E-learning & Artificial Intelligence
Scientific Editor Eugenia Smyrnova-Trybulska
"E-learning", 15, Katowice–Cieszyn 2023, pp. 209–221
https://doi.org/10.34916/el.2023.15.17

EVALUATING THE TOOL FOR ENHANCING PRE-SERVICE TEACHERS' DIGITAL COMPETENCIES IN PROFESSIONAL COMMUNICATION AND COLLABORATION

Ani Epitropova
Plovdiv University "Paisii Hilendarski"
epitropova@uni-plovdiv.bg, https://orcid.org/0000-0003-3189-9007

Abstract: *This study critically examines a tool designed to assess and enhance pre-service teachers' digital competencies in professional communication and collaboration. With the growing importance of technology integration in education, it is crucial for future educators to possess strong digital skills. The research aims to evaluate the effectiveness of the tool through a comprehensive assessment process that involves data collection through assessments and observations to gather insights into initial competencies, progress, and perceptions of the tool's effectiveness. The findings contribute to the existing knowledge on digital competencies in teacher education and inform the development of targeted interventions. Ultimately, the study aims to equip pre-service teachers with the necessary digital competencies for effective communication and collaboration in educational settings.*

Keywords: digital competencies; tool evaluation; initial teacher education; professional communication; collaboration

INTRODUCTION

The development of digital competences among pre-service teachers is crucial for their successful professional realization. Mastery of digital professional communication and collaboration competencies is indispensable for effective 21st-century teaching and learning processes. The increasing emphasis on digital competences for pre-service teachers has spurred a surge in research and publications dedicated to this topic. Scholars and educators are increasingly recognizing the importance of understanding and enhancing the digital competences and capabilities of future teachers, contributing to a growing body of knowledge in the field. According to Bergum Johanson's (2023) findings, "the main factors contributing to their competence in digital interaction and communication are the students' attitudes toward and experiences with virtual communication solutions. The students' mastery of emotional

engagement with virtual collaboration solutions also played a definite but smaller role in their digital competence." Other factors in the acquisition of digital competency that could be considered influential, though not determinative, include gender, age, and academic degree according to Cabezas-González (2021).

Other researchers, such as Reisoğlu (2020), focus on the competences that should be developed, primarily information and data literacy, communication and collaboration, digital content creation, safety and problem-solving, knowledge and practice related to professional engagement, teaching and learning, assessment, and empowering learners. In the literature overview of teachers' professional digital competence, Ewa Skantz-Åberg (2022) and coauthors distinguish seven recurring aspects of teachers' professional digital competence: 1) technological competence, 2) content knowledge, 3) attitudes toward technology use, 4) pedagogical competence, 5) cultural awareness, 6) critical approach, and 7) professional engagement, with technological and pedagogical competences being the most prominent. They also conclude that the concept of teachers' professional digital competence still appears to be ambiguous and elusive, requiring further research in the field.

1. THEORETICAL BACKGROUND

The Key Competences for Lifelong Learning adopted by the European Parliament and the European Council include transversal competences (digital, learning to learn, civic competences) and the meta-competence of learning to learn (adjusting to change, managing, and selecting from huge information flows) (European Commission, 2019). Teachers should understand, deploy and assess key competences; this entails interdisciplinary collaboration skills, as underlined in the document Assessment of Key Competences in initial education and training Cedefop (2020). Assessing the digital competencies in the beginning of initial teacher education and the process of developing and upgrading them for the purposes of professional communication and collaboration are the focus of this research.

The development of digital competences is a priority topic in the policy and publications of the European Commission. There is an apparent growth in academic research publications on digital competences focused on specific areas such as the transition from digital literacy to digital competence (Falloon, 2020), teachers' digital competencies in higher education (Basilotta, 2022), subject-specific technology-related professional competence of teachers like digital competencies for teaching in science education (Kotzebue, 2021).

Gaftandzhieva mentioned that according to a survey conducted among 19,987 teachers in higher education institutions, only 53.03% of the teachers surveyed use social networking sites to share research interests and connect with colleagues. This finding indicates a need to improve the digital competencies of educators on how to use software solutions for professional communication and collaboration. (Gaftandzhieva & Doneva, 2021)

Alonso-García et al., (2023) stated that another aspect to take into account when evaluating digital competences is the branches of knowledge. Therefore, the grouping

by branches of knowledge can be used as a reference to visualize which aspects are more developed and which need further reinforcement.

Sillat et al., (2021) in their systematic literature review stated that there is an opportunity to build a wider scale research on digital competences when basing the instrument design on a common framework. One of the options presented is DigCompEdu which could be used in understanding educators' digital competence. Simultaneously, we can argue that localized competence models better describe the implementation context.

Basilotta (2022) indicates that the growth of academic articles coincides with the publication of the European Framework for Digital Teachers Competence - DigCompEdu (Redecker & Punie, 2017) which is proving to be a key document. The DigCompEdu is a framework describing what it means for educators to be digitally competent and provides a general reference frame to support the development of educator-specific digital competences in Europe and aims to detail how digital technologies can be used to enhance and innovate education and training. Professional Educators' digital competences are grope together in six areas. Using digital technologies for communication, collaboration and professional development is defined as 'Area 1 – Professional Engagement'. The area is divided in to following subunits: organizational communication, professional collaboration, reflective practice, digital continuous professional development (CPD).

Alternative approaches for assessing and enhancing digital competencies in the context of pre-service teacher education are presented by International Society for Technology in Education (ISTE). The ISTE has developed a set of standards that outline the skills and knowledge educators should possess to effectively integrate technology into their teaching practice. These standards provide a framework for assessing and enhancing digital competencies. (ISTE Standards)

The Technology Integration Matrix (TIM) is a tool developed by the Florida Center for Instructional Technology. It provides a rubric-based framework for evaluating and enhancing teachers' technology integration skills. The matrix consists of five levels of technology integration and can be used to assess and guide the development of digital competencies. (TIM)

The Technological Pedagogical Content Knowledge (TPACK) framework emphasizes the integration of technology, pedagogy, and content knowledge. It helps preservice teachers understand how to effectively use technology in the context of specific subject areas. The TPACK framework can be used as a guide to assess and enhance digital competencies (Kurt, 2019) According to the results of the survey preservice teachers portrayed a positive attitude towards the lessons that were conducted in accordance with TPACK. TPACK practices attracted the attention of preservice teachers and they actively participated.

In conclusion, the provided articles and frameworks hold significant importance in the field of education and contribute to defining educators' digital competencies and transforming educational experiences through technology integration.

1.1. Problem Statement

Despite progress and some excellent examples of innovation, combined efforts have so far not resulted in systemic digital transformation in education and training stated the recently published document 'Commission calls for massive boost in enabling digital education and providing digital skills' issued on 18 April 2023. The recommendation on Member States are to ensure universal access to inclusive and high-quality digital education and training, to address the digital divide, to start early by providing digital skills in a coherent way through all levels of education and training. The Bulgarian Ministry of Education and Science aligns its policies with the European Commission's priorities, with a particular emphasis on systemic digital transformation. This is evident in the state requirements for teacher professional qualification, as described in Ordinance (MON, 2021), which emphasize the development of competences related to the application of information and communication technologies in the learning process, supporting student mastery of learning content through e-learning and blended learning, independent and group work through ICT, and acquiring skills for motivating and supporting students' digital skills development, including techniques for enhancing presentation skills.

The problem statement aims to address the challenge of achieving a high level of digital competences among educators. Despite some progress and innovation, efforts have not fully realized the desired outcomes, as evident in the need for universal access to inclusive and high-quality digital education and training, effectively integrating digital competences across all levels of education. The policies of the Bulgarian Ministry of Education and Science align with the European Commission's recommendations, emphasizing the importance of developing teacher competences in applying information and communication technologies (ICT) for learning in the digital environment. A critical consideration lies in equipping pre-service teachers with the necessary competences to use digital technologies for communication, collaboration, and professional development, enabling them to become confident and competent educators through the Initial Teacher Training (ITT) program. As Skalka (2021) stated cooperation in the educational system can be beneficial for all participating groups.

Addressing these challenges and achieving successful digital transformation requires a comprehensive approach to developing educators' digital competences and creating an inclusive and technologically advanced educational environment at all levels.

1.2. Research Question

In the context of this study, two research questions are addressed. Firstly, we sought to determine the efficacy of the designed tool in assessing the initial digital competencies of pre-service teachers, specifically in the domains of professional communication and collaboration. Secondly, we aimed to identify and explore the digital competencies possessed by undergraduate students before they embark on their study of specialized didactics. These research questions serve as the foundation for our investigation into the assessment and understanding of digital competencies among

the targeted participants. The determination of the initial level is of crucial importance for achieving the goal set forth by the Work Package 4 of the project 'Digital Sustainable Ecosystems – Technological Solutions and Social Models for Ecosystem Sustainability (DUEcoS).' The activities in this work package aim to shape and enhance the digital competencies of students preparing to become primary education teachers. The goals and tasks defined in WP 4 are contextualized within the Digital Education Action Plan (2021–2027) and the European Framework for Digital Competence of Educators (DigCompEdu).

The research goals during the entire project duration encompass the formation and development of digital competencies in various areas, including „Professional Engagement" subareas communication and cooperation (Area 1) for undergraduate students preparing to become primary education teachers, as well as digital competencies in „Digital Resources" (Area 2), „Teaching and Learning" (Area 3), „Assessment" (Area 4), „Empowerment of Learners" (Area 5), and „Supporting Learner Digital Competencies" (Area 6). Upon successful project completion and based on the findings of this and future studes, the envisioned outcomes encompass the attainment of accessible and high-quality digital education. Additionally, the project aims to equip prospective primary education teachers with the necessary competencies to effectively utilize digital technologies in a professional capacity. Furthermore, it endeavors to develop updated academic courses that integrate the study of specialized didactics with digital competencies, while also establishing a digital library containing electronic educational resources generated as an integral part of this project.

2. METHODOLOGY

2.1. Research Design

This research aims to assess the designed tool and the initial digital competencies of pre-service teachers in a systematic manner. To achieve this, a mixed-methods approach combining a questionnaire and performance-based evaluation is employed. We created our questionnaire because the existing scientific literature does not provide a tool that is suitable for our research goals. The aim of this diagnostic process is closely aligned with the objectives and tasks set for achievement in the subsequent stages of the project. As a result of engaging with the research instrument, students reflect upon their digital skills and experiences, provide descriptions, and select appropriate examples of activities performed with various web applications. They further develop their ability for adequate self-assessment based on objective criteria and are motivated to pursue further accomplishments.

2.2. Review of the tool

The evaluation tool has two parts - the first one is a self-assessment questioner and the second one is performance-based part. The questionnaire has been piloted and it aims at mapping the digital competences, strengths and weakness of students to help plan an effective future intervention. The added value of two is evident in

performance-based part that provide different ways of capturing information. For example, when compiling examples of their work in e-portfolios, learners' submit information in a variety of formats, including imiges and text, video and audio files, presentations and e-books. This contribute to developing and applying digital competence specifically and communication competence more generally.

2.3. Structure. Dimensions

The self-assessment questionnaire consists of carefully crafted items to gauge preservice teachers' self-reported digital competencies and experiences, towards area of Professional Engagement focusing on communication and collaboration. This tool originally included a total of 9 items, distributed into four analytical dimensions: credentials and personal digital devices used; competences to use applications from Google Workspace, Microsoft Office 365, digital tools for cloud-based services and organizing, storing, and processing files, digital tools for conducting video conference calls. All of them offered the added benefit of convenient sharing and effective collaboration with others. They are designed to enhance communication, collaboration, and efficiency among users in a cloud-based environment that is a key feature matching the results to the goal of teacher professional communication and collaboration. Diagnosing the dimensions of the student's competences to know and work with these applications is absolutely necessary for achieving the goals of the project. Participants responded using a four-point Likert-type scale with the options:
"I don't know this tool." (Unknown)
"I have heard of this tool." (Name)
"I can describe it." (Describe)
"I can apply it." (Apply)
In this scale, participants had to choose one of these options to indicate their familiarity and proficiency with the mentioned tools.
In case the respondent states "I can apply it", he/she should provide an example below. The questions cover aspects such as familiarity with digital tools for communication and collaboration, confidence in using them, exposure to specific software, online platforms, and tools for videoconferencing and chats. The detailed description of the aspects, items and response domains is provided in Table 1.
The performance-based evaluation involves completing tasks related to professional communication, cooperation and collaboration aspects bounded to the questionnaire aspects and items. Their assessment involved peer assessment and feedback procedures.

Table 1. Aspects of pre-service teachers' digital competences

Aspect	Item	Response domain
Sociometric Data	What is your age, gender and study program?	Open question
Device	What kind of device you use daily?	Multiple choice
Google Workspace	Rate your competences regarding the use of Digital Tools from the Google Workspace group.	Four-stage Likert scale
Microsoft Office 365	Rate your competences regarding the use of Digital Tools from the Microsoft Office 365 group.	Four-stage Likert scale
Cloud Tools	Rate your competencies regarding the use of Digital Tools for cloud-based services for the organization, storage and processing of files.	Four-stage Likert scale
External Storage	Where and how do you organize and store your files outside of cloud-based services?	Open question
Video Conferencing	Rate your competences regarding the use of Digital Tools for conducting video conference calls	Four-stage Likert scale
University Digital Communication & Collaboration	Select and highlight actions. List of action phrases provided.	Multiple choice
Video Apps	List of mobile apps you use for video calling.	Open question
Total 9 Aspects		

Source: Own work.

2.4. Instrument validation

Before the full-scale implementation of the questionnaire, a pilot test was carried out to identify any potential issues. The responses received from the pilot were analyzed to validate the instrument through a psychometric analysis. The main findings of the validation are summarized according to the indicator's consistency and correlation. The internal consistency of the results received was verified by means of Cronbach's alpha coefficient and a result of 0.89 was obtained, a value proving that the consistency of the results obtained by the questionnaire was relatively high.

The cross-correlation between items in the questionnaire showed values that were relatively low, so that the items can be considered sufficiently different from each other and that the variables correlate in a directly proportional manner.

2.5. Sample and Procedure

The study was conducted online between 15th February and 30th May 2023. The sample consisted of 121 second-year students enrolled in the specialties of Primary Education Teacher, Primary Education Teacher with a Foreign Language, and Special Pedagogy at the Faculty of Education at Plovdiv University "Paisii Hilendarski" (112 females (92.56%), 9 males (7.44%), aged between 20 and 23 years, with a mean age of 20.53 years and a standard deviation of the participants' ages (SD) of 0.50. On average, they were in their 4th semester of the teacher training program. The teacher training program in Bulgaria consists of an eight-semester bachelor's program and an optional four-semester master's program that qualifies students to teach at the primary level. It is divided into subject-specific didactics taught at the primary level, psychology-pedagogical content courses, as well as interdisciplinary courses in educational science that include ICT in education.

The questionnaire was administered at the beginning of subject-specific didactics courses, ensuring that the topic of technologies in teaching was only addressed after the questionnaire. Depending on the type of specialization, participants were offered the same questionnaire either in paper form or as an online version. Before taking part in the study, participants were required to read and agree to an informed consent form, and their participation was voluntary and anonymous.

3. RESULTS AND DISCUSSION

3.1. Quantitative results by areas

The presented information reveals the usage of various Google applications (Apps) among the respondents, who are pre-service teachers. The data indicates that Google Sites (see Figure1) has the lowest usage rate and many of them might not perceive its practical applications for creating websites. In contrast, Google Translate stands out with a significantly high usage rate among respondents as shown on Figure 1. They report extensive practical application for language translation and perceive it as a popular and valuable tool. The data indicates that both Google Slides and Google Drawings have relatively low usage rates among pre-service teachers. This suggests that these applications might be underutilized or not extensively incorporated into their educational practices. There could be various reasons for this, such as a lack of awareness of their functionalities or limited exposure to their potential applications in teaching and learning contexts.

The data in Figure 2. represents the responses of pre-service teachers on their competences regarding the use of digital tools from the Microsoft Office 365 group. The respondents used a four-stage Likert scale, ranging from "Unknown" (low competence) to "Apply" (highest competence).

Overall, the pre-service teachers showed higher confidence in using Word, Excel, and PowerPoint, with a majority of respondents rating themselves at the highest level of competence (Apply) in these applications. OneDrive and Outlook also had a significant number of respondents at the highest competence level.

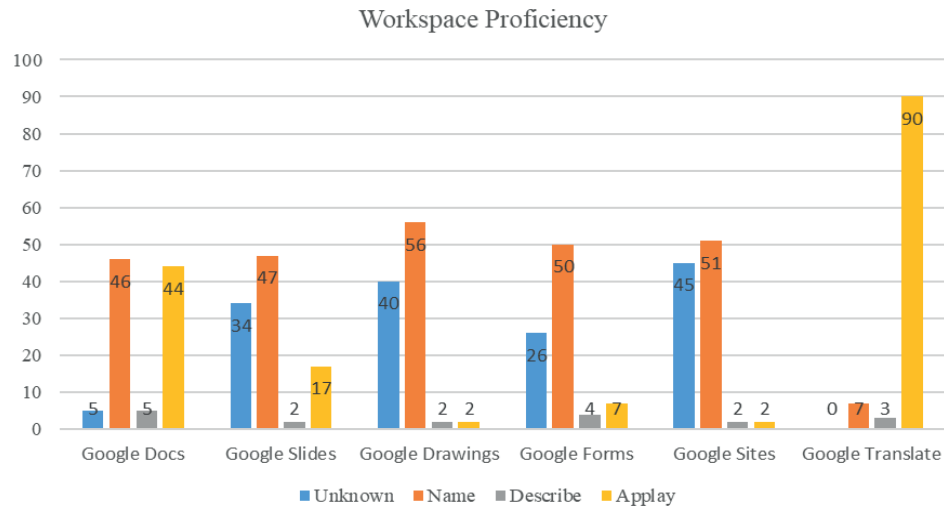

Figure 1. Google App Usage Trends Among Pre-Service Teachers

Source: Own work.

However, the data reveals that pre-service teachers generally feel less confident in using OneNote and Class Notebook, as a higher number of the respondents rated themselves at a lower level of competence (Unknown) in these applications.
This information suggests that there might be a need for further training or support to enhance the pre-service teachers' competence in using OneNote and Class Notebook. Conversely, it also highlights their relative strength in using other Microsoft Office 365 applications.

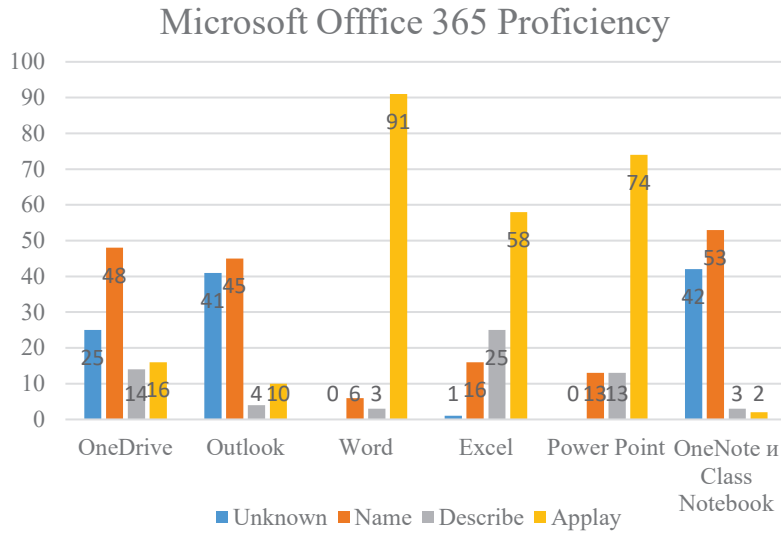

Figure 2. Microsoft Office Usage Trends Among Pre-Service Teachers

Source: Own work.

Cloud-based services for organizing, storing, and processing files are part of the measured digital competencies. The data obtained on the four-point scale where "Apply" category represents the highest Likert scale value, indicating a higher level of usage or application of the cloud storage services among the respondents is presented in Figure 3. The Box Drive received the lowest number of mentions in the "Apply" category representing that it is not being actively used or applied by the respondents. Google Drive performed well in the "Apply" category, receiving a high number of mentions with a count of 43. This indicates that Google Drive is widely used and applied by the respondents. Its strong integration with other Google services and ease of access likely contribute to its popularity for practical applications. OneDrive received the highest number of mentions in the "Apply" category, with a count of 43. This places it on par with Google Drive in terms of user application. One Drive's close association with Microsoft's ecosystem and seamless integration with Microsoft Office suite likely make it a preferred choice for users when it comes to practical usage. Analyzing the data solely based on the "Apply" category reveals that OneDrive and Google Drive are the most dominant cloud storage services among the respondents. Both services received the highest number of mentions in this category, indicating widespread use and application.

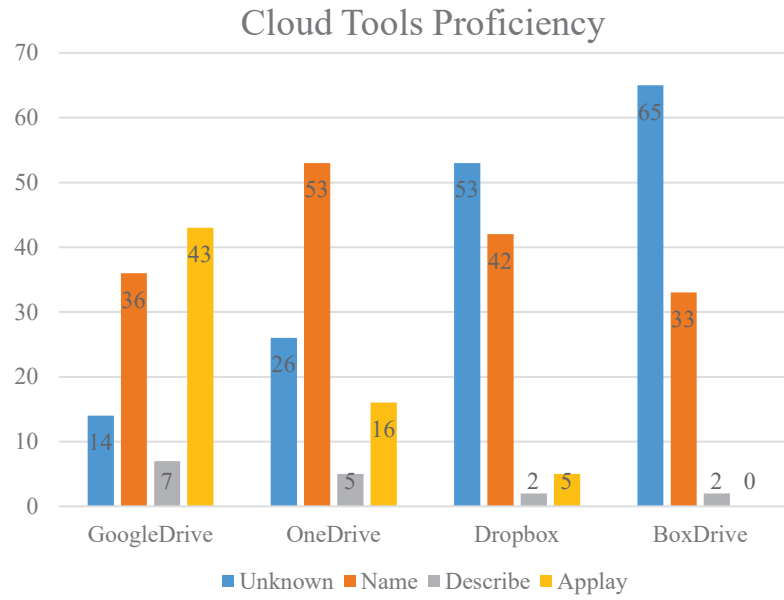

Figure 3. Cloud Tools Usage Trends Among Pre-Service Teachers

Source: Own work.

The fact that more than 90% of the surveyed individuals report storing and organizing their information on the devices they use (predominantly laptops and smartphones) or on flash drives, despite being aware of cloud storage options, is noteworthy. This finding highlights the need to incorporate information and tasks related to enhancing understanding and significance of cloud storage and its connection to

communication and collaboration for professional purposes into the future curriculum for the development of digital competencies.
Regarding the conduct of video conference conversations and their application in education, all students share that they use Google Meet, which is entirely understandable, as the paid version of the application is utilized for training purposes within the Faculty of Pedagogy.

3.2. Quality results

Valuable qualitative data were obtained from the questions, which required respondents to provide descriptions of application or explain specific examples for applying the respective aspect (see Table 1). The analysis of the responses provides valuable information, serving as a measure to either confirm or challenge the self-assessment expressed by the respondents regarding the respective aspect. The examples provided by the undergraduate students allow for a better understanding of the purposes for which they use the applications. The data derived from the descriptions of the respective aspects indicates a satisfactory level of comprehension of applications and functionalities, as well as the appropriateness of their selection for specific study-related tasks. Students have reported a high level of understanding and frequent utilization of Microsoft Office Word, PowerPoint, Google Translate, and Google Drive in the context of their academic and research endeavors at the university. The same conclusion can be reached regarding the items that emphasize ethical aspects of ICT use, specifically respecting copyright and adhering to safety guidelines.
The analysis of the results regarding activities performed by pre-service teachers reveals that they engage in a limited scope of activities, such as chatting, information seeking, content sharing, asking, and answering questions, and sending emails and messages. However, the analysis of the practical tasks indicates that these activities are carried out at an unprofessional level, leaving significant room for development and improvement.

CONCLUSION

The digital competencies formed and developed during the Initial Teacher Training (ITT) program are of crucial importance for teachers' professional development and the digital transformation of education. The approach used in this study includes questionnaire, peer assessment, feedback procedures, and performance-based evaluation, enabling a more comprehensive and practical diagnosis of pre-service teachers' competencies in the area of "Professional Engagement".
The presented and discussed results lead to the following conclusions:
The research instrument utilized for initial diagnosis demonstrates a noteworthy level of precision, detail, and informativeness, providing a substantial dataset specifically pertaining to pre-service teachers' digital competencies, with a particular emphasis on the domains of professional communication and collaboration. As a result, it can effectively serve as a robust foundation for making well-informed decisions in the context of designing and implementing new educational programs for preparing future teachers and ensure digital transformation of education on all levels.

ACKNOWLEDGEMENTS

This study is financed by the European Union - NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project No BG-RRP-2.004-0001-C01.
The study "Evaluating a Tool for Enhancing Pre-Service Teachers' Digital Competencies in Professional Communication and Collaboration" reflects only the author's view, and that the Agency is not responsible for any use that may be made of the information it contains.

REFERENCES

Alonso-García S., Victoria-Maldonado J., García-Sempere P., & Lara-Lara F. (2023). Student evaluation of teacher digitals skills at Granada University. *Frontiers in Education,* 7. ISSN 2504-284X. https://www.frontiersin.org/articles/10.3389/feduc.2022.1069245.

Basilotta-Gómez-Pablos, V., Matarranz, M., & Casado-Aranda, L. & Otto, A. (2022). Teachers' digital competencies in higher education: a systematic literature review. *International Journal of Educational Technology in Higher Education, 19*(8). https://doi.org/10.1186/s41239-021-00312-8.

Cabezas-González M., Casillas-Martín, S., & García-Peñalvo Fr. (2021). The Digital Competence of Pre-Service Educators: The Influence of Personal Variables. *Sustainability*, *13*(4), 2318. https://doi.org/10.3390/su13042318.

Çam, Ş. & Koç, G. (2021). Technological Pedagogical Content Knowledge Practices in Higher Education: First Impressions of Preservice Teachers. *Technology, Knowledge and Learning*, 26, 123–153. https://doi.org/10.1007/s10758-019-09430-9.

Cedefop, (2020). Key competences in initial vocational education and training: digital, multilingual and literacy, *Luxembourg: Publications Office of the European Union.* http://data.europa.eu/doi/10.2801/671030.

European Commission. (2023). *Commission calls for massive boost in enabling digital education and providing digital skills.* https://ec.europa.eu/commission/presscorner/detail/en/ip_23_2246.

European Commission, Directorate-General for Education, Youth, Sport and Culture. (2019). *Key competences for lifelong learning,* Publications Office. https://data.europa.eu/doi/10.2766/569540.

Falloon, G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational Technology Research and Development,* 68, 2449–2472. https://doi.org/10.1007/s11423-020-09767-4.

Gaftandzhieva, S. & Doneva, R. (2021). A Worldwide Survey on the Use of Social Networking in Higher Education: A Teacher's Perspective. *International Journal of Web-Based Learning and Teaching Technologies (IJWLTT).* ISSN 1548-1093,16(5), 58–79. http://doi.org/10.4018/IJWLTT.20210901.oa4.

ISTE Standards: Educators at: https://beta.iste.org/standards/educators.

Johanson, L., Leming, T., Johannessen, B., & Solhaug, T. (2023). Competence in Digital Interaction and Communication – A Study of First-Year Preservice Teachers' Competence

in Digital Interaction and Communication at the Start of Their Teacher Education. *The Teacher Educator*, 58:3, 270–288. https://doi.org/10.1080/08878730.2022.2122095.

Kotzebue, L., Meier, M., Finger, Al., & Kremser, Er. (2021). The Framework DiKoLAN (Digital Competencies for Teaching in Science Education) as Basis for the Self-Assessment Tool DiKoLAN-Grid. *Education Sciences, 11*(12):775. https://doi.org/10.3390/educsci11120775.

Kurt S. (2019). TPACK: Technological Pedagogical Content Knowledge Framework. *Educational Technology,* blog post, 16 September. https://educationaltechnology.net/technological-pedagogical-content-knowledge-tpack-framework/.

Ministry of Science and Education, (2021). Ordinance on the state requirements for acquiring professional qualification 'teacher'. https://web.mon.bg/bg/59.

Redecker, C. & Punie, Y., (2017). Digital Competence Framework for Educators (DigCompEdu). https://data.europa.eu/doi/10.2760/159770.

Reisoğlu, İl. & Çebi A. (2020). How can the digital competences of pre-service teachers be developed? Examining a case study through the lens of DigComp and DigCompEdu. *Computers & Education,* 156, 103940. ISSN 0360-1315. https://doi.org/10.1016/j.compedu.2020.103940.

Sillat, L., Tammets K., & Laanpere M. (2021). Digital Competence Assessment Methods in Higher Education: A Systematic Literature Review. *Education Sciences,* 11, no. 8: 402. https://doi.org/10.3390/educsci11080402.

Skalka, J., Drlik, M., Benko, L., Kapusta, J., Rodríguez del Pino, J.C.; Smyrnova-Trybulska, E., Stolinska, A., Svec, P., & Turcinek, P. (2021). Conceptual Framework for Programming Skills Development Based on Microlearning and Automated Source Code Evaluation in Virtual Learning Environment. *Sustainability,* 13, 3293. https://doi.org/10.3390/su13063293.

Skantz-Åberg, E., Lantz-Andersson, A., Lundin, M., & Williams, P. (2022). Teachers' professional digital competence: an overview of conceptualisations in the literature. *Cogent Education*, 9:1, 2063224. https://doi.org/10.1080/2331186X.2022.2063224.

The Technology Integration Matrix at: https://fcit.usf.edu/matrix/matrix/.

Valtonen, T., Eriksson, M., Kärkkäinen, S. et al. (2023). Emerging imbalance in the development of TPACK – A challenge for teacher training. *Education and Information Technologies,* 28, 5363–5383. https://doi.org/10.1007/s10639-022-11426-5.