedagogical techniques that use technologies in constructive ways to teach content

For each TPACK element it was calculated which percentage of the segments, per participant, was coded as such. The average number of segments in the lesson plans was: $M_{seperate} = 8.25$, $SD_{separate} = 2.15$, $M_{integrated} = 7.56$, $SD_{integrated} = 2.79$. For the reflections average number of segments was: $M_{seperate} = 10.44$, $SD_{separate} = 2.22$, $M_{integrated} = 8.38$, $SD_{integrated} = 2.19$. For TPK and TPCK it was examined whether there were significant differences between the two groups, with the use of a t-test or Mann-Whitney U test.

For the analysis of the quality of the integration, it was examined whether a statement met either high or low quality criteria. It was calculated which percentage of the segments, per participant, met these two criteria. To establish the criteria for high quality, the definition of the TPACK element was used in combination with how the element was described in the support materials. Statements were considered of high quality when it shows that the participant is knowledgeable on the specific element(s) and understands the meaningful integration of the knowledge elements. A statement such as “I will use a movie to introduce the subject of photosynthesis” would, according to the coding scheme, be coded as TCK. However, it does not reflect a broad understanding of how the technology relates to the content. A statement such as “I will show a movie where photosynthesis is explained, because this way the process can be visualized" shows a deeper understanding of how the technology affords a different representation of the content. The quality of the integration was measured for the lesson plans and reflections separately.

Results

Frequency of TPACK integration

The means and standard deviations of the percentages for all TPACK elements are given in tables 3 and 4.

Table 3. Percentage of TPACK elements in the lesson plans

	Separate support		Integrated support	
	M	*SD*	*M*	*SD*
CK	0.00	0.00	1.56	6.25
PK	24.04	12.09	17.13	11.95
TK	4.08	5.59	2.45	5.41
PCK	22.47	4.98	24.89	16.85
TCK	7.93	7.89	7.85	9.67
TPK	13.98	10.02	17.56	11.74
TPCK	28.14	15.44	28.58	15.35

Table 4. Percentage of TPACK elements in the reflections

	Separate support		Integrated support	
	M	*SD*	*M*	*SD*
CK	0.00	0.00	0.00	0.00
PK	69.16	17.24	55.41	25.02
TK	0.52	2.08	0.00	0.00
PCK	6.02	7.21	8.29	16.89
TCK	1.46	4.11	0.89	3.58
TPK	21.05	14.87	32.22	17.52
TPCK	1.78	3.87	3.19	6.93

On average, participants who received the integrated support had more instances of TPK in their lesson plans than those who received the separate support. This difference was not significant, t (30) = -0.93, p = 0.36. For the reflections, participants who received the integrated support also showed more TPK use on average, than those who received the separate support. This difference, -11.17 was not significant either, t (30) = -1.95, p = 0.06.

It was also examined whether there were significant differences between the participants' TPCK use. In their lesson plans, participants who received the integrated support showed slightly more TPCK use on average than those who received the separate support. The difference, -0.44, was not significant *t* (30) = -0.08, *p* = 0.94. In the reflections, the TPCK use of the participants who received the integrated support did not differ significantly from the TPCK use of the participants who received the separate support either, *U* = 123.5, *z* = -0.25, *p* = 0.87.

Quality TPACK integration

Besides the frequency of the use of TPACK, it was also examined whether each statement involved either high or low quality integration. Tables 5 and 6 show the percentages of statements that involved high quality integration.

Table 5. Percentages of high quality integration in the lesson plans

	Separate support		Integrated support	
	M	SD	M	SD
Pedagogy	96.71	6.05	94.85	6.88
Content	38.23	21.49	39.46	27.31
Technology	79.47	16.61	90.31	13.59

Table 6. Percentages of high quality integration in the reflections

	Separate support		Integrated support	
	M	SD	M	SD
Pedagogy	95.77	7.51	99.48	2.08
Content	26.04	41.71	34.38	47.32
Technology	67.18	33.39	90.21	24.96

Quality of pedagogy integration. Generally, statements that involved the integration of pedagogy were of high quality in both conditions. For the lesson plans, the quality of the integration of pedagogy of the participants that received the separate support did not differ significantly from the participants that received the integrated support, U = 110.50, *z* = -0.80, *p* = 0.42. In the reflections, this difference was not significant either, U = 95.00, *z* = -1.83, *p* = 0.07. The findings suggest that the participants are educated in pedagogy and didactics and know how to apply this knowledge in the design of a lesson plan. For instance, one participant wrote: "As the teacher, I walk around to give advice and redirect where necessary". Another participant wrote: "When every student has finished, I ask them to compare their answers in groups. Afterwards I ask each group to explain one assignment. This makes for an interesting variation for the boring reviewing". These excerpts show that the participants possessed pedagogical knowledge and that they know how to apply this knowledge in a lesson. The integration of pedagogy with the other two elements was also often done appropriately. To illustrate, the following statement shows that the participant thought about how pedagogy integrates with technology (TPK): "I start by showing a movie to gain the attention of the pupils. They will also gain knowledge on the subject matter". This participant understands how the technology can be used for pedagogical purposes. Another participant considered how pedagogy can be adapted for specific content (PCK): "I chose to use a model flower, because I think with nature you have to see something for real. This way, the pupils will have a clear image of where they can see the flower in real life.".

Quality of content integration. There were only two statements that concerned content as a separate element. Perhaps the participants lacked content knowledge because when they did mention the subject matter in their lesson plans, it was often rather straightforward. The majority of the statements that involved the integration of content in the lesson plans were of low quality. On average, participants that received the integrated support reported showed slightly more high quality integration than participants that receive the separate support. This difference, -1.24, was not significant t (30) = -0.14, p = 0.88. In the reflections, there was no significant difference either, U = 117.00, z = -0.49, p = 0.62.

To illustrate, one participant applied TPCK: "As an extra clarification I show a movie where photosynthesis is explained again. However, this time it is supported by visual material, making it clearer for the pupils". In this case, the statement was labeled as TPCK although the integration of the content knowledge is rather weak. The participant merely mentioned that the movie will be about photosynthesis, but did not indicate how the technology could benefit the content. A similar example is the following statement: "The pupils receive a handout on photosynthesis so they can read it again at home". This statement was coded as PCK, but the quality of the integration of the content is again rather low. For the purpose of this study, such statements were coded as content. The participants received only a limited amount of information on photosynthesis in their support materials and therefore may not have had a lot of content knowledge to integrate.

However, there were also cases where the participants integrated content into their lesson plans very well. The following participant considered an appropriate pedagogical strategy to this specific content: "I propose putting two plants in the windowsill. One plant will get sunlight, oxygen and carbon dioxide, the other plant will not. After a while, we can look at what the effect is. I choose two students to set this up". Several other participants mentioned bringing materials to visualize the content, for instance: "I start the activity by showing a plant that I brought. I ask the pupils what they think of when they see the plant". In the reflection, the participant explained: "This way, you get the attention of the pupils. They see a real plant and are curious to find out what we will be doing with it".

Quality of technology integration. Overall, the participants used the technological tools very well. They were generally able to see which tool was most appropriate for a certain task, and how the tool would affect the pedagogy and fit in with the content. For the lesson plans, the quality of the integration of technology of the participants that received the separate support did not differ significantly from the participants that received the integrated support, U = 81.50, z = -1.86, p = 0.06. However, in the reflection this difference was significant, U = 60.00, z = -2.96, p = 0.00. This means that in their reflections, participants that received the integrated support showed more high quality integration of technology.

To illustrate, one participant wrote: "I let the pupils draw with Stoodle in pairs. This way, the pupils can work together on one drawing. They have to discuss who draws what and what its added value is". This is a good example of the integration of technological and pedagogical knowledge (TPK). The participant understood the value of the technology and how it affects pedagogy. Another example of good use of TPK is: "To start the lesson I make a word web about the subject with the pupils in Bubbl.us. This will activate the pupils' prior knowledge of the subject". On several occasions the participants also used TPK in their reflections, for instance: "With the use of Socrative I can find out whether the pupils understood the material. I can also see which of the pupils understood it, and who did not". This participant understood what the pedagogical value of the used tool is. A good example of the integration of technology with content (TCK) is the following statement: "The pupils are going to work in pairs. Together, they make a drawing that shows how the process of photosynthesis works. They use "Stoodle" to do this. They will also add text and arrows to indicate the order.". This participant thought about how certain features of the tool could benefit the transfer of knowledge.

The following statement demonstrates an appropriate application of TPCK: "The pupils are going to work with Stoodle. The handout contains information about the process of photosynthesis which the pupils can use. They will draw out this information in pairs with Stoodle. This way, everyone can see how the process goes. A few of these drawings will be discussed so that they can learn from each other's drawings". This participant considered how this tool can be used to make the pupils learn collaboratively (pedagogy), and how the content can be better delivered through the use of the tool.

Discussion and conclusion

This study aimed to answer the following question: Do pre-service teachers who received integrated support show more integration of TPK in their lesson plans and reflections than pre-service teachers who received separate support? From other studies, it was difficult to conclude whether the results could be attributed to the support and whether a different type of support would have led to the same TPACK development (Çalik et al., 2014; Chai, Koh, & Tsai, 2010; Hofer & Grandgenett, 2012). This study compared the TPK development two groups that merely differed with regard to the type of support. Therefore, any between-group differences could be attributed to the support. By comparing the difference of the two means it was established that participants who received the integrated support did not show significantly more TPK and TPCK use in their lesson plans and reflections, than those who received the separate support. This means that in this case, it cannot be concluded that that integrated TPK support leads to more integration of technology and pedagogy in the lesson plans and their reflections.

The absence of a significant difference between the two groups was not expected. Based on the literature study that was conducted previous to this study (Knoef, 2015), it was expected that the participants that received the integrated support would show more integration of technology with pedagogy (TPK). The integrated support introduced the participants to the interactions of technology and pedagogy and therefore, they were expected to be more likely to use this in their design. Walker et al. (2012) also examined the difference between two different types of support; focus on TK and focus on TPK. Although the results of their study showed that both groups reported a positive development of PK, TK, PCK and TPCK, they did not test whether there were significant differences between the two groups. The calculated effect sizes of the pre- and post-tests, implicated that there were differences between the test groups. Furthermore, they did not measure the participants' TPK development. Therefore, it was expected that in this study there would be more between group differences, mostly for TPK. It should be noted that Walker's study took place in a different context and the results are based on pre- and posttest, measuring the knowledge development over the course of three months.

Furthermore, a substantial part of the statements from the participants' lesson plans and reflections was related to PK. This might be due to the fact that the first years of the PABO curriculum are focused on general didactics and pedagogy. Therefore, the participants already had a lot of pedagogical knowledge, which would make it easier to apply in their design. In contrast, only a small amount of statements was related to CK. The majority of the participants had no experience with photosynthesis. Therefore, it could be that the participants might not have had a lot of content knowledge to apply in their lesson plans. Koh and Chai (2014) provided the participants in their study with support focusing on all TPACK elements, except for those relating to content. Consequently, variables related to content showed less development. This might also indicate that pre-service teachers need support that treats content in order to develop and integrate CK. In other studies, the participants were often enrolled in a content-specific teacher program (Agyei & Keengwe, 2014; Çalik et al., 2014; Chittleborough, 2014; Maeng, Mulvey, Smetana, & Bell, 2013; Martinovic & Zhang, 2012; Niess, 2007). In such cases, the participants already possess a larger content knowledge base, which might make it easier to see how content interacts with technology and pedagogy.

With regard to the quality of the integration, it can be concluded that both groups evidenced an equal amount of high quality statements involving the integration of pedagogy and a relatively small amount involving the integration of content. Participants who received the integrated support reported more high quality statements involving the integration of technology in their lesson plans than participants who received the separate support. Martinovic and Zhang (2012) argued that support is necessary for teachers to become comfortable with ICT and aware of restrictions and challenges to ICT use in context. The participants that received the integrated support might have had a better understanding of these restrictions and challenges in relation to pedagogy.

In recent years, ICT has become an integral part of the classroom. Therefore, teachers have to know how to properly integrate technology into their teaching. The TPACK framework shows how technology interacts with pedagogy and content, and is therefore a useful knowledge base for teachers to have. The results of this study can add to the existing research on TPACK development, and how pre-service teachers can be supported in the most effective way. Teacher education programs can use this knowledge to support their pre-service teachers' TPACK development effectively. Consequently, pre-service teachers will learn how to successfully integrate technology into their teaching. In order to establish the most effective support strategy, it is important to know how the support contributed to the TPACK development. Studies like this one, where two different types of support are compared, are necessary to establish what their effect is. The lack of significant differences found in this study, might mean that both types of support were equally effective. It should be noted that the total amount of participants that participated in this study was 32. This amount is not large enough to conclude that any other composition of participants would have led to the same results. In future research, the hypothesis could be tested with a larger sample. In addition, multiple measurement methods could be used to increase the reliability and validity. In this study, the difference in TPK use between the two conditions was not significant. However, this might be different with a larger sample, which is something that could be worth testing. Future research could examine differences between other types of support, for example, the difference between providing separate support and integrated TCK or TPCK support. The same design based learning method could be used for these studies. Furthermore, this study examined the effect of just in time support. It could also be examined what the effect is of providing longitudinal support and measure how pre-service teachers develop their TPACK over time. From the literature it has been established that TPACK is a complex body of knowledge (Koehler & Mishra, 2009). The approach to developing this knowledge therefore, should be appropriate to its complexity. The present study might help in the search to finding the right approach.

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