6-18-2022

ACCEPTANCE OF DIGITAL LEARNING IN HIGHER EDUCATION - WHAT ROLE DO TEACHERS' COMPETENCIES PLAY?

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Research Paper

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Abstract

To transfer knowledge and build competencies effectively and thus make learning processes successful, diverse requirements exist for the teacher. Sufficient knowledge of the content and proficient pedagogical knowledge have long traditions and have been most influential. The currently growing diffusion of digital teaching and learning requires considering the technology itself, equally relevant as pedagogical and content knowledge for teaching in digital learning settings. Teachers are, however, differently skilled in levering the potentials of these technologies for supporting teaching and learning processes. Furthermore, there has not yet been sufficient research on the influence of teachers' competencies on students' acceptance of digital learning. Therefore, this paper presents an empirical study investigating the effects of different teachers' knowledge facets on the perceived usefulness of digital technologies. Results show that students' acceptance of teaching in digital space is influenced by their perception of the teachers' pedagogical, technological, and content knowledge.

Keywords: Digital learning, Higher education, TAM, TPACK, competencies

1 Introduction

"When one teaches, two learn." Robert Heinlein

This inspiring quote from Robert Heinlein has taken on a different meaning in the context of the changes occurring in education due to digitalization. Teachers' competencies have never been so critical and diverse since their pedagogical and subject knowledge is no longer sufficient to successfully teach without further knowledge of the use of digital media. Moreover, never before has it been necessary for teachers to learn how to deal with technology and develop respective competencies more quickly and urgently than with the COVID-19 pandemic, which wholly changed classroom teaching into a digital modus overnight.

Although access to and use of information and communication technology has become omnipresent in education during the last decades, educational processes still depend on teachers' performance (Gros et al., 2012). Teaching practice is influenced by the teachers' attitudes, innovation, routines, vision and competencies, knowledge, and beliefs (cf. Blundell et al., 2018; Wayne and Youngs, 2003; Kukla-Acevedo, 2009; Opdenakker and Van Damme, 2006). In digital learning, media and technology competencies also influence teachers' capabilities (Ally, 2019). According to Boyatzis (2008, p.6), a "competency is defined as a capability or ability. It is a set of related but different sets of behavior organized around an underlying construct, which we call the "intent." The behaviors are alternate manifestations of the intent, as appropriate in various situations or times." Furthermore, when the person's capability or talent is consistent with the needs of the job demands and the organizational environment, maximum performance is believed to occur (Boyatzis, 1982).

For teachers, the constantly changing nature of technology is challenging since it emphasizes the importance of the disposition to continue to learn and adjust to new technologies. Research shows that teachers are less likely to adopt technology for use in the classroom if they are unfamiliar with the technology (Adiguzel et al., 2011) or are not prepared for the technology through formal professional development and ongoing support (Allsop et al., 2009; Kennedy and Deshler, 2010). The importance of using technology in the right way is shown, for example, by studies with special education teachers. They believe that technology has the potential to engage and motivate students in unique ways. Characteristics of these teachers are very strong fundamental dispositions that focus on the student's well-being (e.g., Courduff et al., 2016). Furthermore, teachers are responsible for designing the learning process and the learning environment to achieve the targeted learning outcome. This responsibility is crucial and challenging, given that in digital learning, the learning outcome depends, among other things, on the technology use and – therefore – on the technology acceptance of the learners.

This paper presents a study investigating the teachers' influence on students' acceptance of digital learning. We focus on the perceptions of students regarding the competencies of their teachers and ask:

How do teachers' competencies influence students' acceptance of digital education?

To empirically estimate these competencies from students' perspectives, we conducted a survey using two validated theoretical constructs: 1) an extended technology acceptance model (TAM) (Davis, 1985) for students' acceptance and 2) the TPACK model (Koehler and Mishra, 2005) for teachers' perceived competencies.

We use TAM as one of the established models to capture acceptance of technology, among others, in the context of teaching. In addition, we rely on the TPACK model to survey teachers' competencies from the students' perspective. The TPACK model was developed to explain the critical factors of teaching with technology (Koehler et al., 2013). At the foundation of the model is the assumption that content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK) are fundamental and necessary for effective technology integration in the classroom. Through their interaction, drivers form the fundamental knowledge base required for successful technology integration in digital classrooms (Koehler et al., 2013). The TPACK model provides a framework for teachers' knowledge base when using technology in the classroom (Courduff et al., 2016).

This paper does not focus on any particular technical tool or medium. Instead, we focus on the phenomenon of digital learning, also known as e-learning. e-learning is a global trend for organizations and educational institutions that aims to improve the learning experience and learner effectiveness in terms of learning outcomes through technical media (Davis and Wong, 2007).

In the paper, we first present the related theoretical constructs. In the following, we show the structure and course of our study and discuss the results. We conclude with a summary, limitations, and implications for research and practice of digital teaching.

2 Theoretical background

In the following, we first explain the theoretical basis of the TAM and the TPACK models. Furthermore, we present studies exploring the relationships between these models. All this serves to prepare the hypothesis formation and the own research model.

2.1 TAM in e-learning

The Technology Acceptance Model (TAM) (Davis, 1985) is one of the most widely investigated and applied models of technology acceptance (Venkatesh and Davis, 2000). The perceived usefulness (PU) and the perceived ease of use (PEOU) are the two decisive variables for a person's attitude towards technology (compare figure 1). PU depicts the person's subjective sensation that applying a particular technology improves individual work performance; the PEOU measures a person's perception of how much effort the usage of the new technology takes. Both variables are influenced by diverse external variables such as job relevance, subjective norm, or output quality (Venkatesh and Davis, 2000). TAM was multiple times adopted in the context of e-learning. For example, Lee et al. (2005) added perceived enjoyment (PE) as an intrinsic motivator and PU and PEOU to TAM constructs.

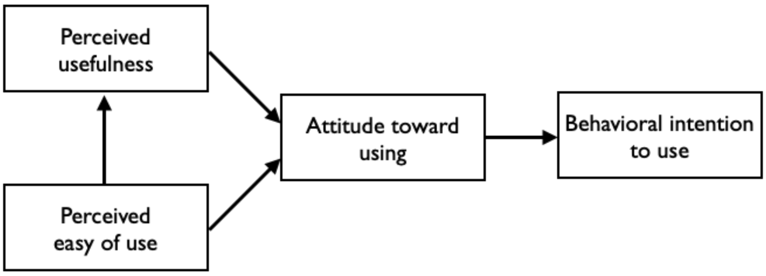

Figure 1. TAM – Technology Acceptance Model (Davis, 1985)

Additionally, the authors renamed "intention to use" towards "attitude" and "usage behavior" to "intention to use." According to the results, PU and PE impact both students' attitudes toward and intention to use internet-based learning media. However, in the same study, PEOU was unrelated to attitude. Šumak et al. (2011) conducted a meta-analysis on the topic, with the result that TAM is the most applied model in e-learning research. Using TAM, Selim (2003) identified course websites as an effective and efficient learning technology. Liu et al. (2005) confirmed a dual identity of the online e-learning user as a system user and as a learner. Furthermore, the authors found that both the flow and the perceived usefulness of the e-learning system strongly predict the intention to continue using e-learning. Pituch and Lee (2006) applied a structural equation model to empirically relate e-learning presentation type and users' intention to use e-learning to one another. Therein, concentration and perceived usefulness were considered intermediate variables. Park (2009) added to the model e-learning self-efficacy as an influencing variable and identified that it was the essential construct, followed by subjective norm, in explicating the causal process in the model. Tarhini et al. (2013) extended the TAM by social norms and quality of work-life and confirmed positive relations towards TAM core constructs. Mohammadi (2015) also extended the core model and confirmed that intention and user satisfaction positively affected the actual use of e-learning. Furthermore, system quality and information quality were found to be the prime driving users' intentions and satisfaction towards the use of e-learning. Al-Azawei et al. (2017) highlight the integration of perceived satisfaction and technology acceptance following psychological traits and learner beliefs. The model successfully integrated intention to use and perceived satisfaction.

2.2 TPACK

As already mentioned, the digitalization of education is changing the requirements for teachers' skills, abilities, and competencies. The interplay of different competencies was identified as necessary a long time ago. To investigate the relationships between pedagogical knowledge (PK) and content knowledge (CK) as well as the combination of both knowledge types, Shulman (1986) developed the Pedagogy Content Knowledge (PCK) model. PK refers to understanding teaching-learning processes, teaching methods, and knowledge about learners' learning styles or motivation. CK addresses discipline and subject-specific knowledge. The aim was to combine the areas of content and pedagogy rather than consider them separately when assessing teachers' knowledge. On this basis, the TPACK model (compare figure 2) took into account the increasingly growing use of technology in teaching and considered technology knowledge to be equally relevant as PK and CK for teaching (Angeli and Valanides, 2009; Cox and Graham, 2009; Koehler and Mishra, 2005; Mishra and Koehler, 2006; Niess et al., 2009). Mishra and Kohler (2006, p. 1025) describe the process of the integration of all circles in the model as follows: "The Three Circles, Content, Pedagogy, and Technology, Overlap to Lead to Four More Kinds of Interrelated Knowledge."

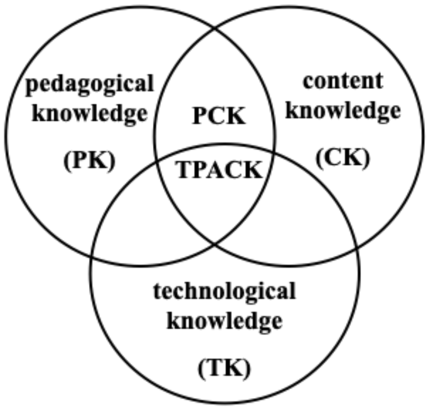

Figure 2. Pedagogical technological content knowledge – TPACK model (compare Mishra and Koehler, 2006).

The TPACK model provides a framework that supports integrating digital technologies into pedagogical practice. Its goal is to point out new aspects of teachers' preparation and professional development (Chai, Koh & Tsai, 2011; Jimoyiannis, 2010). The model builds on the PCK-model and enlarges it with the dimension Technology Knowledge (TK). PCK has been proven to be a crucial building block of TPACK (Pamuk, 2011), implying that teachers need to focus on their pedagogical and content knowledge before integrating technology into their classrooms. The TPACK model (compare figure 2) combines the three dimensions of knowledge (PK, CK, TK), three hybrid forms between the dimensions, and the context. The hybrid forms are respectively 1) Pedagogical Content Knowledge (PCK) - the knowledge of how to convey specific content to learners; 2) Technological Content Knowledge (TCK) - the understanding of the interactions between technology and practice; and 3) Technological Pedagogical Knowledge (TPK) - the knowledge of the possibilities and limitations of a pedagogically motivated integration of technologies.

A central message of the model is that it is not possible to recommend a teaching method (PK) or a technology (TK) in a general way for teaching a particular content (CK). Instead, the three dimensions of knowledge must be brought together. In addition, the context - considered in the model as a framing situational condition - should be taken into account.

The model constructs have been used and investigated in many studies. In the following, some of these will be briefly introduced.

Jang and Chen (2013) explore the TPACK of secondary school teachers and identify group differences that influence the own competence perception of the teachers. Experienced science teachers are more confident in their content and pedagogical content knowledge than novice science teachers. Science teachers with less teaching experience, on the other side, rate their technology knowledge and technological content knowledge significantly higher than did teachers with more teaching experience.

Chai et al. (2010) developed a TPACK instrument to measure self-perceived TPACK. Chai et al. (2011) investigated the instrument's validity in a comprehensive study of younger teachers. The authors validated not all seven constructs from the theory of Koehler and Mishra (2005): TK and CK were validated separately, but the PK and PCK together, and the items of TPK, TCK, and TPACK as a group. Chang et al. (2015), following Graham (2011), calls this a "construct boundary problem." This problem can be partly explained by the fact that some of the components of TPACK are defined similarly (cf. Angeli and Valanides, 2009).

Archambault and Crippen (2009) used the model to assess the knowledge of online teachers in three key areas: Technology, Pedagogy, Content, and the combination of these areas. Teachers were most confident about their pedagogy, content, and pedagogical content but less confident about their technology competencies. The most extensive correlations were found between pedagogy and content; the correlations between technology and pedagogy and technology and content were not that strong. The study thus was not able to empirically validate the framework but recommended TPACK as an instrument to organize critical areas of instruction, including the use of technology and thus addressing online teaching.

The TPACK was also extensively modified in several studies. Shih and Chuang (2013) developed and validated an instrument for assessing students' perceptions of faculty knowledge (SPFK) in technology-supported classroom environments based, among other things, on the 24 items of the TPACK. Jang and Chen (2013) used the modified version of the model to measure students' perceptions of their lecturers' TPACK, different from most existing surveys that assess teachers' self-described knowledge and skills. In their study, Chang et al. (2015) used this modified TPACK questionnaire to investigate the development of teacher competencies over time using self-assessment and feedback (collected with the questionnaire) and students' opinions. They explicitly point out the importance of learners' opinions for the teachers' competence development.

These further developments of the TPACK questionnaire are, in our view, little evaluated in the literature and strongly deviate from the concrete TPACK dimensions. Thus, for this present study, the instrument of Archambault and Crippen (2009), addressing the original TPACK elements, was used.

2.3 TPACK and TAM

The influence of the teachers' competencies (captured using the TPACK-model) on the acceptance of technology has already been investigated in various studies. The focus has been explicitly on the acceptance of the teacher. Hsu (2016) examined in an empirical study teachers' competencies according to the TPACK and their effect on the adoption of the mobile-assisted language, measured using the framework of the TAM. The results show that TPACK significantly influences both PE and PU of the teachers. TPACK is critical to technology adoption, and to teachers' attitudes toward and continued use of the technology. Alsofyani et al. (2012) investigated the interdependencies between TPACK and TAM from a different perspective. In their study, the authors introduced an online training environment for TPACK-development and evaluated the acceptance of this digital environment by using the TAM. Joo et al. (2018) conducted a study to investigate the structural relationships between TPACK, teacher self-efficacy, PEOU, and PU. According to their results, teachers' TPACK positively influences their self-efficacy, PEOU, and PU of technology in the classroom. Yang et al. (2019) found that teachers' TPACK abilities affect their acceptance, PU and PEOU, regarding the use of digital technology in the classroom. The technological knowledge was significantly more correlated with acceptance than pedagogical knowledge and content knowledge. Mayer and Girwidz (2019) investigate the influence of technological knowledge of physics teachers on their acceptance. The authors add TPACK as a superordinate moderator variable to TAM in their study. Their results show that TPACK has a highly significant influence on "perceived ease of use," "perceived usefulness" of the teachers as well as for pupils, and of the "personal job relevance assessment."

Courduff et al. (2016) conducted a systematic grounded theory study aiming to extend the theoretical foundations of the TAM and the TPACK model and to develop a theoretical model for exemplary integration of technology into special education instructional practice. The data collected during the study helped analyze the pedagogy used by special education teachers who successfully integrate technology into their teaching and learning processes. The study results support existing literature in this field regarding the role of teachers' knowledge of technology, pedagogy, and content, which is essential for effective teaching practices, especially in the special education classroom (cf. Tournaki and Lyublinskaya, 2014). Furthermore, the study shows that, at least in special education, teachers saw value in using the technology only if this technology was beneficial for the learner – if learning has been made more accessible and more meaningful. Using these results, the authors propose to add student perceptions on ease of use and usefulness of technology as a component of the TAM in e-learning.

In the following, we use this theoretical framework and the presented studies' results and build our hypotheses and our research model.

3 Teachers influence on the acceptance of digital learning

Digital learning brings new challenges for teachers. The use of technology in the classroom, the motivation, and the abilities of the students to learn with these require new professional competencies. Students' perceptions of teachers' qualifications are among the most critical factors directly influencing their perceptions about the quality of education (Akareem and Hossain, 2016). Arnon and Reichel's (2007) study found that students perceive teachers' professional knowledge - content knowledge and didactic knowledge - alongside personal and essential qualities. Gros et al. (2012) found a correlation between students' perceived usefulness of specific ICT resources and teachers' suggested use of the technologies. The technologies rated highest by learners were suggested by teachers for use in the classroom. In online environments, students see technology as a support for learning and communication and relate the value of ICT to the learning process rather than the content.

Teachers also play an important social role whereby, e.g., missing possibilities of direct communication can negatively influence the acceptance of digital learning (Vladova et al., 2021). Until now, there is no research on the influence of teachers' competencies on the acceptance of digital learning. In the context of university education, however, even in digital learning, students are guided by their teachers. Our research aims to close this gap.

In order to investigate students' acceptance, we use the TAM. TAM in e-learning is usually applied in cases where blended or e-learning is an additional part of classical in-person classroom activities. Consistent with prior studies (cf. Venkatesh and Davis, 2000 and Lee et al., 2005), we investigate the relationships between constructs and expect that it exhibits significant strength and apply the following hypotheses:

H1: There is a positive relationship between perceived ease of use and perceived usefulness.

H2: There is a positive relationship between perceived ease of use and attitude.

H3: There is a positive relationship between perceived usefulness and attitude.

H4: There is a positive relationship between perceived usefulness and behavioural intention.

H5: There is a positive relationship between attitude and behavioural intention.

Our study empirically analyzed students' perception of and trust in teachers' knowledge by adapting the TPACK model (Mishra and Koehler, 2006; Archambault and Crippen, 2009; Schmid et al., 2020) for the development of the items. Students generally rely on the pedagogical skills of their teachers in familiar learning environments. We propose the following hypothesis (compare figure 3):

H6: The perception of the lecturer's pedagogical knowledge positively influences the perceived usefulness of digital learning.

H7: The perception of the lecturer's technological knowledge positively influences the perceived usefulness of digital learning.

H8: The perception of the lecturer's content knowledge positively influences the perceived usefulness of digital learning.

H9: The perception of the lecturer's technological content knowledge positively influences the perceived usefulness of digital learning.

H10: The perception of the lecturer's pedagogical content knowledge positively influences the perceived usefulness of digital learning.

H11: The perception of the lecturer's technological pedagogical knowledge positively influences the perceived usefulness of digital learning.

H12: The perception of the lecturer's technological pedagogical content knowledge positively influences the perceived usefulness of digital learning.

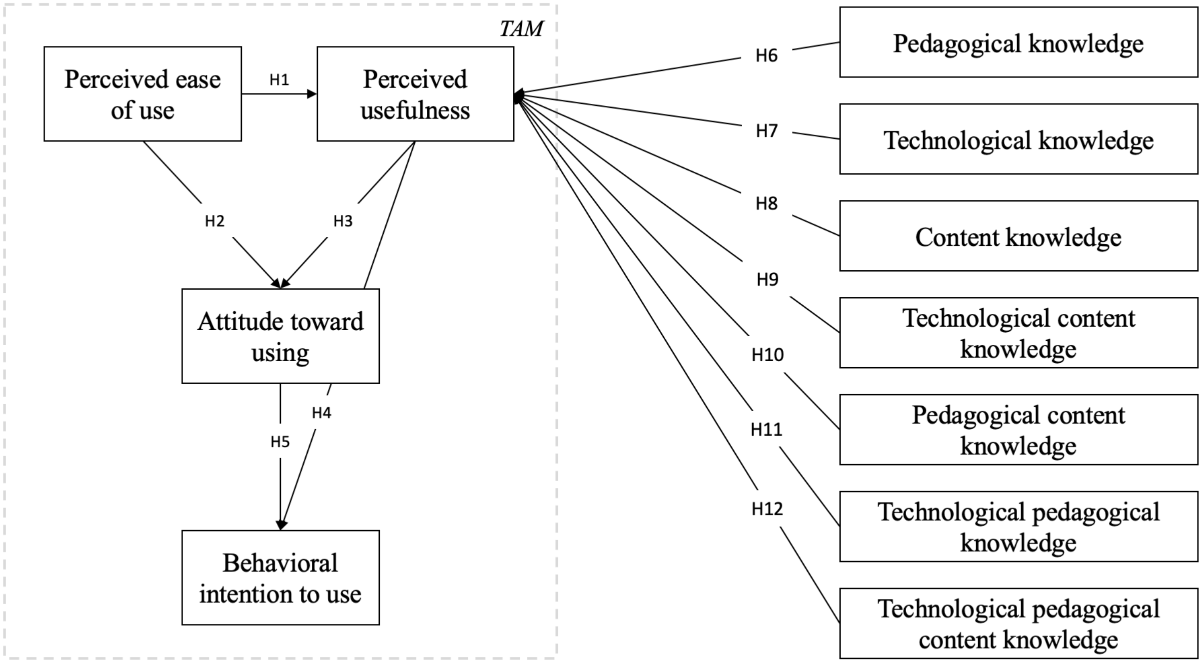

Figure 3. Research model.

4 Materials and methods

In order to measure this research model, an online survey was conducted during the period from September to October 2021. We used the website Prolific. The requirements for participating in the survey were to be a current university student, either on an undergraduate (BA/BSc/similar) or a graduate (MA/MSc/similar) level. We used pre-tested constructs and respective scales for the survey that we adopted for our study. Concerning the constructs of the TAM, we adopted the measurement scales from Lee et al. (2005) and Vladova et al. (2021). Slight modifications to the original wording of the items were made to match the context and wording of the overall study. To measure the constructs of the TPACK, we relied on the scales from Archambault and Crippen (2009), which we modified the wording so that students were able to assess their teachers' knowledge since the original scales were developed for teachers' self-assessment. All the constructs were assessed using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree) for the TAM constructs and from 1 (poor) to 5 (excellent) for the TPACK constructs.

We conducted a pre-test in August 2021 with 45 participants that resulted in minor changes after the received feedback: We formulated additional information for two scales and substituted the first item measuring the attitude toward using.

The survey data was processed and analyzed using IBM SPSS Statistics, version 27. To prevent missing values, all questions were mandatory. Furthermore, we included two attention check questions in different parts of the questionnaire, leading to ten deleted participants due to false answers to these attention checks. To test the hypotheses of the research model, regression analysis using the ordinary least square (OLS) method was applied. For the calculation of the model constructs, the mean values of the individual items were used.

In order to ensure the validity of the constructs, two approaches were applied. First, an explorative factor analysis (EFA) for the TAM and TPACK items was conducted using a principal component analysis with a varimax rotation. Second, the internal validity of the separate constructs was tested using Cronbach's alpha (CA). Table 1 provides an overview of the items and the reliability assessment results. The internal validity of the individual constructs was satisfactory for all the constructs (> 0.7, cf. Tavakol and Dennick, 2011).

First, the 12 items related to the TAM constructs were employed in an EFA, resulting in the four expected constructs with factor loadings between 0.634 and 0.867, exceeding the fulfillment limit (> 0.5, cf. Costello and Osborne, 2005). Secondly, the 24 items of the TPACK constructs were employed in an EFA, resulting in the seven expected constructs with factor loadings from 0.502 to 0.872. Only one item of the Technological pedagogical content knowledge scale missed the fulfillment with a factor loading of 0.446 (see table 1).

Construct	CA	Factor loading	Measurement item
Perceived usefulness	0.817	0.790	Digital learning will improve my course grades.
		0.752	The advantages of digital learning outweigh the disadvantages.
		0.801	Overall, digital learning is advantageous.
Perceived ease of use	0.749	0.795	My lecturers' instructions on how to use the digital technologies for learning are difficult to follow.
		0.844	It is difficult to learn how to use digital technologies for learning.
		0.720	It is easy to operate digital technologies for learning.
Attitude toward using	0.800	0.867	I think that digital learning should replace face-to-face learning in the long term.
		0.841	I welcome the increasing relocation of educational processes to virtual space, i.e., face-to-face teaching being replaced with digital teaching.
		0.634	I am confident that digital teaching content can be taught without major obstacles.
Behavioural intention to use	0.807	0.770	I intend to use digital technologies for learning regularly in the future.
		0.713	I intend to use digital technologies in the future when preparing projects, papers, and assignments.
		0.837	I intend to use digital technologies for learning frequently in the future.
Pedagogical knowledge	0.802	0.688	My lecturers' ability to determine a particular strategy best suited to teach a specific concept.
		0.670	My lecturers' ability to use a variety of teaching strategies to relate various concepts to students.
		0.736	My lecturers' ability to adjust teaching methodology based on student performance/feedback.
Technological knowledge	0.905	0.844	My lecturers' ability to troubleshoot technical problems associated with hardware (e.g., network connections).
		0.872	My lecturers' ability to address various computer issues related to software (e.g., downloading appropriate plug-ins, installing programs).
		0.862	My lecturers' ability to assist students with troubleshooting technical problems with their personal computers.
Content knowledge	0.813	0.649	My lecturers' ability to create materials that map to specific district/state standards.
		0.812	My lecturers' ability to decide on the scope of concepts taught within in my class.
		0.776	My lecturers' ability to plan the sequence of concepts taught within my class.
Technological content knowledge	0.818	0.717	My lecturers' ability to use technological representations (i.e. multimedia, visual demonstrations, etc.) to demonstrate specific concepts in my content area).
		0.693	My lecturers' ability to implement district curriculum in an online environment.

		0.765	My lecturers' ability to use various courseware programs to deliver instruction (e.g., Blackboard, Centra).
Pedagogical content knowledge	0.810	0.735	My lecturers' ability to distinguish between correct and incorrect problem solving attempts by students.
		0.756	My lecturers' ability to anticipate likely student misconceptions within a particular topic.
		0.630	My lecturers' ability to comfortably produce lesson plans with an appreciation for the topic.
		0.622	My lecturers' ability to assist students in noticing connections between various concepts in a curriculum.
Technological pedagogical knowledge	0.880	0.525	My lecturers' ability to create an online environment which allows students to build new knowledge and skills.
		0.638	My lecturers' ability to implement different methods of teaching online.
		0.824	My lecturers' ability to moderate online interactivity among students.
		0.849	My lecturers' ability to encourage online interactivity among students.
Technological pedagogical content knowledge	0.818	0.550	My lecturers' ability to use online student assessment to modify instruction.
		0.638	My lecturers' ability to use technology to predict students' skill/understanding of a particular topic.
		0.446	*My lecturers' ability to use technology to create effective representations of content that depart from textbook knowledge. (Item deleted after EFA)*
		0.502	My lecturers' ability to meet the overall demands of online teaching.

Table 1. Assessment of construct reliability.

Table 2 provides an overview of the descriptive details. With regard to the TAM constructs, it becomes clear that the participants assessed the attitude toward digital learning as relatively low (avg. 2.66, SD = 1.003) compared to the other constructs of the TAM. Referring to the TPACK, the different constructs were rated with similar scores. Despite this, the technological knowledge of instructors was rated the lowest (avg. 2.75, SD = 1.104) and content knowledge the highest (avg. 3.62, SD = 0.779).

Construct	Min	Max	Mean	SD
Perceived usefulness	1	5	3.41	0.929
Perceived ease of use	1	5	3.90	0.731
Attitude toward using	1	5	2.66	1.003
Behavioural intention to use	1	5	3.86	0.777
Pedagogical knowledge	1	5	3.26	0.843
Technological knowledge	1	5	2.75	1.104
Content knowledge	1	5	3.62	0.779
Technological content knowledge	1	5	3.42	0.944
Pedagogical content knowledge	1	5	3.61	0.745
Technological pedagogical knowledge	1	5	3.19	0.971
Technological pedagogical content knowledge	1	5	3.25	0.885

Table 2. Descriptive information on model constructs.

5 Results

In total, we gathered data from 350 students. Of the responses, 196 (56%) were received from female participants and 154 (44%) from male participants. The average age is 24 years, and the most frequent nationalities include South Africa (32%), Portugal (10%), and Italy (9%). Regarding the current education level, 230 (66%) were undergraduate, and 120 (34%) were graduate students.

The overall results of the research model are presented in figure 4. For the scale of *technological pedagogical content knowledge*, the composition of the construct was adjusted according to the results of the EFA. Table 3 shows that all constructed hypotheses could be confirmed using linear regression analysis.

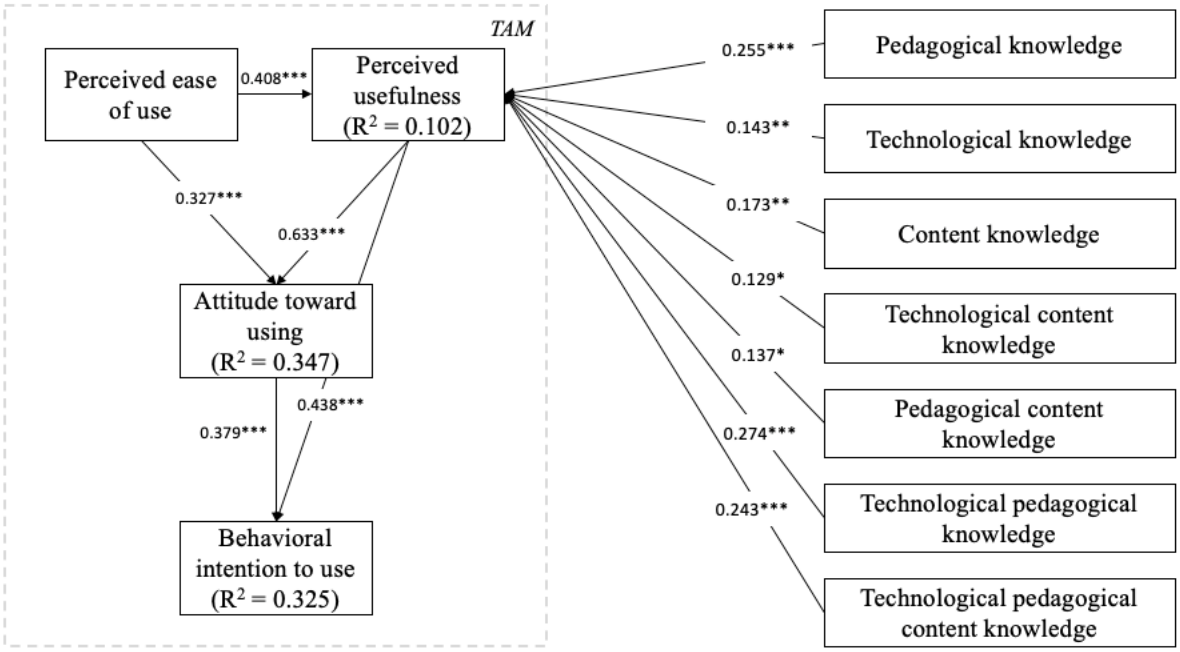

Figure 4. Results of the research model (Significant at the 0.05-level, ** significant at the 0.01-level and *** significant at the 0.001-level).*

With the help of the hypothesis tests, we wanted to identify the effect of teachers' perceived knowledge regarding pedagogical, technological, and content aspects on the acceptance of digital learning by university students. The hypotheses connecting the different constructs inside the TAM (H1-H5) can be confirmed on a highly significant level with this sample. The model accounts for 34.7% of the variance in attitude toward using and 32.5% of the variance in behavioral intention to use (see figure 2).

We found that all constructs of the TPACK had a significant effect on the perceived usefulness. Following the connection of the TAM constructs, this indicates that students' perception of their teachers' competencies influences their acceptance of digital learning. Focussing on the coefficients (table 3), one can see that the pedagogical knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge have a higher effect than the technological knowledge, content knowledge, technological content knowledge, and pedagogical content knowledge of teachers. This indicates that pedagogical knowledge overall has a more significant impact on the perceived usefulness of digital learning than the knowledge related to content. The effects of the TPACK constructs explained 10.2% of the variance in perceived usefulness in the model test.

Hypothesis	Coefficient (p-value)	Test result
H1: Perceived ease of use → Perceived usefulness	0.408***	Confirmed
H2: Perceived ease of use → Attitude	0.327***	Confirmed
H3: Perceived usefulness → Attitude	0.633***	Confirmed
H4: Perceived usefulness → Behavioural intention	0.438***	Confirmed
H5: Attitude → Behavioural intention	0.379***	Confirmed
H6: Pedagogical knowledge → Perceived usefulness	0.255***	Confirmed
H7: Technological knowledge → Perceived usefulness	0.143**	Confirmed
H8: Content knowledge → Perceived usefulness	0.173**	Confirmed
H9: Technological content knowledge → Perceived usefulness	0.129*	Confirmed
H10: Pedagogical content knowledge → Perceived usefulness	0.137*	Confirmed
H11: Technological pedagogical knowledge → Perceived usefulness	0.274***	Confirmed
H12: Technological pedagogical content knowledge → Perceived usefulness	0.243***	Confirmed

Table 3. Summary of hypothesis tests (Significant at the 0.05-level, ** significant at the 0.01-level and *** significant at the 0.001-level).*

The investigation of the correlations between the different competencies (TK, PK, CK, TPC) as part of the TPACK model was not the focus of this study. We therefore did not included them as part of the model and did not explicitly hypothesize them because that would have been beyond the scope of the study. Nevertheless, we examined the correlations between the model constructs in the course of the statistical analysis and found significant positive correlation values for all of them.

6 Discussion, limitations and further work

This paper presented and discussed the results of an empirical study among students in which, for the first time, the acceptance of digital learning was directly linked to learners' perceptions of teachers' competencies.

Theoretical contribution

We used two established constructs from research - the TPACK model and the TAM. These have been investigated and validated in various studies. Their mutual influence has also been explored in studies that, however, focus only on the teachers' acceptance and competencies self-assessment. Our study extends this field of research by explicitly addressing the students' perspectives. Our results show that the constructs and measurement instruments can be applied sufficiently with this new perspective.

For the TPACK investigation, we used Archambault and Crippen's (2009) scale, slightly adapted in terms of wording. We were able to validate it for all knowledge dimensions. Furthermore, we could show that all model constructs are significantly correlated.

For the investigation of the acceptance, we used the scale of Lee et al. (2005) and modified it slightly. We were able to confirm all hypotheses linking the TAM constructs. Our results differ only minimally from those of Lee et al. (2005), who had to reject one hypothesis. These better results could be because we used Vladova et al.'s (2021) scale for the setting, which asks about digital learning in general. Following our results, we suggest that this scale is better suited for studies on the acceptance of digital learning.

Our study investigated and confirmed the relationship between the two models in the form of hypotheses for each knowledge dimension in the TPACK model and the PU construct in the TAM. We were able to verify and show that learners' acceptance of teaching in the digital learning environment is influenced by their perceptions of each type of teacher competency – pedagogical, technological, content, and hybrid forms. We focused on PU following previous studies' results that showed the PU's importance for students (cf. Mayer and Girwidz, 2019; Tournaki and Lyublinskaya, 2014; Courduff et al., 2016).

Our results thus have a theoretical value: The TAM model was extended by a new construct for teaching in the digital space - the teachers' competencies investigated from the perspective of the learners. From our point of view, this should be deepened in further studies and related to and investigated with other constructs such as satisfaction, learning performance, social influence.

Implications for teaching practice

In addition to these extensions of the theoretical model, our findings have concrete implications for the organization of the learning process and the relationship between students and teachers. The study shows that attitude towards digital learning was generally rated lower than the other TAM constructs. A look at the items measuring this attitude shows that students may have a lower attitude towards digital learning when directly confronted with the comparison between face-to-face and digital learning. This result can be explained with the fact that face-to-face teaching creates a more familiar environment through years of tradition than digital teaching. However, the lower acceptance could also be related to the fact that specific learning contents cannot be easily transferred to the digital space. They require more socialization and direct contact. This result should be considered for decisions on whether learning processes can and should be entirely digital.

When discussing the learning process, the following results in the context of the TPACK model are particularly relevant from our point of view: Technological knowledge of the teachers was rated the lowest by the students, which indicates, among other things, that students perceive teachers as not competent in dealing with technology. When comparing the results, it can be seen that the knowledge constructs related to pedagogical knowledge have a more significant influence than the other TPACK constructs. Pedagogical knowledge is a crucial competence of teachers on which the other competencies can build (cf. Pamuk, 2011; Gros et al., 2012). This is illustrated in the TPACK model, where all competencies are interrelated (Pamuk, 2011; Angeli and Valanides, 2009; Cox and Graham, 2009; Koehler and Mishra, 2005; Mishra and Koehler, 2006; Niess et al., 2009).

These findings have a concrete meaning from the perspective of practice - the development of teacher competencies for the digital learning must be recognized as very relevant and be strongly supported; otherwise, the success of the learning process can be jeopardized. However, this should not be addressed as a technology competence only but as part of the training of digital competencies in interaction with the other relevant learning competencies. Our recommendation is to implement the complex interplay between pedagogy, content, and media skills as part of the curriculum for future teachers and the continuing training for teachers already in practice.

Limitations and further work

Our study has some limitations. It has been conducted among students from diverse cultures and at different universities. This fact may affect the results in some circumstances. Further studies should also explicitly consider the student's field of study. Studies have already identified differences in the acceptance of digital learning among technology-savvy students compared to less technology-savvy students (Vladova et al. 2020), so this may also be related to the perception of teacher competencies. In addition, the effect of the COVID-19 pandemic should be explicitly taken into account, where there was increased digital teaching. Furthermore, we do not have data on the respondents' prior experience in the digital learning space - duration, frequency, relationship to face-to-face teaching. We also do not know how teacher competencies were formed. We investigate perception, which is a subjective variable.

Regarding the theoretical constructs, some limitations should be pointed out. In our study, we used the TAM model. This model has been applied in research on technology acceptance very often. However, some research also criticizes the model (e.g., Legris et al., 2003; Li, 2010). Other acceptance models, e.g., the UTAUT, can thus be used to verify and extend our findings. Research has, however, shown that other models also have limitations, e.g., the high number of items in UTAUT (Bagozzi, 2007). The constructs examined in UTAUT were not appropriate for our study in particular. Based on prior work in the literature suggesting a correlation between PU and TPACK, we focused on perceived usefulness as part of the TAM. However, UTAUT could provide exciting insights into the connection between social interaction or facilitating conditions to investigate influences on students' perceptions further.

Student acceptance of digital learning is not a new topic, but the teacher's influence on digital learning acceptance has not yet been investigated. However, these relationships are essential. Students are still supervised by their teachers in e-learning environments in higher education. Furthermore, teachers have an important social role, and the lack of direct communication negatively influences the acceptance of e-learning of their students (Vladova et al., 2021). Therefore, the transition to learner-centered teaching also opens a great need for research on teacher-learner relationships. In order to systematically capture learning feedback, future studies can address evaluation opportunities for the quality of digital teaching in higher education. Their results would allow, among other things, to explore the knowledge components in the TPACK model and the interrelationships between them and to take them into account when studying student acceptance.

The significant correlations that our investigation showed and the interplay of the competencies in the TPACK model opens up opportunities for further studies to measure teachers' competencies in the digital society through students' perceptions in different contexts - school, university, professional education. Comparisons based on demographic or organizational factors, for example, may provide an exciting focus for further studies.

Our study provides significant initial findings and should be reviewed and extended in subsequent research. The literature provides much evidence on the importance of the teacher-student relationship. It is essential to understand what the shift of this relationship into the digital space means. The study was designed and conducted with a focus entirely on digital teaching. However, we believe that hybrid teaching will prevail in the future. It combines off- and online teaching and reduces the disadvantages. For this reason, further research should likewise investigate the acceptance of teaching depending on teacher competencies in a comparison of off- and online teaching. From our point of view, the importance of the combination of the three knowledge types will then be previewed even better. Even the best-trained educators cannot work effectively in the virtual space if they do not know how to use technology.

Funding

This work has been funded by the Federal Ministry of Education and Research of Germany (BMBF) under grant no. 16DII127 (“Deutsches Internet-Institut”).

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