Validation of Survey of Preservice Teachers’ Knowledge of Teaching and Technology in the Context of Croatian Educational System

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Abstract*. Digital competences should be considered in teacher education but also in the field of teacher professional development. Technological Pedagogical Content Knowledge (TPACK) framework represents teacher knowledge for technology integration and is represented by seven domains. Survey of Preservice Teachers’ Knowledge of Teaching and Technology (SPTKTT) is one of the inventories developed to measure TPACK framework. Authors of the inventory have found empirical support for all seven domains of TPACK framework by the use of exploratory factor analysis. Aim of this study is to validate SPTKTT inventory in the context of Croatian educational system by the use of exploratory and confirmatory factor analysis. Results showed that structure of SPTKTT inventory consists of nine factors, while confirmatory factor analysis confirmed that three factors which refers to Content Knowledge domain fall under the one single factor. Internal consistency of the inventory shows high reliability.*

Keywords. TPACK framework, SPTKTT inventory, validation, exploratory factor analysis, confirmatory factor analysis

1 Introduction

Development of education in the 21st century implies the use of the technology in the sense of improving the learning and teaching process. All higher educational systems emphasize the need for development of digital knowledge, skills and accountability of students of educational study programs and in-service teachers. Croatian educational strategies also stress that rapid technological changes place great challenges on the teaching profession that require profound changes in teaching and learning (Vlada Republike Hrvatske, 2014). Competences (as personalized learning outcomes) in the area of education and training include subject-specific (academic) competences and didactic-methodical competencies. Basic teacher's competences imply effective work with information and communication technologies (ICT) e.g. skills and knowledge about them (Agencija za odgoj i obrazovanje, 2014).

Koehler and Mishra (2009) have developed a framework for teacher knowledge for technology integration called Technological Pedagogical Content Knowledge (TPACK). TPACK framework builds on Lee Shulman’s construct of Pedagogical Content Knowledge (PCK) to include technology knowledge. In this model (Figure 1.) there are three main components of teachers’ knowledge: Content (CK), Pedagogy (PK), and Technology (TK). 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). The interaction of these bodies of knowledge, both theoretically and in practice, produces the types of flexible knowledge needed to successfully integrate technology use into teaching (Koehler & Mishra, 2009). It should be pointed out that education for the 21st century, besides acquisition of knowledge, implies the acquisition of skills and competences (European Commission, 2008), (OECD, 2008).

By better describing the types of knowledge teachers need (in the form of content, pedagogy, technology, contexts and their interactions) it allows teachers, researchers, and teacher educators to move beyond oversimplified approaches that treat technology as an “add-on” instead to focus upon the connections among technology, content, and pedagogy as they play out in classroom contexts.

Schmidt et al. (2009) created the inventory for measuring TPACK named Survey of Preservice Teachers’ Knowledge of Teaching and Technology (SPTKTT).

This research represents validation of the SPTKTT inventory carried out by the use of exploratory and confirmatory factor analysis in Croatian context.

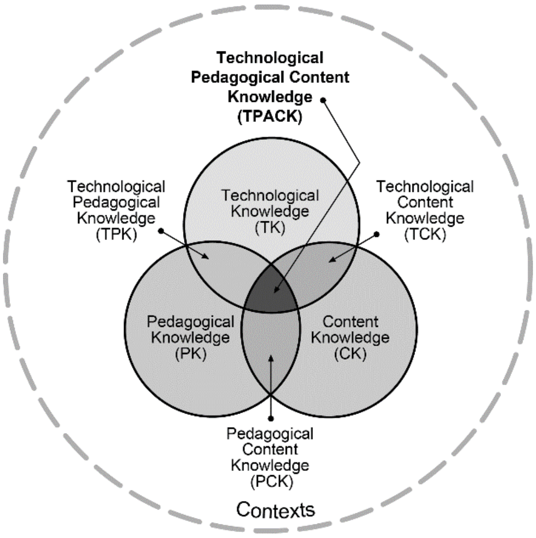

Figure 1. The TPACK framework (reproduced by permission of the publisher, © 2012 by tpack.org)

2 Literature Review

The most significant contribution of the TPACK framework is in the field of teacher education but also in the field of teacher professional development. One of the significant limitations of the TPACK framework is that it is neutral with respect to the broader goals of education. For instance, the TPACK framework does not speak to what kinds of content need to be covered and how it is to be taught (Koehler et al., 2014, p. 109). According to pedagogical approach TPACK framework is considered as pedagogically free and can be used for different pedagogical approaches (Valtonen et al., 2015). Koehler et al. (2014, p. 109) emphasized the need for development in the area of measuring how TPACK works in different disciplinary contexts while Valtonen et al., (2015) distinguished two main challenges related to the available instruments remains—namely, psychometric features and the nature of pedagogical knowledge.

Several TPACK measurement instruments are developed and their factor structure is determined (Table 1).

Rosenberg and Koehler (2015) cite that some researchers have used the measurement of TPACK to confirm the proposed TPACK framework structure composed of seven domains, as represented in Fig. 1, while others have found support for fewer components. Different studies resulted with different number of factors extracted during the exploratory factor analysis: three (Archambault & Barnett, 2010), four (Chai, Koh & Tsai, 2010), five (Koh, Chai & Tsai, 2010), (Lee & Tsai, 2010), (Chai et al., 2011), (Baser et al., 2015), six (Valtonen et al., 2015), seven (Schmidt, et al., 2009), (Pamuk et al., 2013) and eight (Shinas et al., 2013) (

Table ***1***).

Authors of the SPTKTT inventory (Schmidt et al., 2009) conducted exploratory factor analysis over the inventory items and confirmed factor structure with high factor loadings and Cronbach α coefficient values. SPTKTT has been criticised because the process of validation was conducted separately for each of the seven areas of TPACK (Chai et al., 2011).

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

1. What factors of TPACK are perceived by Croatian students of primary education study programs when a SPTKTT inventory is being used?
2. Do differences in educational systems affect the factor structure of the TPACK framework measured by the SPTKTT inventory?

Table 1. Measurement instruments developed on the base of TPACK framework

Study	Number of items	Participants (context)	Number of determined factors
(Schmidt et al., 2009)	47	Undergraduate students	7
(Archambault & Barnett, 2010)	24	Online teachers	3
(Chai et al., 2010)	18	Singaporean preservice teachers	4
(Lee & Tsai, 2010)	30	Self-efficacy of Taiwanese teachers for web-based learning	5
(Chai et al., 2011)	46	Singaporean preservice teachers (ICT for meaningful learning)	5
(Pamuk et al., 2013)	37	Preservice teachers	7
(Baser et al., 2015)	39	Preservice teachers (English as foreign language)	5
(Valtonen et al., 2015)	36	Preservice teachers (ICT in the context of 21st century skills)	6

3 Methodology

3.1 Sample

The data necessary to validate the inventory were collected during the academic year 2015/16 at five faculties in the Republic of Croatia. The sample consists of 337 students and was collected through different study programmes that educate future pre-school teachers (N=21), 1st through 4th grade primary school teachers (N=301) and 5th through 8th grade primary school teachers (N=15). Sample was collected on the undergraduate and graduate level and includes all study years on both levels.

3.2 Measurement instrument

The Survey of Preservice Teachers' Knowledge of Teaching and Technology (Schmidt et al., 2009) is a 47-item Likert scale survey with items (T1 – 47) that includes 10 subscale measures for each TPACK domain, including 4 subscales for different areas of content knowledge (literacy, social studies, mathematics, and science) (Appendix). Participants rated their agreement with each item on a 5-point Likert type scale (5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree). The measure of TPACK domains used in this study represents participants' self-assessment of their knowledge. Schmidt et al. described the development and validation of this instrument and reported Cronbach's α coefficients for the subscales ranging from .75 to .92. The survey was developed specifically for use with students of the primary and/or early childhood education study, so it included multiple subscales to assess perceived content knowledge in all content areas that the students would potentially be teaching in their future classrooms, including mathematics, science, social studies, and literacy (Abbitt, 2011).

SPTKTT focuses on pedagogical themes on a very general level (Valtonen et al., 2015) and was used in this research because of the generic nature of items, since the sample consists of students of the elementary and/or early childhood education attending different study programmes and courses.

The original SPTKTT inventory was written in English language. For the research presented here it was translated into Croatian language using the double-translation method and was proof-read.

3.3 Data analysis

To determine factor structure of the SPTKTT inventory, exploratory factor analysis was carried out. In order to determine fitting between empirical data and theoretical structure, confirmatory factor analysis was used. Internal consistency of the inventory was represented by the use of Cronbach α coefficient.

4 Inventory validation

4.1 Exploratory factor analysis

Considering the differences in Croatian and USA educational systems exploratory factor analysis (EFA) was conducted to establish eventually differences in factor structure. The exploratory factor analysis was carried out on the basis of all 47 items.

EFA was carried out with the help of Statistica 12.7 software. In the course of factor extraction a principal components analysis was used, as well as varimax normalized rotation for the purpose of an easier dimension interpretation. In order to determine the number of factors a Kaiser criterion of eigenvalues > 1 was used (Kaiser, 1960). The usage of Kaiser criterion resulted in extraction of 9 factors which explain 67.9 % of variance.

For the data interpretation only factor loadings higher than 0.32 were considered (Tabachnick & Fidell, 2013, p. 654). Table 2 shows factor loadings for each item in relation to nine factors after applying varimax normalized rotation.

Items T1-T7 (Technological Knowledge), T20-T26 (Pedagogical Knowledge), T27-T30 (Pedagogical Content Knowledge) and T31-T34 (Technological Content Knowledge) distributed in the same way as in EFA conducted by the authors of the inventory. Items T8-T19 distributed among three factors, despite the EFA conducted by the authors of the inventory where these items loaded into four factors. Items T35-T43 loaded into one factor (Pedagogical Content Knowledge), as well as items T44-T47 (Technological Pedagogical Content Knowledge). Items T40-T43 loaded also into the Technological Pedagogical Content Knowledge factor but with lower factor loadings.

4.2 Confirmatory factor analysis

Confirmatory factor analysis was carried out with the help of structural equation modelling software LISREL 9.2. There are different fit indices for the theory model and empirical data. There are different opinions about the need to list particular fit indices, as well as their cut-off values indicating a good model fit. A review work by McDonald and Ho (2002) states that the most frequently cited fit indices are comparative fit index (CFI), goodness of fit index (GFI), normed fit index (NFI) and nonnormed fit index (NNFI). Although GFI is one of the most frequently cited fit indices, researches have shown its inconsistency.

Combining a large number of degrees of freedom (df) regarding the sample size, the GFI yields lower values (Sharma at al., 2005), whereas its value goes up with big samples (Miles & Shevlin, 1998).

In order to confirm a good fit between the model and the data Hu and Bentler (1999) suggest a combination of two indices, one of which is always standardized root mean square residual (SRMR) ($\leq 0{,}09$), and the.

Table 2. Factor loadings for all items of SPTKTT inventory after varimax normalized rotation

Variable	**Factor Loadings** (Varimax normalized) Extraction: Principal components (Marked loadings are >.320000)								
	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**	**Factor 6**	**Factor 7**	**Factor 8**	**Factor 9**
T1	0.173035	0.131705	0.011422	**0.667515**	0.127167	0.196009	0.138205	0.117515	-0.094175
T2	0.059409	0.082655	0.114910	**0.731438**	0.177974	0.025095	0.199975	0.063730	-0.164846
T3	0.061634	-0.005512	0.111991	**0.800331**	0.050166	0.009748	0.062514	0.165128	-0.045069
T4	0.038371	-0.005866	0.118113	**0.776337**	-0.159082	0.106012	0.053215	0.010755	0.209261
T5	0.051833	0.035265	0.077849	**0.779735**	-0.067427	0.216657	0.131650	0.098346	0.134381
T6	0.054271	0.103344	0.027378	**0.698892**	0.173207	0.105881	0.144461	0.014139	0.061781
T7	0.205982	0.042005	0.018260	**0.590959**	0.137798	0.113422	-0.005389	0.076278	0.190329
T8	0.096447	**0.853766**	0.092236	0.083552	0.110161	0.080206	0.058844	-0.002668	-0.021750
T9	0.063385	**0.879355**	0.030641	0.117861	0.086029	0.170269	0.007144	0.052173	-0.022286
T10	0.053230	**0.742583**	-0.004627	0.040052	0.009413	0.238212	0.103616	0.162330	0.187074
T11	0.105297	0.014883	0.131858	0.255574	**0.339561**	**0.576071**	-0.020848	-0.019135	0.096359
T12	**0.372962**	-0.046484	0.076777	0.044865	0.175935	**0.663429**	-0.100741	-0.064809	-0.070354
T13	0.138388	-0.012035	0.066482	0.072899	0.182411	**0.706162**	0.051006	-0.077808	0.260790
T14	0.036491	0.265433	0.074208	0.177561	0.097993	**0.726504**	0.031937	0.140564	-0.045618
T15	-0.019139	0.193453	0.114014	0.178012	0.053727	**0.775783**	0.142523	0.193807	-0.004617
T16	-0.071483	0.258096	0.078839	0.122469	-0.032515	**0.733166**	0.163990	0.244488	0.102308
T17	0.061821	0.117962	0.101489	0.161980	**0.803208**	0.114136	0.117956	0.039958	-0.008222
T18	0.086684	0.104230	0.092600	0.087659	**0.829069**	0.160431	0.156953	0.046995	0.024175
T19	0.081065	-0.004439	0.093177	0.046716	**0.765338**	0.236677	0.108821	0.158668	0.153059
T20	0.100063	0.057367	**0.760569**	0.143349	0.086640	0.040819	-0.081219	0.148333	-0.112826
T21	-0.022029	0.007330	**0.765863**	0.021914	0.099169	0.055152	0.253710	0.139839	0.118827
T22	-0.012368	-0.061393	**0.738486**	0.016992	0.087431	0.066088	0.296029	0.079298	0.107829
T23	0.163274	0.063791	**0.796528**	0.039719	0.068637	0.029388	0.070535	0.098859	0.051802
T24	0.246350	-0.030115	**0.654370**	0.052699	0.048474	0.120489	0.273833	0.076077	0.148870
T25	**0.326815**	0.013285	**0.543568**	0.133066	-0.046868	0.132512	0.068804	-0.180522	0.102796
T26	0.203186	0.188826	**0.603853**	0.101189	0.038259	0.104220	-0.005838	0.147830	**0.335304**
T27	0.181213	0.309014	**0.491314**	0.141015	0.007118	0.080118	0.230117	0.141614	**0.554897**
T28	0.300399	0.013106	**0.438510**	0.149129	0.117692	0.210691	0.129910	0.088509	**0.644434**
T29	0.201669	0.112096	**0.506784**	0.156159	0.024440	0.306422	0.195304	0.206777	**0.516329**
T30	0.253309	-0.002354	**0.448251**	0.067962	0.311154	0.059617	0.182294	0.182008	**0.564667**
T31	0.200324	**0.365351**	0.150268	0.159832	0.027400	-0.005252	0.115207	**0.705263**	0.090211
T32	**0.333070**	0.004356	0.164402	0.188910	0.050088	0.192434	0.170441	**0.648585**	0.134190
T33	0.239908	0.107905	0.183595	0.132482	0.024115	**0.372608**	0.132187	**0.694454**	0.086306
T34	**0.324813**	-0.057856	0.141477	0.125759	0.266378	0.033266	0.242673	**0.658529**	0.094935
T35	**0.396914**	0.018855	0.268498	0.216390	0.203024	0.016379	**0.409795**	**0.384202**	-0.096237
T36	**0.409363**	0.015858	0.280322	0.209754	0.202326	0.007136	**0.446755**	**0.384375**	0.007721
T37	0.051079	0.070074	0.142501	0.055117	0.042688	-0.069456	**0.614434**	0.133409	0.313935
T38	-0.001977	0.071746	0.064334	0.107300	0.106009	0.184005	**0.719462**	-0.031936	0.127952
T39	0.282210	0.049446	0.177673	0.221471	0.083060	0.098454	**0.715104**	0.139560	0.038547
T40	**0.410980**	0.041439	0.142958	0.179492	0.066162	-0.011690	**0.646712**	0.238897	-0.049005
T41	**0.431085**	-0.019787	0.279216	0.077335	0.143574	0.050769	**0.535717**	0.126302	-0.014289
T42	**0.390111**	0.092800	0.258053	0.259113	0.099576	0.145573	**0.436946**	0.112379	-0.071768
T43	**0.462385**	0.078451	0.194947	0.222429	0.163844	-0.033114	**0.484715**	0.224294	-0.027055
T44	**0.699619**	0.289075	0.162192	0.130747	-0.078999	0.030342	0.180235	0.219370	0.077754
T45	**0.789287**	-0.021634	0.161235	0.099308	0.144378	0.075399	0.175974	0.174362	0.175584
T46	**0.762735**	-0.008923	0.159412	0.109399	0.121550	0.160501	0.158011	0.162553	0.259095
T47	**0.733959**	0.150623	0.158615	0.109254	0.008607	0.153186	0.170880	0.248755	0.073425
Expl.Var	4.446140	2.734790	5.076877	4.458359	2.687765	3.753857	3.756096	2.938764	2.076020
Prp.Totl	0.094599	0.058187	0.108019	0.094859	0.057186	0.079869	0.079917	0.062527	0.044171

other one NNFI (≥ 0,96),), root mean square error of approximation (RMSEA) (≤ 0,06) or CFI (≥ 0,96). Kline (2005) states that one should definitely cite Chi-Square test ($\chi 2$), RMSEA, CFI and SRMR when citing fit indices. Hooper and associates (2008) suggest, apart from the previously mentioned, besides Chi-Square test to cite degrees of freedom (df) and the p-value, along RMSEA its confidence interval and also to cite parsimonious normed fit index (PNFI) because stated indices are the least sensitive to the size of the sample, nonspecificity of the model and estimation parameters.

After the confirmatory factor analysis had been carried out, modification indices suggested the addition of error covariance among certain variables in order to improve fit indices (Fig. 2).
Only error covariance among variables belonging to the same factor was taken into account. These changes helped to improve fit indices.

Fit indices of model and empirical data are the following: $\chi2$ = 2117.1, p = 0.0000, df = 994, $\chi2$/df =2.13, RMSEA = 0.0579 with confidence interval (0.0545; 0.0613), SRMR = 0.0591, CFI = 0.889, PNFI = 0.745.

Regarding RMSEA $\leq$ 0.06 and SRMR $\leq$ 0.09, according to Hu and Bentler (1999), these empirical data fit well into the proposed factor structure, through which this model was confirmed.

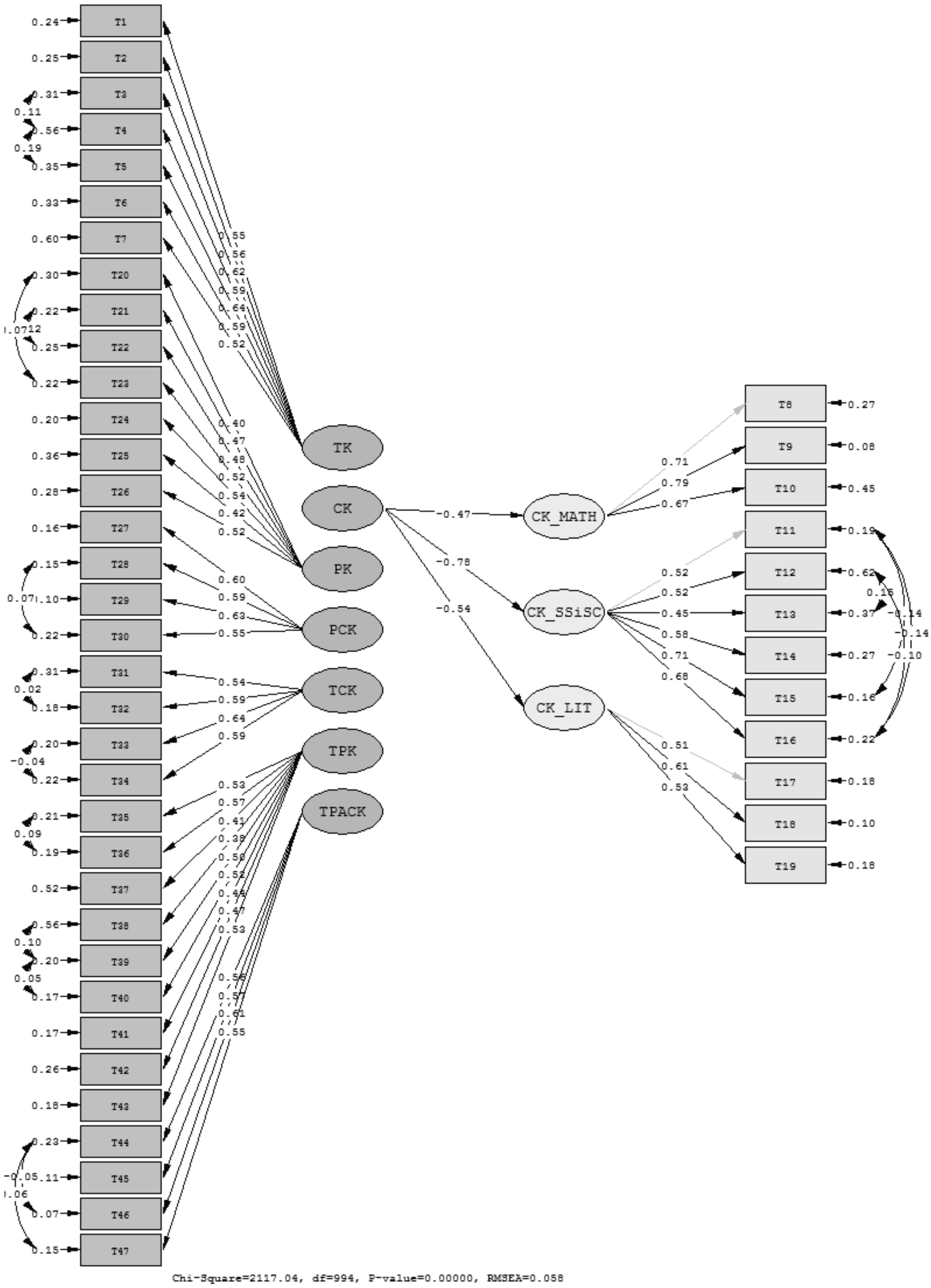

Figure 2. Confirmatory factor analysis of the SPTKTT inventory

4.4. Reliability

Cronbach α coefficients are greater than 0.9 (0.9093 – 0.9328) for every observed item, sub-scale and entire scale which suggests high reliability of the SPTKTT inventory.

5 Conclusion

The main aim of the research presented in this paper is to validate SPTKTT inventory in the context of Croatian educational system by the use of exploratory and confirmatory factor analysis. Results of this research represent empirical support for a TPACK theoretical framework.

In order to answer to the research question 1 exploratory factor analysis was carried out on subscales and items of the SPTKTT inventory, pointing to the structure of the nine factors. The sample used for the factor analysis is suitable for the group of respondents for which the inventory was created. The sample size is also appropriate for the number of items the inventory contains. In order to answer to the research question 2 the differences in the factor structure among this research and research conducted by Schmidt et al. (2009) can be explained with differences in educational systems of the countries in which the research was conducted (USA and Croatia). In the USA school subjects, according to contents, are Mathematics, Science, Social Sciences and Literacy while in Croatia they are Mathematics, Literacy (named Croatian Language) and Social Sciences and Science joined to one subject (named Nature and Society). Confirmatory factor analysis confirmed empirical data and theoretical model.

The reliability of the SPTKTT inventory was shown using Cronbach α coefficient. The results indicate a high level of reliability for all subscales and items of the inventory, what corresponds with already achieved results (Schmidt et al., 2009).

Possible limitations of the research can be observed in the form of inventory that represents self-reported measure and sample that is not representative.

Importance of this research is to analyse Croatian teacher education context regarding knowledge about teaching and technology. As a result it is justified to use the instrument for the further research in Croatia. Since the instrument is content neutral the special challenge can be to align generic items of the instrument to concrete domains and evaluation of knowledge that are not based only on self-reporting.

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References

Abbitt, J. (2011). Measuring Technological Pedagogical Content Knowledge in Preservice Teacher Education. *Journal of Research on Technology in Education Preservice Teacher Education: A Review of Current Methods and Instruments, 43*(4), 281-300.

Agencija za odgoj i obrazovanje. (2014). Strategija stručnog usavršavanja za profesionalni razvoj odgojno obrazovnih radnika (2014-2020). Retrieved from http://www.azoo.hr/images/pkssuor/Dokumenti_hr.zip

Archambault, L., & Barnett, J. (2010). Revisiting technological pedagogical content knowledge: Exploring the TPACK framework. *Computers & Education*, 55(4), 1656–1662.

Baser, D., Kopcha, T., & Ozden, M. (2015). Developing a technological pedagogical content knowledge (TPACK) assessment for preservice teachers learning to teach English as a foreign language. *Computer Assisted Language Learning*, 29(4), 749-764.

Chai, C., Koh, J., Tsai, C.-C., & Tan, L. (2011). Modeling primary school pre-service teachers' Technological Pedagogical Content Knowledge (TPACK) for meaningful learning with information and Knowledge (TPACK) for meaningful learning with information and communication technology (ICT). *Computers & Education*, 57, 1184–1193.

Chai, C., Koh, J., & Tsai, C. (2010). Facilitating preservice teachers' development of technological, pedagogical, and content knowledge (TPACK). *Educational Technology and Society*, 13(4), 63-73.

European Commission. (2008). The European qualifications framework for lifelong learning (EQF). Retrieved from http://ecahe.eu/w/images/3/34/EQF.pdf

Hooper, D., Coughlan, J., & Mullen, M. (2008). Structural Equation Modelling: Guidelines for Determinig Model Fit. *Electronic Journal of Business Research Methods*, 6(1), 53-60.

Hu, L., & Bentler , P. (1999). Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives. *Structural Equation Modeling*, 6(1), 1-55.

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Pshychological Measurement*, 20, 141-151.

Kline, R. (2005). *Principles and Practice of Structural Equation Modeling* (2nd ed.). New York: The Guilford Press.

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

Koehler, M., Mishra, P., Kerel, K., Shin, T., & Graham, C. (2014). The Technological Pedagogical Content Knowledge Framework. In J. Spector, J. Elen, M. Bishop, & M. Merrill, *Handbook of Research on Educational Communications and Technology* (pp. 101-111). New York: Springer.

Koh, J., Chai, C., & Tsai, C. (2010). Examining the technological pedagogical content knowledge of Singapore preservice teachers with a large-scale survey. *Journal of Computer Assisted Learning*, 26, 563-573.

Lee, M., & Tsai, 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, 1-21.

McDonald, R., & Ho, M.-R. (2002). Principles and Practice in Reporting Statistical Equation Analyses. *Psychological Methods*, 7(1), 64-82.

Miles, J., & Shevlin, M. (1998). Effects of sample size, model specifications and factor loadings on the GFI in confirmatory factor analysis. *Personality and Individual Differences*, 25, 85-90.

OECD. (2008). 21st Century Learning: Research, Innovation and Policy (Directions from recent OECD analyses). Retrieved from http://www.oecd.org/site/educeri21st/40554299.pdf

Pamuk, S., Ergun, M., Cakir, R., Yilmaz, H., & Ayas, C. (2013). Exploring relationships among TPACK components and development of the TPACK instrument. *Education and Information Technologies*, 2022, 241–263.

Rosenberg, J., & Koehler, M. (2015). Context and Technological Pedagogical Content Knowledge (TPACK): A Systematic Review. *Journal of Research on Technology in Education*, 47(3), 186-210.

Schmidt, D., Baran, E., Thompson, A., Mishra, P., Koehler, M., & Shin, T. (2009). Technological Pedagogical Content Knowledge (TPACK). *Journal of Research on Technology in Education*, 42(2), 123-149.

Sharma, S., Mukherjee, S., Kumar, A., & Dillon, W. (2005). A simulation study to investigate the use of cutoff values for assessing model fit in covariance structure models. *Journal of Business Research*, 58(1), 935-943.

Shinas, V., Yilmaz-Ozden, S., Mouza, C., Karchmer-Klein, R., & Glutting, J. (2013). Examining Domains of Technological Pedagogical Content Knowledge Using Factor Analysis. *Journal of Research on Technology in Education*, 45(4), 339–360.

Tabachnick, B. G., & Fidell, L. S. (2013). *Using Multivariate Statistics*. Boston: Pearson.

Valtonen, T., Sointu, E., Mäkitalo-Siegl, K., & Kukkonen, J. (2015). Developing a TPACK measurement instrument for 21st century pre-service teachers. *Seminar.net - International journal of media, technology and lifelong learning*, 11(2), 87-100.

Vlada Republike Hrvatske. (2014, 10 17). Strategija obrazovanja, znanosti i tehnologije. Retrieved from Nove boje znanja: http://www.azoo.hr/images/AZOO/Cjelovit_sadrzaj_Strategije_obrazovanja_znanosti_i_tehnologije.pdf

Appendix

Items of the Survey of Preservice Teachers' Knowledge of Teaching and Technology by domains

TK (Technology Knowledge)

T1. I know how to solve my own technical problems.
T2. I can learn technology easily.
T3. I keep up with important new technologies.
T4. I frequently play around the technology.
T5. I know about a lot of different technologies.
T6. I have the technical skills I need to use technology.
T7. I have had sufficient opportunities to work with different technologies

CK (Content Knowledge)
Mathematics

T8. I have sufficient knowledge about mathematics.
T9. I can use a mathematical way of thinking.
T10. I have various ways and strategies of developing my understanding of mathematics.

Social Studies

T11. I have sufficient knowledge about social studies.
T12. I can use a historical way of thinking.
T13. I have various ways and strategies of developing my understanding of social studies.

Science

T14. I have sufficient knowledge about science.
T15. I can use a scientific way of thinking.
T16. I have various ways and strategies of developing my understanding of science.

Literacy

T17. I have sufficient knowledge about literacy.
T18. I can use a literary way of thinking.
T19. I have various ways and strategies of developing my understanding of literacy.

PK (Pedagogical Knowledge)

T20. I know how to assess student performance in a classroom.
T21. I can adapt my teaching based-upon what students currently understand or do not understand.
T22. I can adapt my teaching style to different learners.
T23. I can assess student learning in multiple ways.
T24. I can use a wide range of teaching approaches in a classroom setting.
T25. I am familiar with common student understandings and misconceptions.
T26. I know how to organize and maintain classroom management.

PCK (Pedagogical Content Knowledge)

T27. I can select effective teaching approaches to guide student thinking and learning in mathematics.
T28. I can select effective teaching approaches to guide student thinking and learning in literacy.
T29. I can select effective teaching approaches to guide student thinking and learning in science.
T30. I can select effective teaching approaches to guide student thinking and learning in social studies.

TCK (Technological Content Knowledge)

T31. I know about technologies that I can use for understanding and doing mathematics.
T32. I know about technologies that I can use for understanding and doing literacy.
T33. I know about technologies that I can use for understanding and doing science.
T34. I know about technologies that I can use for understanding and doing social studies.

TPK (Technological Pedagogical Knowledge)

T35. I can choose technologies that enhance the teaching approaches for a lesson.
T36. I can choose technologies that enhance students' learning for a lesson.
T37. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.
T38. I am thinking critically about how to use technology in my classroom.
T39. I can adapt the use of the technologies that I am learning about to different teaching activities.
T40. I can select technologies to use in my classroom that enhance what I teach, how I teach and what students learn.
T41. I can use strategies that combine content, technologies and teaching approaches that I learned about in my coursework in my classroom.
T42. I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches at my school and/or district.
T43. I can choose technologies that enhance the content for a lesson.

TPACK (Technology Pedagogy and Content Knowledge)

T44. I can teach lessons that appropriately combine mathematics, technologies and teaching approaches.
T45. I can teach lessons that appropriately combine literacy, technologies and teaching approaches.
T46. I can teach lessons that appropriately combine science, technologies and teaching approaches.
T47. I can teach lessons that appropriately combine social studies, technologies and teaching approaches.