Verica Milutinović
University of Kragujevac, Faculty of Education, Jagodina

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Modelling pre-service teachers' ICT adoption in education: competencies, perceptions, and support

Abstract
In recent years, integrating Information and Communication Technologies (ICT) into teaching has become essential. This study aims to examine the factors that influence pre-service teachers' intention to adopt ICT in their future teaching, with a particular focus on faculty support and ICT competencies. Grounded in the extended Technology Acceptance Model, the research investigates whether Perceived Usefulness (PU), Perceived Ease of Use (PEU), and ICT Competencies for Instructional Design (ICTC_ID) and Pupil Use (ICTC_PU), along with faculty support measured as Synthesis of Qualitative Evidence (SQD), predict Behavioural Intention (BI) to use ICT. Data from 315 pre-service teachers at the University of Kragujevac, Faculty of Education, were analysed using structural equation modeling. The model explained 66.3% of the variance in BI, with PU, PEU, and ICTC_PU directly influencing BI, while SQD significantly predicted both ICT competencies directly and indirectly through PU and PEU. These findings underscore the pivotal role of faculty support in developing ICT competencies and strengthening BI, offering valuable pedagogical implications for teacher education programmes to enhance instructional strategies, mentorship, and hands-on technology experiences.

Keywords: *ICT integration in education, faculty support, pre-service teachers, ICT competencies, Structural Equation Modeling (SEM).*

Introduction

The integration of Information and Communication Technology (ICT) in education is crucial for modern teaching and learning. Institutions increasingly focus on equipping students with digital skills, making ICT adoption a key area of research (Milutinović & Mandić, 2022; Teo, 2009; Teo & Milutinović, 2015). The Technology Acceptance Model (TAM) highlights the perceived usefulness and ease of use as critical determinants of ICT adoption (Lawrence & Tar, 2018).

For pre-service teachers, ICT competencies and faculty support play a vital role in technology integration (Tondeur et al., 2018). Research shows that teachers' and students' attitudes toward ICT, their digital skills, and institutional support influence technology adoption (Buchanan et al., 2013). Faculty often face structural barriers and question the utility of learning technologies, emphasising the need for better institutional support and training (Buchanan et al., 2013).

Pre-service teachers' ICT competency levels vary, affecting their ability to design interactive instructional materials. Studies highlight challenges in developing digital resources and call for improved training (McGarr & McDonagh, 2020). Similarly, research in Spain identified gaps in digital teaching skills, reinforcing the need for ICT training in teacher education (Tárraga-Mínguez et al., 2021). Understanding the relationships between the perceived usefulness, ease of use, ICT competencies, and faculty support is crucial for enhancing ICT adoption.

This paper proposes a comprehensive model of ICT adoption in education, examining how these factors collectively shape pre-service teachers' intentions to integrate ICT into their teaching. The findings offer insights for institutions aiming to support educators in leveraging technology for improved learning outcomes.

Literature Review

The integration of ICT in education is essential for modern teaching, enhancing accessibility, flexibility, and interactivity (Lawrence & Tar, 2018). Beyond the classroom, ICT improves administrative efficiency and supports online instruction (Lawrence & Tar, 2018). However, successful adoption depends on teacher readiness, institutional support, and professional development (Akram et al., 2022). Despite its benefits, challenges like teachers' resistance and lack of competencies hinder full ICT integration (Ghavifekr & Rosdy, 2015). Addressing these barriers is crucial for maximising the potential of ICT in education.

TAM (Davis et al., 1989) explains technology adoption through the perceived usefulness (PU) and perceived ease of use (PEU). Studies confirm the relevance of TAM in education (Milutinović & Mandić, 2022; Milutinović, 2024a; Teo, 2009; Teo & Milutinović, 2015), showing its effectiveness in predicting behavioural intentions (BI) to use technologies (Granić & Marangunić, 2019). In Serbia, TAM-based research highlights the importance of PU and PEU in technology adoption (Milutinović & Mandić, 2022; Teo et al., 2017).

Based on the TAM we hypothesise:

H1: PU significantly influences BI.

H2: PEU significantly influences BI.

H3: PEU significantly influences PU.

ICT competencies involve integrating digital skills, knowledge, and attitudes to enhance teaching and learning (Tondeur et al., 2016). These competencies support instructional design and student engagement, influenced by PU, PEU, and behavioural intention (Tondeur et al., 2018). Training programmes incorporating role models and reflective practices significantly improve pre-service teachers' ICT competencies (Ristić, 2018).

Research highlights two key ICT competencies: (1) using ICT to enhance pupil learning (ICTC_PU) and (2) managing ICT for instructional design (ICTC_ID) (Tondeur et al., 2016). Studies show a strong correlation between self-perceived ICT competencies and the likelihood of integrating ICT in future teaching (Aslan & Zhu, 2017). Structured training, collaborative lesson planning, and continuous feedback improve instructional innovation with ICT (Chen et al., 2022).

Therefore, we formulated the following hypotheses:

H4: PU significantly influences ICTC_PU.

H5: PU significantly influences ICTC_ID.

H6: ICTC_PU significantly influences BI.

H7: PEU significantly influences ICTC_ID.

H8: ICTC_ID significantly influences ICTC_PU.

Faculty support and institutional training play a crucial role in pre-service teachers' ICT adoption. Teacher educators serve as role models, providing authentic technology experiences that shape ICT competencies (Tondeur et al., 2018). Structured training enhances pedagogical knowledge and technological skills, facilitating ICT integration into teaching (Aslan & Zhu, 2017).

Strategies like reflection, design-based learning, collaborative environments, and authentic experiences strengthen ICT competencies (Tondeur et al., 2018). Continuous feedback further supports technology integration, improving perceptions of the usefulness of ICT and ease of use (Petko et al., 2019).

Based on the above said, we formulated the following hypotheses:

H9: SQD significantly influences ICTC_PU.

H10: SQD significantly influences PU.

H11: SQD significantly influences PEU.

H12: SQD significantly influences ICTC_ID.

Present Study

The primary goal of this research is to evaluate whether the Perceived Usefulness, Perceived Ease of ICT Use, ICT Competencies for Pupil Use, ICT Competencies for Instructional Design, and Faculty Support for ICT Use (with subscales: Collaboration, Role Modeling, Reflection, Instructional Design, Feedback, and Authenticity) predict pre-service teachers' intentions to integrate ICT. It also examines the interconnections among these factors, providing insights for teacher educators and researchers (Milutinović, 2016; Milutinović & Mandić, 2022).

Focusing on Serbian pre-service teachers, this study aligns with national efforts to enhance digital competencies through policies, infrastructure upgrades, and training (Ministry of Education, Science and Technological Development, 2021). Serbia's digital education strategies follow European frameworks such as DigCompEdu and DigCompOrg, guiding teacher digital competence development (Kampylis et al., 2015; Redecker, 2017). The revised 2023 national framework underscores the role of ICT in modern education, equipping educators with essential digital skills.

Serbian researchers, like those in other developing nations, aim to identify factors influencing ICT adoption among pre-service teachers, particularly ICT competencies and faculty support. The study's research model (Figure 1) includes six key factors: Behavioural Intention (BI), Perceived Ease of Use (PEU), Perceived Usefulness (PU), ICT Competencies for Instructional Design (ICTC_ID), ICT Competencies for Pupil Use (ICTC_PU), and Faculty Support (SQD) with subscales: Collaboration (COL), Instructional Design (DES), Reflection (REF), Role Modeling (ROL), Feedback (FEE), and Authentic Experiences (AUT).

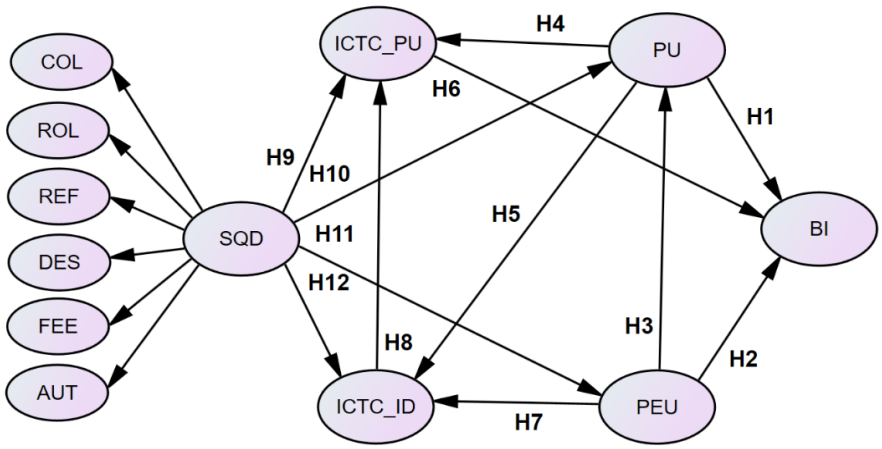

Fig. 1 *Research model*

This study aims to address the following research question in line with the hypotheses: How effectively does the research model predict pre-service teachers' behavioural intention (BI) to use ICT in their future teaching?

Methodology

Participants in the Research

A total of 315 students from the University of Kragujevac, and a well-established Serbian teacher education faculty, participated in this study. These students were randomly selected from a single public university, which reflects the typical structure of teacher education programmes in Serbia. Participants were enrolled in two compulsory courses, Pedagogical Informatics and Methodology of Informatics Education, which combined theoretical and practical ICT training. They also gained additional ICT exposure in other courses throughout their studies.

Each participant provided informed consent, which assured data anonymisation and clarified that the study was voluntary and for research purposes only. Ethical principles such as autonomy, respect, fairness, confidentiality, and compassion were maintained throughout the study. The online survey, available in Serbian, took approximately 10 minutes to complete. Participants' average age was 21.46 years (SD = 4.08), with 9.2% male, reflecting the gender distribution of Serbian education programmes, consistent with previous studies (Milutinović, 2022).

Instrument

This study used a two-part survey (questionnaire, Appendix 1) to explore key research variables. The first section collected demographic data (age, gender), while the second gathered self-reports on six variables using validated subscales: BI (3 items), PU (4), PEU (4), ICTC_ID (6), ICTC_PU (9), and SQD (24). All items used a five-point Likert scale, except SQD, which had six points.

Survey items for PU, PEU, and BI were adapted from established studies (Davis et al., 1989; Teo, 2009). To assess the support of teacher training institutions (TTIs), we modified Tondeur et al.'s (2016) instrument, evaluating six SQD strategies: role modelling, reflection, design-based learning, peer collaboration, authentic experiences, and feedback. The adapted ICTC scale (Tondeur et al., 2017) was used, where the ICTC_PU scale measured pre-service teachers' ability to teach ICT, and ICTC_ID assessed their ICT integration skills.

Items unsuitable for this context were excluded, and those with low factor loadings were removed after an exploratory factor analysis (EFA). The survey was translated by the author, reviewed by an EFL professor, and refined by a bilingualism expert through multiple iterations.

Data Analysis

We used structural equation modelling (SEM) to analyse the data, first assessing normality and then developing the study model. SEM, suitable for examining relationships between observed and latent variables (Hoyle, 2011), was conducted using Amos 23.0 and SPSS 17.0 with maximum likelihood estimation.

Following Anderson and Gerbing's (1988) two-step approach, we first evaluated the measurement model to confirm how well items represented latent variables, then tested the structural model for variable relationships. The measurement model included six components with uncorrelated errors. Based on Kline's (2011) N:q ratio of 20:1, a minimum of 120 participants was needed for six parameters. With 315 participants, SEM was appropriate.

Results

Descriptive Statistics of the Variables

Table 1 shows the descriptive statistics of the variables as calculated by SPSS. The mean values for all components exceed the scale means (3.5 for the SQD scale and 3.0 for the other scales), suggesting predominantly positive responses to the model's constructs. Following the guidelines of Schumacker & Lomax (2010) and Kline (2011), skewness and kurtosis values were within the acceptable range of |3|, and |10| respectively. Consequently, the data in this study were assumed to adhere to the principles of univariate normality.

Table 1 *The descriptive statistics, reliability and convergent validity of the study's constructs*

Construct	Mean	Std. Deviation	Skewness	Kurtosis	α	CR	AVE
SQD	4.566	0.801	-0.188	-0.519	0.957	0.968	0.835
ICTC_ID	4.119	0.662	-0.330	-0.753	0.869	0.859	0.504
ICTC_PU	4.274	0.637	-0.801	0.046	0.871	0.921	0.565
BI	4.306	0.716	-0.863	0.006	0.851	0.852	0.658
PU	4.444	0.645	-1.005	0.087	0.922	0.873	0.632
PEU	4.236	0.637	-0.545	-0.263	0.843	0.843	0.573

Note. α = Cronbach's Alpha; CR= composite reliability;
AVE = average variance extracted.

Assessment of the Measurement Model

Maximum likelihood estimation (MLE) and confirmatory factor analysis (CFA) were used to assess the measurement model with uncorrelated errors. Mardia's (1970) normalised multivariate kurtosis (586.074) was below the threshold (2600) for 50 observed items (Raykov & Marcoulides, 2008), confirming multivariate normality.

Table 2 presents discriminant validity results based on Fornell and Larcker's (1981) criteria. The square root of the AVE for each construct exceeded its correlations with other constructs, except for the ICTC subscales (ICTC_PU and ICTC_ID). While they were designed as distinct dimensions, high intercorrelations suggest partial overlap in practice. Despite this, each sub-scale offers valuable insights, and both will be analysed separately and together, consistent with our theoretical framework.

Table 2 *Assessment of discriminant validity and correlations among the constructs of the measurement model (N=315)*

	PEU	PU	ICTC_PU	BI	SQD	ICTC_ID
PEU	0.757					
PU	0.718	**0.795**				
ICTC_PU	0.681	0.724	0.752			
BI	0.739	0.758	0.683	**0.811**		
SQD	0.552	0.560	0.625	0.515	**0.914**	
ICTC_ID	0.716	0.698	**0.861**	0.647	0.606	0.710

Evaluations were conducted to examine the measurement model's internal consistency, convergent validity, and indicator reliability. Data reliability was assessed using the average variance extracted (AVE) and composite reliability (CR), with values of 0.50 or above deemed acceptable (Fornell & Larcker, 1981). As shown in Table 2, all constructs exhibited CRs, and AVEs within acceptable limits. Furthermore, the standardised estimates for the items were reviewed, with values above 0.50 indicating a satisfactory representation of the underlying construct (Hair et al., 2010), and all estimates met this criterion, ranging from 0.62 to 0.86.

The fit of the measurement model was evaluated using the minimum fit function ($\chi 2$) and the ratio of $\chi 2$ to the degrees of freedom ($\chi 2/df$), with a ratio below 3.0 regarded as optimal (Kline, 2011). Furthermore, a Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) values greater than 0.90 were considered to indicate a good fit (Hair et al., 2010; Schumacker & Lomax, 2010).

Additionally, we examined the standardised root mean square residual (SRMR) and the root mean square error of approximation (RMSEA). According to Hu and Bentler (1999), a good model fit is achieved when the

RMSEA is below 0.05 and the SRMR is under 0.08. Based on the CFA results, the measurement model used in this study fits the data well ($\chi 2$ = 1865.616, $\chi 2/df$ = 1.627, CFI = 0.927, TLI = 0.923, RMSEA = 0.045 [90% CI: 0.041–0.048], SRMR = 0.045).

Structural Model Assessment

We assessed the structural model's fit using the same goodness-of-fit indices and criteria applied to the CFA model. The results confirmed that the structural model demonstrated a good fit to the data ($\chi 2$ = 1865.971, $\chi 2/df$ = 1.623, CFI = 0.929, TLI = 0.924, RMSEA = 0.045 [90% CI: 0.041–0.048], SRMR = 0.045).

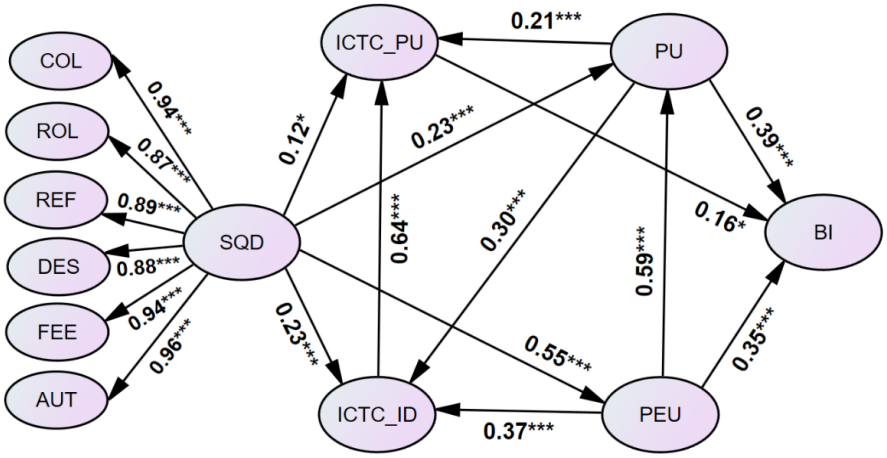

Fig. 2 *Standardised path coefficients for hypothesis outcomes*

Note. * p < 0.05; ** p < 0.01; *** p < 0.001.

Hypothesis Testing

Figure 2 presents the findings from testing all 12 hypotheses, along with the five endogenous variables (PU, PEU, ICTC-ID, ICTC-PU, and BI).

Table 3 presents the breakdown of effects derived from the path model, displaying the standardised total, direct, and indirect effects for each of the five endogenous variables and the exogenous variable.

The results showed that PU, PEU, and ICT_PU directly influenced pre-service teachers' intention to use ICT in the classroom. Five variables—SQD, PU, PEU, ICT_PU, and ICT_ID—accounted for 66.3% of the variance in behavioural intention (BI), with positive effects.

SQD significantly influenced both ICTC_PU and ICTC_ID directly and indirectly through PU and PEU, explaining 78.0% and 61.6% of the variance in ICTC_PU and ICTC_ID, respectively. SQD, along with PEU, explained 55.4% of the variance in PU, while SQD explained 30.6% of PEU's variance.

The findings highlight SQD as essential in developing ICT competencies for both pupil use and instructional design, influencing these competencies directly and indirectly through PU and PEU. Overall, the model explains 66.3% of the variance in BI, underscoring the key role of faculty support in fostering ICT competencies and shaping pre-service teachers' intentions to integrate ICT into their teaching.

Table 3 *Results of research model testing (standardised estimates of direct, indirect, and total effects)*

Outcome	Factor	Direct	Indirect	Total
Behavioral intention ($R^2 = 0.663$)	SQD	—	0.512	0.512
	ICTC_ID	—	0.104	0.104
	PEU	0.346	0.308	0.654
	ICTC_PU	0.162	—	0.162
	PU	0.393	0.065	0.458
Perceived Usefulness of ICT ($R^2 = 0.554$)	SQD	0.235	0.325	0.560
	PEU	0.588	—	0.588
Perceived Ease of Use ($R^2 = 0.306$)	SQD	0.553	—	0.553
ICT competencies - Pupil use ($R^2 = 0.780$)	SQD	0.117	0.508	0.625
	PU	0.211	0.192	0.403
	PEU	—	0.477	0.477
	ICTC_ID	0.643	—	0.643
ICT competencies - Instructional design ($R^2 = 0.616$)	SQD	0.232	0.374	0.606
	PU	0.298	—	0.298
	PEU	0.374	0.175	0.549

Discussion

This study aimed to evaluate whether Perceived Usefulness (PU), Perceived Ease of Use (PEU), ICT Competencies for Instructional Design (ICTC_ID), ICT Competencies for Pupil Use (ICTC_PU), and Faculty Support for ICT Use (SQD) serve as significant predictors of pre-service teachers' behavioural intention (BI) to use ICT in their future teaching. The findings indicate that these factors collectively explain 66.3% of the variance in BI, highlighting their importance in shaping pre-service teachers' technology adoption. Additionally, faculty support, represented by SQD,

plays a crucial role in developing ICT competencies for both pupil use and instructional design, with direct and indirect effects through PEU and PU.

Predicting Pre-Service Teachers' Behavioural Intention to Use ICT

The model in this study demonstrated a good fit to the data, supporting the validity of the relationships and the overall framework for understanding pre-service teachers' ICT integration.

The results showed that all 12 hypotheses were supported. PU, PEU, and ICTC_PU directly impacted pre-service teachers' intention to use ICT in the classroom. PU had the strongest effect ($\beta = 0.393$), followed by PEU ($\beta = 0.346$) and ICTC_PU ($\beta = 0.162$). The study also found that ICTC_PU is influenced by ICTC_ID ($\beta = 0.643$), highlighting the importance of instructional design competencies in supporting pupil use of ICT. These findings align with previous research that underscores the role of the perceived usefulness, ease of use, and competencies in driving technology adoption (Davis et al., 1989; Milutinović, 2022; Teo, 2009).

SQD significantly influenced both ICTC_PU and ICTC_ID, with direct and indirect effects. SQD explained 78.0% of the variance in ICTC_PU and 61.6% in ICTC_ID. Faculty support directly impacted PEU ($\beta = 0.553$) and PU ($\beta = 0.560$), while also indirectly influencing ICTC_ID ($\beta = 0.104$). These results emphasise the key role of faculty support in developing ICT competencies and fostering positive perceptions of ICT integration, consistent with research by Petko et al. (2019) and Tondeur et al. (2016, 2017), who highlighted the importance of faculty role modelling, feedback, and collaboration in technology adoption.

SQD also influenced ICTC_PU and ICTC_ID through PU and PEU, demonstrating the importance of practical training, collaboration, and feedback. The study suggests that teacher training programmes should focus on real-world ICT applications, enhancing both instructional design and pupil-use competencies to improve pre-service teachers' ICT adoption. These findings align with the work of Mandić et al. (2017), who found that innovative teaching approaches contributed to improved ICT competencies among students, and Tondeur et al. (2025), who emphasised the importance of continuous adaptation of teacher education programmes to digital teaching practices.

Theoretical and Practical Contributions, Limitations, and Future Research

This study contributes to the literature by extending the Technology Acceptance Model (TAM) framework through the inclusion of faculty support and ICT competencies. While prior research has focused on self-efficacy and attitudes toward ICT (Teo et al., 2016), this study emphasises the institutional and instructional factors that shape teachers' ICT competencies and acceptance.

The study emphasises the importance of faculty support in shaping pre-service teachers' intention to use ICT and the development of their ICT competencies. Although SQD did not directly predict behavioural intention, its strong indirect impact highlights its vital role in ICT integration. Teacher education programmes should focus on key SQD elements like role modelling, reflection, instructional design, collaboration, authentic experiences, and feedback to enhance ICT integration. Given the rapid evolution of digital learning, these programmes must continuously adapt to equip pre-service teachers with relevant competencies, as highlighted by Tondeur et al. (2025).

Furthermore, the study underscores the significant impact of PU and PEU on ICT competencies and BI. Programmes should enhance pre-service teachers' perceptions of ICT's usefulness and ease of use through hands-on experiences, modelling, and collaborative learning. Additionally, ICTC_ID serves as a foundational skill for effective ICTC_PU which directly influences BI, emphasising the need to prioritise both instructional design and pupil-centred applications.

By fostering ICTC_ID and ICTC_PU through faculty support, teacher education programmes can ensure that future educators feel competent and motivated to integrate ICT. The successful integration of ICT depends on sustained institutional support, as Ristić (2018) pointed out, as well as Janković and Ristić (2018), who emphasised the importance of faculty support in shaping pre-service teachers' intention to use ICT and develop their competencies. They advocate for teachers to transition from being mere knowledge providers to facilitators, fostering a dynamic learning environment with the use of ICT that motivates continuous development among educators and students alike. Ristić (2024) emphasises that achieving digital maturity is imperative for educational institutions, underscoring the necessity of faculty support in shaping pre-service teachers' intentions, attitudes, and ICT competencies.

Overall, the study highlights the importance of holistic, practice-based, interdisciplinary (Milutinović, 2024b) ICT training that combines techni-

cal proficiency with pedagogical competencies. Faculty involvement should include role modelling, collaborative learning, authentic experiences, and continuous feedback to strengthen pre-service teachers' ICT competencies and foster a technology-integrated teaching environment.

This study has some limitations. First, reliance on self-reported data may introduce bias, as participants could overestimate or underestimate their ICT competencies. Second, the sample was from a single university in Serbia, limiting the generalisability of the findings.

Future research should focus on longitudinal studies to assess the long-term impact of faculty support on ICT adoption, cross-cultural comparisons to explore variations across educational systems, and experimental or intervention studies to examine the effects of faculty-led ICT training on pre-service teachers' competencies.

Conclusion

This study highlights key factors influencing pre-service teachers' behavioural intention (BI) to integrate ICT into their teaching. The results show that the perceived usefulness (PU), perceived ease of use (PEU), and ICT competencies for pupil use (ICT_PU) significantly impact BI. Together, five factors – SQD, PU, PEU, ICT_PU, and ICT_ID – explain 66.3% of the variance in BI, emphasising the interconnected role of faculty support (SQD), ICT competencies, and technology perceptions in shaping ICT adoption intentions. Notably, ICT_PU's strong influence suggests that pre-service teachers' confidence in using ICT for student engagement is crucial, reinforcing the need for hands-on ICT training and pedagogical integration in teacher education.

The study also underscores the importance of faculty support in developing pre-service teachers' ICT competencies. By demonstrating how SQD influences both ICTC_PU and ICTC_ID directly and indirectly, it stresses the need for teacher education programmes that promote active engagement with technology. Emphasising role modelling, continuous feedback, and collaborative learning can better prepare future educators to effectively integrate technology into their classrooms. Future research should examine other contextual factors that may influence ICT adoption in teacher education.

References

Akram, H., Abdelrady, A., Al-Adwan, A., & Ramzan, M. (2022). Teachers' Perceptions of Technology Integration in Teaching-Learning Practices: A Systematic Review. *Frontiers in Psychology*, 13.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin*, *103*(3), 411–423.

Aslan, A., & Zhu, C. (2017). Investigating variables predicting Turkish pre-service teachers' integration of ICT into teaching practices. *British Journal of Educational Technology*, 48, 552-570.

Buchanan, T., Sainter, P., & Saunders, G. (2013). Factors affecting faculty use of learning technologies: implications for models of technology adoption. *Journal of Computing in Higher Education*, 25, 1 - 11.

Chen, W., Pi, Z., Tan, J., & Lyu, Q. (2022). Preparing pre-service teachers for instructional innovation with ICT via co-design practice. *Australasian Journal of Educational Technology*.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8) , 982–1003.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 48*, 39–50.

Ghavifekr, S., & Rosdy, W. (2015). Teaching and Learning with Technology: Effectiveness of ICT Integration in Schools. *Indonesian Journal of Educational Research and Technology*, *1*(2), 175.

Granić, A., & Marangunic, N. (2019). Technology acceptance model in educational context: A systematic literature review. *British Journal of Educational Technology.*, 50, 2572-2593.

Hair, J. F., Jr., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis* (seventh ed.). New Jersey: Prentice-Hall International.

Hoyle, R. H. (2011). *Structural equation modeling for social and personality psychology*. London: Sage.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural equation modeling: a multidisciplinary journal*, *6*(1), 1-55.

Janković, N., & Ristić, M. (2018). Hand in hand – developing university teachers' and pre-service teachers' cross-curricular competences. In: Zacłona, Z. and Radovanović, I. (Eds.) *Chosen issues of education in the modern era* (38–50). Nowy Sacz ‑ Belgrade: State University of Applied Sciences ‑ Teacher Education Faculty.

Kampylis, P., Punie, Y. and Devine, J. (2015). *Promoting Effective Digital-Age Learning: A European Framework for Digitally-Competent Educational Or-*

ganisations, EUR 27599 EN, Publications Office of the European Union, Luxembourg, ISBN 978-92-79-54005-9.

Kline, R. B. (2011). *Principles and practice of structural equation modelling.* 3rd ed. New York: Guilford Press.

Lawrence, J., & Tar, U. (2018). Factors that influence teachers' adoption and integration of ICT in teaching/learning process. *Educational Media International*, 55 (1), 79 - 105.

Mandić, D., Jauševac, G., Jotanović, G., Bešić, C., Vilotijević, N., & Ješić, D. (2017). Educational innovations in the function of improving students' ICT competences. *Croatian Journal of Education*, *19*(Sp. Ed. 3), 61-74.

Mardia, K. V. (1970). Measures of multivariate skewness and kurtosis with applications. *Biometrika, 36*, 519–530.

Mcgarr, O., & McDonagh, A. (2020). Exploring the digital competencies of preservice teachers on entry onto an initial teacher education programme in Ireland. *Irish Educational Studies*, *40* (1), 115 - 128.

Milutinović, V. (2016). An exploration of acceptance of innovative computer use in teaching mathematics among pre-service class teachers and mathematics teachers. *Zbornik Instituta za pedagoška istraživanja 48*(2), 339-366.

Milutinović, V. (2022). Examining the influence of pre-service teachers' digital native traits on their technology acceptance: A Serbian perspective. *Education and Information Technologies, 27*, 6483–6511.

Milutinović, V. (2024a). Unlocking the code: Exploring predictors of future interest in learning computer programming among primary school boys and girls. *International Journal of Human-Computer Interaction*, 1–18.

Milutinović, V. (2024b). An iterative algorithm for determining the greatest common divisor of two or more univariate polynomials. *Mathematics and Informatics*, 67(4), 392–405.

Milutinović, V., & Mandić, D. (2022). Predicting Teachers' Acceptance to Use Computers at Traditional and Innovative Levels in Teaching Mathematics in Serbia. *Teaching Innovations, 35*(2), 71–88.

Ministry of Education, Science and Technological Development of the Republic of Serbia. (2021). *Strategy for the development of education in Serbia until 2030*. (Official Gazette of the Republic of Serbia, No. 63, June 23, 2021).

Petko, D., Schmid, R., Müller, L., & Hielscher, M. (2019). Metapholio: A Mobile App for Supporting Collaborative Note Taking and Reflection in Teacher Education. *Technology, Knowledge and Learning*, 24, 699 - 710.

Raykov, T., & Marcoulides, G. A. (2008). *An introduction to applied multivariate analysis*. New York, NY: Taylor & Francis.

Redecker, C. (2017). European Framework for the Digital Competence of Educators: DigCompEdu. Punie, Y. (ed). EUR 28775 EN. Publications Office of the European Union, Luxembourg, ISBN 978-92-79-73494-6, JRC107466

Ristić, M. (2018). Digitalne kompetencije nastavnika i saradnika. *Digitalizacija Visokog Obrazovanja: XXIV Skup Trendovi Razvoja: Zbornik Radova* (Paper No. T1. 4-6, pp. 1-4). Novi Sad: Fakultet tehničkih nauka.

Ristić, M. (2024). A proposal of a multidimensional model for the assessment of OER quality standards. In: Visković, I., Zacłona, Z. and Radovanović, I. (Eds.) *Pedagogy in Education Practice*, 197-217. University of Split, Faculty of Humanities and Social Sciences

Schumacker, R. E., & Lomax, R. G. (2010). *A beginner's guide to structural equation modeling (3rd ed.)*. New York: Routledge.

Tárraga-Mínguez, R., Suárez-Guerrero, C., & Sanz-Cervera, P. (2021). Digital Teaching Competencies Evaluation of Pre-Service Teachers in Spain: A Review Study. *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*, 16, 70-76.

Teo, T. (2009). Modeling technology acceptance in education: A study of pre-service teachers. *Computers & Education*, 52, 302–312.

Teo, T., & Milutinović, V. (2015). Modelling the intention to use technology for teaching Mathematics among pre-service teachers in Serbia. *Australasian Journal of Educational Technology, 31*(4), 363–380.

Teo, T., Milutinović, V., & Zhou, M. (2016). Modelling Serbian pre-service teachers' attitudes towards computer use: A SEM and MIMIC approach. *Computers & Education, 94*, 77-88.

Teo, T., Milutinović, V., Zhou, M., & Banković, D. (2017). Traditional vs. innovative uses of computers among mathematics pre-service teachers in Serbia. *Interactive Learning Environments*, *25*(7), 811–827.

Tondeur, J. (2018). Enhancing future teachers' competencies for technology integration in education: Turning theory into practice. *Seminar.Net, 14*(2), 216–224.

Tondeur, J., Aesaert, K., Prestridge, S., & Consuegra, E. (2018). A multilevel analysis of what matters in the training of pre-service teacher's ICT competencies. *Computers & Education*, *122*, 32-42.

Tondeur, J., Aesaert, K., Pynoo, B., Van Braak, J., Fraeyman, N., & Erstad, O. (2017). Developing a validated instrument to measure preservice teachers' ICT competencies: Meeting the demands of the 21st century. *British Journal of Educational Technology*, *48*(2), 462-472.

Tondeur, J., Trevisan, O., Howard, S. K., & van Braak, J. (2025). Preparing pre-service teachers to teach with digital technologies: An update of effective SQD-strategies. *Computers & Education*, 105262.

Tondeur, J., van Braak, J., Siddiq, F., & Scherer, R. (2016). Time for a new approach to prepare future teachers for educational technology use: Its meaning and measurement. *Computers & Education, 94*, 134-150.

Appendix 1:

List of Constructs and Corresponding Items

Perceived ease of use (adapted from Davis et al. 1989; Teo 2009)
(PEU1) I find it easy to interact with ICT;
(PEU2) I find it flexible to interact with ICT;
(PEU3) It would be easy for me to become skillful at using ICT in educational practice;
(PEU4) In general, I consider ICT to be easy to use.

Perceived usefulness (adapted from Davis et al. 1989; Teo 2009)
(PU1) The use of ICT improves the educational practice;
(PU2) The use of ICT makes the educational practice more effective;
(PU3) The use of ICT makes it easier to carry out educational tasks;
(PU4) In general, I consider that ICT are useful in education.

Behavioural intention (adapted from Teo 2009)
(BI1) I intend to use ICT frequently in my future educational practice;
(BI2) I will probably use ICT in my educational practice as soon as I start working;
(BI3) I will use ICT in my future educational practice.

ICT competencies - Pupil use (adapted from Tondeur et al., 2017)
I am able to . . .
(ICTC-PU1) motivate pupils to use ICT in a positive way;
(ICTC-PU2) provide pupils with activities to exercise knowledge/skills by means of ICT;
(ICTC-PU3) provide pupils with activities on subject matters to learn with ICT;
(ICTC-PU4) offer pupils opportunities to express ideas in a creative way by means of ICT;
(ICTC-PU5) support pupils in searching information by means of ICT;
(ICTC-PU6) support pupils in processing and managing information by means of ICT;
(ICTC-PU7) support pupils to present information by means of ICT;
(ICTC-PU8) support pupils to communicate with ICT in a safe, responsible and effective way;
(ICTC-PU9) support pupils to work together with ICT;

ICT competencies - Instructional design (adapted from Tondeur et al., 2017)

I am able to . . .

(ICTC-ID1) use ICT to differentiate learning and instruction;
(ICTC-ID2) track the learning progress of pupils in a digital way;
(ICTC-ID3) evaluate pupils with the help of ICT;
(ICTC-ID4) use ICT appropriately to communicate with pupils;
(ICTC-ID5) design a learning environment with the available infrastructure;
(ICTC-ID6) select ICT applications effectively in creating a learning environment (e.g, in view of the group size).

Faculty support measured as Synthesis of Qualitative Evidence (SQD) (Tondeur et al., 2016)

During my pre-service training, …

(ROL1) I saw many examples of ICT use in an educational setting;
(ROL2) I observed sufficient ICT use in an educational setting in order to integrate applications myself in the future;
(ROL3) I saw good examples of ICT practice that inspired me to use ICT applications in the classroom myself;
(ROL4) The potential of ICT use in education was demonstrated concretely;
(REF1) I was given the chance to reflect on the role of ICT in education;
(REF2) We discussed the challenges of integrating ICT in education;
(REF3) We were given the opportunity to discuss our experiences with ICT in the classroom
(i.e., during internships);
(REF4) There were specific occasions for us to discuss our general attitude towards ICT in education;
(DES1) I received sufficient help in designing lessons that integrated ICT;
(DES2) We learnt how to thoroughly integrate ICT into lessons;
(DES3) We received help to use ICT when developing educational materials;
(DES4) I received a great deal of help developing ICT-rich lessons and projects to use for my internship;
(COL1) There were enough occasions for me to work together with other students on ICT use
in education (i.e., we developed ICT-based lessons together);
(COL2) I was convinced of the importance of co-operation with respect to ICT use in education;
(COL3) Students helped each other to use ICT in an educational context;
(COL4) Experiences using ICT in education were shared;
(AUT1) There were enough occasions for me to test different ways of using ICT in the classroom;
(AUT2) I was able to learn to use ICT in the classroom through the internships;

(AUT3) I was encouraged to gain experience in using ICT in a classroom setting;
(AUT4) Students were encouraged when they attempted to use ICT in an educational setting;
(FEE1) I received sufficient feedback about the use of ICT in my lessons;
(FEE2) My competences with ICT were thoroughly evaluated;
(FEE3) I received sufficient feedback on how I can further develop my ICT competences;
(FEE4) My competences in using ICT in the classroom were regularly evaluated.

Моделовање прихватања ИКТ-а у образовању од стране будућих учитеља: компетенције, перцепције и подршка

Иако је значај интеграсања информационо-комуникационих технологија (ИКТ) у наставу широко признат, многи наставници и даље избегавају или не успевају да користе ИКТ у својим учионицама. Упркос бројним предностима, разне баријере ометају њихову широко распрострањену употребу у образовању. Ово истраживање бави се факторима који утичу на намеру будућих учитеља да прихвате ИКТ у својој будућој настави, с посебним фокусом на подршку факултета и ИКТ компетенције. Разумевање ових фактора кључно је за развој ефикасних програма за обуку наставника.

Истраживање је засновано на проширеном Моделу прихватања технологије (TAM) и истражује да ли доживљај корисности (PU), доживљај лакоће употребе (PEU), ИКТ компетенције за дизајн наставе (ICTC_ID), ИКТ компетенције за коришћење са ученицима (ICTC_PU) и подршка факултета (SQD), предвиђају намеру (BI) да се користи ИКТ у настави. SQD укључује подскале као што су сарадња, моделовање, рефлексија, дизајн наставе, повратне информације и аутентичност, које су кључни фактори у развоју ИКТ компетенција будућих учитеља.

Подаци који су прикупљени од 315 будућих учитеља на Факултету педагошких наука Универзитета у Крагујевцу, анализирани су коришћењем моделовања структуралним једначинама (SEM). Резултати су показали да модел има добру подесност са подацима и објашњава 66,3% варијансе у BI за употребу ИКТ у будућој настави. PU, PEU и ICTC_PU директно су утицали на BI, док је подршка наставника (SQD) значајно предвидела ИКТ компетенције, како директно, тако и индиректно кроз PU и PEU. SQD, заједно са PU и PEU, објаснили су 61,6% варијансе у ICTC_ID, а заједно са ICTC_ID, PU и PEU, чинили су 78,0% варијансе у ICTC_PU. SQD и PEU објаснили су 62,5% варијансе у PU, а SQD самостално објашњава 55,5% варијансе у PEU. Ови резултати истичу кључну улогу подршке факултета у обликовању ИКТ компетенција будућих учитеља и њихове намере да интегришу ИКТ у своје наставне праксе.

Истраживање има важне педагошке импликације, наглашавајући потребу за ефикасним наставним стратегијама које развијају ИКТ компетенције. Програми образовања учитеља требало би да подстичу укљученост наставног особља у моделовање, менторство, сарадњу и аутентична ИКТ искуства. Обезбеђивање практичних искустава уз коришћење ИКТ и континуираних повратних информација помогло би будућим учитељима да побољшају своје перцепције о корисности и лакоћи употребе ИКТ-а, што би их охрабрило да интегришу ИКТ у своје учионице.

Закључак овог истраживања пружа вредне увиде у факторе који утичу на намеру будућих учитеља да прихвате ИКТ у образовању. Резултати потврђују важност подршке факултета и развоја ИКТ компетенција у обликовању њихових намера. Интегрисањем ових налаза у програме образовања учитеља, образовне институције могу их боље припремити за ефикасну употребу ИКТ у настави, што би допринело побољшању образовних пракси и интеграцији ИКТ у учионицама.

Кључне речи: *интегрисање ИКТ у наставу, подршка факултета, будући учитељи, ИКТ компетенције, моделовање структуралним једначинама (SEM).*

Modelowanie akceptacji ICT w edukacji przez przyszłych nauczycieli: kompetencje, percepcje i wsparcie

Choć znaczenie integracji technologii informacyjno-komunikacyjnych (ICT) w nauczaniu jest powszechnie uznawane, wielu nauczycieli wciąż unika korzystania z ICT lub nie potrafi skutecznie wykorzystywać tych technologii w swoich klasach. Pomimo licznych korzyści, różne bariery niestety utrudniają ich szerokie zastosowanie w edukacji. Niniejsze badanie dotyczy czynników wpływających na zamiar podjęcia przez przyszłych nauczycieli starań w zakresie wdrażania ICT w ich pracy dydaktycznej, ze szczególnym uwzględnieniem wsparcia ze strony wydziału i kształtowania kompetencji z obszaru ICT. Zrozumienie tych czynników ma kluczowe znaczenie dla tworzenia efektywnych programów kształcenia nauczycieli.

Badanie opiera się na rozszerzonym Modelu Akceptacji Technologii (TAM) i analizuje, czy postrzegana użyteczność (PU), postrzegana łatwość użycia (PEU), kompetencje ICT w projektowaniu nauczania (ICTC_ID), kompetencje ICT w pracy z uczniami (ICTC_PU) oraz wsparcie wydziału (SQD) przewidują zamiar (BI) korzystania z ICT w nauczaniu. SQD obejmuje takie podskale jak współpraca, modelowanie, refleksja, projektowanie zajęć, informacja zwrotna i autentyczność, które stanowią kluczowe czynniki w rozwijaniu kompetencji ICT przyszłych nauczycieli.

Dane zebrane od 315 przyszłych nauczycieli Wydziału Nauk Pedagogicznych Uniwersytetu w Kragujevcu przeanalizowano z wykorzystaniem modelowania równań strukturalnych (SEM). Wyniki wykazały, że model dobrze dopasowuje się do danych i wyjaśnia 66,3% wariancji BI dotyczącej wykorzystania ICT w przyszłej pracy dydaktycznej. PU, PEU i ICTC_PU miały bezpośredni wpływ na BI, a wsparcie wykładowców (SQD) istotnie przewidywało kompetencje ICT - zarówno bezpośrednio, jak i pośrednio poprzez PU i PEU. SQD wraz z PU i PEU wyjaśniały 61,6% wariancji ICTC_ID, a wspólnie z ICTC_ID, PU i PEU stanowiły 78,0% wariancji ICTC_PU. SQD i PEU wyjaśniały 62,5% wariancji PU, a samo SQD wyjaśniało 55,5% wariancji PEU. Wyniki te podkreślają kluczową rolę wsparcia wydziału w kształtowaniu kompetencji ICT przyszłych nauczycieli oraz ich gotowości do integracji ICT w praktyce dydaktycznej.

Badanie niesie istotne implikacje pedagogiczne, podkreślając potrzebę stosowania skutecznych strategii dydaktycznych, rozwijających kompetencje w zakresie ICT. Programy kształcenia nauczycieli powinny sprzyjać zaangażowaniu kadry w modelowanie, mentoring, współpracę i tworzenie autentycznych doświadczeń związanych z ICT. Zapewnienie praktycznych doświadczeń z wykorzystaniem ICT i ciągłej informacji zwrotnej pomogłoby przyszłym nauczycielom w kształtowaniu pozytywnego nastawienia do tego zagadnienia i w efekcie łatwości użycia ICT, co z pewnością zachęciłoby ich do integrowania technologii w ich klasach.

Wnioski z niniejszego badania dostarczają cennych informacji na temat czynników wpływających na zamiar podjęcia przez przyszłych nauczycieli starań w zakresie wdrażania ICT w edukacji. Wyniki potwierdzają znaczenie wsparcia wydziału i dużą rolę rozwijanych kompetencji ICT. Uwzględniając te ustalenia w programach kształcenia nauczycieli, instytucje edukacyjne mogą lepiej przygotować przyszłych nauczycieli do skutecznego wykorzystania ICT w nauczaniu, przyczyniając się do poprawy praktyk dydaktycznych oraz integracji ICT w klasach.

Słowa kluczowe: *integracja ICT w nauczaniu; wsparcie wydziału; przyszli nauczyciele; kompetencje ICT; modelowanie równań strukturalnych (SEM).*

Modeliranje prihvaćanja IKT-a u obrazovanju od strane budućih učitelja: kompetencije, percepcije i podrška

Iako je važnost integracije informacijsko-komunikacijskih tehnologija (IKT) u nastavi široko prepoznata, mnogi nastavnici i dalje izbjegavaju ili ne uspijevaju koristiti IKT u svojim učionicama. Unatoč brojnim prednostima, razne prepreke ometaju njihovu široku primjenu u obrazovanju. Ovo istraživanje bavi se čimbenicima koji utječu na namjeru budućih učitelja da prihvate IKT u svojoj nastavi, s posebnim naglaskom na podršku fakulteta i IKT kompetencije. Razumijevanje ovih čimbenika ključno je za razvoj učinkovitih programa obrazovanja učitelja.

Istraživanje se temelji na proširenom Modelu prihvaćanja tehnologije (TAM) i ispituje predviđaju li percipirana korisnost (PU), percipirana lakoća uporabe (PEU), IKT kompetencije za oblikovanje nastave (ICTC_ID), IKT kompetencije za rad s učenicima (ICTC_PU) te podrška fakulteta (SQD) i namjeru (BI) korištenja IKT-a u nastavi. SQD uključuje podskale poput suradnje, modeliranja, refleksije, oblikovanja nastave, povratnih informacija i autentičnosti, koje su ključni čimbenici u razvoju IKT kompetencija budućih učitelja.

Podaci prikupljeni od 315 budućih učitelja na Fakultetu pedagoških znanosti Sveučilišta u Kragujevcu analizirani su korištenjem modeliranja strukturnim jednadžbama (SEM). Rezultati su pokazali da se model uklapa u podatke i objašnjava 66,3% varijance u BI za uporabu IKT-a u budućoj nastavi. PU, PEU i ICTC_PU izravno su utjecali na BI, dok je podrška nastavnika (SQD) značajno predviđala IKT kompetencije, i izravno i neizravno putem PU i PEU. SQD, zajedno s PU i PEU, objasnila je 61,6% varijance ICTC_ID, a zajedno s ICTC_ID, PU i PEU činila je 78,0% varijance ICTC_PU. SQD i PEU objasnili su 62,5% varijance PU, a SQD sama objašnjava 55,5% varijance PEU. Ovi rezultati ističu ključnu ulogu podrške fakulteta u oblikovanju IKT kompetencija budućih učitelja i njihove namjere da integriraju IKT u svoju nastavnu praksu.

Istraživanje ima važne pedagoške implikacije, naglašavajući potrebu za učinkovitim nastavnim strategijama koje razvijaju IKT kompetencije. Programi obrazovanja učitelja trebali bi poticati uključivanje nastavnog osoblja u modeliranje, mentorstvo, suradnju i autentična IKT iskustva. Osiguravanje praktičnih iskustava u korištenju IKT-a te kontinuiranih povratnih informacija pomoglo bi budućim učiteljima poboljšati njihovu percepciju korisnosti i lakoće uporabe IKT-a, što bi ih ohrabrilo u integriranju IKT-a u nastavi.

Nalazi istraživanja pružaju uvid u čimbenike koji utječu na namjeru budućih učitelja da prihvate IKT u nastavi. Naglašena je važnost podrške fakulteta i razvoja IKT kompetencija u oblikovanju njihovih namjera. Integracija nalaza ovog istraživanja u programe obrazovanja učitelja doprinijela bi boljoj pripremi za učinkovitu uporabu IKT-a u nastavi što što može doprinijeti kvaliteti nastavne prakse i integraciji IKT-a u učionicama.

***Ključne riječi*:** *integracija IKT-a u nastavu, podrška fakulteta, budući učitelji, IKT kompetencije, modeliranje strukturnim jednadžbama (SEM).*