REVIJA ZA ELEMENTARNO IZOBRAŽEVANJE
JOURNAL OF ELEMENTARY EDUCATION
Vol. 16, No. 1, pp. 79–92, March 2023

THE IMPACT OF THE TEACHER EDUCATION STUDY PROGRAM ON THE DEVELOPMENT OF TPACK

KAROLINA DOBI BARIŠIĆ & MAJA BRUST NEMET

Josip Juraj Strossmayer University of Osijek, Faculty of Education, Osijek, Croatia

CORRESPONDING AUTHOR/KORESPONDENČNI AVTOR
mbrust@foozos.hr

Potrjeno/Accepted
23. 9. 2022

Objavljeno/Published
22. 3. 2023

Abstract/Izvleček This study compares students' TPACK at the beginning and at the end of their college education according to their involvement and the number of computer science courses. Research was conducted at the Faculty of Education in Osijek, Croatia, with the same generation of students, in 2015 (N=71) and 2020 (N=43). The results showed a statistically significant difference for Technological, Pedagogical and Content Knowledge, for all students in the sample and for students with additional computer science courses. In the case of overall TPACK, there is no difference for the overall sample of students but for students with additional computer science courses, the difference is significant.

Keywords:
pedagogical knowledge, pre-service teachers, teacher education, technological knowledge, TPACK

Vpliv študijskega programa izobraževanja učiteljev na razvoj modela TPACK

V članku analiziramo komunikacijske sposobnosti vzgojiteljev/vzgojiteljic med starševskimi sestanki v vrtcih. V skladu z metodologijo kvalitativnega raziskovanja smo opazovali in zabeležili izbrane elemente komunikacije zaposlenih med 12 starševskimi sestanki v različnih vrtcih. Rezultati so pokazali, da so bili opazovani starševski sestanki dobro pripravljeni, strukturirani, primerni in interaktivni, izvedeni z ustreznim besediščem in elementi učinkovite govorne komunikacije. Največja pomanjkljivost komunikacije zaposlenih je bila nerazvita tehnika aktivnega poslušanja. Prav tako so bile očitne razlike v individualnih komunikacijskih spretnostih zaposlenih. Rezultati te raziskave lahko služijo kot orodje za razmišljanje o pedagoški praksi pri zgodnjem učenju in poučevanju.

Ključne besede:
pedagoško znanje, predšolski učitelji, izobraževanje učiteljev, tehnološko znanje, model TPACK

UDK/UDC:
378.091.3:004

DOI https://doi.org/10.18690/rei.2064

University of Maribor Press

Introduction

The Croatian Qualifications Framework (CQF, Ministry of Science and Education, 2021) is an instrument for regulating the qualifications system in the Republic of Croatia. The National Development Strategy 2030 of the Republic of Croatia (Croatian parliament, 2021) emphasizes the importance of acquiring and developing basic and vocational competences through raising the digital competence of professionals from non-information professions, as well as the digital transformation and informationalisation of the education system. In the Strategic framework for digital maturation of schools and the school system in the Republic of Croatia and in Education Action Plan 2021-2027, teachers' self-confidence in integrating ICT into the teaching process is important, but during their initial education, teachers are not prepared to use ICT in teaching which emphasizes the importance of initial teacher education in the areas of applied ICT in teaching. In addition to strategic documents, scientific research also confirms the importance of initial teacher education in the area of ICT application in teaching (European Commission, 2020). The use of ICT in teaching enables the use of new teaching methods, and easier access to information, while offering diversity of knowledge transfer and storage (Ministry of Science and Education, 2020). The Strategy for Education, Science and Technology (Ministry of Science and Education, 2014) emphasizes the importance of investing in people (teachers) who will be responsible for the integration of technology in education. In the Republic of Croatia, the goal is to integrate technology tailored to students, teachers and other school employees in all primary and secondary schools by 2030, with the purpose of developing learning, teaching and business, taking into account the needs of society, community and other stakeholders (Ministry of Science and Education, 2020). Research (Ministry of Science and Education, 2020) has shown that during their initial education, teachers are not being prepared to use ICT in teaching. The importance of professional development in the field of ICT application to learning and teaching should be emphasized through the development of a methodology for the use of ICT in teaching, a guide for applying ICT in individual subjects and individualized approaches. This also includes the development of university educational programs in the field of ICT application in teaching (Ministry of Science and Education, 2020).

Literature review

The complexity of the teaching profession is constantly increasing because of the rapid expansion of new scientific knowledge, global mobility, technical development and technology, new social relations and the organization of life and work (Đuranović, 2005). To successfully assume all these new roles, the teacher must be open, ready for change and motivated for lifelong learning and continuous professional development (Razdevšek Pučko, 2005). Teachers need to possess pedagogical and technological competences to be able to teach students and strengthen them in the field of digital competences. The integration of ICT into teaching and across the entire education system is a complex area (Ministry of Science and Education, 2020). Eurydice (2003) identifies teaching using modern ICT technology as an important area of new teacher competence that should be an integrative part of teachers' pedagogical competences and become a necessary component of lifelong learning content, as well as an integrative part of modern teacher education programs (Brust Nemet, 2015). Future teachers should be trained to work with information, technology and knowledge; work with people - students, associates and other partners in education; and to work in and with society, at local, regional, national and European levels, as well as at the global level ("Education and Training", 2010). The shortcomings include a digital divide that means unequal conditions in terms of digital technology in different schools (Ministry of Science and Education, 2020).

When differences in TPACK in relation to gender are observed, research shows that either there are no differences related to gender (Schmid et. al., 2021), or that the differences are inor and inconsistent throughout the components of TPACK (Ergen et. al, 2019; Scherer, Siddiq, and Teo, 2015).

The development of TPACK among pre-service teachers is a complex process with important factors such as previous experience with technology, subject knowledge, and beliefs about the use of technology (Mudzimiri, 2012). The inclusion of ICT in courses during study programs, as well as teaching about its integration, can empower students to work with digital technology (Choe and Lee 2015; Yigit, 2014). The development of TPACK can also be influenced by the education system as a contextual factor (Dobi Barišić et. al, 2019).

Pre-service teachers should be better enabled to develop competence in technology integration planning (Mudzimiri, 2012). Research conducted by Baran et al. (2019) pointed out the positive connection between the teacher education program itself and the development of TPACK.
Significant differences in the level of TPACK components were found in pre-service teachers attending STEM courses compared to those attending social science courses (TK and TCK component) (Schmid et. al, 2021). Similar results were obtained in a study by Altun and Akyildizs (2017), which showed that pre-service teachers preparing to teach science have obtained a higher level of TPACK than pre-service teachers preparing to teach social sciences and Turkish language. Moreover, a difference (a positive effect) was observed in students who took the designed lecture and those who took ordinary ICT literacy lectures (TK, TCK, TPK and TPACK) (Choe and Lee, 2015). In contrast, there are studies that have found no statistically significant differences in TPACK components among teachers in the areas of mathematics, science, and literacy (Tokmak et al., 2013).

TPACK framework

One of the frameworks that describes successful integration of digital technology in teaching is TPACK, developed by Koehler and Mishra in 2009 (Koehler and Mishra, 2009). In the TPACK framework (Figure 1), there are three main components of teachers' knowledge: content, pedagogy, and technology. Equally important to the model are the interactions between and among these bodies of knowledge, represented as PCK (pedagogical content knowledge), TCK (technological content knowledge), TPK (technological pedagogical knowledge), and TPACK (technological, pedagogical, content knowledge). Back in 2009, Koehler and Mishra stated that integrating new technologies into teaching posed a major challenge for teachers. Therefore, they developed the theoretical framework of Technological Pedagogical Content Knowledge (TPACK) as a framework for the successful integration of digital technology in teaching.

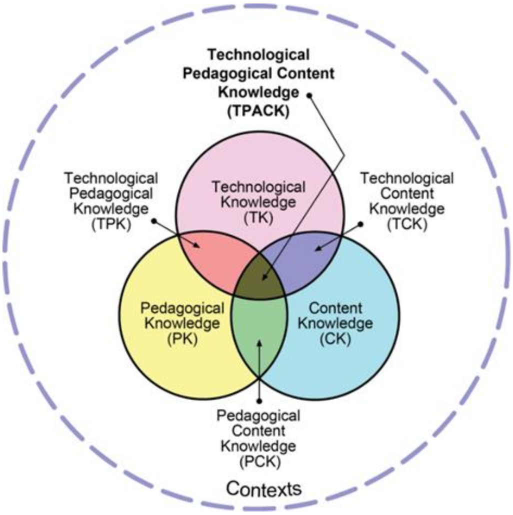

Figure 1: TPACK framework (Reproduced with the permission of the publisher, © 2012 by tpack.org)

TPACK is a new form of knowledge that derives from basic pedagogical, technological and content knowledge. Although this knowledge forms the foundation of TPACK, it differs for each of them. TPACK means effective teaching with the help of technology, and in order to make this possible, it is necessary to have knowledge from all three areas separately, and more importantly, to understand the interactions between these areas (Koehler and Mishra, 2009).

The main goal of this theoretical framework is to connect the knowledge of teachers from the basic domains of the framework with their actions and the effects of these procedures (Koehler and Mishra, 2009).Naslov naslov.

Research aims and hypotheses

The aim of the research is to determine whether there is a difference in the development of TPACK in relation to the number of computer science courses that students attend during their studies.

At the Faculty of Education, after the first semester, students choose between three elective modules, which differ from each other in 20% of courses that are specific to the selected module (Table 1). All students, regardless of the chosen module, take six computer science courses, four of which relate to general computer knowledge, while two contain elements of the application of ICT in teaching. Students who choose module B take an additional nine computer science courses, six of which relate to general computer knowledge, while three contain elements of the application of ICT in teaching.

Considering the purpose of module B (Computer Science orientation), we specifically studied whether the number and nature of computer science courses affects the development of TPACK.

Based on the reviewed literature, this study aims to address the following hypotheses:

H1: The involvement of computer science courses in the teacher education study program influences the development of students' TPACK.

H2: The number of computer science courses in the teacher education study program influences the development of students' TPACK.

Table 1: Elective modules at the Faculty of Education, University of Osijek, Croatia

Module A *Developmental orientation* - selected courses from pedagogy, psychology and methodology broadly enable students to understand specific issues in education and child development.
Module B *Computer science orientation* - more thoroughly trains the student to use information and communication technologies in the education of children in the first four grades of primary school.
Module C *Foreign language orientation* – additionally trains students for teaching younger school-age children foreign language.

Methodology

The study is longitudinal. The data were collected using the survey method combining demographic questions and questions from SPTKTT (Schmidt et al., 2009). SPTKTT is a tool for self-assessment of knowledge about the application of technology in teaching and was created for preservice teachers (preschool and lower grades of primary school) with the aim of examining their TPACK development.

It consists of 47 items grouped by components of the TPACK theoretical framework, with answers located on a 5-point semantic scale (Likert type). The questionnaire was translated into Croatian by the double translation method (Dobi Barišić, 2018). The questionnaire was conducted via the Survey of Preservice Teachers' Knowledge of Teaching and Technology online, in the first phase via the learning management system (based on Moodle), and in the second phase by using Google Forms. The study was carried out at the Faculty of Education, Josip Juraj Strossmayer University of Osijek, Republic of Croatia. The sample consists of students who enrolled in the Integrated undergraduate and graduate university teacher study in the academic year 2015/16 (78 students). Research was conducted in two phases: first, when respondents enrolled in the initial study year in the academic year 2015/2016 (N1=71), and the second time, after completing all courses (or after graduating) in the academic year 2020/2021 (N2=42).
The implementation of the online Questionnaire was followed by quantitative data analysis using the statistical program SPSS 19.0. Since the data were collected on a 5-point semantic scale (Likert type), non-parametric statistics was performed; more precisely, the Wilcoxon test was used.

Results and interpretation

Demographic data--gender, module and student status--(only for 2020), are shown in Table 2.

Table 2: Demographic data (gender, module and student status)

Gender				
		2015		2020
	N	%	N	%
Female	67	94.4%	41	97.6%
Male	4	5.6%	1	2.4%
Student status				
		2015		2020
	N	%	N	%
All courses completed	-	-	11	26.2%
Graduated	-	-	31	73.8%
Module				
		2015		2020
	N	%	N	%
Module B	15	21.1%	10	23.8%
Module A & Module C	56	78.9%	32	76.2%

In the second table, the number of male students is underrepresented in the study, which is a common ratio in teacher education research. Data on the status of the student (graduated or passed all exams) and the module they attended are also presented.

Table 3 shows the descriptive statistics for a sample of respondents who attend Module A and Module C, and for respondents who attended Module B. Descriptive statistics is shown for each sub-scale of the SPTKTT questionnaire, using data from 2015 and 2020, and includes the arithmetic mean, standard deviation, median and mean rank.

Table 3: Descriptive statistics and results of Wilcoxon test in relation to the research phase

Sub-scale	phase	N	Q1	Median	Q3	Mean Rank	Wilcoxon test	
							z	*p*
TK	2015	71	3.14	3.57	4.00	46.78	-3.41	<0.05
	2020	42	3.71	4.07	4.61	74.27		
CK	2015	71	3.00	3.33	3.67	43.11	-4.71	<0.05
	2020	42	3.73	4.00	4.42	80.49		
PK	2015	71	3.29	3.86	4.14	45.08	-3.82	<0.05
	2020	42	4.00	4.43	4.75	77.14		
PCK	2015	71	3.00	3.50	4.00	43.54	-4.25	<0.05
	2020	42	4.00	4.25	5.00	79.76		
TCK	2015	71	3.00	3.50	4.00	44.55	-4.10	<0.05
	2020	42	4.00	4.33	5.00	78.05		
TPK	2015	71	3.20	3.80	4.00	45.92	-3.93	<0.05
	2020	42	3.80	4.40	5.00	75.73		
TPACK	2015	71	3.13	3.50	4.00	52.62	-1.59	>0.05
	2020	42	3.46	3.75	3.91	64.40		

The TPACK of all students, regardless of the selected module, after completing all courses, or after graduating, (Mdn=3.75, Q1=3.46, Q3=3.91) is higher than the TPACK at the beginning of their college education (Mdn=3.50, Q1=3.13, Q3=4.00) (Table 3). A Wilcoxon test indicated that the difference was not statistically significant, $z = -1.59$, $p>0.05$ (Table 3).

The results of the Wilcoxon test for all students (regardless of the module selected), in relation to the beginning and end of their studies, suggest the rejection of hypothesis H1: i.e., the involvement of computer science courses in the teacher education study program does not influence the development of their TPACK.

Table 4: Descriptive statistics and results of Mann-Whitney U-test in relation to selected module

Sub-scale	phase	N	Q1	Median	Q3	Mean Rank	Wilcoxon test	
							z	*p*
TK	Module B	10	3.96	4.14	4.64	24.40	-0.56	>0.5
	Module A&C	32	3.46	4.07	4.68	20.59		
CK	Module B	10	3.75	3.88	4.27	21.05	-0.41	>0.5
	Module A&C	32	3.58	4.08	4.42	21.64		
PK	Module B	10	4.25	4.50	4.89	23.55	-0.36	>0.5
	Module A&C	32	4.00	4.43	4.71	20.86		
PCK	Module B	10	4.00	4.38	5.00	22.75	-0.96	>0.5
	Module A&C	32	4.00	4.25	5.00	21.11		
TCK	Module B	10	4.00	5.00	5.00	28.25	-1.15	>0.5
	Module A&C	32	3.75	4.00	4.92	19.39		
TPK	Module B	10	3.80	4.20	4.60	32.00	-1.68	>0.5
	Module A&C	32	3.80	4.20	4.60	18.22		
TPACK	Module B	10	4.50	4.94	5.00	32.30	-2.32	<0.5
	Module A&C	32	3.91	4.25	4.50	18.13		

The TPACK of students attending Module B (Mdn=4.94, Q1=4.50, Q3=5.00) is higher than those of students from Module A and Module C (Mdn=4.25, Q1=3.91, Q3=4.50) (Table 4). A Wilcoxon test indicated that this difference was statistically significant, z= -2.32, p<0.5.

The results of the Mann-Whitney U-test in relation to Module after completing all courses, or after graduating, suggest the acceptance of hypothesis H2: i. e. the number of computer science courses in the teacher education study program does influence the development of their TPACK.

Discussion

Mailizar, Hidayat, and Artika (2021) found among high school math teachers that the demographic characteristics of teachers, such as gender and level of education, determined their TPACK. Gómez-Trigueros, and De Aldecoa (2021) found that female teachers had very poor self-perceptions of their own digital competence.

According to the research available to the authors, most other studies report no differences related to gender (Schmid et al., 2021) or minor differences (Ergen et. al, 2019; Scherer, Sissiq and Teo, 2015), while in this study there are insufficient male students to determine a difference by gender, but a difference was determined according to students' selected study module.

The results of this study showed that the involvement of computer science courses, regardless of number and content, positively affected the development of all types of knowledge (TK, Pk, CK, TPK, TCK, PCK) except TPACK. Nevertheless, the development of TPACK is positively influenced by the number of computer science courses that students take. These results confirm those from research among Chinese students at teacher training colleges, showing that students do not distinguish between technological-pedagogical knowledge and knowledge of technological content (Qiu et al., 2022).

If we look at the research conducted by Voithofer and Nelson (2021) who found that faculty members were increasingly integrating technology into curricula and teaching but that the level of TPACK adoption was quite low and that TPACK concepts differed greatly, we may wonder whether technology integration into other courses (that are not computer science oriented) is sufficient for the development of TPACK, or whether it is still necessary to offer specific courses to teach students how to properly integrate technology into teaching. In doing so, we should always take into account that the influence of will and desire of the individual teacher is another important factor to be taken into account, which Dikmen and Demirer (2022) emphasize in their research. Dikmen and Demirer (2022) believe that those teachers who feel digitally more competent will more often integrate technology into teaching. In addition to teacher competence, global factors such as the COVID-19 pandemic, which has led to more frequent online teaching, impose on teachers the strengthening of digital competences. At what level TPACK developed during the pandemic and under what influence (self-initiative or initiatives of superiors) still needs investigation.

This study has shown that the teaching content of Module B (computer science oriented) has a greater positive impact on TPACK, which is in line with results from Lachner et al. (2021), which highlighted the need for continuous student support for the development of professional knowledge and motivation related to the inclusion of technology in teaching.

The advantages of this longitudinal study are the comparison of the level of pedagogical and technological knowledge of students, future teachers at the beginning and end of their studies and determining the connection between higher knowledge of students and the study program they attend. The disadvantages of this research are the small number of respondents and the self-assessment of students, where there may be a potential for giving socially desirable answers.

Conclusion

Technological Pedagogical Content Knowledge (TPACK) shows us whether teachers are competent to effectively co-construct, organize and implement a teaching process in which technology is implemented. Teachers with a higher level of knowledge in pedagogy and technology can be expected to feel more competent, motivated and ready to integrate technology into teaching, which proved necessary during the global COVID-19 pandemic.

When differences in TPACK in relation to gender are observed, research has shown either no differences related to gender (Schmid et. al., 2021), or minor differences distributed inconsistently across the components of TPACK. In this study we could not reach a conclusion regarding gender, since the number of male students in the sample was very low.

Development of TPACK depends on the number and nature of ICT courses that students attend, which means that there is a difference between courses that include lectures on technology application and ordinary ICT literacy lectures.

It can be concluded that there is a positive connection between the teacher education program itself and the development of TPACK, which is in accordance with research by Baran et al. (2019). The results of the study emphasize the importance of further analysis of study programs, as well as the need to enrich study programs with pedagogical and IT content intended for future teachers so that they can encourage students' key competences for lifelong learning, especially digital. Moreover, in future research it will be necessary to continue researching the development of TPACK among Croatian students at teacher training colleges with regard to global factors, especially changes in study programs caused by the COVID-19 pandemic.

References

Alun, T., and Akyıldız, S. (2017). Investigating student teachers' technological pedagogical content knowledge (TPACK) levels based on some variables. *European Journal of Education Studies, 3*(5), 467–485. https://doi.org/10.5281/zenodo.555996

Baran, E., Canbazoglu Bilici, S., Albayrak Sari, A., and Tondeur, J. (2019). Investigating the impact of teacher education strategies on preservice teachers' TPACK. *British Journal of Educational Technology, 50*(1), 357–370.

Baser, D., Akkus, R., Akayoglu, S., and Top, E. (2021). Training in-service teachers through individualized technology-related mentorship. *Educational Technology Research and Development, 69*(6), 3131–3151. https://doi.org/10.1007/s11423-021-10065-w

Brust Nemet, M. (2015). *Socio-pedagogical competences of teachers in the contemporary school culture curriculum* (Doctoral dissertation). Zagreb: Filozofski fakultet Sveučilišta u Zagrebu.

Choe, H., and Lee, T. (2015). Implementation and Analysis about Technology Knowledge Education Program for Pre-service Teacher based on the TPACK Model. *Journal of the Korea Society of Computer and Information, 20*(2), 231–239. https//doi.org/10.9708/jksci.2015.20.2.231

Dobi Barišić, K. (2018). *The influence of peer and self-assessment on future teachers' approach to learning and use of information and communication technology* (Doctoral dissertation). Varaždin: Fakultet organizacije i informatike Sveučilišta u Zagrebu. Available at: https://urn.nsk.hr/urn:nbn:hr:211:905006 (Accessed: 20/4/2021)

Dobi Barišić, K., Divjak, B., Kirinić, V. (2019). Education Systems as Contextual Factors in the Technological Pedagogical Content Knowledge Framework. *Journal of Information and Organizational Sciences, 43(2),* 163–183. Available at: https://jios.foi.hr/index.php/jios/article–/view/1173/860 (Accessed: 20/4/2021)

Dikmen, C. H., and Demirer, V. (2022). The role of technological pedagogical content knowledge and social cognitive variables in teachers' technology integration behaviors. *Participatory Educational Research, 9*(2), 398-415. https://doi.org/10.17275/per.22.46.9.2

Durdu, L., and Dag, F. (2017). Pre-service teachers' TPACK development and conceptions through a TPACK-based course. *Australian Journal of Teacher Education (Online), 42*(11), 150–171.

Đuranović, M. (2005). *Kurikulum pedagoške kompetencije učitelja (*Master's thesis). Zagreb: Filozofski fakultet.

"Education & Training 2010" (2010). The success of the Lisbon strategy hinges on urgent reforms — Joint interim report of the Council and the Commission on the implementation of the detailed work programme on the follow-up of the objectives of education and training systems in Europe. (2004*). Official Journal, C 104*, 1–19. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52004XG0430(01) [legislation] (Accessed: 20/4/2021)

Ergen, B., Yanpar Yelken, T., and Kanadli, S. (2019). A meta-analysis of research on technological pedagogical content knowledge by gender. *Contemporary Educational Technology, 10*(4), 358–380. https://doi.org/10.30935/cet.634182

European Commission (2020). *Communication from the commission to the European parliament, the council, the European economic and social committee and the Committee of the Regions digital education action plan 2021-2027 resetting education and training for the digital age*. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0624&from=EN (Accessed: 20/4/2021)

European Commission (2019). *Eight Key Competences for Lifelong Learning*. Available at: https://op.eur–opa.eu/en/publication-detail/-/publication/297a33c8-a1f3-11e9-9d01-01aa75ed71a1/langu–age-en (Accessed: 20/4/2021)

European Parliament (2006). *Recommendation of the European Parliament and of the Council of 18 December 2006 on key competences for lifelong learning*. Available at: https://op.europa.eu/en/publication-detail/-/publication/0259ec35-9594-4648-b5a4-fb2b23218096/language-en (Accessed: 20/–4/2021)

EURYDICE (2003). *The Teaching Profession in Europe: Profile, trends and concerns. Key topics in education in Europe, 3*. Brussels: European Commission / EURYDICE.

George, D., and Mallery, P. (2010). *SPSS for Windows step by step. A simple study guide and reference*. Boston: Pearson Education.

Gómez-Trigueros, M., and De Aldecoa, C. Y. (2021). The digital gender gap in teacher education: The TPACK framework for the 21st century. *European Journal of Investigation in Health, Psychology and Education, 11*(4), 1333–1349. https://doi.org/10.3390/ejihpe11040097

Hrvatski sabor (2021). *Nacionalna razvojna strategija Republike Hrvatske do 2030*. [Croatian parliament (2021), Croatian National Development Strategy 2030]. Available at: https://hrvatska2030.hr–/wp-content/uploads/2021/02/Nacionalna-razvojna-strategija-RH-do-2030.-godine.pdf (A–ccessed: 20/5/2021)

Huang, L., and Lajoie, S. P. (2021). Process analysis of teachers' self-regulated learning patterns in technological pedagogical content knowledge development. *Computers and Education, 166*(1), 104169. https://doi.org/10.1016/j.compedu.2021.104169

Koehler, M., and Mishra, P. (2009). What is Technological Pedagogical Content Knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70. Waynesville, NC USA: Society for Information Technology & Teacher Education. Available at: https://www.learntechlib.o–rg/primary/p/29544/ (Accessed: 20/5/2021)

Lachner, A., Fabian, A., Franke, U., Preiß, J., Jacob, L., Führer, C., Küchler, U., Paravicini, W., Randler, C, and Thomas, P. (2021). Fostering pre-service teachers' technological pedagogical content knowledge (TPACK): A quasi-experimental field study. *Computers and Education, 174*, 104304. https://doi.org/10.1016/j.compedu.2021.104304

Mailizar, M., Hidayat, M, and Artika, W. (2021). The effect of demographic variables on mathematics teachers' TPACK: Indonesian context. *Journal of Physics: Conference Series, 1882*(1), 012041. https://doi.org/10.1088/1742–6596/1882/1/012041

Ministarstvo znanosti i obrazovanja (2020). *Strateški okvir za digitalno sazrijevanje škola i školskog sustava u Republici Hrvatskoj (2030)*. [Ministry of Science and Technology (2020), Strategic Framework for Digital Maturation of Schools and the School System in the Republic of Croatia (2030)] Available at: https://mzo.gov.hr/UserDocsImages//dokumenti/PristupInformacijama/St–rateski-digitalno2030//Strateski%20okvir%20za%20digitalno%20saz–rijevanje%20skola–%20i%20skolskog%20sustava%20u%20Republici%20Hrvatskoj%20-%202030.pdf (Access–ed: 20/5/2021)

Ministarstvo znanosti i obrazovanja (2021). *Zakon o Hrvatskom kvalifikacijskom okviru*. [Ministry of Science and Education (2021), The Croatian Qualifications Framework Act] Available at: https://www.zakon.hr/z/566/Zakon-o-Hrvatskom-kvalifikacijskom-okviru (Accessed: 20–/6/2021)

Ministarstvo znanosti, obrazovanja i sporta (2014). *Nove boje znanja – strategija obrazovanja, znanosti i tehnologije*. [Ministry of Science, Education and Sports (2014), New Colours of Knowledge-Strategy for Education, Science and Technology] Acailable at: https://mzo–.gov.hr/UserDocsImages/dokumenti/Obrazovanje/Strategija%20obrazovanja,%20znanosti%20i%20tehnologije.pdf (Accessed: 20/6/2021)

Ministarstvo znanosti, obrazovanja i športa (2011). *Nacionalni okvirni kurikulum za predškolski odgoj i obrazovanje te opće obvezno i srednjoškolsko obrazovanje*. [Ministry of Science, Education and Sports (2011), National Curriculum Framework for Preschool Education and General Compulsory and Secondary Education] Available at: http://mzos.hr/datoteke/Nacionalni_okvirni_kurik–ulum.pdf (Accessed: 20/6/2021)

Mudzimiri, R. (2012, July). *A study of the development of technological pedagogical content knowledge (TPACK) in pre-service secondary mathematics teachers*. Available at: http://scholarworks.montana.edu/xml–ui/handle/1/1910 (Accessed: 20/6/2021)

Putri, S. A., Sulaeman, N. F., and Damayanti, P. (2021). Fostering TPACK in pre-service physics teachers during the covid-19 pandemic. *Journal of Physics: Conference Series, 2104*(1), 012006. doi:10.1088/1742-6596/2104/1/012006

Qiu, C. A., He, H. X, Chen, G. L, and Xiong, M. X. (2022). Pre-service teachers' perceptions of technological pedagogical content knowledge in mainland China: A survey of teachers of Chinese as a second language. *Education and Information Technologies*. https://doi.org/10.1–007/s10639-022-10888-x

Razdevšek-Pučko, C. (2005). Kakvog učitelja/ nastavnika treba (očekuje) škola danas (i sutra). *Napredak, 146*(1), 75–90.

Scherer, R., Siddiq, F., and Teo, T. (2015). Becoming more specific: Measuring and modeling teachers' perceived usefulness of ICT in the context of teaching and learning. *Computers & Education, 88*, 202–214. https://doi.org/10.1016/j.compedu.2015.05.005

Schmid, M., Brianza, E., and Petko, D. (2021). Self-reported technological pedagogical content knowledge (TPACK) of pre-service teachers in relation to digital technology use in lesson plans. *Computers in Human Behavior, 115*, 106586. https://doi.org/10.1016/j.chb.2020.106586

Schmidt. D., Baran. E., Thompson. A., Punya. M., Koehler. M., and Shin. T. (2009). Technological pedagogical content knowledge: the development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education, 42*(2), 123–149.

Tokmak, H. C., Incikabi, L., and Ozgelen, S. (2013). An investigation of change in mathematics, science, and literacy education pre-service teachers' TPACK. *Asia-Pacific Education Researcher, 22*(4), 407–415. https://doi.org/10.1007/s40299-012-0040-2

Voithofer, R., and Nelson, M.- J. (2021). Teacher Educator Technology Integration Preparation Practices Around TPACK in the United States. *Journal of Teacher Education, 72*(3), 314-328. https://doi.org/ 10.1177/0022487120949842

Yigit, M. (2014). A review of the literature: How pre-service mathematics teachers develop their technological, pedagogical, and content knowledge. *International Journal of Education in Mathematics, Science and Technology, 2*(1), 26–35.

Authors:

Dr. Karolina Dobi Barišić, PhD
Postdoctoral Researcher, Josip Juraj Strossmayer University of Osijek, Faculty of Education, Cara Hadrijana 10, 31000 Osijek, Croatia, e-mail: kdobi@foozos.hr
Podoktorski sodelavec, Univerza Josip Juraj Strossmayer v Osijeku, Pedagoška fakulteta, Cara Hadrijana 10, 31000 Osijek, Hrvaška, e-pošta: kdobi@foozos.hr

Dr. Maja Brust Nemet, PhD
Associate Professor, Josip Juraj Strossmayer University of Osijek, Faculty of Education, Cara Hadrijana 10, 31000 Osijek, Croatia, e-mail: mbrust@foozos.hr
Izredna profesorica, Univerza Josip Juraj Strossmayer v Osijeku, Pedagoška fakulteta, Cara Hadrijana 10, 31000 Osijek, Hrvaška, e-pošta: mbrust@foozos.hr