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Levels of academic teachers digital competence: Polish case-study

Nataliia DEMESHKANT[a*], Katarzyna POTYRAŁA[a] & Łukasz TOMCZYK
[a]*Pedagogical University of Cracow, Poland*
*nataliia.demeshkant@up.krakow.pl

Abstract: The purpose of this study is to examine levels of academic teachers' digital competences regarding the demographics and professional backgrounds in Polish educational context. The 2-factor (Pedagogical and Technological knowledge) TPACK model is using in the study. A survey was administered to 103 academic teachers from Polish universities. Descriptive analysis indicated a significant negative correlation between some demographic variables (age, years of teaching, titles and degrees) and domains from both factors. However, some positive associations with certain variables from the professional background (using for teaching online learning environments, digital quizzes or polls, interactive apps or games; providing on-line courses; creating videos for teaching) were also noticed. Implications for professional development and suggestions regarding teachers' digital competences and TPACK have been discussed.

Keywords: academic teachers; digital competence; TPACK; demographics and professional backgrounds

1. Introduction

Professional teachers' digital competences are seen as a combination of professional, pedagogical and technological knowledge and skills (Koehler & Mishra, 2009), but also the ability to apply learning outcomes as is appropriate to the context (CEDEFOP, 2014). Most educators have been led to believe that the integration of technology into classrooms, or the transition from face-to-face learning to online learning, is a simple task requiring merely some technology skills training (Schmid & Hegelheimer, 2014). Professional development for educators moving to an online environment frequently provides only instruction on how to use the new Learning Management System and other technical skills, without a discussion about the content or pedagogical issues that intertwine with technology (Benson & Ward, 2013). The ability to use a variety of technologies did not necessarily result in the effective use of technology to impact teaching or learning. Technology skills learned in isolation may even hurt an instructor's ability to see the complex application of that technology in a pedagogically and contextually sound manner (Benson & Ward, 2013). Therefore, the role of teachers and the systems around them must be reinvented. Many countries are currently in the process of developing or revising frameworks and training programs to guide teacher training and continuous professional development in this area (Castéra et al., 2020; Cubeles et al., 2018; Ghomi & Redecker, 2019; Starkey, 2020).

During the last few years, Polish universities also have been making conscientious efforts to improve the educational process with modern digital teaching and learning methodology (*The digitalisation of Polish Education Vision and proposals*, 2016). According to the Digital Economy and Society Index (DESI) profile developed by the European Commission, Poland is in the group of countries with low level of digitization (European Commission, 2019). Significant changes connected with informatization in the Polish higher education system have been done in the sphere of university management, reporting, scientific and research activities as well as teaching digitalization. Despite this, there is no clear proof about using theoretical scientific conceptions for academic teachers' development.

The main research question was to explore how demographics and professional backgrounds of academic teachers are correlated with their levels of digital competences. Results of the study would be useful for selecting effective methods of teachers' professional development for promoting ICT in education.

2. Theoretical background

The study is focused on academic teachers' TPACK as one of the most important elements in teachers' professional training and development. TPACK adds technological knowledge as a new component that has to blend in with domain and pedagogical knowledge to effectively integrate ICT in instructional practices (Voogt & Mckenney, 2016). As the results of the previous studies indicate, there is no scale using the TPACK framework, which is suitable for all settings – in-service, pre-service, academic teachers, different subjects, and different countries (Cubeles et al., 2018). Controversial results have also been found in terms of how demographic data correlates with TPACK components and which TPACK components are rated higher. One more reason for our study is that the TPACK model has been applied principally in primary and secondary education and its use in the university sector is still in its initial phases and the role of the university professor has yet to be fully defined (Cubeles et al., 2018). There is a significant difference between the functions of school teachers and academic lectures. Academic teachers combine research activity with the transfer of knowledge to students. For modern academic teachers, the technological side of ICT is a part of their routine professional work, including teaching. Nevertheless, there are doubts about the pedagogical context of effective and methodically correct use of ICT for work with students. For this reason in our study, we decided to modify the classic 7-factor model structures of the TPACK framework and to combine some original factors. In this way PK, CK, and PCK were merged into one Pedagogical Knowledge factor F1 (PK). All items with technology (TK, TCK, TPK, and TPACK) were merged into second Technological Knowledge factor F2 (TK). TK factor meaning that academic teachers perceive technology already integrated with content and pedagogy. The use of the 2-factor TPACK model allows us to thoroughly examine the basic components (TK and PK) of the study's subject (digital competences of academic teachers), as well as to determine more precisely the relationships regarding this components' mutual dependence and development.

Besides TPACK theory there is The European Framework for the Digital Competence of Educators (DigCompEdu) describes the digital competences specific to the teaching profession (Redecker, 2017). According to the DigCompEdu, there are twenty-two educator-specific digital competencies organized in 6 areas that are focused on different aspects of educators' professional activities (see table 1).

Table 1. *Areas of educator-specific digital competences*

Sections	Areas of Digital Competences		Description
I. Professional Engagement	1.1 Organizational Communication	OC	Using digital technologies for communication, collaboration and professional development
	1.2 Professional Collaboration	PC	
	1.3 Reflective Praxis	RP	
	1.4 Digital CPD (Certified Program Development)	DCPD	
II. Digital Resources	2.1 Selecting Digital Resources	SDR	Sourcing, creating and sharing digital resources
	2.2 Creating and Modifying Digital Resources	CMDR	
	2.3 Managing, protecting and sharing digital resources	MPSDR	
III. Teaching and Learning	3.1 Teaching	T	Managing and orchestrating the use of digital technologies in teaching and learning
	3.2 Guidance	G	
	3.3 Collaborative Learning	CL	
	3.4 Self-regulated learning	SrL	
IV. Assessment	4.1 Assessment strategies	AS	Using digital technologies and strategies to enhance assessment
	4.2 Analyzing evidence	AE	
	4.3 Feedback and Planning	FP	
V. Empowering Learners	5.1 Accessibility and Inclusion	AI	Using digital technologies to enhance inclusion, personalization and learners' active engagement
	5.2 Differentiation and Personalization	DP	

VI. Facilitating Learners' Digital Competence	6.1 Information and Media Literacy 6.2 Digital Communication and Collaboration 6.3 Digital Content Creation 6.4 Responsible Use 6.5 Digital Problem Solving	IML DCC DCCr RU DPS	Enabling learners to creatively and responsibly use digital technologies for information, communication, content creation, wellbeing and problem-solving

3. Materials and methods

3.1 Participants

The target population of this pre-piloting and item revision study was academic teachers of a few Polish universities (N=103). Ethical approval to conduct the research has been addressed. Participants have been provided with sufficient information about the goals of the study. To protect and respect the personal data provided by participants, the survey tool was anonymous. The data was collected during the 2018-2019 academic year. The sample included 50,5% female respondents, 42,7% male respondents and 5,8% of respondents did not indicate their gender. The age range of the respondents was between 28 and 69 years. Participants' teaching experience ranged from 1 year to more 40 years.

3.2 Instrument and procedure

In our study, the two-factor TPACK model was used for analysis. As the first step it was preliminary investigated how academic teachers perceive their levels of digital competences regarding different competence areas (table 1). Obtained results were consistent with modifying TPACK theoretical model, and then the possible links between academic teachers' digital competences in different areas and their demographic (gender, age, previous academic experience and titles and degrees) and professional (using of different digital techniques and resources for teaching) backgrounds were analyzed. In this quantitative survey study, an anonymous questionnaire was designed based on the European DigCompEdu self-assessment tool. All items of the questionnaire were assigned to the appropriate area of digital competences and Cronbach's alpha item reliability analysis was done. Items with the Cronbach's alpha score less than 0.75 were eliminated from the study. After checking the properties of the items, an analysis was performed to verify how closely related a set of items are as a group. For that purpose, the reliability of the instrument was calculated. Cronbach's alpha was computed to measure the internal consistency of the instrument for the Polish sample of teachers.

Finally, university experts evaluated selected items and marked, which of these two factors of the modifying TPACK model particular areas of digital competences represent (e.g. F1PK or F2TK) and how representative items are describing in the model on a 5-point scale. Factors and internal consistency of the TPACK scale are shown in table 2.

3.3 Data analysis

Several quantitative research methods were applied to establish evidence for the validity and reliability of the instrument. Whole instrument with 73 items and each of the six competence areas for internal consistency using Cronbach's alpha reliability technique was assessed. Statistical analysis was carried out as follows. A descriptive analysis between variables of the chosen demographic and professional background and different areas of the digital competences carried out.

4. Results

4.1 Levels of teachers' digital competences

To reach the first research question we used SPSS 25. Levels of digital competences were established based on percentiles: low level – till 25 percentiles, medium level – between 26 to 75 percentiles, and higher-level from 76 and above (see Table 3).

Table 2. *Areas of educator-specific digital competences*

Factors	Areas of digital competences	Cronbach's α
Technological Knowledge (TK)	TK1 OC	.852
	TK2 PC	.775
	TK3 RP	.815
	TK4 SDR	.760
	TK5 CMDR	.824
	TK6 MPSDR	.816
	TK7 Teach	.780
	TK8 G	.803
	TK9 IML	.792
	TK10 DCC	.750
	TK11 DCCr	.854
	TK12 RU	.831
	TK13 DPS	.808
Pedagogical Knowledge (PK)	PK1 DCPD	.826
	PK2 CL	.810
	PK3 SrL	.807
	PK4 AS	.773
	PK5 AE	.846
	PK6 FP	.813
	PK7 AI	.835
	PK8 DP	.764

A pre-pilot diagnostic test of levels of digital competences of academic teachers in the Polish higher educational environment concerning TPACK factors allows to state that about half of the respondents scored a medium level in the examined range for both factors (PK and TK). About a third of respondents (34% F1PK and 30% F2TK) show a low level of digital competences. Polish academic teachers scored lowest on a higher level of digital competences (19% for the F1PK and 16% for the F2TK).

4.2 Relationships between demographics and professional backgrounds and areas of digital competences

To examine the correlations between demographic and professional backgrounds and areas of digital competences the following variables were taken into account: gender, age, years of teaching, titles and degrees (as the demographic background); providing of on-line course; the percentage of teaching time for using digital technologies, using presentation for teaching, watching videos during classes, creating videos for teaching, using online learning environments, using digital quizzes or polls, using interactive apps or games, using digital posters, mindmaps, planning tools, using blogs or wikis (as the professional background).

Taking into account gender, this variable differentiated IML (Mmale = 2.621; SD = .471 vs. Mfemale = 2.386; SD = .588), $t(94) = 2.176$; $p < .05$; Cohen's d = .450) and RU (Mm = 2.298; SD = 0.399 vs. Mf = 2.477; SD = .450), $t(94) = -2.065$; $p < .05$; Cohen's d = .430).

Perception of Information and Technology Literacy (F2TK) among male respondents was higher compared with the perceptions of female participants. Opposite results concern Responsible Use (F2TK) which were higher among female compering with the male.

Other relationships were analyzed using Persona correlations, significant results are summarized in Table 4.

Table 3. *Academic teachers' levels of digital competences*

Areas and groups of digital competences	TPACK factors	The levels of competence					
		Low		Medium		High	
		N	%	*N*	%	*N*	%
Area 1 Professional Engagement							
1.1 OC	TK	28	27	59	57	16	15
1.2 PC	TK	30	29	53	51	20	19
1.3 RP	TK	37	36	43	41	23	22
1.4 DCPD	PK	55	53	34	33	14	13
Area 2 Digital Resources							
2.1 SDR	TK	29	28	74	71	0	0
2.2 CMDR	TK	31	30	64	62	8	8
2.3 MPSDR	TK	28	27	53	51	22	21
Area 3 Teaching and Learning							
3.1 T	TK	35	34	46	44	22	21
3.2 G	TK	26	25	52	50	25	24
3.3 CL	PK	28	27	57	55	18	17
3.4 SrL	PK	29	28	56	54	18	17
Area 4 Assessment							
4.1 AS	PK	40	38	42	40	21	20
4.2 AE	PK	31	30	53	51	19	18
4.3 FP	PK	33	32	50	48	20	19
Area 5 Empowering Learners							
5.1 AI	PK	31	30	48	46	24	23
5.2 DP	PK	32	33	53	51	17	16
Area 6 Facilitating Learners' Digital Competence							
6.1 IML	TK	27	26	55	53	21	20
6.2 DCC	TK	28	27	65	63	10	10
6.3 DCCr	TK	28	27	57	55	18	17
6.4 RU	TK	30	29	53	51	20	19
6.5 DPS	TK	39	38	53	51	11	11
Average value for PK/TK			34/30		47/54		19/16

There were significant negative relationships between demographic background variables (age, years of teaching and titles and degrees) and the majority of areas of digital competences. The highest

negative correlations were between age and DCPD (F1PK) and SDR (F2TK), years of teaching and DP (F1PK), and titles and degrees and DCPD (F1PK).

All these results could be explained by the low technological skills of the older generation of academic staff in Poland's higher education environment as well as their reluctance according to digital professional development. At the same time, there were no statistically significant correlations between age and AE (F1PK), FP (F1PK) as well as between years of teaching and CL (F1PK) and FP (F1PK). All of these areas of digital competences were from the first Pedagogical Knowledge TPACK Factor. And obtained results might be clarified by academician teaching experience what allows them to be updated with analyzing evidence to support students, organize collaborative learning as well as use different ways to provide feedback either with the use of digital approaches.

The majority of positive associations were between variables from the professional background and a lot of areas of digital competencies from both TPACK factors (PK and TK). The highest correlations were between SrL and using for teaching online learning environments, digital quizzes or polls, interactive apps or games; AS and online learning environments; FB and online learning environments, and digital quizzes. In the case of TPACK factors, significant positive correlations were between F1PK and such professional background variables as providing on-line courses; the percentage of teaching time for using digital technologies; creating videos for teaching; using online learning environments, digital quizzes or polls, interactive apps or games, digital posters, mindmaps, planning tools, blogs or wikis. All these activities prove academic teachers' digital pedagogical knowledge and influence positively on the rising of the digital competences' level. Significant negative correlations were noticed between F2TK and the age of the respondents and positive links with the percentage of teaching time for using digital technologies in class and using blogs or wikis for teaching and learning.

5. Discussion

Investigation of the levels of Polish university teachers' digital competences based on percentiles shows that near 50% of the respondents are at the medium level in the examined range for both factors (PK and TK), near 30% demonstrated low level and less than 20% are in the higher level of the digital competences. These results might be opposite to the statement about the lower rating of the technological knowledge of the university teachers (Blayone et al., 2018; Castéra et al., 2020; Cubeles et al., 2018).

The second aim was to find links between university teachers' backgrounds variables and areas of digital competences. On completion of a joint analysis of the responses, the averages of the different areas of digital competences were compared to study whether there were significant differences according to the respondents' demographic and professional backgrounds.

Perception of Information and Technology Literacy (F2TK) among male respondents was higher compared with the perceptions of female participants. These results proved previous studies conclusions that male teachers are more confident in using computers than their female colleagues (Markauskaite, 2006); males report higher T-competency than females (J. Koh et al., 2015; Scherer et al., 2017). Opposite results concern Responsible Use (F2TK) which were higher among female compering with the male. These results might be explained that EFA analysis showed the similar practical significance of the RU for both factors – pedagogical and technological knowledge. So, females in our study demonstrated higher scores in the area which could belong to Pedagogical Knowledge factor. This results confirming the studies which gave similar conclusions (Lin et al., 2013; Luik et al., 2017), and it is in contrast with one of the last study which claims that there is no gender difference in the TPACK perception (Castéra et al., 2020).

Regarding the rest of demographic variables (age, years of teaching and titles and degrees), significant negative correlations have been confirmed (Castéra et al., 2020; J. H. L. Koh et al., 2010; Lee & Tsai, 2010; Luik et al., 2017). This result is also in contrast to previous studies, such as Cubeles (2018) where didn't confirm differences in the TPACK domains for any age group and Lin et al. (2013) who argued that gender did not have a significant effect on the preservice teachers' perceptions of pedagogical knowledge and technological knowledge. The highest negative correlations were between age and Digital Certified Program Development (DCPD) area which belongs to the Pedagogical knowledge factor and Selecting Digital Resources (SGR) area from the Technological Knowledge factor. To cope with this negative trend the training modules based on the specific lacks should be organized in each university. Since age is an important factor influencing technology knowledge and to

integrate it into instruction, Learning Activity Types approach (Hofer & Harris, 2010) for building TPACK and differentiating experimented and unexperimented teacher educators would be an interesting framework for developing teacher educators' TPACK (Castéra et al., 2020).

There were noticed a lot of positive associations between variables from a professional background and different areas of digital competences from both TPACK factors (PK and TK). The biggest positive influence on the higher scores of digital competences was using for teaching online learning environments, digital quizzes or polls, interactive apps or games; providing on-line courses; creating videos for teaching. The values obtained could be due to the intrinsic use of technology in the online format as the professors have to design their course and adapt the contents to an online learning environment and this process itself improves their technological knowledge (Cubeles et al., 2018). Virtual collaboration increases teachers' opportunities to work with different technologies (Bueno-Alastuey et al., 2018), increases critical thinking, and develops collaboration skills (Kopcha et al., 2014). This coincides with other studies that teacher achievement goal orientation is strongly associated with practices of pedagogical ICT use (Karaseva et al., 2018). Our findings reveal that a video is a key tool in teaching and learning, using video for remote teaching/learning is commonplace in higher education and the group of regular video producers contains a larger proportion of university teachers (Espino et al., 2020).

6. Conclusion

We can conclude that the study survey for investigation of teachers' digital competencies developed on the base of the TPACK scale connected with the self-assessment tool of the European Competence Framework for the Digital Competence of Educators is valid and useable in the higher education context. The CFA confirmed the two-factor TPACK model of technology and pedagogy areas.

Polish academic teachers seem to have a medium level of digital competences both in Pedagogical as well as Technological Knowledge. Therefore, teacher training and re-training programs for the professional development of university teachers should pay more attention to those elements. Also, it was not surprising that age, years of experience teaching and titles, and degrees of university teachers negatively correlated their Technology Knowledge; however, we did not expect that their evaluations on some domains of Pedagogical Knowledge also be significant.

The present study argues about the positive influence of practical use of different digital technologies for teaching and learning on the rise of all areas of teachers' digital competences. Specifically aimed at university teachers, the developed and tested survey with satisfactory validity and reliability proposed in this paper may be useful to further explore the TPACK of university teachers in other countries. Moreover, it is the next challenge to discover indicators to qualify the teachers' professional development in different areas of digital competences.

Table 4. *Correlations for some demographic and professional backgrounds variables*

Areas of Digital Competences	1	2	3	4	5	6	7	8	9	10	11	12	13
1.1 OC	-.202*			.252*	.245*			.269**	**.475****	**.375****	.360**	**.374****	.342**
1.2 PC					.215*		.199*	.368**	.290**	.337**	**.428****	**.379****	.323**
1.3 RP	-.231*			.242*	.291**			.256**	.317**	.247*	.269**	.230*	.310**
1.4 DCPD	-.360**	-.246*	-.254**					.241*	.384**	.231*	.297**	.228*	.216*
2.1 SDR	-.304**					.252*							.297**
2.2 CMDR					.249*				.264**		.267**	**.379****	
2.3 MPSDR						-.233*							.241*
3.1 T				.197*	.235*				.362**	.218*	.235*	.276**	.267**
3.2 G				.233*	.297**			.329**	.318**	.314**	.236*	.474**	
3.3 CL					.228*							.213*	
3.4 SrL	-.196*	-.195*	-.203*	.291**	.316**			.342**	**.574****	**.598****	**.524****	.434**	.309**
4.1 AS			-.196*	.331**	.260**			**.405****	**.573****	**.487****	**.498****	.360**	.240*
4.2 AE								**.384****	**.409****	.311**	.289**	**.390****	.234*
4.3 FP				.328**	.248*			.267**	**.497****	**.510****	.411**	**.425****	**.428****
5.1 AI												.207*	
5.2 DP	-.248*	-.266**	-.198*		.199*			.268**	**.385****	.297**	.247*		.337**
6.1 IML	-.118*			.225*					.325**	**.388****	.288**	.309**	.319**
6.2 DCC												.248*	.213*
6.3 DCCr					.197*								.242**
6.4 RU													

6.5 DPS					.269**			.216*	.268**	.340**	.278**	.301**	.323**
F1PK				.326**	.278**			.425**	.576**	.527**	.490**	.504**	.350**
F2TK	-.267**				.233*				.248*	.196*			.332**

1 – age; 2 – years of teaching; 3 – titles and degrees; 4 – providing online courses; 5 – the percentage of teaching time for using digital technologies; 6 – using presentation in teaching; 7 – watching videos during classes; 8 – creating videos for teaching; 9 – using online learning environments; 10 – using digital quizzes or polls; 11 – using interactive apps or games; 12 – using digital posters, mindmaps, planning tools; 13 – using blogs or wikis

* correlation is both sides significant on the level 0.05; ** correlation is both sides significant on the level .01

References

Benson, S., & Ward, C. (2013). Teaching with technology: using TPACK to understand teaching expertise in online higher education. *Journal of Educational Computing Research*, *48*(2), 153–172.

Blayone, T. J. B., Mykhailenko, O., VanOostveen, R., Grebeshkov, O., Hrebeshkova, O., & Vostryakov, O. (2018). Surveying digital competencies of university students and professors in Ukraine for fully online collaborative learning. *Technology, Pedagogy and Education*, *27*(3), 279–296. https://doi.org/10.1080/1475939X.2017.1391871

Bueno-Alastuey, M. C., Villarreal, I., & García Esteban, S. (2018). Can telecollaboration contribute to the TPACK development of pre-service teachers? *Technology, Pedagogy and Education*, *27*(3), 367–380. https://doi.org/10.1080/1475939X.2018.1471000

Castéra, J., Marre, C. C., Chan, M., Yok, K., Sherab, K., Impedovo, M. A., & Sarapuu, T. (2020). *Self-reported TPACK of teacher educators across six countries in Asia and Europe*.

CEDEFOP. (2014). Terminology of European education and traninig. In *Cedefop*. https://doi.org/10.2801/15877

Cubeles, A., Riu, D., Cubeles, A., & Riu, D. (2018). The effective integration of ICTs in universities : the role of knowledge and academic experience of professors The effective integration of ICTs in universities : the role of knowledge and academic experience of professors. *Technology, Pedagogy and Education*, *5139*, 1–11. https://doi.org/10.1080/1475939X.2018.1457978

Espino, J. M. S., Suárez, M. D. A., & González-Henríquez, J. J. (2020). Video for teaching: classroom use, instructor self-production and teachers' preferences in presentation format. *Technology, Pedagogy and Education*, *00*(00), 1–16. https://doi.org/10.1080/1475939X.2020.1726805

European Commission. (2019). *Digital Economy and Society Index Report 2019: Human Capital - Digital Inclusion and Skills*. https://ec-europa-eu.proxy.library.uu.nl/newsroom/dae/document.cfm?doc_id=59976

Ghomi, M., & Redecker, C. (2019). Digital competence of educators (DigCompedu): Development and evaluation of a self-assessment instrument for teachers' digital competence. *CSEDU 2019 - Proceedings of the 11th International Conference on Computer Supported Education*, *1*(Csedu), 541–548. https://doi.org/10.5220/0007679005410548

Hofer, M., & Harris, J. (2010). Differentiating TPACK development: Using learning activity types with inservice and preservice teachers. *Proceedings of Society for Information Technology Teacher Education International Conference 2010*, *23*(3), 3857–3864. http://www.editlib.org/p/33981

Karaseva, A., Pruulmann-Vengerfeldt, P., & Siibak, A. (2018). Relationships between in-service teacher achievement motivation and use of educational technology: case study with Latvian and Estonian teachers. *Technology, Pedagogy and Education*, *27*(1), 33–47. https://doi.org/10.1080/1475939X.2017.1339633

Koehler, M. J., & Mishra, P. (2009). What Is Technological Pedagogical Content Knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60–70.

Koh, J., Chai, C., Benjamin, W., & Hong, H. Y. (2015). Technological Pedagogical Content Knowledge (TPACK) and Design Thinking: A Framework to Support ICT Lesson Design for 21st Century Learning. *Asia-Pacific Education Researcher*, *24*(3), 535–543. https://doi.org/10.1007/s40299-015-0237-2

Koh, J. H. L., Chai, C. S., & Tsai, C. C. (2010). Examining the technological pedagogical content knowledge of Singapore pre-service teachers with a large-scale survey. *Journal of Computer Assisted Learning*, *26*(6), 563–573. https://doi.org/10.1111/j.1365-2729.2010.00372.x

Kopcha, T. J., Ottenbreit-Leftwich, A., Jung, J., & Baser, D. (2014). Examining the TPACK framework through the convergent and discriminant validity of two measures. *Computers and Education*, *78*, 87–96. https://doi.org/10.1016/j.compedu.2014.05.003

Lee, M. H., & Tsai, C. C. (2010). Exploring teachers' perceived self efficacy and technological pedagogical content knowledge with respect to educational use of the World wide Web. *Instructional Science*, *38*(1), 1–21. https://doi.org/10.1007/s11251-008-9075-4

Lin, T. C., Tsai, C. C., Chai, C. S., & Lee, M. H. (2013). Identifying Science Teachers' Perceptions of Technological Pedagogical and Content Knowledge (TPACK). *Journal of Science Education and Technology*, *22*(3), 325–336. https://doi.org/10.1007/s10956-012-9396-6

Luik, P., Taimalu, M., & Suviste, R. (2017). *Perceptions of technological , pedagogical and content knowledge (TPACK) among pre-service teachers in Estonia*. https://doi.org/10.1007/s10639-017-9633-y

Markauskaite, L. (2006). *Gender issues in preservice teachers ' training : ICT literacy and online learning*. *22*(1), 1–20.

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge : A Framework for Teacher Knowledge. *Teachers College Record*, *108*(6), 1017–1054.

Redecker, C. (2017). *Digital Competence of Educators*. https://doi.org/10.2760/159770

Scherer, R., Tondeur, J., & Siddiq, F. (2017). On the quest for validity: Testing the factor structure and measurement invariance of the technology-dimensions in the Technological, Pedagogical, and Content Knowledge (TPACK) model. *Computers and Education*, *112*, 1–17.

https://doi.org/10.1016/j.compedu.2017.04.012
Schmid, E. C., & Hegelheimer, V. (2014). Collaborative research projects in the technology-enhanced language classroom: Pre-service and in-service teachers exchange knowledge about technology. *ReCALL*, *26*(3), 315–332. https://doi.org/10.1017/S0958344014000135
Starkey, L. (2020). A review of research exploring teacher preparation for the digital age. *Cambridge Journal of Education*, *50*(1), 37–56. https://doi.org/10.1080/0305764X.2019.1625867
The digitalisation of Polish Education Vision and proposals. (2016). https://ngoteka.pl/bitstream/handle/item/367/cyfryzacja-polskiej-edukacji_final_EN.pdf?sequence=1
UNESCO. (2011). *UNESCO ICT Competency Framework for Teachers*. https://unesdoc.unesco.org/ark:/48223/pf0000213475
Voogt, J., & Mckenney, S. (2016). TPACK in teacher education : are we preparing teachers to use technology for early literacy ? *Technology, Pedagogy and Education*, *5139*(May). https://doi.org/10.1080/1475939X.2016.1174730