Computers and Education Open 4 (2023) 100140

Contents lists available at ScienceDirect

Computers and Education Open

journal homepage: www.sciencedirect.com/journal/computers-and-education-open

No more technology? A TPACK-survey for pre-service teachers with social media in the digital world

Isabelle Muschaweck

Institute of Human Geography, Goethe University Frankfurt

ARTICLE INFO

Keywords:
TPACK
Construct validity
Pre-service teachers
Geography
Social media
Survey

ABSTRACT

In the digital age, social media are integrated into everyday life. To include corresponding topics of the digital world in the classroom, future teachers require specific knowledge and abilities. The extent to which these prerequisites are connected to technology, however, needs to be reevaluated in light of social media's ubiquitous nature. Through adopting the TPACK model for an exemplary topic of the digital world, constructions of space in Geography education, a self-evaluation survey instrument for pre-service teachers is compiled and validated (n = 364); social media are conceptualized as an aspect of technological knowledge. Confirmatory factor analysis confirms that the TPACK model is appropriate for the data, as fit-indices show favorable results. A transformative view of the model is supported. Correlations among all constructs exist, endorsing previous studies' findings on the difficulties in distinguishing the TPACK knowledge constructs. Technological knowledge, noticeably, displays comparatively low correlations with the other knowledge constructs. This result is contrary to previous studies on TPACK and social media, as well as the relation of TPACK to technological knowledge. Albeit these results are not generalizable for all digital world content in pre-service teacher education, this study, by way of example, contributes to a debate on the conceptualization of technological knowledge when introducing phenomena of the digital world that are related to social media through the TPACK model. Additionally, this study advances research in the area of embedding pre-service teacher education with social media in domain-specific pedagogies.

1. Introduction

Today's society is digital [1,2] and thus learning is situated in a digital context shaped by everyday encounters with social media (e.g. [3]). For teacher educators, this prompts questions of preparing pre-service teachers for teaching in a digital society underlain with "fake news" [4] and continued discussions on the "digital divide" [5,6]. This includes teachers being digitally literate themselves, but also fostering students' digital literacy [7]. I conceptualize digital literacy from a practice-oriented approach: this implies that digital literacy is evoked when interacting with the digital world (cf. [8]).

A topic-specific point of connection for fostering reflexive and analytical learning with the goal of digital literacy are *constructions of space* in Geography education. While they existed prior to the Web 2.0, constructions of space have been reconfigured through the pervasion of space by social media (see [9] for an overview). This phenomenon can be illustrated by searching for your town or city on social media: A conglomerate of visual, textual and audiovisua information transports the place's image in the form of posts. Through this, constructions of space are an exemplarily learning instance for acting in the context of social media – not only for Geography education, but also for disciplines under the "umbrella" of social sciences as subjects designed to enable students to act responsibly and as digital-sovereign citizens (cf. [10]) in the digital world. To include constructions of space as a topic in the classroom, teachers require specific prerequisites. What the corresponding knowledge and abilities consist of and in how far pre-service teachers already dispose of them, however, is unclear. One possibility for framing teacher knowledge and abilities is the Technological-Pedagogical-Content Knowledge (TPACK) model by Mishra and Koehler [11]. In the following, I will review literature at the intersections of social media as content for teacher education, TPACK and social media, as well as the role of subject-specificity to identify gaps in the literature and to deduce the research question guiding this paper.

1.1. Teachers' and prospective teachers' social media usage

According to the "International Computer and Information Literacy Study 2018", 12% of teachers report to use social media in learning

E-mail address: muschaweck@geo.uni-frankfurt.de.

https://doi.org/10.1016/j.caeo.2023.100140
Received 30 November 2022; Received in revised form 25 April 2023; Accepted 1 May 2023
Available online 1 May 2023

contexts frequently, with most countries scoring well below 10% ([12], 209). This presents a strong contrast with the extensive everyday use of information and communications technology (ICT) in students' leisure time ([12], 132, 273). While it cannot be concluded from these numbers that social media are not used as content in the classroom, assuming that their role as providers of content is low, seems rational.

This argument is strengthened when reviewing studies on the purpose of teachers' and prospective teachers' social media usage. Corresponding research has increased in recent years. Here, most studies target teachers' professional interaction with social media as tools (see literature review by [13]). In the context of this, several authors identify a commercial use of social media by teachers to promote themselves and their teaching materials alongside collaboration between teachers on different topics on a professional scale [3,14,15]. Social media have also been examined specifically in the context of teacher education regarding teacher students' mental health [16]. Neither of these strands of discussion has a direct bearing on social media as part of content in pre-service teacher education. However, the presented research may suggest a critical stance towards approaching social media as content that includes pre-service teachers reflecting their own social media practices and their adaptation of teaching materials promoted online.

The literature review by van den Beemt et al. [13,17] furthermore suggests that linking social media to domain-specific pedagogies is rare. It is not possible to refute or confirm this claim for Geography teacher education, as too view examples exist in the literature. Studies in Geography education and social media in general, however, may allow for a careful support of the argument, as pedagogical rationales and how they relate to the implementation of social media are rarely sufficiently explained (e.g. [18,19]; for an exception see: [20]). For content in the realm of social media in Geography teacher education, this implies a need for identifying a frame that can link this content to suitable pedagogical approaches. Due to its openness, establishment and conceptualization of technological knowledge as a separate knowledge domain, the TPACK model by Mishra and Koehler [11] can provide a fitting starting point.

1.2. TPACK and social media

Embedded in the dynamic evolvement of TPACK relevant technologies [21], social media can be regarded as new additions to teachers' repertoire. One theme displayed in the research on social media in relation to TPACK is its possibilities for spreading TPACK scholarship (e.g. [22]). Beyond this issue, the positioning of social media as part of technological knowledge and the related knowledge domains is still a marginal topic. However, examples by Bingimlas [23], as well as Setiawan and Phillipson [24] indicate that social media can and should be included in TPACK to prepare future teachers for a digital world. Here, elements of the survey developed by Bingimlas [23] mirror the focal point of social media as tools and for teacher professional development primarily discussed in relation to teachers' social media usage (compare 1.1).

Results by Setiawan and Phillipson [24] suggest that social media usage is highly correlated with technological knowledge, technological-pedagogical and technological-pedagogical-content knowledge, while

Bingimlas [23] identifies low confidence in combining social media and teaching techniques. Taken together with general results on the relevance of technological knowledge for the development of TPACK [25], results on social media and TPACK point towards a relevance of social media as an aspect of technological knowledge. However, further research is necessary to support this claim.

1.3. Subject-specific TPACK

As summarized by Wang et al. [[25], 252], there is a trend in TPACK research towards more subject-specific adaptations of the model in self-report surveys. These adaptations are primarily located in science education (e.g. [26,27]) and language learning [28,29]. A common theme among these subject-specific adaptations is a focus on subject-specific technologies. This also holds true in the realm of Geography teacher education where the TPACK model has been adopted in a number of studies with a focus on geographic information systems (GIS) as Geography-specific technologies (e.g. [30,31]), but also for more general ICT knowledge [32]. However, distinguishing between subject-specific technologies and more general technological knowledge is challenging [7]. A possibility for solving this issue may lie in acknowledging the formative power of the knowledge domain for TPACK [33,34]. Through this, domain-specific content knowledge is conceptualized as the starting point and the identification of appropriate technologies presents a subsequent step. Seen in the context of adopting a topic produced by the digital world – such as constructions of space – this prompts questions regarding the relation of technological knowledge to the other knowledge domains. As summarized in 1.2, technological knowledge has shown to be highly correlated with TPACK in the past. Nevertheless, given the increase of digital phenomena that need to be addressed in the classroom, it is vital to determine in how far they are connected to teachers' technological knowledge.

1.4. Deduction of the research question

So far, social media have, both in the context of teacher education and in relation to the TPACK model, been conceptualized as new technological means. Based on this, they are primarily positioned in the realm of technological knowledge in the TPACK model. Accordingly, social media have thus far not been regarded as facilitators of new subject-specific content knowledge. As illustrated by the case example of constructions of space in the introduction, however, the creation of new content is immanent to the digital world and social media. Consequently, a research gap can be identified between social media as tools for teachers and as technological knowledge in TPACK on the one hand, and digital topics facilitated by social media as content knowledge in TPACK on the other hand. Given that young persons' and teachers' everyday-life alike is shaped by social media and engaging with related subject-specific phenomena is vital to foster reflexive, digitally-sovereign citizens that actively and creatively engage with their digital life-world [10,35], subject-specific concepts in teacher education need to be developed. Here, the role of technological knowledge as including social media and in relation to the other knowledge domains need to be determined to contribute to teacher education in the digital world.

While this article cannot address this whole desideratum, it means to provide a starting point by selecting an exemplarily phenomenon of the digital world, i.e. constructions of space, that is being brought forward by a technological means, i.e. social media. Along this example, the following research question will be explored:

Are the theoretical constructs of teacher knowledge and their interrelations as described by the TPACK model [11] valid for an adaptation of the model for the area of constructions of space and social media with pre-service Geography teachers?

Through this research question, the role of technological knowledge for an exemplarily digital topic can be addressed, while simultaneously illustrating a possibility for conflating social media and pedagogical knowledge through a model of teacher knowledge.

I will approach the research question by presenting topic-specific normative descriptors of content knowledge, pedagogical knowledge and pedagogical-content knowledge for constructions of space. Next, I will integrate these descriptors with existing TPACK self-evaluation instruments to synthesize a topic-specific TPACK instrument. Data gathered by means of this instrument will allow me to approach the research question. Here, I will conduct confirmatory factor analysis and discuss correlations among constructs. Based on this, I will deduce implications for the role of technological knowledge in digital topics and reflect on

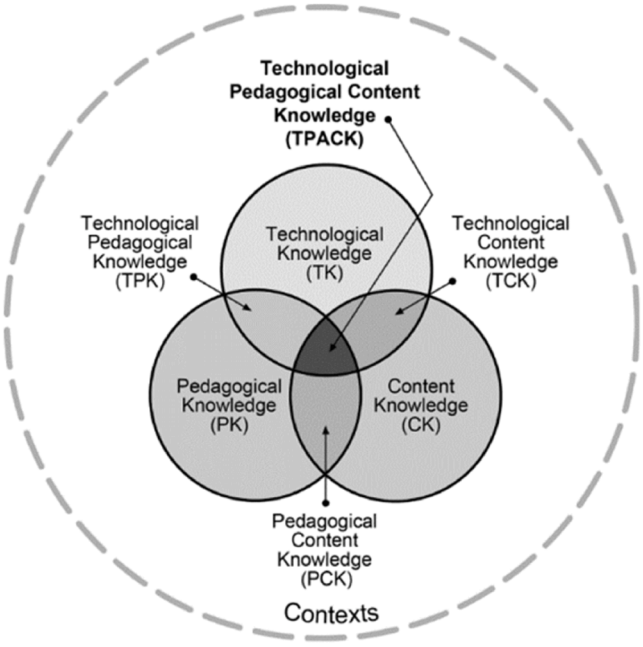

Fig. 1. The TPACK model [11]; image © 2012 by TPACK.org [37].

possibilities for future research.

2. Method

Introduced in 2006, the model of Technological-Pedagogical-Content Knowledge (short: TPACK) by Mishra and Koehler has become one of the most broadly received models in teacher education. Based on Shulman's [36] conceptualization of teacher knowledge as content knowledge, pedagogical knowledge and their combination, pedagogical-content knowledge, Mishra and Koehler [11] add technological knowledge and the corresponding intersections to the model. As illustrated in the following Fig. 1, teacher knowledge is thus regarded as constituted by seven domains that are interconnected.

For the purpose of this study, the TPACK model was applied as an analytical frame to deduce descriptors of knowledge and to develop a topic-specific survey. Based on existing self-evaluation surveys, the compilation of an instrument for constructions of space followed a three-part process outlined in the following chapter. Starting from the content knowledge to be measured, i.e. constructions of space, the TPACK model was adapted for this topic based on a structured analysis of literature. In the course of this, corresponding media education approaches were identified and analyzed for the realm of pedagogical knowledge. Through this, knowledge descriptors were deduced in a second step and integrated with existing surveys in a third step. As this paper focuses on survey development and construct validity, the method of analysis of literature itself is not part of the present paper (see [38] and [39]).

2.1. Topic-specific theoretical background

2.1.1. Constructions of space & integrative media education approaches

As the topic- and subject-specific context for constructions of space is not the focal point of this article and thus not explored in depth, only a brief overview is provided in this section. First, it should be noted that, based on a practice-oriented approach, everyday actions can be regarded as inherently mediated by digital media [40]. As social media function as suppliers of digital information – including information on places and space – they are entangled with everyday life. Constructions of space arise in this context through the ascriptions of meaning to specific places and corresponding actions. However, they are not neutral suppliers of spatial information but can transport notions of stigma [41] or trendiness (cf. [42]). Therefore, they need to be deconstructed and addressed in a reflexive manner to contribute to digital literacy. Corresponding knowledge on constructions of space and related abilities in identifying and dealing with them are thus constituents of "content knowledge" as defined for the topic-specific TPACK model.

Integrative media education approaches were selected as a pedagogical means to address constructions of space, as they respond to the integrative nature of society and the digital and thus social media. Here, an exemplary approach is learning through creative practices as introduced by Richter and Allert [43]. Creative practices, in this context, describe collective patterns of interacting with the world and others. Amplified through social media, creativity is, accordingly, called for constantly and can only be fostered through learning in the context of social media themselves; this is, because it is only ever evoked in real-life situations. While these situations can never be fully reproduced in formal learning settings, learners' creative practice can become the center of reflexive and deconstructive endeavors. Related knowledge on integrative media education approaches and abilities regarding the creation of learning situations that foster reflexive, critical and creative learning thus comprise "pedagogical knowledge" as part of the topic-specific TPACK model.

The synthesis of constructions of space through integrative media education approaches form the realm of pedagogical-content knowledge.

2.1.2. Deduction of descriptors of teachers' knowledge and abilities

To operationalize constructions of space and integrative media education approaches with the goal of conceptualizing a corresponding topic-specific TPACK instrument, I firstly analyzed literature on constructions of space and integrative media education approaches. For content knowledge on constructions of space, themes of (1.) constructivist concepts of space, (2.) the interconnection of space and the digital and (3.) characteristics of constructions of space were identified. Characteristics of constructions of space focuses on the empirically explored variants of the efficacy of constructions of space. For pedagogical knowledge on integrative media education approaches, three identified themes included (1.) learning through creative practices, (2.) reflection on action and (3.) emancipation as well as digital sovereignty.

Following the identification of knowledge domains, descriptors of teachers' necessary knowledge and abilities to include constructions of space in the classroom in the areas of CK, PK and PCK were deduced. These concrete descriptors, translated from German, are listed in the appendix A.1 (originally published in German by author [[39], in press] *) and present the basis for the conception of the topic-specific instrument.

2.2. Adaption of TPACK instruments

2.2.1. Available instruments

Parallel to the investigation of the topic-specific theoretical background, available TPACK surveys to include in the development of the topic-specific survey were structurally analyzed, to maintain comparability with other instruments. As summarized by Wang et al. [25], self-evaluation instruments are most common among quantitative methods of data collection in the area of the TPACK model. While such instruments are to be criticized for their dependence on variables such as teachers' academic self-concept (e.g. [17]), the author of this study also opted for a self-evaluation survey. This is due the research-interest

Table 1
Thematic overview on the constructs measured in the survey on constructions of space and social media and their theoretically assumed interrelation.

Construct as defined in the TPACK model	Knowledge and abilities surveyed for on constructions of space	Items	Postulated correlation
Technological Knowledge (TK)	Digital media and social media usage on the private and professional scale; knowledgeability on digital media and social media.	TK1-TK11	/
Pedagogical Knowledge (PK)	Facilitating learning in the sense of integrative media education; fostering reflexive, critical and creative learning in problem-based contexts.	PK12-PK20	/
Content Knowledge (CK)	Theoretical background on constructions of space and the digital society; integration of constructions of space with social media.	CK21-CK26	/
Technological-Pedagogical Knowledge (TPK)	Application of social media in the realization of integrative media education/ reflexive, critical and creative learning in problem-based contexts.	TPK27-TPK33	TK, PK
Pedagogical-Content Knowledge (PCK)	Application of integrative media education/ reflexive, critical and creative learning in problem-based contexts to constructions of space.	PCK34-PCK39	PK, CK
Technological-Content Knowledge (TCK)	Application and usage of social media in the preparation of content for the presentation and implementation of constructions of space.	TCK40-TCK43	TK, CK
Technological-Pedagogical and Content Knowledge (TPCK)	Integration of all prior knowledge domains under the premise of realizing constructions of space in the classroom.	TPCK44-TPCK47	TPK, PCK, TCK

regarding implications for future interventions, the novelty of the topic and the availability of established instruments of that kind.

As a starting point, the "Survey of Preservice Teachers' Knowledge of Teaching and Technology" by Schmidt, Baran, Thompson, Mishra, Koehler and Shin [44] was identified. This survey has already been successfully adapted for Geography education [30]. Due to this papers' focus on the digital world, surveys that included this idea or corresponding pedagogical demands were also selected. The surveys integrated in the development include the one by Chai, Ling Koh, Tsai and Lee Wee Tan [45] for their shift to information and communication technologies and the one by Valtonen, Sointu, Kukkonen, Kontkanen, Lambert and Mäkitalo-Siegl [46] for their development of items regarding changed pedagogical demands. To improve the item selection process, Schmid, Brianza and Petko's [47] survey, which presents a condensed version of the surveys already listed, was considered.

2.2.2. Adaption for constructions of space

Following Mishra and Koehler [11], teacher knowledge can be defined as an assemblage of seven domains. Therefore, each knowledge domain equals a latent construct. Three of the constructs are postulated to be independent, while specific correlations are assumed among the rest. This view is consistent with a transformative perspective on the model. Here, the combination of all knowledge domains in TPACK surpasses the sum of its parts and TPACK constitutes a distinct form of knowledge itself (see [47] for TPACK as "transformative" or "integrative"). The goal of this survey was the collection of self-evaluations associated with each of the seven constructs by means of items assigned to each construct. In the following, the item selection and adaptation process is specified. Table 1 provides additional information on the constructs, their relation and definition, while all items are listed in appendix A.2.

In the area of TK, items by Schmidt et al. [44] for the realm of digital media (TK2, TK6, TK7) were adopted. Alterations were made to Schmidt et al.'s [44] items on the TK scale in item TK2 by adding concrete context regarding the means through which participants kept up with digital media (for example through newspapers). Items TK3, TK4 and TK5 were revised based on Schmidt et al. 's [44] original item of "playing around with technology", as the group discussion performed before the main study revealed difficulties in understanding the original item. Additionally, digital media items were revised to represent social media in particular (TK8 to TK11).

Regarding the realm of PK, the items are based on Valtonen et al.'s [46] scale for 21st century TPACK skills. As mentioned above, the goal was not to strive for original items for PK, but to select items available in line with integrative media education. Valtonen et al.'s [46] items best fit this requirement. Their grammatical syntax was adjusted to match TK items and therefore to not interfere with participants' item comprehension due to differing word order within the items of the whole survey. PK17 was altered in terms of deleting "problem solving skills" and replacing it with "problem-based learning". This was done due to the complexity of the digital world and the theoretical background in integrative media education, which negate the possibility of truly "solving" a problem. Instead, it can merely be approximated to. PK19 and PK20 were added to reference topics of learning with social media and spatial socialization respectively.

Due to the focus on CK for constructions of space as a specific topic within Geography, specific CK items needed to be developed. In line with this, the descriptors of content knowledge (A.1) were transferred as six items for the CK scale on constructions of space (CK21 to CK26, A.2). Here, "specific posts" were dominantly used as a point of reference. This was done due their supposed familiarity to participants, which would enable them to rate their own abilities. An example of this includes "relat[ing] constructions of space to actions on social media and "offline" and debate possible interactions" (Descriptor of content knowledge, listed in A1), which was adapted as "I can relate posts on social networks on one topic to corresponding 'real-life' phenomena" (CK25, A.2).

As the latent constructs of TK, PK and CK are not presented as interrelated in the TPACK model (cf. Fig. 1), an independence of each knowledge domain is to be expected from a theoretical stance.

TPK items are adopted from Valtonen et al. [46] – the terms "ICT" and "tools" were replaced with "social media" and "basis" respectively to represent the theme of the survey and integrative media education. TPK33 was developed additionally for the context of spatial education.

For the area of PCK, item PCK34 was adopted from Schmid et al. [47]; PCK35 is loosely based on Schmid et al. [47] also, while the item was altered to represent the usage of social media content in teaching, which is essential for the inclusion of constructions of space in the classroom. PCK36 to PCK39 are a combination of the adaption of Valtonen et al.'s [46] and Schmid et al.'s [47] PCK items for constructions of space. Using the formulation "to design tasks…" that is applied in these items is based on Schmid et al. [47] who refer to the design of tasks as demonstrating the ability to apply content knowledge through pedagogy.

The first and the last item on the TCK scale, TCK40 and TCK43, were specifically developed for constructions of space and social media. They focus on technical aspects regarding the usage of social media as well as the interconnection of social media and their users in the production of

space. TCK41 to TCK43 are loosely based on items by Valtonen et al.'s [46] and Schmid et al. [47]. However, they have been significantly altered to blend with social media as technological facilitators of constructions of space.

The TPCK items are adopted from Schmidt et al. [44] and Chai et al. [45]. TPCK44, TPCK45 and TPCK47 were adjusted to fit constructions of space and social media.

In contrast to the exclusiveness of TK, PK and CK, an interrelation of TPK with TK and PK is to be expected, as well as an interrelation of PCK with PK and CK, of TCK with TK and CK and of TPCK with TPCK, TCK and PCK, based on the theoretical assumptions of the TPACK model from an integrative stance.

2.3. Final survey

2.3.1. Data collection

Following the translation of the instrument to German, a pre-test ($n = 25$) and a group discussion ($n = 5$), the final survey, consisting of 47 items, was compiled; the final survey – including descriptive statistics – is displayed in the appendix A.2. It was distributed digitally through thirteen university mailing list and two German teacher associations. In total, the main study data collection period lasted from January 2021 to May 2021.

On the final survey, participants reported their knowledge on a four-point Likert-like scale ranging from "disagree", "disagree to some extent", "agree to some extent" to "agree". In addition to the items, participants were also provided with definitions of key terms. This was to ensure that participants were familiar with the terms occurring in the survey. Participants were made aware of the project context and its funding at the beginning of the survey.

2.3.2. Sampling process

It is central to note that the sample constituting the basis of this study is based on voluntary sampling. Participants were allowed to self-select weather to participate following the e-mail request. Neither payments nor rewards were offered to study participants.

The population consists of students studying to become Geography teachers in Germany in secondary schools and General Studies teachers in primary schools. The quantity of this study population could not be finally ascertained, as the German Federal Office of Statistics [48] in Germany only provides data on the first subject selected by students. However, as teachers are expected to study two subject, students studying Geography as a second subject are not included in the official data provided. Thus, the group of 5.757 students studying Geography as a first subject for a teaching degree and the 1.136 students studying to become General Studies teachers can merely provide a point of orientation (ib., 198–199).

2.3.3. Sociodemographic data

364 people completed the survey, most of them university students studying Geography in the course of their pre-service teacher training ($n = 347$). Out of the university students, 30% ($n = 105$) study to become primary school teachers – Geography is part of their training as general studies teachers. The remaining 70% ($n = 242$) study to teach Geography as a school subject in secondary schools, "Gymnasium" (German Grammar School) or special needs schools. The remaining participants are in-service teachers. Participants are predominantly in their mid-20 s (Mean value: 1996, SD= 5.85). This is supposedly due to their domineering occupation as students. 72% report their gender as "female" ($n = 264$), 24.5% report their gender as male ($n = 89$). The remaining participants "preferred not to say" or were missing data. This unequal distribution among genders is congruent with the data provided by German Federal Office of Statistics ([48], 198–199). Here, roughly 60% of Geography teacher students and 85% of general studies teachers are reported as "female".

2.3.4. Reliability

Cronbach's Alpha was calculated for each of the seven scales to measure scale reliability. All results were excellent. However, with $\alpha = 0.9$, TPK could be arguably too high, as values starting from $\alpha = 0.9$ may point to a redundancy of items (cf. [49]). This should be kept in mind when interpreting the results of this scale. Item discrimination was also satisfactory for all items, except for TK1 ($r = 0.29$).

3. Results

3.1. Descriptive statistics

Due to voluntary sampling, the following descriptive results do not allow for generalization onto all students studying to become Geography or General Studies teachers. Furthermore, considering the focus of this article on the TPACK construct, a report on all descriptive results in depth is not possible. Therefore, only the most interesting aspects will be highlighted in this paragraph.

These include, as a first general statement suggested on the basis of the data, that pre-service teachers evaluated their knowledge higher in the independent knowledge domains – that is TK, PK, CK – than in the combined knowledge domains of TPK, PCK, TCK and TPCK. This could be attributed to an, in fact, higher knowledge and greater abilities in these areas. However, it may also be due to the character of the items that increase in sentence-structure complexity following the description of the application of knowledge in the combined knowledge domains. An increase in doubt regarding the correct understanding of the items might have been the corresponding reason for evaluating one's knowledge lower.

Among the independent knowledge domains, CK was self-evaluated the lowest. This may be explained by the novelty of the topic that is not yet well-integrated into Geography teacher education and still evolving in subject-specific research (cf. Ash, Kitchin & Leszczynski [50] on the "Digital turn" in Geography). This thesis is supported by a comparison with Schmidt et al.'s [44], Schmid et al.'s [47] and Valtonen et al.'s [46] results that constituted the basis of this survey. Here, CK was never evaluated the lowest among the independent knowledge domains. In Schmid e al.'s [47] survey, participants even evaluated their CK the highest compared to PK and TK. The crux here, however, lies in the broadness of CK measured in these surveys. As was already addressed above, CK here referred to a teaching subject as a whole. In contrast, in the present survey, the knowledge to be had was confined to a specific topic area. This may explain why CK was evaluated lower, as awareness of knowledge on "the topic" was specified.

Regarding the TK scale, variations among the items is noteworthy. While digital media and social media alike are integrated into everyday life (TK5, TK11), their usage in a work-related context (TK4, TK10) differs. Here, digital media are reported to be used more often. Furthermore, TK is self-evaluated the highest out of all the knowledge domains. Following concepts of the digital society (e. g. [2]), this may be pointing towards an infusion of everyday-life with the digital that could result in a higher self-evaluation in technological aspects.

Analyzing the data from a Geography teacher education perspective, the PCK results are striking: participants reported their knowledge to be the lowest in this domain. As summarized in a literature review by Wang et al. [[25], 243] on the topic of TPACK development, authentic teaching tasks can be credited with the greatest potential for developing knowledge in the integrated knowledge domains. In light of the limited application of social media in the work-context (TK10) and the fairly low CK, the integration with PK in application (i. e. PCK) may be

hindered. This can be reconnected to the novelty of the topic and lack of opportunity to apply social media – as a constituent of constructions of space as CK – in teaching.

3.2. Confirmatory factor analysis

Confirmatory factor analysis (CFA) can provide insights into weather the predefined factors (i.e. TK, PK, CK, TPK, PCK, TCK and TPCK) and their interrelation are reproduced in the data. This method additionally supplements information on the fit of the predefined model.

CFA was conducted by use of R Studio (Version 2022.07.1 + 554) on R version 4.2.1.. R-Packages included lavaan, semPlot, ggplot2 and tidyverse. Regarding the line of action, items were assigned to a construct of teacher knowledge as illustrated in Table 1 (second to right column) first. As the TPACK model indicates correlation between several constructs (Table 1, right column), correlation of latent variables was allowed for in the calculation. As a measure of goodness-of-fit of the model for the data, Maximum-Likelihood was set as an estimator. This approach was oriented on suggestions made by Field, Miles and Field [51].

3.2.1. Model fit

As summarized by Schermelleh-Engel, Moosbrugger and Müller [52], a combination of fit indices from different classes should be applied when evaluating model fit. Following their recommendations for fit indices and limiting values, three indices were selected and calculated. The results are displayed in Table 2.

$\chi 2/$ df, rmsea and srmr point to an acceptable fit of the adopted TPACK model. Thus, it can be considered to be an acceptable depiction of the knowledge constructs displayed by the sample. However, none of the indices point to an excellent fit – therefore, the model should be accepted with reservations. With the goal of possibly improving model fit, model modification indices were determined. Here, PCK35 appeared quadruply among the ten items most likely to improve model fit. As a first measure, this item was excluded from the analysis. However, this did not improve model fit. In future research, further approaches should be considered when aiming to improve the fit of the model.

To supplement the results of CFA, average variance extracted (AVE) and composite reliability (CR) were calculated. While, as shown in Table 3, CR yielded exemplary results for all scales, AVE indicates that the latent knowledge constructs LCK, LPK and LTK do not sufficiently describe the assigned items.

First, these results strengthen the argument of accepting the model with reservations. Regarding AVE, it is however notable, that the latent knowledge constructs of LTPK, LPCK, LTCK and LTPCK display satisfactory results, as, based on the theory, the assigned items could be argued to be at higher risk of being related to the fundamental latent knowledge areas (i.e. LCK, LPK, LTK). In future studies, it could be advisable to investigate if these results are reproduced in other samples to possibly draw further implications.

3.2.2. Factor loading

The detailed results on factor loadings, as well as a detailed measurement model of the latent constructs in relation to the items, are listed in the appendix A.3. Regarding the latent construct of technological knowledge (LTK), this construct is described well by all items. TK2, TK8 and TK9 present the highest factor loading. While the first two refer to "keeping up" with digital and social media respectively, TK9 refers to trying out new social media. This may indicate an important connection of technological knowledge with consistently informing oneself and proactively trying out new developments.

The latent variable of pedagogical knowledge (LPK) is also well described by nearly all items, save PK20. This item refers to the linkage of one's own mindset regarding social media to one's teaching. Here, the loading is comparatively low. A possible reason for this may lie in self-reflexive abilities being more separate from pedagogical knowledge than theoretically postulated. However, it may also indicate reduced relevance of reflection on personal social media usage in relation to teaching for general pedagogical knowledge. For the latent construct of content knowledge (LCK), a similar result is the case: except one item, all items appear to describe the factor well. CK22, an item inquiring about the knowledge on characteristics of constructions of space, in comparison presents lower loading. Here, item formulation should be critically reevaluated, as this item is possibly phrased too broad.

The constructs of latent technological-pedagogical knowledge (LPK) and latent technological-pedagogical knowledge (LTPK) are all well represented by the items. Here, no particularly high loadings are present either.

Latent pedagogical-content knowledge (LPCK) is well represented by all items as well. PCK35, the item possibly contributing to the not-sufficient model fit, however, ranks lowest here by comparison. This constitutes further evidence that this item on choosing content from social media with the goal of fostering complex thinking may need to be excluded in further research.

Finally, the latent construct of technological-pedagogical-content knowledge (LTPCK) is presented well by most factors. TPCK46 is comparatively low, however. This item on the expansion of teaching content and process by digital media, in German in particular, is worded rather "awkward". Thus, a reason for its lower fit could lie in it being formulated too complicated resulting in participants' struggling with understanding and related self-evaluation. Another possible explanation may be located in this items' missing connection to either constructions of space or social networks, displayed, in contrast, by all other LTPCK items.

Table 2
Fit Indices for the TPACK model adopted for constructions of space and social media.

	$\chi^2/$ df	Rmsea	srmr
Result	2.6441	0.067	0.068
Cut-off criteria*	$2 < \chi 2/df \leq 3$	$.05 <$ rmsea ≤ 0.08	$.05 <$ srmr ≤ 0.10
Acceptable fit*:	**Yes**	**Yes**	**Yes**

* Fit measure criteria taken from Schermelleh-Engel et al. [[52], 52].

Table 3
Results of average variance extracted and composite reliability.

	LTK	LPK	LCK	LTPK	LPCK	LTCK	LTPCK
average variance extracted (AVE)	0.299*	0.397*	0.413*	0.560	0.573	0.620	0.571
Cut-off criterion	AVE > 0,5 (following [53])						
composite reliability (CR)	0.802	0.858	0.811	0.899	0.891	0.867	0.839
Cut-off criterion	CR > 0,6 (following [54])						

* below cut-off criteria.

3.2.3. Correlations

Correlation among certain constructs was expected based on the TPACK model as listed in Table 1. This expectation was confirmed by the data. Nevertheless, the remaining constructs expected to be independent were also found to be positively correlated with an at least small effect size, as Table 4 illustrates.

One noteworthy result is the correlation of LTCK with LCK and LPCK with large effects. While the former is to be expected based on the model, the latter is not. This result could allude to a high integration of technological knowledge and skills in their application with pedagogical and content knowledge. Contrasted with the small effect-correlations of LTK with other constructs, LTCK as the presentation of content (i.e. constructions of space) through technological means (i.e. social media) could be more central for the development of content-related TPACK for the subject matter investigated. It must be noted however, that very high correlations may also point to redundancies of items – the previous line of argument should thus be regarded with caution.

A transformative view of the TPACK model as summarized in Table 1 is supported by the correlations to a degree. While the constructs assumed to be independent are correlated only with small effects with one another, correlations between LTPCK and the combined constructs (LTPK, LPCK, LTCK) hold a large effect size. Correlation between LPK and LCK and their respectively assumedly related constructs is also comparatively high: they display large effect sizes respectively. The constructs postulated to be associated with LTK (i.e. LTCK and LTPK), however, show comparatively low correlations with LTK: here, only small effect sizes are present. For the TPACK model adapted for the subject matter of constructions of space, this may indicate a lower relevance of technological knowledge as an indirect influence for the development of related TPACK.

While correlation among items cannot be discussed at length here, the separateness of TK items from the other highly correlated items is also present (see supplementary material for the item correlation matrix).

The correlation of all constructs with each other could be linked to additional underlying variables. This is supported by existing literature on the TPACK model, which identified self-efficacy beliefs as well as academic self-concept to be interrelated with TPACK self-evaluation (for example: [56,57]). The low correlation of TK with theoretically related concepts could indicate a decrease of the importance of technological skills in a world permeated by the digital or at least a lower relevance of technological knowledge for the area of constructions of space and social media.

Table 4
Correlations (Pearson's *r*) among latent constructs of knowledge for the TPACK model adopted for constructions of space and social media.

	LTK	LPK	LCK	LTPK	LPCK	LTCK	LTPCK
LTK*	1.000						
LPK*	0.326	1.000					
LCK*	0.440	0.481	1.000				
LTPK*	0.313	0.518	0.484	1.000			
LPCK*	0.215	0.594	0.563	0.627	1.000		
LTCK*	0.382	0.363	0.724	0.512	0.613	1.000	
LTPCK*	0.380	0.439	0.645	0.696	0.729	0.755	1.000

* LTK= Latent technological knowledge, LPK= Latent pedagogical knowledge, LCK= content knowledge, LTPK= Latent technological-pedagogical knowledge, LPCK= Latent pedagogical-content knowledge, LTCK= Latent technological-content knowledge, LTPCK= latent technological-pedagogical-content knowledge

Effect sizes for Pearson's *r*: from *r*= 0,1: small effect; from *r*= 0,3: medium effect, from *r*= 0,5: large effect [55].

4. Discussion

The TPACK model has been subject to criticism due to several drawbacks since its introduction. While Brantley-Dias and Ertmer [58] commented on it possibly containing too many constructs from a conceptual stance, a review by Willermark [59] demonstrated that a clear distinction of the seven separate knowledge constructs is empirically difficult. This fits with the results of the present study. Nevertheless, the results of CFA – which did allow for correlations among constructs – also provided reasons for considering the TPACK model to be a possible fit for the data. This suggests, on the one hand, that the model is less representative of independent knowledge constructs of teacher knowledge. On the other hand, the results may point to a transformative view (cf. [47]) on technology-related teacher knowledge as presented by interrelated and partially mutually amplifying constructs.

Concretely, the results of CFA and the analysis of correlations largely align with the theoretically postulated constructs and their interconnectedness as presented in the TPACK model, albeit independence of separate constructs could not be confirmed. To answer the research question: The theoretical constructs of teacher knowledge and their interrelations as described by the TPACK model are valid for the adaptation of the model for constructions of space and social media. Validity here refers to "structural validity" as summarized by Cavanagh and Koehler [60] for the TPACK model and excludes other criteria of validity.

The correlation of all constructs alludes to a lack of one-dimensionality of the constructs and confirms results of previous studies in that the separate TPACK knowledge domains are difficult to disseminate [59]. Nevertheless, correlation among the independent constructs of TK, PK and CK were found to be comparatively low, which indicates relative distinguishability of each other. This supports discussions in the literature, which identified lack of subject-specificity in TPACK instruments as a possible reason for reduced construct validity (for a summary: [27]).

Critically relating the results of the present study to earlier TPACK studies with pre-service teachers, possible heterogeneity among pre-service teachers should be considered. That is, factors such as pre-service teachers' self-efficacy, behavioral intentions of using ICT and attitudes towards ICT have been found to be statistically linked to TPACK and different groups among pre-service teachers were identified [61,62]. When interpreting the present study, these earlier results highlight the need to bear in mind that while the TPACK model was found to be an acceptable fit, it should not be transferred onto pre-service teacher education unreservedly. Instead, future learning settings should account for pre-service teachers' individual characteristics to enable an effective fostering of TPACK.

Pedagogical and content knowledge, as well as their adjacent knowledge domains and their adjacent knowledge domain of TPACK, appear not to be affected by the insertion of a topic of the digital world in the present study. Technological knowledge was found to present a striking exception, as it does not match the level of correlation with the knowledge domains theoretically assumed to be interrelated with it compared to content or pedagogical knowledge. This result presents a contrast to previous studies on social media as aspects of TPACK, which found high correlations of TK and social media with TPACK ([23,24]). It also is not in line with social media-independent studies on pre-service teachers' TPACK that identified TK to be a strong predictor of TPACK [25]. A possible explanation for this could be located in that participants were pre-service teachers in their mid-twenties, who mostly indicated to use social media regularly. Thus, the role of TK as being less relevant in the context of the TPACK model and in relation to an everyday-technology only holds explanatory power for the studies particular sample. Conducting the same study with older, experienced teachers may very well yield different or contrary results. As analyzed in

the review of literature, evaluating a digital topic facilitated by technology may necessitate a reevaluation of the relevance of technological knowledge for such content. While historically, technological knowledge was added as a knowledge domain to address increased technological demands on teachers [11], the present study provides reasons for a diminishing relevance of technological knowledge, rather than providing evidence for an inclusion of social media in the realm of technological knowledge. The subsuming of technology in content is further supported by the comparatively high correlation of technological-content knowledge with other knowledge constructs, apart from technological knowledge itself [24].

Another explanation for the surprising result on technological knowledge could be located in the analytical stance selected: domain-specificity (cf. [33,34]) was considered the integral starting point for the development of knowledge descriptors that became the basis of the survey, and domain-specific pedagogy was analyzed. This has been rare in approaches using social media in teacher education [13]. Accordingly, the low correlation of technological knowledge with the other knowledge domains may be contributed to the specific analytical lens applied in this study that emphasized the importance of content before technology. Further research is necessary to determine the explanatory power of these arguments for the whole population of pre-service teachers studying to become Geography/ General Studies teachers. A starting point for this future research may be located in the DPACK model ("D" stands for "digital") by Huwer, Irion, Kuntze, Schaal and Thyssen [63]. Here, the digital society is a core point and therefore mirrors theoretical presumptions made on the topic of constructions of space and social media. On the flipside, this model, in contrast to the TPACK model, is not established teacher education yet and in need of reflection regarding its suitability for the subject matter.

5. Conclusion

The generalizability of the results of this study are limited by the use of voluntary sampling on the one hand, and an exclusive self-assessment survey on the other hand. Furthermore, its explanatory power is limited to pre-service teachers in Geography and General Studies. However, this study may provide a valuable starting point for a closer and more nuanced inspection of the role of technological knowledge in topics of the digital world, as well as in relation to social media. Concretely, this refers to clearly defining the aspects technological knowledge should include – particularly against the backdrop of everyday-life technologies, such as social media, on one end of the spectrum, and increasingly complex technologies ingrained in society, such as algorithms, on the other end of the spectrum. This should be followed up by discussions on the continued conceptualization of technological knowledge as an independent knowledge domain for all teaching content, versus its elimination when evaluating topics of the digital world facilitated by every-life technologies. Furthermore, this article contributes to the advancement of the field of situating pre-service teacher education with social media in a theory-based pedagogical foundation. In the future, similar endeavors should be implemented in relation to in-service teacher education to further adhere to the ubiquitous nature of the digital world.

The relatively low connection of technological knowledge to the theoretically related knowledge domains displayed in this study opens up room for comparisons with adaptations of other digital topics in pre-service teacher education. In the realm of social science education, these topics could include adoptions of examples from remembrance culture in connection to social media in history education (e.g. [64]), or fake news dissemination through social media in political education (e.g. [65]).

Through this, it may be investigated whether the result of this study is an anomaly, or weather similar endeavors also suggest a general diminishing of technological knowledge for topics of the digital.

Based on the descriptive results, the comparatively low self-evaluation of content knowledge should be considered a primary point of concern in university seminars or lectures designed to foster topic-specific TPACK. This approach is supported by discussions on the importance of subject-specificity for teacher knowledge [33,34] and the acquisition of content-related knowledge in university settings [66]. Hence, fostering content knowledge on constructions of space in particular and subordinating content-unrelated technological knowledge in favor of its integration with the other knowledge constructs may be a fruitful line of action. This is supported additionally by the lower connection of technological knowledge to constructs theoretically assumed to be related to it found in this study. A "vessel" for fostering topic-specific TPACK could include practice-oriented tasks, such as the development of own technology-related tasks or lesson plans by Geography teacher students. Such endeavors are evaluated to be particularly accommodating of the integration of TPACK knowledge domains with each other [25]. They may also be particularly called for, considering digital knowledge and abilities in general have been commonly found to be separated by a "gap" (see literature review by [67]). Future research could include triangulation of the developed instrument with additional methods and applying the survey in longitudinal studies to provide insights into pre-service Geography teachers' TPACK development for the subject area. This may also contribute to an understanding of how teachers' knowledge on digital phenomena and related pedagogies can be fostered.

On a broader level, this study provides an argument for advancing research at the intersection of TPACK, social media and teacher education on topics facilitates by the digital world. Through this, learning within and with today's digital society can be facilitated to ultimately foster digitally-sovereign citizenship in the digital age.

Funding

This work was supported by the "Qualitätsoffensive Lehrerbildung", a joint initiative of the Federal Government and the Länder which aims to improve the quality of teacher training under grant number 01JA2025. The program is funded by the Federal Ministry of Education and Research. The authors are responsible for the content of this publication.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data statement

Data can be made available on request.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.caeo.2023.100140.

Appendix

(Table A1,Table A2,Table A3).

Table A.1
Descriptors of teacher knowledge for the areas of content, pedagogical and pedagogical-content knowledge (first published in German by Muschaweck and Kanwischer [39]).

Content Knowledge
The teacher can… • explain constructivist concepts of space. • explain discourse-, practice- and action-oriented approaches. • relate space/place to social media and the digital. • discuss digital information as an element of geoinformation and as a part of a digital mediatization of space/place. • describe the characteristics of constructions of space in social media. • relate constructions of space to actions on social media and "offline" and debate possible interactions.
Pedagogical Knowledge
The teacher can… • summarize the goals of integrative media education concepts regarding the development of maturity and digital sovereignty. • explain the dimensions of orientation of the structural media education approach as well as learning through creative practices in social media. • develop ideas for students' reflexive examination of their own actions and creative practices in the context of social media. • develop ideas for students' creative examination of their own actions and creative practices in the context of social media. • develop ideas for students' dialog on actions and creative practices in the context of social media. • plan classes with regard to the goals of fostering maturity and digital sovereignty with the aid of integrative media education concepts.
Pedagogical-Content Knowledge
The teacher can… • choose one or more constructivist concepts of space to draw on to explain constructions of space in social media. • choose theories on the relation of space and the digital to draw on to explain constructions of space in social media. • analyze constructions of space in social media regarding their didactical potential in the classroom. • relate integrative media education concepts to constructions of space. • develop tasks that foster students' reflexive examination of their own actions and creative practices in the context of reconfigured constructions of space. • develop tasks that foster students' create examination of their own actions and creative practices in the context of reconfigured constructions of space. • develop tasks that foster students' dialog on actions and creative practices in the context of reconfigured constructions of space. • compile tasks on constructions of space in social media to plan lessons on reconfigured constructions of space.

Table A.2
Descriptive statistics (M, SD), corrected item discrimination (r) and reliability (α) of the scales and items of the TPACK survey on Constructions of Space and Social Media (first published by [38]).

	Item	M	SD	r	α
TK1	Social networks should be used in the context of education.	2.97	0.87	.29	
TK2	I keep up with important new digital media through information sources such as newspaper/journal articles or content on social networks.	3.14	0.83	.53	
TK3	I try out new digital media.	3.04	0.78	.52	
TK4	I use digital media multiple times a day in a work-related context.	3.10	0.94	.38	
TK5	I use digital media multiple times a day in my private life or for entertainment.	3.73	0.55	.55	
TK6	I know many different digital media.	3.57	0.62	.54	
TK7	I have the necessary abilities to use digital media.	3.50	0.63	.47	
TK8	I keep up with important new social networks through information sources such as newspaper/journal articles or content on social networks.	3.03	0.85	.61	
TK9	I try out new social networks.	2.81	0.85	.59	
TK10	I use social networks multiple times a day in a work-related context.	2.60	0.99	.43	
TK11	I use social networks multiple times a day in my private life or for entertainment.	3.55	0.74	.55	
TK		**3.19**	**0.49**		**.82**
PK12	I can guide students' discussions during group work (2–5 students).	3.32	0.58	.64	
PK13	I can support students' critical thinking.	3.17	0.63	.60	
PK14	I can guide students in planning their own learning.	3.16	0.67	.59	
PK15	I can support students' reflective thinking.	3.16	0.62	.65	
PK16	I can guide students to make use of each other's thoughts and ideas during group work (2–5 students).	3.25	0.61	.64	
PK17	I can support students' problem-based learning.	3.11	0.66	.61	
PK18	I can support students' creative thinking.	3.08	0.70	.51	
PK19	I can explore students' spatial socialization with them.	2.92	0.69	.54	
PK20	I can relate my own attitudes towards social networks reflexively to teaching.	3.13	0.68	.40	
PK		**3.15**	**0.45**		**.85**
CK21	I have sufficient knowledge on the interweaving of space and social networks.	2.84	0.72	.59	
CK22	I know different characteristics of constructions of space.	2.96	0.75	.41	
CK23	I can spot relevant underlying phenomena (e.g. dominant discourses, reproduced social inequality, alternative representations) in specific posts on social networks.	2.99	0.76	.63	
CK24	I can identify the spatio-temporal context of specific posts on social networks.	2.88	0.69	.63	
CK25	I can relate posts on social networks on one topic to corresponding "real-life" phenomena.	3.08	0.73	.54	
CK26	I have sufficient knowledge on the potential for participation in social networks.	2.86	0.79	.55	
CK		**2.94**	**0.53**		**.8**
TPK27	I know how to use social networks in teaching as a basis for students' reflective thinking.	2.62	0.81	.69	
TPK28	I know how to use social networks in teaching as a basis for students to construct individual learning paths.	2.49	0.78	.71	
TPK29	I know how to use social networks in teaching as a basis for individual students' problem-based learning.	2.49	0.78	.78	
TPK30	I know how to use social networks in teaching as a basis for students' creative thinking.	2.68	0.83	.68	
TPK31	I know how to use social networks in teaching as a basis for students' problem-based learning in groups (2–5 students).	2.58	0.79	.74	

(*continued on next page*)

Table A.2 (*continued*)

	Item	M	SD	r	α
TPK32	I know how to use social networks in teaching as a basis for students' critical thinking.	2.81	0.80	.67	
TPK33	I know how to use social networks in teaching as a basis for exploring students' spatial socialization with them.	2.65	0.83	.66	
TPK		**2.62**	**0.64**		**.9**
PCK34	I know how to select effective teaching approaches that support students' thinking and learning in constructions of space.	2.64	0.77	.65	
PCK35	I know how to select content on social networks that fosters students' complex thinking in constructions of space.	2.50	0.79	.59	
PCK36	I know how to design tasks that foster students' reflective thinking in constructions of space.	2.54	0.79	.74	
PCK37	I know how to design tasks that foster students' creative thinking in constructions of space.	2.57	0.79	.71	
PCK38	I know how to design tasks that foster students' critical thinking in constructions of space.	2.66	0.78	.79	
PCK39	I know how to design problem-based learning tasks for constructions of space.	2.62	0.78	.72	
PCK		**2.59**	**0.63**		**.89**
TCK40	I have the technological skills to select social media posts representative of constructions of space.	3.07	0.80	.67	
TCK41	I know how to identify new constructions of space appearing on social media.	2.85	0.82	.77	
TCK42	I am familiar with social media that facilitate constructions of space.	2.87	0.86	.73	
TCK43	I know how social networks and their users change the spaces that they co-produce.	2.85	0.87	.70	
TCK		**2.92**	**0.71**		**.87**
TPCK44	I can use strategies that combine constructions of space, social networks and teaching approaches.	2.37	0.81	.69	
TPCK45	I can select constructions of space that combine familiar learning content and new digital applications.	2.64	0.80	.72	
TPCK46	I can select digital media that expand what I teach, how I teach and what students learn, by providing additional levels of comprehension and content.	3.00	0.78	.56	
TPCK47	I can teach lessons that appropriately combine constructions of space, social networks and teaching approaches.	2.50	0.83	.70	
TPCK		**2.63**	**0.69**		**.84**

Items adapted/ revised based on Schmidt et al. [44], Chai et al. [45], Valtonen et al. [46], Schmid et al. [47]; CK items developed by the authors.

Table A.3
Factor Loadings.

	Estimate	Std. Err	z-value	P(>|z|)	Std.lv	Std. all
LTK =~						
TK1	1.000			0.264	0.303	
TK2	2.013	0.384	5.238	0.000	0.532	0.644
TK3	1.747	0.339	5.149	0.000	0.462	0.596
TK4	1.277	0.296	4.316	0.000	0.338	0.358
TK5	1.278	0.247	5.179	0.000	0.338	0.611
TK6	1.506	0.288	5.229	0.000	0.398	0.639
TK7	1.376	0.269	5.112	0.000	0.364	0.579
TK8	2.258	0.423	5.332	0.000	0.597	0.706
TK9	2.070	0.395	5.244	0.000	0.547	0.647
TK10	1.459	0.325	4.484	0.000	0.386	0.390
TK11	1.690	0.327	5.165	0.000	0.447	0.604
LPK =~						
PK12	1.000			0.406	0.698	
PK13	1.053	0.090	11.720	0.000	0.428	0.677
PK14	1.074	0.095	11.314	0.000	0.436	0.652
PK15	1.072	0.088	12.161	0.000	0.436	0.704
PK16	1.057	0.086	12.231	0.000	0.430	0.709
PK17	1.067	0.093	11.465	0.000	0.433	0.661
PK18	0.966	0.099	9.774	0.000	0.392	0.558
PK19	0.983	0.097	10.088	0.000	0.399	0.577
PK20	0.744	0.094	7.890	0.000	0.302	0.447
LCK =~						
CK21	1.000			0.466	0.646	
CK22	0.768	0.097	7.951	0.000	0.358	0.477
CK23	1.187	0.105	11.267	0.000	0.553	0.725
CK24	1.048	0.095	11.048	0.000	0.488	0.707
CK25	0.983	0.097	10.101	0.000	0.458	0.631
CK26	1.092	0.106	10.288	0.000	0.509	0.645
LTPK =~						
TPK27	1.000			0.587	0.729	
TPK28	1.015	0.071	14.225	0.000	0.596	0.762
TPK29	1.120	0.071	15.720	0.000	0.657	0.840
TPK30	1.002	0.076	13.174	0.000	0.588	0.708
TPK31	1.074	0.072	15.003	0.000	0.630	0.802
TPK32	0.959	0.074	13.025	0.000	0.563	0.700
TPK33	0.986	0.076	13.026	0.000	0.578	0.700
LPCK =~						
PCK34	1.000			0.518	0.671	
PCK35	0.985	0.088	11.208	0.000	0.511	0.647
PCK36	1.176	0.089	13.157	0.000	0.610	0.776
PCK37	1.162	0.089	13.037	0.000	0.602	0.768
PCK38	1.290	0.090	14.326	0.000	0.669	0.861
PCK39	1.193	0.089	13.461	0.000	0.618	0.797
LTCK =~						
TCK40	1.000			0.603	0.751	
TCK41	1.149	0.071	16.087	0.000	0.693	0.848
TCK42	1.126	0.075	14.963	0.000	0.679	0.790
TCK43	1.097	0.076	14.354	0.000	0.661	0.760
LTPCK =~						
TPCK44	1.000			0.636	0.785	
TPCK45	0.979	0.063	15.455	0.000	0.623	0.778
TPCK46	0.749	0.064	11.709	0.000	0.476	0.612
TPCK47	1.063	0.065	16.367	0.000	0.677	0.818

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