Nordic Journal of Digital Literacy

UNIVERSITETSFORLAGET

RESEARCH PUBLICATION

Vol. 15, No. 1-2020, p. 38–54
ISSN Online: 1891-943X
https://doi.org/10.18261/issn.1891-943x-2020-01-04

Validating an Instrument to Measure Teachers' Preparedness to Use Digital Technology in their Teaching

Olga Viberg
Assistant professor, School of computer science and communication, The Royal Institute of Technology (KTH)
oviberg@kth.se

Anna Mavroudi
Associate professor, School of computer science and communication, The Royal Institute of Technology (KTH)

Mohammad Khalil
Researcher, SLATE: Centre for the Science of Learning and Technology, University of Bergen

Olof Bälter
Assistant professor, School of computer science and communication, The Royal Institute of Technology (KTH)

Abstract

In order to effectively integrate digital technology into education, it is necessary to examine and understand teachers' preparedness to use digital technology in education. The objective of this pilot study is to validate a self-reported instrument to measure teachers' preparedness to use Information and Communication Technologies for learning and teaching. The survey items of the instrument are grounded and developed on the basis of the Unified Theory of Acceptance and Use of Technology and Technological Pedagogical Content Knowledge. Data was collected from a sample of 157 teachers at seven K-9 schools in Sweden and analysed mainly using exploratory factor analysis. The results yielded a seven-factor structure comprising a model of teachers' digital competence focusing on their preparedness. These factors are: (1) Abilities to use digital learning technology, (2) Social influence and support, (3) Intention of use, (4) Usefulness and efficiency, (5) Limitation awareness, (6) Pedagogical potential, and (7) Assistance awareness. The results of this study aim to support schools when encouraging and supporting teachers to use technology in teaching and learning. They can also be used to measure differences before and after inventions, such as on the job teacher training.

Keywords
Teachers' preparedness, teachers' digital competence, instrument development, technology integration, UTAUT, TPACK

Introduction

Developments in digital technology offer opportunities to improve the quality of education (Krumsvik, Jones, Øfstegaard & Eikeland, 2016). There is a considerable agreement on the critical importance of integrating Digital Learning Technology (DLT) into teaching (e.g. Howard, Thompson, Yang, & Ma, 2019; Maderick, Zhang, Hartley, & Marchand, 2016). One of the drivers towards successful integration is teachers' preparedness. Consequently, teachers' preparedness to use digital technology in education effectively, together with their digital competence, becomes central and is recognised as being a key element for the construction of useful pedagogical knowledge for practice, thus improving students' learning (Ramírez-Montoya, Mena, & Rodríguez-Arroyo, 2017).

In addition to research evidence, there is currently a relevant social mandate active at a European level. For instance, the European Commission (EC; Redecker, 2017) has stressed the importance of understanding and supporting all the diverse facets of teachers' digital competence. To this end, the EC has developed the *European Framework for the Digital Competence of Educators,* which explains what it means to be a digitally competent educator and further operationalises it through 22 competences required on the part of educators. In line with this mandate, some instruments aiming to support the integration of Information and Communication Technologies (ICTs) in schools have been developed on a national level in Sweden. One of dominating ones is *LIKA, IT-thermometer for school and pre-school* (LIKA in Swedish stands for Leadership, Infrastructure, Use and Competence Development), originally developed by practitioners (municipalities and the Swedish Association of Local Authorities and Regions) and aimed at school principals, and from April 2018 offered even for secondary and high school teachers (SKL, 2019a). Yet, this instrument targets mainly school leadership and schools as organisations, rather than individual teachers. Further, the recently developed version to support teachers in their "digital everyday practices" (SKL, 2019a) does not include the assessment of teachers' preparedness to use ICT in teaching. To be able to respond to the aforementioned mandate at the school level, we need a holistic and coherent net of plans that could be effectively employed in schools and that target school teachers, as well as theoretically sound and validated research instruments that can provide evidence in line with these plans. To this end, this paper aims to validate the instrument that assesses teachers' preparedness to use ICT in their everyday teaching practices and to answer the following research question: *How can we measure teachers' preparedness to use ICT in education?* This study examines the potential structure of the instrument in particular.

Background

Teachers' digital competence and digital preparedness

An increased interest in the concept of digital competence has been noted during the last decade (Pettersson, 2018). However, the notion of digital competence should be perceived as a pluralistic concept that presents "*a network of intricately connected purposes, domains, and levels of ICT use*" (Janssen et al., 2013, p. 480). A similar understanding of digital competence is offered by Johannesen, Øgrim, and Giæver (2014), who advocate the need for a broad and holistic definition, stressing the role of ICT in learning.

In earlier definitions, some researchers explain digital competence as the set of knowledge, skills and attitudes required when using ICT (Calvani, Cartelli, Fini, & Ranieri, 2008). In more recent ones, researchers explain it as "*the teacher/TE's [teacher educator's] proficiency in using ICT in a professional context with good pedagogic-didactic judgment and his or her awareness of its implications for learning strategies and the digital Bildung of pupils and students*" (Krumsvik, 2011, pp. 44–45). In this study, we adopt the following definition of digital competence: "*skills, knowledge and attitudes required to use digital media for learning and comprehension in a knowledge society*" (Røkenes & Krumsvik, 2016, p.2). This is in accordance with Instefjord's definition (2015), which similarly explains digital competence as "*knowledge, skills and attitudes required in order to use technology critically and reflectively in the process of building new knowledge*" (p. 155). In this study, teachers' preparedness is viewed as a constituent component of digital competence touching upon attitudes or dispositions. Instefjord and Munthe (2017) suggest that teachers' attitudes towards the use of ICT in education are influenced by their beliefs about the topic at stake, including their perceived preparedness. In general, it can be argued that competence and preparedness are closely interwoven in the sense that "*competence is a performance-related term describing a preparedness to take action*" (Søby, 2013, p. 134).

Examining teachers' preparedness

In regard to examining *teacher preparedness* to use ICT in education, research efforts have so far largely targeted pre-service teachers (i.e., student teachers) rather than in-service teachers, with a few exceptions (e.g. Saltan & Arslan, 2017; Kim & Kim, 2017).

Pre-service teachers' preparedness to use ICT in education has been analysed across countries. Røkenes and Krumsvik (2016) examined digital competence of English language student teachers in Norway, focusing on whether they are prepared to teach with ICT. They created a theoretical model that served as an analytical lens in investigating digital competence among the study's participants. The model consists of two axes, one representing practical proficiency aspects and the other, aspects of the participants' self-awareness. To validate the variables in their model, a confirmatory factor analysis was performed. The ensuing questionnaire of pre-service teachers' self-perceived digital competence caters for: 1) how well student teachers master the use of digital tools for various purposes, 2) the digital learning strategies used, 3) the development of digital Bildung focusing on ethical challenges, and 4) overall digital competence for teaching purposes. Others investigated in-service teachers' technology preparedness in Korean schools focusing on the use of tablets (Kim & Kim, 2017). Teacher preparedness in this study reflected teachers' self-confidence in using technology in the classroom, operationalised as perceived ability and skills to use electronic boards, tablets, interactive solutions, and to troubleshoot while using these technologies in the classroom. The results indicated a statistically significant correlation between teachers' preparedness and tablet integration in the classroom. Saltan and Arslan (2017) compared Turkish in-service and pre-service teachers' self-confidence in technology, pedagogy and content knowledge for technology integration in education (see Koehler & Mishra, 2009). The results showed differences between the two main groups of teachers in relation to some of the constituent components (i.e., pedagogy, technology or content knowledge) of the used model and combinations of them.

Context

Digitalisation is increasingly transforming not only business, but also the Swedish education system. One of the recent developments in this regard are: i) the Swedish government decision on digitalisation of schools, with a supplement that presents a national strategy for this (Regeringen, 2017) and ii) National action plan for digitalisation of the Swedish school system (SKL, 2019b) that offers 18 initiatives with the aim to realise the national strategy. In this, the development of adequate digital competence among educators is one of the strategic focuses. Hanell (2018) has explored how policymakers argue for the importance of digital competence in Swedish teacher education. He examines the logic between different implied "problem" representations by examining policy documents and identifying passages concerning the use of digital tools and teachers' digital competence. Findings include that digitalisation in education is strongly linked to the use of digital tools and the digital competence concept; also, that it is considered that low digital competence among teachers in Sweden causes shortcomings in schools, negatively affecting the use of digital tools and the development of digital competence on behalf of the students. Hanell (2018) also references Røkenes and Krumsvik (2017), largely agreeing on the importance of Bildung, while stressing this concept does not appear anywhere in relevant Norwegian or Swedish policy documents. Finally, he argues for the need to leave more space for diverse views that conceptualise digital competence in education, also in relation to the key stakeholders' (teachers and students) needs and profiles, in addition to the needs of a competitive workforce, economic growth, and innovation.

Theoretical frameworks

To measure teachers' preparedness to use digital technology in education, this study employs the theoretical lenses of two frameworks, Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh, Morris, Davis, & Davis, 2003) and the Technology, Pedagogy, and Content Knowledge framework (TPACK; Koehler & Mishra, 2009).

The Unified Theory of Acceptance and Use of Technology

UTAUT was originally formulated by Venkatesh et al. (2003) in their effort to construct a unified model regarding both user acceptance and behaviour with respect to newly introduced information technology. According to UTAUT, four key constructs determinate use behaviour: 1) performance expectancy (i.e. the belief that technology can help the user attain his/her work performance goals), 2) effort expectancy (i.e. perceived ease of using technology), 3) social influence (i.e. influence that stems from the fact that the user believes that important persons believe that he/she should be using the technology), and 4) facilitating conditions (i.e. the belief that the underlying organisational support and technical infrastructure can assist the usage of technology). The model presents three direct determinants of intention to use (i.e. performance expectancy, effort expectancy, and social influence) and two direct determinants of usage behaviour (i.e. intention and facilitating conditions). In addition, four other constructs, i.e. users' gender, age, experience, and the voluntariness of use, were reported to play a moderating role in acceptance and use of information technology. The UTAUT model, originally developed for organisational research, has been earlier applied in educational research, for example to examine factors influencing Singaporean teachers' intention to use technology (Teo, 2013) or to explain the intention to use technology among pre-service teachers (Teo & Noyes, 2014). The results of the later study stress that strength and influences of the core determinants of the UTAUT may work differently when applied to another culture.

The Technological, Pedagogical, and Content Knowledge framework

TPACK is a framework on teacher knowledge for technology integration (Koehler & Mishra, 2009). The model consists of three key components of teachers' knowledge needed to integrate technology in their classrooms: content, pedagogy, and technology (Koehler & Mishra, 2009). Content knowledge refers to teachers' knowledge about the subject matter to be taught and learned. Pedagogical knowledge is teachers' knowledge about the processes, practices and methods of teaching and learning, including educational purposes, values and aims. Pedagogical content knowledge is knowledge of pedagogy that is applicable to the teaching of a particular content. Technological knowledge is more difficult to define as it is in a constant state of flux (Koehler & Mishra, 2009), suggesting that it touches upon deep knowledge about information processing, communication, and problem solving, and thus can be viewed as more complex than computer literacy. Technological content knowledge involves the manners in which technology and content influence and construct one another. Technological pedagogical knowledge refers to how teaching and learning interplay when particular technologies are used in particular ways. Overall, TPACK suggests that content, technology and pedagogy as well as teaching and learning contexts have roles to play in teachers' knowledge and ability for technology integration. The TPACK model has been widely used in the literature in order to better understand technology integration by teachers, and several systematic reviews exist on its usage (e.g., Rosenberg & Koehler, 2015; Young, 2016)

Research Model and Instrument Design

As the UTAUT model describes as much as 70% of the variance in intention, Venkatesh et al. (2003) recommend that future research should focus on identifying constructs that can add to the prediction of intention and behaviour "*over and above of what is already known and understood*" (p.471). Considering the focus and the context of this research, our study aims to fill this gap by also considering and empirically testing the constructs of TPACK (Koehler & Mishra, 2009) to compensate for the specificities of technology integration by teachers. Consequently, the design of the instrument (Figure 1) is inspired by both UTAUT and TPACK.

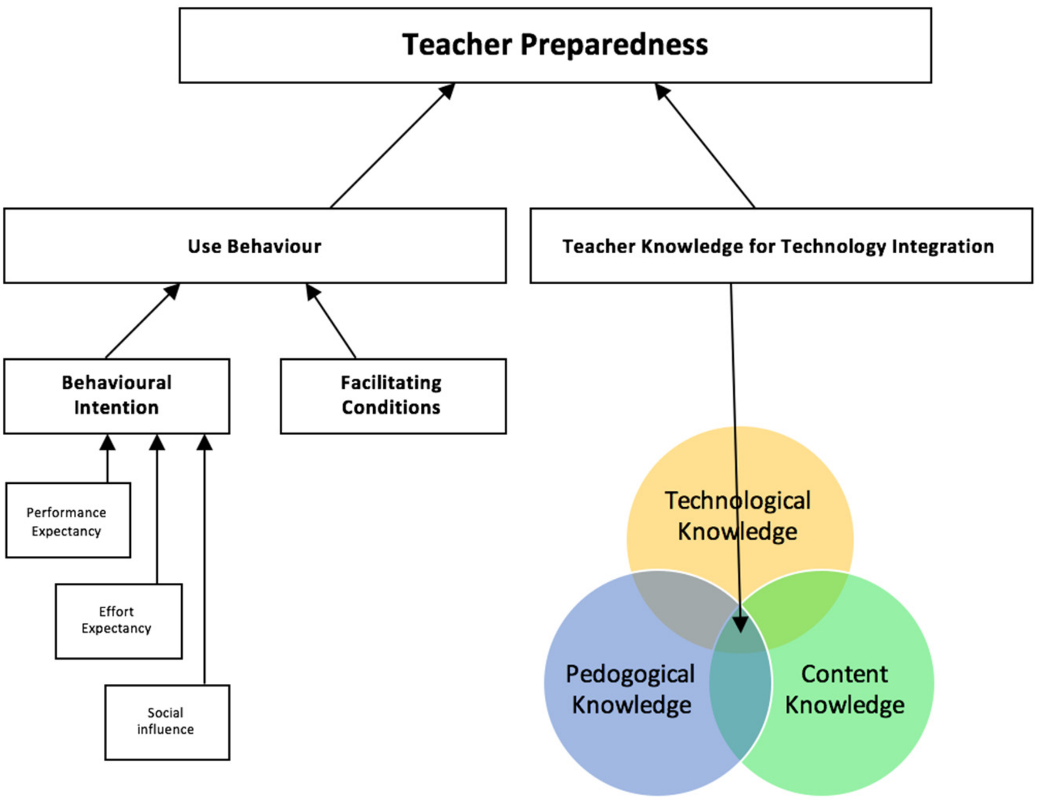

Figure 1 Research model

The instrument items that are in line with the UTAUT model have been adapted from a standardised instrument originally proposed by Venkatesh et al. (2003), where some items have been slightly paraphrased in order to fit the specific context at stake. Relevant example: *"The organisation (school) has supported the use of digital technology"*. The survey items that are in line with the TPACK model are not taken from any specific standardised instrument. Even though several instruments have been developed with the aim to assess one or another aspect of TPACK (e.g., Yeh, Hsu, Wu, Hwang, & Lin, 2014) or to update it (Valtonen et al., 2017), the authors of this study could not identify an instrument that includes items specifically for the readiness aspect. The seminal paper that inspired the TPACK-related part of the instrument is a work by Koehler and Mishra (2009). Finally, a small sub-section of the questionnaire refers to teachers' attitudes related to technology integration, but not directly related to the interplay between technology, pedagogy and content. These items refer to the teachers' vision of the role of technology in the classroom, the perceived influence that the teacher has, and the teacher's confidence on the matter, respectively.

Validation of the instrument

Procedures

Data collection

The questionnaire used a five-point Likert scale (*1*=completely disagree and *5*=completely agree) for all items. Participants' demographics (age and gender) were also included in the survey. The online survey was distributed via email to 283 teachers at seven K-9 schools in different locations in Sweden. The participation in the study was conducted on a voluntary basis. The participating schools constitute a convenience sample since all of them were offered some relevant in-service training on the use of digital technology in their teaching practices by one company, which assisted this study's authors in approaching these schools and their teachers. From a research ethics viewpoint, all procedures were in accordance with the ethical standards recommended by the Swedish Ethical Review Authority.

Sampling Error and Method Limitation

We tried to build a solid sampling plan by having a heterogeneous sub-population in this research study. To avoid bias and a lack of representativeness in our sampling, the surveys were sent randomly to teachers (who were offered in-service training) across Sweden, and not to specific city schools. We also tried as far as possible to avoid the overrepresentation of one gender when we selected the sample. For generalising this study onto a larger population, the findings only point to further required research if we wish, for example, to consider the broader Scandinavian context. The data only covers teachers in K-9 schools in Sweden following the country's educational school system.

Data analysis

The main statistical method used was Factor Analysis (FA) following a five-phase procedure: 1) screen the data (i.e. testing data suitability for FA), 2) define factor extraction (i.e. consider how many factors to retain), 3) define factor rotation (i.e. consider what rotation to use), 4) interpret and label factors, and 5) use the factor structure to perform reliability analysis (Beavers et al., 2013). The data were analysed using the SPSS software. Missing responses/data was taken into account when weighting the data.

Regarding *data screening*, to ensure that the sample size is large enough to reliably extract factors, we used the Kaiser-Meyer-Okin (KMO) measure of sampling adequacy; it represents the ratio of the squared correlation between variables to the squared partial correlation between variables (Field, 2013). To check for correlations, the Pearson test was used. Bartlett's Test of Sphericity, which tests a very extreme case of non-correlation (i.e. when all items of the questionnaire do not correlate with any other item) was also used (Hoj, 2012). When *extracting factors* , we used Kaiser's criterion of retaining factors with eigenvalues greater than 1, as it is logical to retain only factors with large eigenvalues (Field, 2013). In addition, we graphed the eigenvalues using a scree plot and compared the results with those of the first criterion. Regarding *factor rotation*, we used oblique rotation as we aimed at rotating factors while keeping them correlated (Field, 2013). Interpretation of results involved examining which items were attributable to a factor and giving that factor a name or theme. The idea was to thoroughly and systematically isolate items with high loadings, i.e., above .4, in the resulting pattern matrix and in the structure matrix (Williams et al., 2010). Finally, we used Cronbach's alpha to measure the questionnaire's reliability. The value of Cronbach's α indicates the overall reliability of the scale (Hinton, Brownlow, McCurray, & Cozens, 2004).

Results

Participants

The response rate varied between the schools from 41% to 84%, with an average of 60%. In total, 157 (out of the 283) teachers answered the questionnaire (see Table 1). The median age was 43 years. 64% women and 14% men participated in the study, whereas 22% did not want to specify their gender. With regards to the teaching experience of the participants, the range was between the recently qualified and up to more than 21 years. The largest cluster is between none to five years, followed by six to ten years. The smallest group is those with teaching experience between 11–15 years.

Table 1 Demographics of participants

Groups (Years of Teaching Experience)	Age			Gender (%)	
	N	Mean	SD	M	F
Group 1: 0 – 5 years	63	33.49	6.25	13.20	86.80
Group 2: 6 – 10 years	27	42.04	8.02	16.70	83.30
Group 3: 11 – 15 years	15	42.27	9.21	7.70	92.30
Group 4: 16 – 20 years	26	48.76	6.73	29.20	70.80
Group 5: 21 – more	26	54.35	4.31	16.70	83.30
Total	157	–	–	–	–

Factor analysis

Although the sample size in this study is 157, which is less than the recommended 300 cases (Tabachnick & Fidell, 2013), the KMO measure of sampling adequacy was .784, which is above the minimum criterion of .5 and falls into the range of "good" (Field, 2013), indicating it was acceptable to proceed with the FA.

Phase 1: Data screening

The correlation analysis showed that all questions correlate reasonably well with one another and none of the correlation coefficients are excessively large, although some items correlate slowly with several other items. This result does not mean that these items should be eliminated. It rather means that the items with which they do not correlate enough could constitute another factor. The results of Bartlett's test indicate that the items correlate with one another ($X2(157) = 2639$, $p < 0.001$). Hence, these items were not excluded before the FA was conducted.

Phase 2: Factor extraction

Table 2 lists the eigenvalues associated with each factor before extraction, after extraction and after rotation. Before extraction, we had 38 items in the data set. The table shows only the 11 factors with eigenvalues greater than 1. These factors together explain 72.7% of the total variance of the model as we aimed to retain factors that explain a considerable amount of the variance in the data set (Hoj, 2012). The first factor explains 25.4% of the total variance and the remaining ones explain only small amounts of variance. Before rotation, factor 1 accounted for considerably more variance than the remaining 10 factors (24.4% compared to 7.2%, 6.8% etc.). After rotation, the total sums of squared loadings ranged from 0.89 to 5.36.

Table 2 Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	9.64	25.36	25.36	9.28	24.43	24.43	5.39
2	3.04	8.01	33.38	2.72	7.16	31.59	3.56
3	2.84	7.46	40.84	2.59	6.82	38.41	4.28
4	2.47	6.50	47.33	2.15	5.66	44.06	4.01
5	1.98	5.20	52.53	1.61	4.23	48.30	2.97
6	1.67	4.39	56.92	1.29	3.40	51.69	2.85
7	1.32	3.48	60.39	0.92	2.43	54.12	3.06
8	1.30	3.43	63.82	0.90	2.38	56.50	3.97
9	1.21	3.18	67.00	0.86	2.26	58.75	4.33
10	1.12	2.95	69.95	0.67	1.77	60.52	1.04
11	1.03	2.70	72.65	0.58	1.53	62.05	0.89

The scree plot (Figure 2) shows the initial eigenvalues. Analysis of this plot – looking at the points where the slope of the curve is clearly levelling off – suggests either six or nine factors due to the way the slope levels off twice (both six and nine factors correspond to inflexion points).

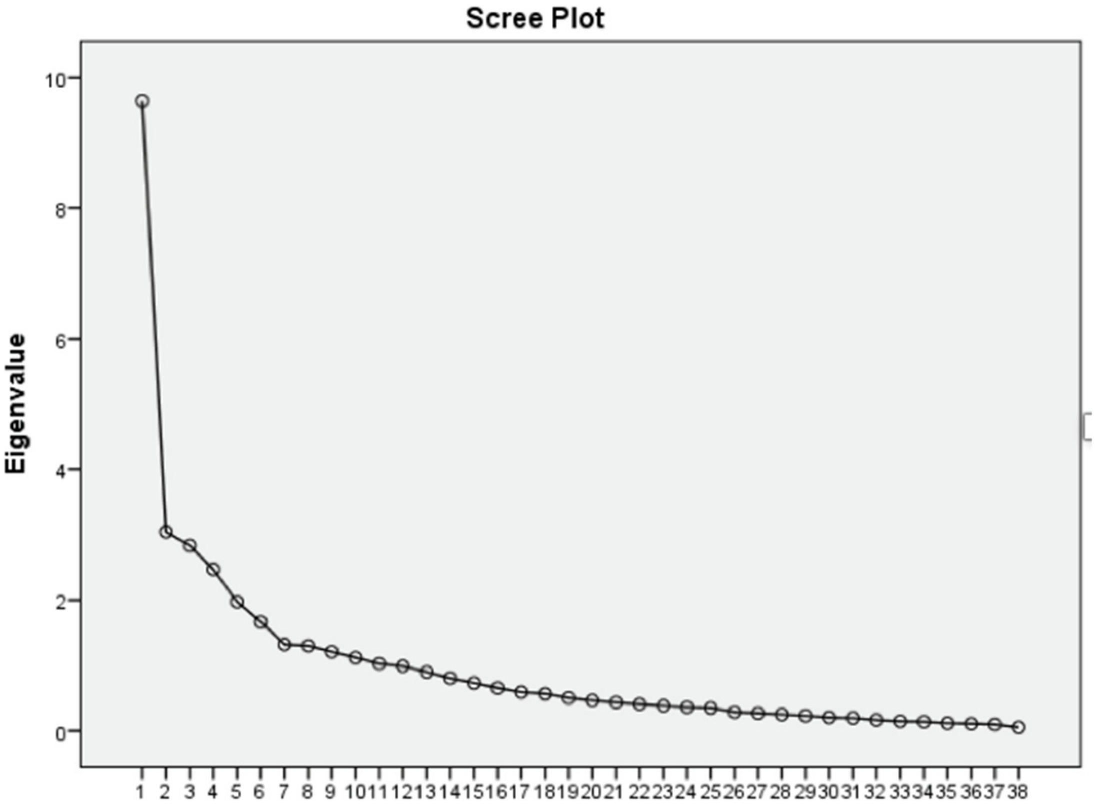

Figure 2 Scree plot of factors underlying the data set

Phase 3: Factor rotation

The pattern matrix (Table 6, Appendix) displays the coefficients for the linear combination of the items and the factors, while the structure matrix represents the correlations between the items and the factors(Table 7, Appendix). An Oblimin rotation was performed since the factors were expected to be correlated. Only items with a factor loading above .4 are presented in those tables. These results suggest that three items from the original instrument (containing 38 items) were eliminated. After extracting factors to six, seven, eight or nine (as suggested from the scree plot), results for factors 8 and 9 yielded factors with less than three items. The correlation between factors ranged between –.01 and .27. The structure matrix indicates that three factors (2, 4 and 11) have fairly large correlations, but all other factors have fairly small relationships with the other factors. These correlations indicate that the constructs measured can be interrelated and were therefore eliminated. Overall, seven factors were included in the model.

Phase 4: Interpretation and labelling of factors

While the pattern matrix contains information about the unique contribution of a variable to a factor, the structure matrix takes into account the relationship between factors and shows that several items load highly on more than one factor (Appendix).

The structure matrix (Table 7) shows factor one to consist of eight items that regard the respondents' perceived abilities to use, learn and teach with digital learning technology (DLT). Example statementsare "*I find digital technology easy to use for my purposes*" and *"I have sufficient knowledge to be able to use digital technology"*. This factor was termed "Abilities to use DLT" and showed a high internal consistency. The second factor consists of three items that concern support and help from the school that teachers are working in, and peer influence. Example statements are: "*The conduit (e.g., school authorities) has, generally, supported the use of digital technology*" and *"Colleagues affecting my work think I should use digital technology"*. Therefore, this factor was called as "Social Influence and Support". The internal consistency of this factor is fairly high. The third factor comprised four items, all of which were related to intention and availability to use DLT and productivity. It was labelled "Intention of use" and is considered highly reliable.Similar conceptualisations (i.e. interpretations and labelling of factors) were made for the remaining four factors. Factors four to seven related respectively to teachers' attitudes towards digital technology's usefulness for and efficiency in their teaching, teachers' limitation awareness of the use of digital technology in education, the potential of digital technology's use in education, and teachers' awareness of how to find useful digital tools and assistance when using them in their teaching practice.Table 3 reports the summary of the seven factors along with explanations.

Table 3 Explanation of identified factors Digital Learning Technology

Factor	Name	Explanation
1	Abilities to use	Perceived abilities to use, adapt and learn DLT
2	Social influence and support	Social influence, support and help from the organisation
3	Intention of use	Intention and availability to use DLT
4	Usefulness and efficiency	DLT's usefulness for teaching and learning
5	Limitation awareness	Awareness of limitations of DLT
6	Pedagogical potential	Awareness of the pedagogical potential of DLT
7	Assistance awareness	Awareness of how to find, get assistance for and influence DLT

The final instrument that measures teachers' preparedness to use digital technology in education is presented in Table 4.

Table 4 Teachers' preparedness to use ICT in education

Abilities to use DLT
My use of digital technology does not require much effort.
It is easy for me to learn how to use digital technology.
It would be easy for me to become adept at using digital technology.
I find digital technology easy to use for my purposes.
I have sufficient knowledge to be able to use digital technology.
I can use these digital tools in my teaching.
I have sufficient skills to teach my pupils to use digital technology as a tool for knowledge search, communication, creativity and learning.
I feel comfortable using digital technology in education.

Social influence & support
Colleagues affecting my work think I should use digital technology.
The conduit (e.g., school authorities) has, generally, supported the use of digital technology. The organisation (school) has supported the use of digital technology.
Intention of use
I intend to use digital technology in the coming year. I expect that I will use digital technology in the coming year. I plan to use digital technology in the coming year. I believe that the available supply of digital technology supports my teaching.
Usefulness & efficiency
I have found digital technology that is useful in my work.
Digital technology means that I can do my work faster.
Digital technology increases my productivity.
I believe that digital technology may enable a new and more diversified production of knowledge content.
I believe that digital technology can increase flexibility to choose between these representations.
The digital tools in teaching help students achieve their learning goals.
The digital tools facilitate your way to assess the pupils' learning.
The digital tools facilitate the pupils' learning.
I think the digital tools that I have found, or been introduced to, support my pedagogical ideas.
Pedagogical potential
I understand the potential of digital technology and how this can be used differently. depending on the purpose and course content.
I'm actively looking for digital technology that I can use to facilitate student learning.
I am aware of the possibilities and limitations of digital technology in my teaching and how it may affect the pedagogical design in my topic.
Assistance awareness
I have access to the necessary resources to be able to use digital technology.
I know where I can get help if I encounter a problem with digital technology.
If I run into problems with digital technology, I get help within a reasonable time.
I can find useful digital tools that can be easily integrated into my teaching.
I can influence which digital tools I use in my teaching.
Limitation awareness
I believe that there are limitations to what the available digital technology can be used to teach in certain areas of my subjects.
I believe that some choices of knowledge content can limit the type of digital technology I can use.
I believe that digital technology can limit representations of knowledge content.

Phase 5: Reliability analysis

Reliability tests show that the values of Cronbach's α range from 0.64 to 0.87 (Table 5). Most values of Cronbach's α are in the region indicating high reliability, expressed as internal consistency (Hinton et al., 2004). In particular, factors 1, 3–5 and 7 sub-scales have high levels of internal consistency; all Cronbach's αare above .73. For factors 2 and 6, the sub-scales are of moderate reliability, i.e., moderate level of internal consistency(Hinton et al., 2004), with values of Cronbach's α =.69 and Cronbach's α =.64, respectively.

Table 5 Reliability statistics for all factors

Factor	N of Items	Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items
1	8	0.87	0.88
2	3	0.69	0.71
3	4	0.84	0.89
4	9	0.86	0.86
5	3	0.73	0.73
6	3	0.64	0.64
7	5	0.76	0.75

Discussion and conclusions

The purpose of this study was to validate the potential structure of the instrument that can be used to gauge (self-perceived) digital preparedness of teachers, as an attitudinal aspect of their digital competence to integrate technology in their classrooms. We retained seven factors that represent (1) Abilities to use digital learning technology, (2) Social influence and support, (3) Intention of use, (4) Usefulness and efficiency, (5) Limitation awareness, (6) Pedagogical potential, and (7) Assistance awareness.

The validity of the study could improve with more schools and teachers in the study (see Section 5.1.2). However, it is difficult to get access to schools, and getting teachers to volunteer their time was challenging due to local and time restrictions, but still the convenience sample we used was appropriate for this situation. The schools in the sample represent both large and small cities in varying socio-economic communities. Further validation would be recommended on a larger sample in K-12 schools (both in Sweden and other countries), in which school systems, and especially the pace and the forms of the digitalisation of education, differ.

The items that form the factors represent both frameworks that constitute the proposed research model (Figure 1). In particular, the results of this study show that *all* the four key constructs of the UTAUT determining user behaviour, (i.e., performance expectancy, effort expectancy, social influence, and facilitating conditions) are important for assessing teachers' preparedness to use ICT in education, as an essential part of their digital competence. For example, three items uncovering performance expectancy form a part of the new factor termed "Usefulness and Efficiency", or four items that originate from the effort expectancy construct constitute the "Abilities to use DLT" factor. Similarly, the TPACK-related items are represented in most of the new factors, often in a combination with the UTAUT items. In particular, such new factors as "Abilities to use DLT", "Usefulness and efficiency" and "Intention to use" comprise items that originally derive from both UTAUT and

TPACK. Consequently, when assessing teachers' preparedness, the teacher knowledge for technology integration, their acceptance of and behaviour with respect to the use of ICT in their teaching practices are important. For example, the teachers' knowledge concerning technology integration into their teaching practices is critical for their abilities to successfully transform targeted learning practices (i.e., to improve learning and/or learner support), rather than just to simply substitute them with some chosen technology. This is important since integration entails several dynamic factors, such as effective practices, technological aspects of new tools, potential to transform learning, as well as enabling new forms of teaching and learning practices (Howard et al. 2019). Moreover, teachers' behaviour with respect to the integration of ICTs in teaching is similarly decisive. For example, if a teacher plans to effectively adapt some new technology (e.g., a software for studying mathematics or language learning) in her teaching, she needs not only to show how to use it to students once, but also to use it proactively and continuously in classrooms by herself. This would facilitate the students' understanding concerning the tool's functionality and the associated affordances provided by its use; consequently, this would improve students' conditions for learning. Finally, teachers' acceptance of the use of ICTs is of paramount importance; it should be considered as the first step for any potential successful integration of technology in education. For that, teachers need to be offered better support in terms of their understanding of all the functionality provided by the offered technologies, and continuous support that would help them to re-consider their established teaching practices and transform them into more effective ones.

This work extends earlier research that directly links self-perceived teachers' preparedness with their self-confidence (Kim & Kim, 2017) and suggests a more holistic model that touches upon the aforementioned seven factors and that focuses not only on the key constructs determining teacher/user behaviour, but also on the constructs that reflect upon teacher knowledge for technology integration into teaching and learning. These results could be applied by researchers and policymakers alike interested in contributing to the diffusion of technology-enhanced learning innovations in two different ways. First, in a proactive way, by administering the questionnaire to the teachers at the outset of such innovations in order to better understand their profile in relation to their readiness to integrate the technology in their teaching practices. Second, to study technology-enhanced learning innovations by monitoring how these seven factors are manifested in the teachers' contexts.

The proposed instrument evaluates the *preparedness* for the use of digital technology in teaching, which is one of the important factors. However, attitudes are not everything, and an evaluation of a school's level of digitalisation also requires an objective measure concerning the *knowledge level* of the school teachers, e.g. how they are interacting with the ICT tools, or how much they know about the ICT tool affordances. Limitations of this work pertain both to the fact that all participant teachers are living in Sweden, as well as to the number of participants. Thus, future research efforts should be directed at testing and further validating the proposed research instrument on larger samples of teachers in various cultural contexts, as the strength and influences of the core determinants of the proposed research model may work differently when applied to another culture, as suggested by the earlier research results (Teo & Noyes, 2014). Future research could also study teachers' preparedness by combining objective measures with attitude-oriented measures.

All in all, the development of teachers' digital competence is a complex and challenging task. To facilitate such development, the proposed in this study instrument is aimed to be used both as a starting point and to evaluate the effect of interventions.

References

Beavers, A. S., Lounsbury, J. W., Richards, J. K., Huck, S. W., Skolits, G. J., & Esquivel, S. L. (2013). Practical considerations for using exploratory factor analysis in educational research. *Practical assessment, research & evaluation, 18* (6). https://doi.org/10.7275/qv2q-rk76

Calvani, A., Cartelli, A., Fini, A., & Ranieri, M. (2008). Models and instruments for assessing digital competence at school. *Journal of E-learning and Knowledge Society, 4*(3), 183–193.

Field, A. (2013). *Discovering Statistics Using SPSS*. (4th ed.). SAGE Publications.

Hanell, F. (2018). What is the 'problem' that digital competence in Swedish teacher education is meant to solve? *Nordic Journal of Digital Literacy, 13*(03), 137–151. https://doi.org/10.18261/issn.1891-943x-2018-03-02

Hinton, P., Brownlow, C., McMurray, I., & Cozens, B. (2004). *SPSS Explained.* London: Routledge.

Hof, M. (2012). Questionnaire evaluation with factor analysis and Cronbach's Alpha: an example. Retrieved from http://www.let.rug.nl/nerbonne/teach/rema-stats-meth-seminar/student-papers/MHof-QuestionnaireEvaluation-2012-Cronbach-FactAnalysis.pdf Retrieved 2019-05-27

Howard, S., Thompson, K., Yang, J., & Ma, J. (2019). Working the system: Development of a system model of technology integration to inform learning task design. *British Journal of Educational Technology, 50* (1), 326–341. https://doi.org/10.1111/bjet.12560

Instefjord, E. (2015). Appropriation of digital competence in teacher education. *Nordic Journal of Digital Literacy, 10*, 155–171.

Instefjord, E., & Munthe, E. (2017). Educating digitally competent teachers: A study of integration of professional digital competence in teacher education. *Teaching and Teacher Education, 67*, 37–45. https://doi.org/10.1016/j.tate.2017.05.016

Janssen, J., Stoyanov, S., Ferrari, A., Punie, Y., Pannekeet, K., & Sloep, P. (2013). Experts' views on digital competence: Commonalities and differences. *Computers & Education, 68*, 473–481. https://doi.org/10.1016/j.compedu.2013.06.008

Johannesen, M., Øgrim, L., & Giæver, T. H. (2014). Notion in motion: Teachers' digital competence. *Nordic Journal of Digital Literacy, 9*(4), 300–312.

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge? What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60–70.

Krumsvik, R. J. (2011). Digital competence in Norwegian teacher education and schools. *Högre utbildning, 1*(1), 39–51.

Krumsvik, R., Jones, L., Øfstegaard, M., & Eikeland, O. (2016). Upper secondary school teachers' digital competence: Analysed by demographic, personal and professional characteristics. *Nordic Journal of Digital Literacy, 11*(03), 143–164. https://doi.org/10.18261/issn.1891-943x-2016-03-02

Maderick, J. A., Zhang, S., Hartley, K., & Marchand, G. (2016). Preservice teachers and self-assessing digital competence. *Journal of Educational Computing Research, 54*(3), 326–351. https://doi.org/10.1177/0735633115620432

Pettersson, F. (2018). On the issues of digital competence in educational contexts–a review of literature. *Education and Information Technologies, 23*(3), 1005–1021. https://doi.org/10.1007/s10639-017-9649-3

Ramírez-Montoya, M.-S., Mena, J., & Rodríguez-Arroyo, A. (2017). In-service teachers' self-perceptions of digital competence and OER use as determined by a xMOOC training course. *Computers in Human Behavior, 77*, 356–364. https://doi.org/10.1016/j.chb.2017.09.010

Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu (No. JRC107466). Joint Research Centre (Seville site). Retrieved from https://ec.europa.eu/jrc/en/printpdf/137812

Rosenberg, J. M., & Koehler, M. J. (2015). Context and technological pedagogical content knowledge (TPACK): A systematic review. Journal of Research on Technology in Education, 47(3), 186–210. https://doi.org/10.1080/15391523.2015.1052663

Regeringen (2017). Nationell digitaliseringsstrategi för skolväsendet. Bilaga till regeringsbeslut I:1, 2017-10-19. Retrieved from https://www.regeringen.se/4a9d9a/contentassets/00b3d9118b0144f6bb95302f3e08d11c/nationell-digitaliseringsstrategi-for-skolvasendet.pdf

Røkenes, F., & Krumsvik, R. (2016). Prepared to teach ESL with ECT? A study of digital competence in Norwegian teacher education. *Computers & Education, 97*,1–20.

Saltan, F., & Arslan, K. (2017). A comparison of in-service and pre-service teachers' technological, pedagogical content knowledge self-confidence. *Cogent Education, 4*(1), 1–12. https://doi.org/10.1080/2331186X.2017.1311501

SKL (2019a). LIKA lärare. Retrieved from https://likalarare.skl.se 2019-05-27.

SKL (2019b). Skoldigplan. Handlingsplan för digitalisering av skolväsendet. Retrieved from http://skoldigiplan.se 2019-05-27

Søby, M. (2013). Learning to be: Developing and understanding digital competence. *Nordic Journal of Digital Literacy, 8*(3), 134–138.

Tabachnick, B., & Fidell, L. (2013). *Using Multivariate Statistics*. Pearson New International Edition. Pearson Education Limited: E-book.

Teo, T., & Noyes, J. (2014). Explaining the intention to use technology among pre-service teachers: a multi-group analysis of the Unified Theory of Acceptance and Use of Technology. *Interactive Learning Environments, 22*(1), 51–66. https://doi.org/10.1080/10494820.2011.641674

Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. *Australasian Journal of Educational Technology*, 33(3), 15–31. https://doi.org/10.14742/ajet.3518

Venkatesh, V., Morris, M., Davis, G., & David, F. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425–478. https://doi.org/10.2307/30036540

Williams, B., Onsman, A., & Brown, T. (2010). Exploratory factor analysis: A five-step guide for novices. *Australasian Journal of Paramedicine, 8*(3), 1–13.

Yeh, Y.-F., Hsu, Y.-S., Wu, H.-K., Hwang, F.-K., & Lin, T.-C. (2014). Developing and validating technological pedagogical content knowledge-practical (TPACK-practical) through the Delphi survey technique. *British Journal of Educational Technology, 45* (4), 707–722. https://doi.org/10.1111/bjet.12078

Young, J. (2016). Unpacking TPACK in Mathematics Education Research: A Systematic Review of Meta-Analyses. *International Journal of Educational Methodology, 2*(1), 19–29. https://doi.org/10.12973/ijem.2.1.19

Appendix

The factor rotation process generated two matrices: the pattern matrix (Table 6) and the structure matrix (Table 7)[1] . The latter presents factor loadings and communalities based on Principal Axis Factoring with Oblimin rotation (N=157).

Table 6 Pattern Matrix

Items	Factor						
	1	2	3	4	5	6	7
Item 6	0.89						
Item 7	0.77						
Item 8	0.62						
Item 37	0.60						
Item 5	0.58						
Item 38	0.58						
Item 14	0.57						
Item 11		−0.89					
Item 12		−0.77					
Item 19			−0.93				
Item 18			−0.91				
Item 17			−0.78				
Item 20			−0.45				
Item 1			−0.40				
Item 24				0.67			
Item 25				0.63			
Item 31				0.57			
Item 32				0.57			
Item 36				0.49			
Item 3				0.48			
Item 2				0.43			
Item 22					0.79		
Item 21					0.63		
Item 23					0.54		
Item 28						0.57	
Item27						0.54	
Item 26						0.44	
Item 16							0.74
Item 15							0.72
Item 13							0.69

Note: Factor loadings < .4 are suppressed

1. The numbering of items presented in Tables 5 and 6 refers to the original survey instrument, which is available online at https://docs.google.com/document/d/1QaXrf_a7ILFR-d698Zz_70Bmw3YxU03obIRdwD5N434/edit?usp=sharing

Table 7 Structure matrix

Items	1	2	3	4	5	6	7	Communality
6	.89							.81
7	.78							.80
38	.69			.513				.74
8	.68							.66
37	.67			.402				.64
14	.66							.66
5	.61							.58
34	.45						.443	.58
11		−.88						.72
12		−.7					.442	.73
9		−.42						.66
19			−.93					.91
18			−.90					.88
17			−.79					.73
20		−.44	−.59	.53			.456	.75
24				.71		.416		.75
25				.68		.416		.71
36				.64		.426		.52
32				.63				.57
31				.60				.63
3			−.43	.56				.74
30				.54				.57
2			−.49	.53				.69
1			−.52	.52				.52
22					.81			.65
21					.63			.59
23				−.40	.60			.65
28						.59		.61
27						.57		.59
26						.52		.52
16							.77	.70
13		−.44					.76	.66
15							.75	.69
33						.42	.48	.64
35				.40			.40	.64