

Implementing Innovative Technologies Through Lesson Plans: What Kind of Support Do Teachers Prefer?

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Published online: 30 June 2015

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Abstract Lesson plans are a potentially powerful means to facilitate teachers' use of technology in the classroom. This study investigated which supplementary information is preferred by teachers when integrating a new technology into the classroom. Forty-six high school biology teachers (23 pre-service and 23 in-service) received a technology-infused lesson plan and were asked to choose between two sets of support materials that differed with regard to the extensiveness and integration of pedagogical and content information. Based on the technological, pedagogical, and content knowledge (TPACK) framework, pre-service teachers ($n = 23$) were expected to prefer the appendix containing extensive and separate information, whereas in-service teachers ($n = 23$) were predicted to prefer the succinct and integrated version. Teachers' responses to a forced-choice question confirmed the latter expectation, but lent insufficient support to the former. Semi-structured interviews further showed that the justifications of in-service teachers were generally consistent with the TPACK framework. Most pre-service teachers, by contrast, were future-oriented and preferred support that would help increase their proficiency rather than consolidate their existing knowledge base.

Keywords TPACK · Pre-service teachers · In-service teachers · Technology integration · Lesson plan · Teacher support

Introduction

Existing and emerging technologies such as simulations, online learning environments, and modelling software are increasingly being tested and implemented in educational practice (e.g. Mulder et al. 2012; Van Dijk and Lazonder 2013). Although these technologies can enhance student learning, they do not always reach their full potential because teachers often find it difficult to use new technologies in the classroom (e.g. Voogt et al. 2013; Mishra and Koehler 2006). According to Mishra and Koehler (2006), these problems arise because most efforts to implement information and communication technology (ICT) aim to promote teachers' knowledge of technologies per se, leaving the productive use of this knowledge in the teaching and learning process largely unaddressed. Mishra and Koehler (2006) therefore recommended offering additional guidance that helps teachers develop and *integrate* technological, pedagogical, and content knowledge. This proposition laid the foundations for the technological, pedagogical, and content knowledge (TPACK) framework depicted in Fig. 1.

The TPACK framework is predominantly applied to develop technology integration courses. Even though some of these initiatives have been proven successful to help promote teachers' ability to design technology-enhanced lessons (e.g. Maeng et al. 2013; Niess 2005; So and Kim 2009), attending formal training courses is not always possible for teachers. In-service teachers in particular often lack the time to take extensive courses which, in addition, generally offer insufficient follow-up guidance to facilitate and sustain teachers' use of technology in the classroom (Valcke et al. 2007).

A potentially more accessible way to support technology integration is to provide teachers with technology-infused

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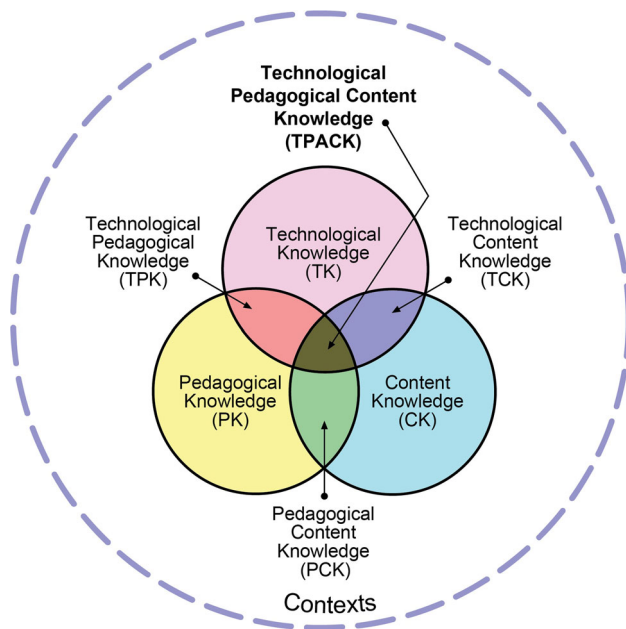


Fig. 1 Technological, pedagogical, and content knowledge framework (TPACK). Reproduced by permission of the publisher, © 2012 by tpack.org

lesson plans that guide the preparation and delivery of a lesson. Lesson plans are teaching aids that outline the course of instruction for one class by specifying what students are expected to learn (learning objectives, subject matter), how the teaching and learning process will be organized (learning activities, teaching approach), and which resources are needed (study materials, technology). Lesson plans are inherent in teachers' daily practice (cf. Ball and Cohen 1996). In-service teachers often create lesson plans themselves or use the ones made by their peers, and pre-service teachers learn about lesson planning in their teacher preparation programme, for example, to demonstrate how they intend to use technology in their lessons (Maeng et al. 2013; Koh 2013). This widespread use makes lesson plans a potentially appropriate means to assist both in-service and pre-service teachers to integrate technology in the classroom. Still, as lesson plans are mere outlines of instruction, supplementary guidance seems needed to promote teachers' understanding and use of the lesson plan (Ball and Cohen 1996; Davis et al. 2014).

Until now, little is known about how pre-service and in-service teachers are best supported in using lesson plans. Nor is it clear which type of support teachers prefer and whether these preferences differ as a function of their teaching experience. The present study is a first attempt to shed light on these important issues. The study used the TPACK framework as a basis for designing lesson plan support that addressed the technology as well as the pedagogy and content in which this technology should be

implemented. Design decisions were based on empirical evidence regarding pre-service and in-service teachers' technology integration efforts and tested in an experimental study.

The TPACK Framework

The TPACK framework is an extension of pedagogical content knowledge (PCK), a term coined by Shulman (1986) who defined it as the integration and interrelatedness of the pedagogical and content knowledge teachers need in their classroom practices. Mishra and Koehler (2006) added the concept of technology to PCK to emphasize that technology should not be learned in isolation, but in tandem with pedagogical and content knowledge.

As shown in Fig. 1, the TPACK framework contains three pillars: (1) *content knowledge* about the subject matter to be taught, (2) *pedagogical knowledge* about the teaching and learning processes, and (3) *technological knowledge* about standard technologies, such as chalk and blackboard, as well as more advanced technologies not commonly integrated in the classroom such as educational games and interactive online learning environments. These three pillars were integrated to form four knowledge bases: (1) *pedagogical content knowledge (PCK)* about the way teaching methods match the subject matter to be taught, (2) *technological pedagogical knowledge (TPK)* about the way techniques fit with teachers' teaching methods, (3) *technological content knowledge (TCK)* about the way techniques align with the learning content, and (4) *technological, pedagogical, and content knowledge (TPACK)* about the combination of techniques, content, and pedagogies (Mishra and Koehler 2006).

The pillars and their integration into TPACK can be conceived as a continuum. At one end is the *integrative view* which asserts that teacher knowledge can be explained by the pillars per se, and TPACK is simply the sum of its parts. At the other extreme, the *transformative view* posits that TPACK is a unique knowledge element that needs to be developed independently of its underlying constructs (cf. Graham 2011; Gess-Newsome 1999). This study takes an intermediate position by acknowledging that knowledge of the pillars contributes to successful technology integration *and* that TPACK is a unique construct that should be supported accordingly. This perspective is in line with Mishra and Koehler (2006), who adopted the integrative view by visualizing the TPACK framework as a Venn diagram, but also argued that TPACK is “an emergent form of knowledge that goes beyond all three components” (p. 1028). As a result, this study postulates that support for teachers' technology integration should address both TPACK and its constituent elements.

However, it seems reasonable to assume that support for the TPACK elements and their integration should be tailored to teachers' prior knowledge and experience. In other words, support for in-service teachers might, or perhaps *should*, differ from the support offered to pre-service teachers. In order to find out how support is best designed, the present study used teachers' TPACK starting position as a basis for developing tailor-made support that guides teachers' use of technology-infused lesson plans. More specifically, two sets of support materials were created that matched the extent to which pre-service teachers and in-service teachers have developed and integrated pedagogical and content knowledge into PCK.

PCK was taken as vantage point for design because it clearly differentiates pre-service and in-service teachers. When faced with a new piece of technology, neither type of teacher will be cognizant of the technology per se, but differences do exist with regard to PCK. In-service teachers have developed and integrated pedagogical and content knowledge through formal training and, more importantly, practical experience (Gess-Newsome 1999; Van Driel et al. 1998). This suggests that in-service teachers have to integrate new technological knowledge into their existing PCK (cf. Graham 2011). Evidence supporting this conjecture comes from Niess et al. (2010), who used in-service teachers' PCK as a starting point for a technology integration course that proved effective in implementing a new technology in the classroom.

Pre-service teachers are still in the process of acquiring pedagogical, content, and technological knowledge and therefore have a different TPACK starting position compared with in-service teachers. Even though most teaching training programmes aim to support aspiring teachers in the integration of pedagogy and content, not all of them manage to successfully develop PCK (Hume and Berry 2011; Van Driel et al. 2002). Similarly, research on courses addressing the development of TPACK found that few pre-service teachers managed to fully develop PCK and TPACK (e.g. Pamuk 2012; So and Kim 2009). Pre-service teachers might therefore benefit most from separate support for pedagogy and content because it enables them to extend their incomplete and fragmented knowledge base. As pre-service and in-service teachers alike have only minimal technological knowledge, support for the use of new technologies should be presented separately.

Nonetheless, teachers' actual uptake of professional development possibilities in general, and just-in-time support in particular, depends on its perceived usefulness (cf. Kwakman 2003). This can be further substantiated by research on the technology acceptance model, which showed that the intention to use new technologies predicts the actual usage of those technologies (see for a review, Turner et al. 2010). Based on these studies, it can be concluded that the decision to use TPACK-based support materials may depend

on their anticipated use. So prior to assessing the actual effectiveness of supplementary support for lesson plans, teachers' support preferences should be identified.

Research Question and Hypotheses

The main research question of this study was: What TPACK-based support for a technology-infused lesson plan do in-service and pre-service teachers prefer? A technology-infused lesson plan was presented to in-service and pre-service teachers. It outlined a biology unit that aimed to teach high school students about glucose–insulin regulation (content) by means of an inquiry-based method (pedagogy) using modelling software (technology). Additional technological, pedagogical, and content support was given in two types of support materials. Both variants offered the same elaborate technological information, but differed with regard to the presentation of the pedagogical and content information. The first type of support presented this information in a compact and integrated manner (hereafter: integrated support). The second type of support presented pedagogical and content information separately and elaborately (hereafter: separate support). Pre-service and in-service teachers were asked to evaluate both support materials, make an informed decision about which type of material they would prefer, and justify their choice.

Pre-service teachers are generally inexperienced in inquiry-based teaching of glucose–insulin regulation with the use of modelling software. They were therefore expected to prefer the separate support, as it contained elaborate information about all three knowledge components. In-service teachers were expected to prefer the integrated support. They too are largely unfamiliar with the use of modelling software, but more experienced in the teaching of glucose–insulin regulation through inquiry-based methods, which is consistent with the compact and integrated information regarding content and pedagogy (PCK) in the integrated support.

Method

Participants

The sample comprised 23 pre-service and 23 in-service high school biology teachers. The pre-service teachers (9 males and 14 females; $M_{\text{age}} = 26.78$, $SD = 6.58$, range = 22–51) came from three Dutch teacher training institutes where they were enrolled in the postgraduate biology teacher programme for 6 months on average ($SD = 2.80$). Pre-service teachers had little or no experience with teaching about glucose–insulin regulation ($M = 0.76$ times, $SD = 1.34$) and inquiry learning ($M = 0.95$ per month, $SD = 1.21$).

They did not use any modelling programmes in their teaching, but six of them had used this type of software in their graduate biology courses.

The in-service teachers (16 males and 7 females; $M_{age} = 42.61$, $SD = 12.28$, range = 26–63) were recruited from 21 Dutch secondary schools. Their average teaching experience was 13 years ($SD = 10.01$); they all taught regularly about glucose–insulin regulation ($M = 2.45$, $SD = 1.18$, per year) and used inquiry learning in their teaching 2.42 times per month on average ($SD = 2.78$). Ten in-service teachers had some experience with the use of modelling software in their teaching, but none of them had used the specific modelling software in this study. All teachers volunteered for the study, signed an informed consent form, and received a €10 gift voucher for their participation.

Materials

Lesson Plan

The study revolved around a lesson plan for the use of modelling software (technology) in a four-lesson biology unit on glucose–insulin regulation (content) delivered through inquiry-based teaching (pedagogy). The lesson plan was designed for use in fourth year pre-university classes and consisted of four main activities to be processed in sequential order. Students were first introduced to the modelling software, then built a glucose–insulin model, tested their model by simulating the effect of eating a pizza, and explored the complications caused by type 1

diabetes. Learning goals were specified for each activity, and explanations were given to indicate what students should attend to during that activity.

Support Materials

The lesson plan was supplemented with two sets of teacher support materials. The set referred to as *separate support* contained three stand-alone sections with elaborate information about the content, pedagogy, and technology addressed in the lesson plan. The second set presented *integrated support* on pedagogy and content in a condensed and integrated way (i.e. PCK support); the technological information was identical to that of the separate support. The key characteristics of both sets of support materials are summarized in Table 1.

Student Materials

Participants in this study also had access to the student materials that came with the lesson plan. The main student material was the SCYDynamics model editor which facilitates system dynamics modelling (De Jong et al. 2010). As shown in Fig. 2, the glucose–insulin reference model consisted of variables and relations that define how the variables interact. Students had to build this model from scratch; teachers received the reference model. Other student materials were (1) a paper model editor tutorial, (2) an instructional text about glucose–insulin regulation, (3) an assignment about diabetes, and (4) an exemplary test and test answers.

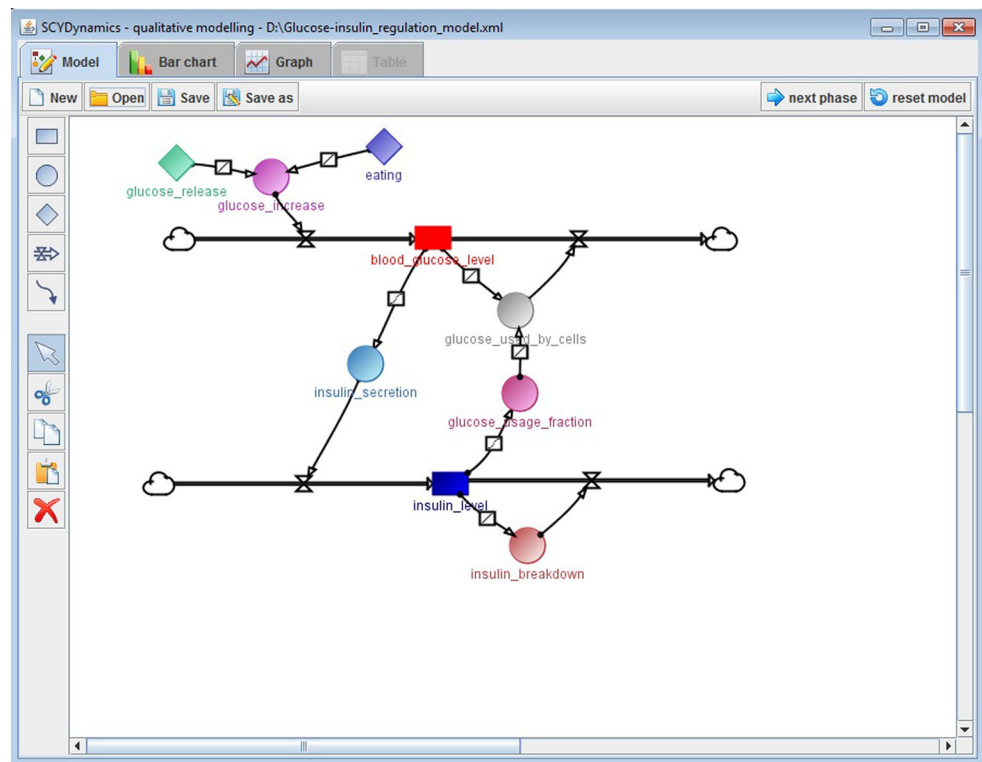
Table 1 Support provided in the components of the support materials

Support	Description	Example
<i>Separate support</i>		
Content	Summary of the content information given to students. The information was presented so that teachers could readily see how domain concepts relate to variables in the model ^a	Insulin is secreted by the beta cells in the pancreas when the blood glucose level is higher than its usual value
Pedagogy	Description of the phases in inquiry-based learning: orientation, hypothesis generation, experimentation, reaching conclusions, evaluation, and the planning and monitoring process (e.g. De Jong 2006)	When evaluating experimental outcomes, the meaning of the results should be discussed so that the relevance of the model becomes clear to the students
Technology	Step-by-step description of the modelling software, supplemented with screenshots and a glossary of the symbols used	When clicking on a variable, the <i>start value</i> of that variable can be defined
<i>Integrated support</i>		
PCK ^b	Succinct information about glucose–insulin regulation purposefully integrated with the inquiry learning phases	When evaluating experimental outcomes [pedagogy], it can be discussed what eating a pizza does to the glucose level [content]
Technology	<i>Identical to the separate support</i>	

^a No information was provided regarding the technical features of the use of modelling software

^b Pedagogical content knowledge

Fig. 2 Model editor tool with the glucose–insulin regulation reference model



Background Questionnaire

A questionnaire aimed to assess participants' teaching experience as well as their experience with ICT and modelling software. Nine open-ended items measured participants' teaching experience (which in case of pre-service teachers referred to the experiences gained during internships) with regard to inquiry learning, glucose–insulin regulation, and the use of (biology) models. For example, one item about inquiry learning asked: “How many times per month do you apply inquiry learning in your classroom practices?” Participants' experience with ICT and modelling software was assessed by two rating questions and eight open-ended questions. The former asked participants to indicate their knowledge of ICT and modelling software on a 5-point Likert scale ranging from *much less* to *much more*. A sample item measuring ICT experience is: “Compared to your colleagues, how much knowledge do you think you have of ICT in general?” The eight open-ended items inquired after participants' use of ICT and modelling software outside and inside the classroom (e.g. “Can you describe a lesson where you used modelling software?”).

Interview

Semi-structured interviews were the main data source of this study. Prior to this study, pilot interviews were held with a professional instructional designer, two in-service

teachers, and one pre-service teacher to find out whether the interview questions elicited sufficient responses and how much time an interview would take. Based on these pilot interviews, some questions were improved or removed.

The final interview protocol contained five questions about teachers' preference for the support materials and the reasons underlying their choice, and three follow-up questions that inquired after their opinion regarding the lesson plan and support materials in general (see Table 2).

Procedure

The study was conducted in the spring of 2013. Every participant attended a 45-min session. Participants were first introduced to the study and completed the background questionnaire. Next, the interviewer followed a script to introduce participants to the lesson plan and the student materials. The script contextualized the study as an Internet search for educational resources: Participants were asked to imagine that their search for materials on glucose–insulin regulation had yielded the materials they were about to receive. They were then given the student materials and a preview of the lesson plan and were instructed to scan these materials. Hereafter, teachers received the complete lesson plan and were asked to read it carefully. Finally, the separate and integrated support were presented and closely studied by the teachers. To prevent possible order effects, teachers

Table 2 Interview protocol

Question	Goal
Reasons for preferring the support:	
1. Which appendix ^a do you think is most useful for your own teaching practices?	1. Identify participants’ preferences for either separate or integrated support
2. Why did you choose this appendix?	2. Identify why the participants chose certain support
<i>Referring to the appendix preferred by the participant</i>	
3 and 4. Why do you think this part is (not) relevant for you?	3 and 4. Identify why the participants chose certain support, specifically related to the differences between the support materials
<i>Question asked per part of the appendix (not) preferred by the participants</i>	
5. (Short summary of answers) Is this a correct interpretation of your ideas regarding your decision for appendix 1/2? Do you have any additions?	5. Summarize participants’ answers to find out if they were interpreted correctly by the interviewer
Evaluation of the support materials and lesson plan:	
6. Which improvements do you think could be relevant regarding the usefulness of the appendices in general?	6. Identify how teachers value the support materials
7. Which improvements do you think are relevant regarding the usefulness of the lesson plan as a whole?	7. Investigate to what extent participants consider the lesson plan and support materials useful for their teaching practices
8. Do you think I have a good impression of your ideas regarding this lesson plan? Do you have any additions?	8. Ensure participants’ opportunity to provide additional comments

^a In the interview, support materials were referred to as ‘appendices’ to exemplify the relation to the lesson plan

received both types of support at the same time so they could readily see the differences between the materials.

Once teachers had been exposed to all materials, they were asked to think about their own lesson preparations, and whether they considered the support materials useful for these activities. Then, the interviewer indicated the key differences between the separate and integrated support, and the focus interview was administered using the protocol in Table 2. All interviews were audio recorded.

Data Analysis

Interview recordings were transcribed verbatim and analysed using a stepwise approach consisting of three stages. The first stage served to separate responses that were key to answering this study’s research question (interview questions 1–5; see Table 2) from the ones that concerned a general evaluation of the preferred support and the lesson plan (questions 6–8). The latter were not included in the main analyses.

In the second stage, the responses key to answering this study’s research question were segmented into utterances: meaningful phrases with a single communicative function (Van Boxtel 2000). Ten transcripts were segmented independently by the first author and a fellow researcher; interrater agreement reached 84 %.

In the third stage, a rubric was developed to classify the utterances. In addition to participants’ actual choice, eight types of reasons for preferring the support materials were identified (see Table 3). The first two types concerned the amount of information and its presentation format (i.e.

pedagogical and content information either separated or integrated). Four reasons served to classify statements given by teachers about other aspects of the support; these concerned the transparency, concreteness, theoretical rigour, and how well the materials conveyed the instructional views of its designer. The remaining three types of reasons concerned plain approvals or disapprovals of the support, the ‘miscellaneous’ category, and ‘irrelevant’ statements that could not be related to the support materials. To establish interrater reliability, ten segmented transcripts (377 utterances) were independently coded by two raters using the rubric in Table 3; Cohen’s κ reached 0.72. As both interrater reliability estimates proved sufficient, one rater coded the utterances from the remaining transcripts.

Results

Table 4 presents a cross-tabulation of pre-service and in-service teachers’ preference for either separate or integrated support. These data show that the majority of the teachers (69.57 %) opted for the integrated support. The separate support was preferred by 14 teachers (30.43 %). Teachers’ choice of support proved to be independent of their professional experience, $\chi^2(1, N = 46) = 0.41, p = .52$, which means that pre-service and in-service teachers were comparable in their general preference for the integrated support.

Teachers’ responses during the interview were analysed to identify the reasons underlying their preference. The

Table 3 Rubric for the classification of utterances from the interview transcripts

Type of reason	Description	Example
Choice	A decision towards either separate or integrated support	Then, I think this is the support I'll choose
Amount of information	Whether the support contains too much or too little information	It's good to have more information, so I can always look it up
Presentation format	Whether the support addresses pedagogy and content in an integrated or separated manner	This shows how the subject [content] should be taught by means of inquiry [pedagogy]
Transparency	How the information is structured in the support	I think the information is mixed up, it is confusing to me
Concreteness	Whether the information is more concrete, and related to classroom practice	This is really adapted to the lesson series, and matches what students are doing
Theoretical rigour	Whether the information is more theoretical, general and unrelated to practice	Here the pedagogy is quite general, shallow, and it's not related to the subject [content]
Designer's view	Whether and how the support conveys the ideas of its maker	I think it is clear here why the lesson series is made so that I'll interpret it correctly
Plain judgments	Respondent's opinion of the support without further justification	I think this is nice, yes
Other/miscellaneous	Remarks that, although on-topic, cannot be related to the other codes	I will apply it in my own way anyway, and here there is the least attention to that
Irrelevant	Remarks that were not related to the support materials	At my school we use laptops for this type of practicum

Table 4 Distribution of teachers' support preferences

Teacher	Preferred support		Total
	Separate	Integrated	
Pre-service	8	15	23
In-service	6	17	23
Total	14	32	46

transcribed interviews contained 2326 utterances, 984 of which pertained to reason justification. The 1342 remaining utterances were not included in the analysis. These remarks were coded as 'irrelevant' because they did not refer to the support materials, and were mostly elaborate accounts of the teachers' own experiences, comments on the process of reading the materials, or confirmations of statements made by the interviewer.

A closer inspection of the reason justification utterances revealed that teachers' preference was based on the merits of the preferred support rather than the demerits of the unpreferred one. Almost exclusive positive reasons were given by pre-service ($M = 92.95$, $SD = 11.27$) and in-service teachers ($M = 96.32$, $SD = 6.42$) about the support they preferred. As these data were not normally divided, Mann-Whitney U tests were performed to compare differences between groups. Pre-service and in-service teachers did not differ significantly in their supportive argumentation, $U = 231.00$, $z = -0.87$, $p = .39$, $r = -0.13$. However, the in-service and pre-service teachers who preferred the integrated support ($M = 96.76$, $SD = 6.64$) generated relatively more supportive arguments than those who preferred the

separate support ($M = 89.77$, $SD = 12.37$), $U = 143.00$, $z = -2.25$, $p = .02$, $r = -0.33$.

Classification of the utterances aimed to shed light on the reasons why in-service and pre-service teachers preferred a particular type of support. As shown in Table 5, reasons pertaining to the amount of information, presentation format, and concreteness prevailed and were mentioned by (nearly) all teachers; the occurrence rate of all three types of reasons proved independent of teachers' professional experience. The other types of reasons were mentioned less often and by fewer teachers. Here too no significant differences were found between pre-service and in-service teachers.

Qualitative Analysis

Detailed descriptive analyses of the teachers' justifications were performed to gain more insight into the specific reasons for choosing the separate or integrated support. The analyses addressed the *amount of information* and *presentation format* because these characteristics best differentiate the two appendices and can bear a strong relationship with pre-service and in-service teachers' TPACK starting positions.

Amount of Information

As shown in Table 5, every participant reflected on the amount of information. Those who favoured the separate support all mentioned its elaborate information, but there were some notable differences between pre-service and in-

Table 5 Classification of the mean number of reasons

Type of reason	Pre-service teachers			In-service teachers			<i>F</i> (1, 45)	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>		
Amount of information	9.21	4.01	23	8.57	5.51	23	0.21	.65
Information presentation	4.89	2.42	18	4.76	3.38	17	0.09	.76
Concreteness	3.68	2.16	19	2.72	1.96	18	1.89	.18
Theoretical rigour	2.14	1.35	7	2.17	1.47	6	– ^a	–
Transparency	1.70	0.67	10	2.13	2.03	8	– ^a	–
Designer’s view	2.33	1.52	3	2.67	2.89	3	– ^a	–
Plain judgments	2.72	2.08	18	2.55	1.67	19	0.02	.88
Other/miscellaneous	2.40	2.07	5	1.83	0.75	16	– ^a	–

^a Numbers too low for meaningful statistical analysis

service teachers. Although some pre-service and in-service teachers argued that (part of) the information was already known—which was in fact the prevalent critique of the participants who preferred this support—seven pre-service teachers considered the large amount of information appropriate. They felt that it provided them with a safety net in case they would forget or be unaware of certain details, which according to two of them was necessary given that they were “novice teachers”. The in-service teachers were also generally positive about the amount of information, albeit for a different reason. They did not relate it to a lack of knowledge, and four of them considered the elaborate information useful for reference purposes. For example, one participant argued: “When I would prepare a lesson myself then I will think about the order of the lesson and the length. So I think it is nice that I can have a bit more ideas to choose from”.

Most pre-service (*n* = 12) and in-service teachers (*n* = 15) who preferred the integrated support also commented on the amount of information. Fourteen in-service teachers felt that the amount of information was sufficient. Surprisingly, most pre-service teachers (*n* = 11) gave the same reason, and three of them justified this by arguing that they were familiar with most information. One of them said: “I will be finished faster using this one, and then I can practice it myself, and when I don’t understand it I think I can really find it here”. This shows that this pre-service teacher considered himself quite knowledgeable about the pedagogical and content information and therefore favoured the same amount of information as in-service teachers.

Presentation Format

Seven pre-service teachers who preferred the separate support referred to its presentation format. Six of them appreciated the separate presentation of pedagogy and content, although not for reasons related to their teaching experience. Instead, their justifications concerned the

layout of the support which suggests that their opinion was based on styling preferences rather than a lack of knowledge. On the other hand, the five in-service teachers who referred to the presentation format of the support did this in relation to their own teaching experience. For example, one in-service teacher declared that regarding his lesson preparation: “I really feel like that’s the content and that’s the pedagogical part, that’s for me and that should meet the lesson content, these are the demands and that’s what they should be able to do and what they should know”. This excerpt corresponds with the opinion of four others, who also reasoned that this format enabled them to refer to just the pedagogy or just the content, and hence eased their search for information during lesson preparation.

Most of the in-service teachers (*n* = 11) who preferred the integrated support felt that the combined presentation of pedagogical and content information was useful. This was substantiated by ten in-service teachers’ additional justifications that evidenced their integrated understanding of pedagogy and content (i.e. PCK). They felt that this support better linked pedagogy and content, as one of them argued: “Especially because everything that is related is provided together. For example, content is content, but when you teach you do not talk only about content, but also about the pedagogy that relates to it”.

The pre-service teachers who preferred the integrated support speculated on how the presentation format could support them in future teaching practices. Ten of the 11 pre-service teachers who commented on the presentation format felt it eased the process of integrating pedagogy and content, as one of them explained:

I think that this [integrated support] will also take a lot less time. Because I think that when you have to come up with this yourself, how will I do that, how should I guide the students, how will I increase students’ understanding?... Then this will take much more time than when I get examples like address the effect of eating or the effect of diabetes in this way.

This excerpt exemplifies the relationship between teaching experience and support preference. The pre-service teacher lists several issues regarding the integration of pedagogy and content that need to be addressed and appreciates the integrated support offered through the examples for efficiency reasons. Hence, this suggests that pre-service teachers seem to have difficulties with the integration process itself, and specific guidance for the integration of pedagogy and content seems to fit best to their current knowledge base.

Based on pre-service teachers' unexpected preference for the integrated support, and their confidence in choosing this support, the differences in pre-service teachers' preference for either the separate or integrated support might be attributable to differences in teaching experience during internships. A posteriori analysis showed that this was not the case: the pre-service teachers who preferred the separate support had 5.00-month teaching experience on average, which was not statistically different from the 6.73 months of experience by the pre-service teachers who chose the integrated support, $U = 44.00$, $z = -1.24$, $p = .22$, $r = -0.2$.

Discussion

This study used the TPACK framework to adapt the design of lesson plan support to teachers' level of experience. A technology-infused lesson plan with two types of supplementary support materials was presented to pre-service and in-service teachers. The separate support contained elaborate information about pedagogy, content, and technology and was assumed to meet the needs of pre-service teachers. The integrated support was deemed appropriate for in-service teachers because it contained compact information about PCK and separate, elaborate information about technology. Both hypotheses were investigated by having pre-service and in-service teachers select their preferred support materials and justify their choice.

Consistent with expectations, most in-service teachers preferred the integrated support. They appreciated the compact and interrelated information about pedagogy and content as it matched the set-up of the lesson plan and the way they prepared and taught their own lessons. This result seems to indicate that the integrated support was indeed designed in accordance with in-service teachers' level of PCK, and supports the notion that in-service teachers' TPACK starting position can be a sound basis for the design of lesson plan support.

A few in-service teachers preferred the separate support, but not for reasons specifically related to their teaching experience. Instead, they envisioned using this support for reference purposes and as a source of inspiration. This is consistent with research by Doering et al. (2014) who

found that in-service teachers liked elaborate support on pedagogy, content, and technology, but argued that they did not always need this in their teaching. Thus, separate support seems to enable experienced teachers to decide for themselves what information to use during the preparation and conduct of a lesson. Still, as this view was held by just a few in-service teachers, it does not necessarily lead to different implications for the TPACK framework.

Contrary to expectations, few pre-service teachers preferred the separate support. Those who did justified their choice only partially from their limited teaching experience. They did not relate the presentation format to their teaching experience, but mainly preferred the separate presentation of pedagogy and content because it made the information more transparent. Similar to in-service teachers, some of them felt that part of the information was already known, which might explain why participants who preferred this support gave slightly less positive justifications than those who preferred the integrated support. However, pre-service teachers generally indicated that they appreciated the elaborate information because it provided them with a safety net in case they would forget or be ignorant of certain information. This is consistent with Pamuk (2012) who argued that pre-service teachers need additional support on technology, pedagogy, and content when engaging in the design of technology-infused lessons. It thus seems that these teachers were aware of their incomplete pedagogical and content knowledge, but unaware of how the presentation format addressed these knowledge bases. As the true reason could not be revealed in the interviews (this would have interfered with the participants' spontaneous reactions), future research might investigate whether this explanation holds true.

Perhaps the most intriguing outcome of this study is that the majority of the pre-service teachers preferred the integrated support. Even though their justifications referred to their experiences (or the lack thereof), the gist of their comments was inconsistent with the TPACK framework. They generally believed the integrated support provided enough information that, due to its integrated presentation, could easily be related to teaching practice. It thus seems most pre-service teachers were less concerned about possible gaps in pedagogical and content knowledge. They looked ahead towards the development of PCK for their future teaching career and preferred support in this respect. This suggests that these participants were more aware of the complexity of the interrelatedness of pedagogy and content than their fellow pre-service teachers who preferred the separate support. A possible reason could be that pre-service teachers' experience played a role, but the a posteriori analysis showed that this was not the case. Another explanation might be related to the focus of the teacher education programme on PCK. From the start of their programme, pre-

service teachers need to learn and develop PCK in several courses and internships (e.g. De Jong et al. 2005; Van Driel et al. 2002; Hume and Berry 2011). Although they do not always succeed in integrating PCK, pre-service teachers are continuously made aware of the challenges of PCK development and its relevance for (future) teaching. As a result, these pre-service teachers may have been less concerned about their actual knowledge and focused on their PCK development instead, which could be the reason why they preferred support in the form of PCK information.

Nonetheless, pre-service teachers' preference for support that integrates pedagogy and content points to a different interpretation and application of the TPACK framework in designing support for pre-service teachers. That is, pedagogical and content support should not be tailored to pre-service teachers' TPACK starting position, but geared towards the next proficiency level. Support on PCK could help them develop from their own separate knowledge bases of pedagogy and content, via PCK and technological support, to eventually reach understanding of TPACK. Such an approach has been successfully applied by Niess (2005), who offered pre-service teachers TPACK-based courses in addition to the PCK courses that were already part of the regular teacher education programme. Most pre-service teachers developed their TPACK, and future research should examine whether these findings generalize to lesson plan support materials. This additionally opens up the possibility to offer support on other integrated TPACK levels, that is, technological pedagogical knowledge (TPK) and technological content knowledge (TCK). Studies in TPACK-based courses show that pre-service teachers could benefit from TPK and TCK support (e.g. Krauskopf et al. 2014; Koh and Chai 2014), and future research might compare support on these elements with support on PCK.

Still, some caution seems in order when interpreting the results of this study. One of the requirements of the upper secondary biology teacher education programme is a bachelor's degree in biology-related sciences. As teachers' content knowledge is pivotal to the development of PCK (Hashweh 2005), future research should also include teachers who are less well versed in the content area. One possibility would be to examine the PCK development of pre-service teachers in primary or lower secondary education, who do not have a formal background in the subject matter to be taught. Furthermore, as the focus in the present study was on teachers' preferences, results were subjective to teachers' self-assessment of their knowledge. Agyei and Keengwe (2014) did not find a correlation between pre-service teachers' scores on a TPACK self-report survey and performance measures (i.e. lesson plans, observations, and product evaluations). This could imply that pre-service teachers' lack of teaching experience led to discrepancies between what they thought they knew and what they

actually knew. This issue could also be the case in the current study; both in-service and pre-service teachers could only predict which information would be most useful to them in their teaching practices. Teachers already knew that they would not actually put the lesson plan into practice, and as a result, there were not real consequences to their actions which could have led to overconfident accounts of their knowledge. Additionally, based on the results in this study, conclusions cannot be made regarding teachers' TPACK development. This was a one-occasion study and consequently only teachers' reflections and ideas at that moment can be taken into account. As teachers' beliefs may change over time (Pajares 1992), future research should focus on teachers' reflections during an extensive period of lesson preparation and conduct.

To conclude, this study is a first attempt to use the TPACK framework as a prescriptive means for designing lesson plan support. The findings give useful insights in pre-service and in-service teachers' support preferences regarding technology-infused lesson plans. Providing in-service teachers support based on their TPACK starting position seems appropriate when they are integrating technology into teaching. However, pre-service teachers' TPACK starting position seemed less appropriate to guide the design of lesson plan support. Most pre-service teachers felt that TPACK-based support should focus not on what they already (partially) know, but on what they need to learn for their future career. For teacher education institutes, these results indicate that when teaching pre-service teachers to integrate technology, support should focus not on pedagogy and content separately, but on PCK as a whole additionally to technological information. Exploring pre-service teachers' development from their separate knowledge bases via PCK to eventually reach TPACK is an important step for future research.

Ethical standard All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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