



Teacher education is a deeply pedagogical process rooted in values, ethics, and the social purpose of schooling. Globally, it sits at the core of educational quality and fairness, as research in comparative and international education demonstrates: the training of teachers directly influences students' learning chances, social inclusion, and the democratic aims of schools. Teachers are not simply transmitters of curricula, but active professionals whose convictions, reflective skills, and ability to manage the complexities of classroom life give shape and substance to the educational experience itself.

The pedagogical dimension of teacher education frames teaching as a relational, context-aware, and ethically grounded profession rather than just a set of procedural skills. From a research perspective, this demands robust research methodologies that can critically examine the complex realities of schools and inform evidence-based policies. Equally important is the connection between theory and practice, which helps to bridge the persistent gap between universities and schools.

The contributions gathered in this volume reflect the richness and diversity of experiences showcased during the ATEE Spring Conference 2024, held at the University of Bergamo from May 29 to June 1, 2024. The volume presents 70 selected papers out of more than 300 presented by researchers representing over 40 countries.

This broad spectrum of studies highlights promising directions that can inspire renewed inquiry and concrete proposals aimed at improving contemporary educational systems.

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Teacher education research in Europe: trends, challenges, practices and perspectives

May 29th – June 1st, 2024
S. Agostino, Bergamo



Edited by Nicole Bianquin and Francesco Magni





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BOOK OF PROCEEDINGS
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Table of contents

Introduction

Francesco Magni, Nicole Bianquin, *Back to the Core: Rediscovering the Power of Teacher Education Research* 7

Teacher education and pedagogical perspective in uncertain times: history, theory, policies and practices

Brigitta Bekesi, Eva Ulbrich, Tony Houghton, Jana Trgalova & Zsolt Lavicza, *The Reflected Double Tetrahedron Model: Project-based learning in teacher training* 11

Andrea Dessardo, «*The Italian didactic secret*». *Teachers' education according to Giuseppe Lombardo-Radice's thought* 19

Ylenia Falzone & Alessandra La Marca, *Lifelong Learning for Mongolia: Occupational Health & Safety project (3L4MHOS)* 25

Ylenia Falzone, Benedetta Miro & Elif Gülbay, *Teachers and Artificial Intelligence: Developing Digital Citizenship Skills* 31

Eleonora Florio, Tanu Biswas, Ilaria Castelli & Letizia Caso, *Bleak Pedagogy: A new term unveiled from research on Adultcentrism* 38

Deirdre Harvey & Maria Campbell, *Promoting and supporting learner resilience in the hospital school* 44

Aggelos Kavasakalis & Angeliki-Despoina Varouxli, *Reasons and beliefs of (Greek) teachers for participating in an MSc relevant to their profession* 54

Semih Kaygisiz & Hanife Akar, *Challenges Head to Train Culturally and Linguistically Responsive Teachers* 62

Sabina Leoncini, *Gender Stereotypes between School and Guidance: A Look at European Regulations and Vocational Education in Italy* 69

Silvia Maggiolini & Elena Zanfroni, *Emergency and people with intellectual disabilities. Teachers' training in the LEBEL proposal* 77

Cristina Miralles-Cardona, María C. Cardona-Moltó & José M. Esteve-Faubel, <i>Gender-responsive teaching: What strategies are teacher educators using for gender mainstreaming implementation?</i>	83
Benedetta Miro & Alessandra La Marca, <i>Service Learning in teacher education for soft skills development</i>	93
Georgia Natsiou & Melpomeni Tsitouridou, <i>Reflecting together online and offline: A systematic review on the types of peer reflection activities in teacher education</i>	102
Laura Parigi & Maria Elisabetta Cicognini, <i>Exploring the Transformative Impact of Teacher Professional Development on Student-Centered Assessment Approaches</i>	109
Francesca Pileggi, <i>Non-cognitive competence and critical-creative skills. A critical review of the current perspectives</i>	116
Francis J. Prescott-Pickup, <i>Finding a successful teacher identity: the role of the mentor-mentee relationship</i>	122
Nathanaili Valbona, <i>Analyzing poor academic performance of Albanian pupils in PISA</i>	129
Elena Zanfroni, <i>Problematic behaviours and classroom management: teachers' representations</i>	137

Teaching and learning challenges and professional development

Monica Banzato, <i>Attitudes of Humanities Students and Aspiring Teachers Toward Quantitative Educational Research: An Introductory Study</i>	146
Ane Bergersen, <i>Global awareness and professional teacher competence through student mobility from Norway to Zambia</i>	152
Barbara Bocchi, Elena Bortolitti & Paola Damiani, <i>Informal Support Teacher Networks: training and self-training between Communities of Practice</i>	160
Barbara Bocchi, Elena Bortolitti, Paola Damiani, Giuseppe Filippo Dettori & Barbara Letteri, <i>The use of artificial intelligence (AI) in inclusive learning: an exploratory investigation</i>	167
Virginia Capriotti, <i>The Impact of Teaching and Learning Centers (TLCs) on Initial Teacher Education Programs in Italy</i>	176
Giorgia Coppola, <i>From Burnout toward Pedagogical Teacher Education. A communities perspective</i>	183
Alexandra Efstathiades, Christiane Gesierich, Christian Rudloff & Anna Kapsalis, <i>FOOTT PRINTTS: Advancing Quality Standards in Teacher Training</i>	189

Elena Gabbi, Ilaria ancillotti & Maria Ranieri, <i>Rethinking digital competences for teaching in the Post-Covid Era: A participatory approach</i>	197
Marco Giganti, <i>Emergency Remote Teaching and Teacher Training: The Role of Implicit Beliefs in Lasting Educational Change</i>	205
Hege Knudsmoen & Mette Birgitte Helleve, <i>Develop teachers' professional identity through global internship</i>	212
Charlotte Kohlloffel, <i>Opening the black box of writing instruction in times of change: insights from Italian secondary school teachers</i>	220
Regine Lehberger, <i>A learning-design to promote reflection and digital media skills for professionalisation of teacher students</i>	229
Marica Liotino, Taiwo Isaac Olatunji, Marianne Grace Araneta, & Monica Fedeli, <i>Reflective Practice in MOOCs: Exploring the Role of Tutors and Fostering Teacher Professional Development</i>	236
Cristina Lisimberty & Katia Montalbetti, <i>Guiding students from lower to upper secondary: a challenging and shared task for families and schools</i>	244
Sabrina Natali, <i>Rethinking teacher training in emotional education through sports</i>	256
Sara Nosari & Emanuela Guarcello, <i>The question of non-cognitive skills and the cheetah's coat perspective</i>	262
Alessandro Oro, Ira Vannini & Elisa Guasconi, <i>A formative assessment framework to develop primary school pre-service and in-service teachers' video analysis programs</i>	271
Federica Pelizzari & Simona Ferrari, <i>Exploring Coding and Educational Robotics in Primary Schools. Results and Perspectives from an Action Research Approach to Teaching Innovation</i>	278
Annfrid Rosey & Tove Leming, <i>Internationalization in Teacher Education: How can student practice in Southern Africa contribute to strengthening the professional work as teachers in Northern Norway?</i>	293
Stefano Spennati, <i>Educating on complexity at the time of transition</i>	300
Chiara Urbani, <i>Collaborative and epistemic advances: a study on teacher agency</i>	305
Gerd Wikan, <i>Global Teachers and Practicum in the Global South. A study of Long-Term Impact of International Practicum in Namibia</i>	312
Franco Zengaro & Sally A. Zengaro, <i>Teachers Reflect on Their Identities as Former Students and Future Teachers</i>	318
Sally A. Zengaro & Franco Zengaro, <i>Supporting Active Learning in Online Learning: Creating a Culture of Care</i>	326

Inclusion in teaching and learning processes and school improvement

Luca Angelone & Federica Festa, <i>Cultivating Inclusive Education: A Collaborative Journey of Secondary School Teachers in Promoting Cognitive and Linguistic Accessibility through Picture Books and AAC</i>	333
Luca Ballestra Caffaratti, Cecilia Marchisio, Alessandro Monchietto, Alessandro Zanzo & Marco Secchia, <i>The Use of Artificial Intelligence in Secondary Schools: Experiences in Initial Teacher Training</i>	340
Daniele Bullegas & Martina Monteverde, <i>Theory into practice: exploring teacher perceptions about Early Intervention in the Italian school system</i>	346
Sara Cecchetti & Nicole Bianquin, <i>The work plan (Plan de Travail) as an educational device that addresses everyone's needs. A survey of teachers' and pupils' perspectives</i>	354
Federica Cilia, Jeanne Kruck, Marie-Hélène Plumet & Mélina Dell'armi, <i>Well-Being and Social Participation of Autism Spectrum Disorder Students at University: the impact of Atypie Friendly Inclusion Program</i>	362
Alice Di Leva & Federica Festa, <i>The Student Voice in teacher training, an investigation into the inclusiveness of European practices</i>	370
Ilaria Folci & Anna Monauni, <i>Differentiation in Preschool. Pedagogical Issues and Best Practices</i>	378
Mabel Giraldo & Fabio Sacchi, <i>Planning the transition to adulthood for students with disabilities: knowledge, perceptions, challenges from STRADE teacher training program</i>	384
Jørgen Klein, Ann Sylvi Larsen & Tove Grete Lie, <i>'People are people' - An investigation of long-term impacts of an international practicum</i>	393
Daniela Maccario & Annamaria Garibaldi, <i>Helping to learn. What are good practices of educational intervention? Structure and preliminary results of a participatory research study</i>	400
Cecilia Marchisio & Alessandro Monchietto, <i>Improving Inclusive Education: The Turin Model of Collaboration between Schools, Universities and Communities</i>	405
Francesca Placanica, Rosa Sgambelluri & Alessandra Priore, <i>Life Designing and inclusive prospects in Italian schools</i>	411
Ilaria Ravasi, <i>Preventing early school leaving. Perspectives of intervention research between school and territory</i>	417

Digital innovation and artificial intelligence (AI): schools, teachers and students between real and virtual world

Valentina Berardinetti, Michele Ciletti, Andreana Lavanga & Giusi Antonia Toto, <i>Digital Innovation and Artificial Intelligence in Museum Education: perspectives, debates and psychological implications</i>	424
Roxana-Madalina Cristea, <i>Investigating the Relationships between In-service Teachers' Technology Pedagogy Content Knowledge and Virtual Learning Environment Success</i>	432
Francesca De Vitis & Marcello Tempesta, <i>Touch in small hands. Responding to the challenges of technology in childhood 0-6</i>	439
Silvia Larghi & Edoardo Datteri, <i>Programming errors and the attribution of intentionality to educational robots</i>	445
Juliana Elisa Raffaghelli, Francesca Crudele, Laura Foschi & Graziano Cecchinato, <i>Let me introduce open education... Facilitating Prospective teachers' understanding of open Education through an ai-based tool</i>	453
Alice Roffi, <i>Digital technologies and collaborative activities for science teaching in the upper secondary school: a qualitative study on teacher's perspective</i>	464
Alice Roffi, Gabriele Biagini, Stefano Cuomo & Maria Ranieri, <i>Development of teachers' competences on Learning Design and on supporting student's Self-Regulated Learning in the lower secondary school</i>	472
Marcello Tempesta, <i>Teacher education and motivation culture</i>	481

School & work and the role of teachers in Vocational Education and Training

Maria Concetta Carruba, Mariateresa Cairo & Magdalena Tsoneva, <i>Comparative Analysis of Inclusive Education Practices in Italy and Bulgaria: Reflections from the Erasmus Plus ASuMIE Project</i>	488
Valerio Ferrero, <i>Teacher Education as a Game Changer: Non-Traditional Factors of Inequality and the Role of Teachers for Equity</i>	494
Anna Granata & Valerio Ferrero, <i>Beyond Patriarchy: Teaching Profession, Gender Issues and Teacher Education in Italy</i>	502
Paola Zini & Dalila Raccagni, <i>Teacher training and well-being best practices: the 3H project</i>	508



POSTER SESSION

Antinea Ambretti, Chiara Gamberini & Arianna Fogliata, *Integration of the Sincrony method in physical education during school age in the digital era* 517

Francesca Finestrone, *Music as an inclusive tool for promoting a sustainable Culture* 523

Francesca Finestrone, Francesco Pio Savino, Leonardo Palmisano & Giusi Antonia Toto, *Nature Connection and Music in Early Education: Insights from the CNS-ch Scale and TEAL Methods* 532

Paula Matijašević, Bruno Matijašević, Ana Žnidarec Čučković & Vesna Babić, *Kinesiologists' and Coaches' Self-Assessment of Their Pedagogical Competences* 538

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Investigating the Relationships between In-service Teachers' Technology Pedagogy Content Knowledge and Virtual Learning Environment Success

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Abstract

Teachers' Technology Pedagogy Content Knowledge (TPACK) skills and virtual learning environments (VLE) outcomes register an increasing interest from various stakeholders. Using a quantitative research design, the article aims to investigate the relationship between TPACK and VLE success. Following an informed consent, data was collected from 107 teachers who answered an online questionnaire. The statistical analyses revealed a strong positive correlation between TPACK components and VLE success, teachers with higher TPACK levels achieving greater success in the VLE. The findings underscore the importance of enhancing TPACK skills through teacher training programs and policy reforms to improve VLE outcomes. Future research should explore longitudinal impacts and mixed-method approaches.

Keywords: TPACK; VLE; teacher training; digital pedagogy; pre-university teachers.

1. Introduction

Nowadays, the integration of technology in education has a great contribution in transforming teaching practices, offering new opportunities that enhance students' learning and engagement (Mishra & Koehler, 2006; Selwyn, 2011). The Technological, Pedagogical, and Content Knowledge (TPACK) framework provides a comprehensive model for understanding how technology can be integrated effectively into teaching practice by considering the interplay between pedagogy, content, and technology (Mishra & Koehler, 2006). As Koehler and colleagues (2013) has shown teachers are able to create more engaging and effective learning experiences for their students if they manage to influence the synergy between technological tools, pedagogical strategies, and content knowledge in a meaningful and contextually adapted manner.

With the growing prevalence of Virtual Learning Environments (VLEs), which facilitate remote and blended learning through digital platforms, teachers must adapt their practices to leverage these technologies effectively (Bates, 2019; Picciano, 2017). VLEs offer different kinds of tools and functionalities that support teaching and learning, yet their successful implementation requires a deeper understanding of how technology, pedagogy, and the domain-specific content intersect (Aydin & Gumus, 2016).

Although there are some previous studies that have highlighted the importance of the TPACK framework in the effectiveness of integrating technology (Chai et al., 2013; Koehler & Mishra, 2009), limited research has examined its specific impact on teachers' perceived success in what concerns VLEs usage in their classroom practice. Therefore, the present study aims to cover this gap by investigating the way in which in-service pre-university teachers' TPACK level influences their perceived success in using VLEs in teaching highlighting the importance of understanding the integration of technology, pedagogy, and content knowledge in modern educational contexts.

2. Theoretical background

The Virtual Environment Learning Success, as defined by Awang and collaborators (2018), is a construct comprising the information quality, system quality, service quality, intention to use, use, user satisfaction and the net benefits perceived by the teachers. These dimensions reflect the overall success or satisfaction of a VLE from the user's perspective, namely the pre-university in-service teachers, encompassing both technological and pedagogical aspects. Recent studies have shown that teachers' satisfaction and perceived benefits from using VLEs are strongly associated with their ability to effectively integrate technology, pedagogy, and content knowledge in their teaching practices (Caprara, & Caprara, 2022). Previous studies have shown that teachers define VLE as successful when they are able to use the VLE to enhance their teaching and their students' learning experiences in meaningful ways (Lawless & Pellegrino, 2007; Liu, 2012; Orlando, 2013). Moreover, research has shown that virtual environments such as platforms that simulate professional work experiences are an excellent source for teachers' TPACK development. For instance, through virtual internships, namely epistemic games which put professionals in a situation (Oner, 2020).

The TPACK framework facilitates the integration of technology into teaching, relating it with content knowledge and pedagogical knowledge, understanding the relationship between TPACK and teaching success in virtual environments is crucial for enhancing educational outcomes in digital settings, recent research highlighting a positive impact of TPACK on virtual teaching readiness and effectiveness. According to Thohir et al. (2023) TPACK positively influences pre-service teachers' readiness and ability to integrate virtual reality (VR) into science education, enhancing their perceived usefulness and ease of use of VR tools. Moreover, using the TPACK model in university development training leads to improvements in teaching abilities, effectiveness and in course design for online instruction (Brinkley-Etzkorn, 2018).

Teachers' first-hand experience with virtual technologies in education settings provides critical insights for TPACK growth. For instance, virtual exchange programs support the development of TPACK competencies, though the degree of growth may differ across participants. Prior TPACK proficiency can also shape the acquisition of other skills, such as foreign language abilities (Rets et

al., 2020; Rienties et al., 2020). Another manner of increasing teachers' TPACK level is by learning to create technology-enriched lesson plans on virtual platforms, this being proven to substantially boosts teachers' self-confidence in their TPACK and their capacity to integrate educational technology into their classroom practice (Kapici, & Akcay, 2020).

3. The present study

The paper aims to provide a comprehensive overview of teachers' practice regarding the integration of TPACK in the teaching process, presenting the relationships between TPACK and the success in the virtual learning environment as perceived by pre-university teachers.

3.1 Research questions

This study seeks to investigate the following research questions:

1. What are the differences between teachers' TPACK usage in terms of age, teaching environment, academic background, subject they teach and position status?
2. What is the relationship between in-service teachers' TPACK and their perceived success in implementing VLE in their teaching practice?
3. Is teachers' TPACK level a predictor for VLE success?

4. Methodology

4.1 Participants and sampling

The study included 107 pre-university teachers from the public school system who voluntarily participated to the study. A convenience sampling method was employed, and data collection was conducted through an online questionnaire distributed on Google Forms platform.

The majority of participants were comprised in the 30 to 39 years old range (38.3%) and in the 40- 49 years range (32.7%). Younger teachers (under 25 and 25-29) accounted for 8.4% and 11.2% of the sample, respectively, while older participants (50-59 and over 60) comprised 8.4% and 0.9%. Also, the most part of the participants worked in urban environments (66.4%), while 33.6% were based in rural areas.

In what concerns the academic background of the teachers, nearly all participants held higher education qualifications. The majority had earned a bachelor's degree (52.3%), followed by master's degree holders (43%). A small proportion reported having a Ph.D. (1.9%), while 2.8% declared high school as their highest level of education.

The largest proportion of participants were primary education teachers (43.9%), followed by vocational educators (18.7%), language teachers (15.9%), social sciences teachers (10.3%), sciences teachers (8.4%), and mathematics teachers (2.8%). Moreover, in terms of the position status, the majority of participants (61.7%) have indicated to held a temporary position, while 38.3% indicated their position as a permanent one.

4.2 Instruments

The Virtual Learning Environment Success (VLES) Scale developed by Awang and collaborators (2018) was used to assess in-service teachers' satisfaction regarding the use of VLE in their teaching practice. The VLES scale comprises 45 items grouped in 7 dimensions, namely the information quality, system quality, service quality, intention to use, use, user satisfaction and the net benefits perceived by the teachers. The scale has an alpha Cronbach value for this sample of .967, indicating an excellent level of reliability.

The TPACK questionnaire (Liu et al., 2015) was employed for measuring teachers' TPACK as it is a well-known and validated instrument. This questionnaire consists of 29 items organized in 7 dimensions: Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical

Knowledge (TPK), Technological Pedagogical Content Knowledge (TPACK). The TPACK questionnaire showed a Cronbach's alpha of .944.

4.3 Procedure

The participants to the study are pre-university in-service teachers. They were informed about the purpose of the study through an informed consent form. The participation was voluntary, ensuring that the teachers could withdraw at any stage without providing a reason. The questionnaire was filled-in by accessing Google Forms platform.

5. Results

The investigation of the results started with a normality test of the VLE success and TPACK scores. The results indicated that while VLE success scores were approximately normally distributed (Kolmogorov-Smirnov statistic = 0.056, $p = 0.200$; Shapiro-Wilk statistic = 0.979, $p = 0.094$), TPACK scores deviated from normality (Kolmogorov-Smirnov statistic = 0.117, $p = 0.001$; Shapiro-Wilk statistic = 0.975, $p = 0.042$).

Based on these findings, we proceeded to verify the validity of the following research hypothesis:

H1: There are significant differences in the level of TPACK integration among teachers based on their age, teaching environment, academic background, subject they teach and position status.

In order to determine if there were differences in the level of TPACK integration based on teachers' age a Kruskal-Wallis test was conducted. The results showed no statistically significant difference between the level of TPACK integration perceived by teachers when teaching in the virtual environment according to the age group they belong to, $\chi^2(5) = 5.738$, $p = .333$.

The Mann-Whitney U test was performed in order to compare the level of TPACK integration between teachers based in rural and urban environments. The results showed no significant difference between these two groups, $U = 1101.0$, $p = .243$.

To assess the relationship between the academic background and the level of TPACK integration a Kruskal-Wallis test was conducted, the results revealing no significant differences, $\chi^2(3) = 1.870$, ($p = .393$). The Kruskal-Wallis test was performed in order to check for the differences concerning the level of TPACK integration across the different subject specializations (Mathematics, Science, Social Sciences, Languages, Primary Education, Vocational Education). The results showed no significant differences, $\chi^2(5) = 1.623$, $p = .898$.

For assessing whether the position status (permanent or temporary) has an impact on the level of TPACK integration a Mann-Whitney U test was carried out. With a $U = 1273.5$ and a $p = .610$, it has been found that there is no significant difference between the temporary and permanent position holders. Therefore, we fail to reject the null hypothesis.

H2: There is a significant relationship between the level of integration of technological pedagogical content knowledge and the success in using the virtual learning environment, the TPACK level of the teachers predicting the success of the VLE.

A linear regression analysis was performed to investigate the relationship between TPACK and VLE success among pre-university teachers. The results showed that teachers' TPACK level significantly predicts the VLE success ($\beta = 0.486$, $p < .001$), explaining 23.6% of the variance in VLE success as $R^2 = 0.236$, and with a $F(1,105) = 32.391$, ($p < .001$). The unstandardized regression coefficient ($B = 0.595$) indicates that for each unit increase in TPACK, VLE success increases by 0.595 units.

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.091	1	7.091	32.391	.000 ^b
	Residual	22.988	105	.219		
	Total	30.079	106			

Table 1: Dependent Variable: VLE Success Overall; Predictors: (Constant), TPACK Overall

For the purpose of assessing the relationship between teachers' TPACK level and VLE success a non-parametric alternative was used due to the fact that the distribution of the TPACK variable is not normal. The Spearman's rho coefficient ($r_s = .515, p < .001, N = 107$) has confirmed a strong positive correlation between the two variables of the study, namely teachers' technological pedagogical and content knowledge integration level and the success they perceived concerning the virtual learning environment usage in their classroom practice. These results confirm the robustness of the relationship identified by the parametric test.

		TPACK Overall	VLE Overall	Success	
Spearman's rho	TPACK Overall	Correlation Coefficient	1.000	.515**	
		Sig. (2-tailed)	.	.000	
		N	107	107	
	VLE Success Overall	Correlation Coefficient	.515**	1.000	
		Sig. (2-tailed)	.000	.	
		N	107	107	

** . Correlation is significant at the 0.01 level (2-tailed).

Table 2: Correlations.

As may be seen in the table below, we have addressed not only the relationship between the overall TPACK and VLE Success scores, but also deeper insights into the relationships between the components of the TPACK framework and the components of the VLES scale. Therefore, the Spearman's rho coefficients were computed in order to assess these relationships, the results indicating several significant associations.

VLE Success components	TPACK components						
	CK	PK	TK	PCK	TCK	TPK	TPACK
Information Quality	0.127	0.337**	0.315**	0.292**	0.332**	0.303**	0.310**
System Quality	0.183	0.358**	0.278**	0.318**	0.263**	0.322**	0.293**
Service Quality	0.307**	0.486**	0.284**	0.224*	0.223*	0.376**	0.280**
Intention to Use	0.203*	0.404**	0.462**	0.291**	0.455**	0.453**	0.490**
Use	0.202*	0.418**	0.375**	0.175	0.326**	0.303**	0.333**
User Satisfaction	0.279**	0.507**	0.328**	0.273**	0.428**	0.395**	0.370**
Net Benefits	0.204*	0.439**	0.245**	0.127	0.230**	0.254**	0.312**

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Table 3: VLE Components.

As clearly illustrated by the table above PK, TK, PCK, TCK, TPK and TPACK components have registered moderate positive significant correlations with the Information Quality and the System Quality of the VLE, with correlation coefficients ranging between $r_s = 0.263$ and $r_s = 0.358$, with a $p < 0.01$, highlighting the contribution of these integrative knowledge forms to information and system quality perceived as offered by the VLE.

Significant moderate correlations were also found across the majority of components in terms of Service Quality, operationalized as responsiveness, assurance, empathy and tangibility. In this case, stronger associations were observed for PK ($r_s = 0.486, p < 0.01$) and TK ($r_s = 0.284, p < 0.01$), but also CK has shown to have a significant association ($r_s = 0.307, p < 0.01$). These findings empower us to imply that both pedagogical and technological expertise enhance teachers' satisfaction with VLE services. Teachers' Intention to Use VLE was observed to correlate stronger with TK ($r_s = 0.462, p < 0.01$) and TPACK ($r_s = 0.490, p < 0.01$), this suggesting the fact that technological and integrative TPACK knowledge significantly impact their intention to use VLEs. Nevertheless, in what concerns the VLE usage, understood as frequency and nature of usage (testing students, gathering educational information, accessing resources or communicating to students and colleagues), PK and all the technology-related dimensions demonstrated strong correlations, particularly TK ($r_s = 0.462, p < 0.01$)

and TPACK ($r_s = 0.490$, $p < 0.01$). Whereas VLE success is concerned, the critical roles are played by PK ($r_s = 0.507$, $p < 0.01$) and TPK ($r_s = 0.395$, $p < 0.01$) in enhancing teachers' satisfaction.

When it comes to VLE's Net benefits, namely perceiving VLE as being time-saving or improving teachers' productivity and contributing to their personal development, significant positive correlations were found specially with PK ($r_s = 0.439$, $p < 0.01$) and the TPACK dimension ($r_s = 0.312$, $p < 0.01$).

As it has been shown, the current results indicate that the integrated components of TPACK, particularly TPACK, TPK, and PK, reliably show moderate to strong positive correlations with the dimensions of VLE success, particularly with Intention to Use, User Satisfaction, and Net Benefits. This suggests that teachers' ability to synthesize technological, pedagogical, and content knowledge significantly influences their effective use and perceptions of virtual learning environments.

The findings of the present study highlight the critical role played by the integration of the TPACK components in driving the success of the VLE. To sum up, we may advocate that teacher training programs should focus on fostering a holistic integration of technology, pedagogy, and content knowledge in order to maximize the effectiveness and the benefits of the virtual learning environments perceived by in-service pre-university teachers.

6. Conclusions and discussion

The main concern of the paper was to analyse the relationship between in-service teachers' perceived TPACK integration in their teaching practice and the success level registered through the usage of the virtual learning environment. To our knowledge, this is the first Romanian study to examine the link between the two educational constructs. We have also considered the consequences of some demographic factors that may have an implication in integrating the TPACK framework in the educational process.

Summing up the results of the study, it can be concluded that teachers' TPACK level plays a significant role in the success of virtual learning environments perceived by the teachers. However, no significant differences were observed when considering the demographic factors such as teachers' age, environment, academic background, specialization or position status. Furthermore, the linear regression analysis revealed that TPACK significantly predicts VLE success, a finding reinforced by the Spearman's correlation analysis conducted due to the non-normality of the TPACK scores. These results highlight the need for focused professional development programs that enhance TPACK competencies for virtual teaching success no matter the demographic variables. Therefore, an important implication of these findings resides in the fact that enhancing TPACK skills could lead to more effective use of digital tools, fostering better outcomes in terms of virtual learning environments usage.

The paper clearly has shown that higher levels of TPACK are associated with higher levels of success in the virtual learning environment. Therefore, enhancing teachers' ability to integrate technology with pedagogy and content can lead to better outcomes in virtual teaching environments. Moreover, the results are of direct practical relevance, consequently we may state that in order to improve teachers' TPACK skills and also the effectiveness of their teaching practice in the virtual environment some of the following measures may be implemented:

- integrating TPACK into initial and continuing training programs;
- promoting the exchange of good practices;
- updating educational policies.

One of the first limitations that should be acknowledged involves of the use of a convenience sampling which may have restricted the generalizability of this study's findings. Additionally, the reliance on self-reported measures may present the possibility of a response bias. With a view to overcoming the limitations of this investigation mixed-methods research appears to be needed for a better understanding of the relationship between teachers' TPACK levels and VLE outcomes in different educational contexts. Nevertheless, future research could explore longitudinal impacts of TPACK training on VLE outcomes and investigate the contextual factors that affect its application in different learning environments.

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