

# Microlearning in Teacher Education: Effects on Pre-service Teachers' Digital Self-efficacy and Digital Competence

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**Abstract:** The rapid digital transformation of education has increased demands on teachers' digital competences and their ability to meaningfully integrate digital technologies into teaching practice. Developing these competences in pre-service teachers therefore represents a key challenge for contemporary teacher education. Microlearning has emerged as a promising instructional approach that enables flexible, targeted and time-efficient development of digital skills through short, focused learning units. However, empirical evidence regarding the impact of microlearning on the development of digital competences among future teachers remains limited. This study therefore examines the effects of a microlearning course on pre-service teachers' perceived self-efficacy in using digital technologies for teaching. The study employed a quantitative pre-post research design conducted over four academic years (2021–2025). Data were collected through an online questionnaire administered before and after completion of a microlearning course designed to support the development of selected digital skills relevant to teaching practice. The analysis included responses from 1,437 students in the pre-survey and 871 students in the post-survey. The questionnaire measured students' perceived competence across multiple domains of digital skills, including activities such as creating presentations, designing interactive worksheets, editing video materials and preparing electronic tests. The collected data were analysed using descriptive and inferential statistical methods to evaluate changes in perceived competence and examine differences across selected demographic variables. The findings demonstrate statistically significant improvements across all examined domains of digital skills following completion of the microlearning course. The most pronounced improvements were observed in areas that students initially perceived as the most challenging, particularly in creating interactive worksheets, editing video content and designing electronic tests. The results also indicate a partial reduction in differences between student groups defined by factors such as gender, age and mode of study, suggesting a homogenising effect of the microlearning intervention on students' perceived digital competence. Overall, the study shows that microlearning can effectively support future teachers' digital competences and strengthen their confidence in using digital technologies for teaching.

**Keywords:** Microlearning, Pre-service teachers, Digital competences, Self-efficacy, Teacher education, Digital literacy

## 1. Introduction

The accelerating digital transformation of education has intensified expectations that future teachers will integrate digital technologies meaningfully into pedagogical practice. Although pre-service teachers commonly use digital tools in everyday life, their ability to apply them for instructional purposes remains uneven. Developing technological–pedagogical competence has therefore become a central objective of teacher education, commonly framed through models such as TPACK (Koehler and Mishra, 2005) and European competence frameworks including DigCompEdu (Redecker, 2017).

Despite these frameworks, the integration of digital competences into teacher education remains inconsistent. TALIS 2018 data show that only 56% of teachers reported that digital technologies were included in their initial preparation and fewer than 40% felt prepared to use them effectively (OECD, 2019). In the Czech context, DigCompEdu provides a framework for competence development (Ministry of Education, Youth and Sports, n.d.), yet the use of digital technologies in teaching remains below the OECD average (OECD, 2023). Teacher-related barriers, including insufficient skills and negative attitudes, continue to constrain effective integration (Schmitz et al., 2022), while systematic preparation for technology integration in initial teacher education often remains limited and is frequently supported through modelling and mentoring during teaching practice (Heine et al., 2024).

These challenges became particularly visible during the COVID-19 pandemic, which accelerated educational digitalisation and increased expectations regarding teachers' digital readiness (Weigold and Weigold, 2021; Zancajo, Verger and Bolea, 2022). At the same time, disparities in digital literacy persisted among teachers and across the wider population (Deursen, 2020; Tejedor et al., 2020). European initiatives such as the Digital Education Action Plan 2021–2027 therefore emphasize the need to strengthen digital skills and educational ecosystems, although their success depends largely on teacher preparedness (European Commission, 2020).

A key determinant of successful technology integration is teachers' self-efficacy, which influences their willingness to experiment with digital tools and adopt innovative pedagogical practices. Even in environments with adequate technological infrastructure, low confidence may inhibit pedagogical innovation (Ertmer and Ottenbreit-Leftwich, 2010). Teachers with lower technological self-efficacy are less likely to implement innovative digital practices (Fransson et al., 2019). Self-confidence and motivation are widely recognised as important determinants of learning effectiveness (Hoz et al., 2024; Ormrod, Anderman and Anderman, 2020), while professional knowledge is closely related to instructional quality (Shulman, 1987). Teacher professional identity evolves through experience and reflection (Vanassche and Kelchtermans, 2014), and digitalisation may either strengthen or weaken teachers' confidence depending on their level of competence (Fransson et al., 2019).

Professional development—formal, informal, and self-directed—plays an important role in strengthening technological self-efficacy (Barton and Dexter, 2020). Meta-analytic evidence confirms a strong positive relationship between technological self-efficacy and the TPACK framework (Zeng, Wang and Li, 2022), while structured preparation and continuous professional development positively influence teachers' confidence and technology integration practices (Amponsah et al., 2024). Higher self-efficacy is also associated with greater willingness to adopt innovative tools and overcome barriers (Prestridge, 2012; Tondeur et al., 2017). Consequently, teacher characteristics interact dynamically, with professional self-confidence representing a significant secondary barrier after the availability of technologies and opportunities for further training (Abedi and Ackah-Jnr, 2023).

Taken together, these findings indicate that teacher education needs flexible, structured, and practice-oriented approaches that can support the gradual development of digital competences while strengthening pre-service teachers' confidence in using technologies for teaching. In response to these challenges, new forms of professional learning have emerged within technology-enhanced education, among which microlearning has recently attracted increasing attention.

## **2. Literature Review**

Microlearning represents a promising instructional approach. Although no single, universally accepted definition exists (Mohammed, Wakil and Nawroly, 2018), microlearning is typically characterized by short, learner-centered, and predominantly asynchronous instructional segments (Major and Calandrino, 2018), delivered through modular multimedia units that can be accessed anytime and anywhere (Cronin and Durham, 2024). Individual learning activities usually last between two and ten minutes (Buchem and Hamelmann, 2010) and support distributed practice, which enhances retention (Nowak, Speed and Vuk, 2023), although their effectiveness may vary depending on learners' individual characteristics (Rof, Bikfalvi and Marques, 2024).

The potential effectiveness of microlearning can also be explained through established cognitive and instructional design theories. From the perspective of Cognitive Load Theory, short and clearly structured units may reduce extraneous cognitive load by limiting the amount of information processed at one time and focusing attention on a specific task or concept (Paas, Renkl and Sweller, 2003). Microlearning is also consistent with distributed practice and retrieval-based learning, which emphasize repeated engagement and recall as mechanisms supporting retention (Dunlosky et al., 2013). It should therefore be understood not merely as fragmented content, but as an instructional design approach combining concise content, focused activity, feedback, and repeated practice.

Microlearning aligns well with learning preferences frequently associated with Generation Z. Research suggests that these learners prefer concise multimedia content, mobile accessibility, interactive activities, and rapid feedback (Aivaz and Teodorescu, 2022; Jayathilake et al., 2021; Manzoni et al., 2021; Navarrete et al., 2025; Wang et al., 2023; Zhang et al., 2025). These characteristics correspond closely with core microlearning principles such as short modular units, multimedia segmentation, mobile delivery, and gamified or socially supported learning activities (Arnab et al., 2021; Buchem and Hamelmann, 2010; Göschlberger, 2017). The

relationship between learning characteristics frequently attributed to Generation Z and the design principles of microlearning is summarized in Table 1.

Empirical research across higher education, medical education, and professional development indicates that microlearning can enhance short-term learning outcomes, knowledge retention, learner satisfaction, and practical skill development (Dennen, Arslan and Bong, 2024; Gorham, Majumdar and Ogata, 2023; Hlazunova et al., 2024; Javorcik, Kostolanyova and Havlaskova, 2023; Kohnke et al., 2024; Richardson et al., 2023; Román-Sánchez et al., 2023; Waldia et al., 2023;). At the same time, common methodological limitations persist, including small sample sizes, short intervention periods, and a strong reliance on self-report instruments (Al-Zahrani, 2024; Richardson et al., 2023; Román-Sánchez et al., 2023).

**Table 1:** Structural alignment between Generation Z learning characteristics and microlearning design principles

Generation Z Learning Characteristic	Corresponding Microlearning Design Principle
Preference for concise and brief content	Modular micro-lessons (typically 2–10 minutes)
Strong orientation toward multimedia (visual/auditory)	Segmented multimedia instructional design
High level of mobile device usage	Mobile-first approach with anytime, anywhere accessibility
Affinity for gamification and interactive formats	Game-oriented and activity-driven micro-tasks
Preference for social interaction and collaboration	Integration of social media and peer interaction elements
Demand for personalization and autonomy	Adaptive learning systems and individually paced instruction
Expectation of immediacy and rapid feedback	Immediate feedback mechanisms embedded within micro-lessons
Multitasking and fragmented attention	Short, focused learning segments supporting distributed practice

It should be noted, however, that multitasking should not be interpreted as an inherently beneficial learning strategy. Evidence from educational research suggests that media multitasking may interfere with attention, working memory, comprehension, recall, and academic performance (May and Elder, 2018). In the present study, microlearning is therefore not understood as a response that encourages multitasking, but rather as a design strategy intended to reduce cognitive overload, focus attention on clearly defined tasks, and support distributed practice through short, structured learning sequences.

Although microlearning has been associated with increased self-efficacy in several educational contexts, including medical education (Sozmen, 2022; Zarshenas et al., 2022), patient education (Janssen et al., 2023; Rahbar, Zarifsanaiey and Mehrabi, 2024), language education (Prasittichok and Smithsarakarn, 2024), and corporate training (Karlsen, Balsvik and Rønnevik, 2023), its impact on the digital self-efficacy of pre-service teachers remains underexplored. Digital literacy and self-efficacy constitute significant predictors of innovative thinking (Al-Hattami, 2025), and teacher self-efficacy develops primarily through practical experience rather than as a function of gender differences (Symes, Lazarides and Hußner, 2023).

In response to this research gap, the present study aims to examine the impact of a microlearning course on pre-service teachers' perceived self-efficacy in the use of digital technologies for instructional purposes within the Czech educational context. The study addresses the following research questions:

**RQ1:** *What differences in pre-service teachers' self-efficacy across specific domains of digital skills can be identified before and after completing the microlearning course?*

**RQ2:** *To what extent did participation in the microlearning course influence pre-service teachers' self-efficacy in individual digital skills, and are these changes statistically significant?*

**RQ3:** *What is the effect of factors such as gender, age, and mode of study on pre-service teachers' self-efficacy in digital skills before and after completing the course?*

**RQ4:** *Are there differences in self-efficacy across academic cohorts, and how did the microlearning course affect these differences?*

### 3. Methods

The study employed a quantitative pre–post design to examine changes in pre-service teachers’ perceived self-efficacy in digital competences following completion of a microlearning course. This approach allows comparison between baseline and post-intervention levels of perceived professional confidence. Given that self-efficacy represents a subjective belief in one’s capability to perform specific tasks (Bandura, Freeman and Lightsey, 1999), a pre–post measurement approach is considered an appropriate method for identifying changes resulting from mastery experiences (Ertmer and Ottenbreit-Leftwich, 2010; Jahnke et al., 2020; Schmitz et al., 2022).

The research was carried out over four consecutive academic years (2021–2025) at a Czech university (Faculty of Education, University of Ostrava) within a compulsory course focused on the development of pre-service teachers’ digital competences and the pedagogical use of digital technologies. The pre-survey was completed by 1,437 respondents and the post-survey by 871 respondents. The discrepancy in the number of responses reflects voluntary participation in the research component and the anonymous nature of data collection. The demographic characteristics of the sample (gender, age categories, mode of study—full-time/part-time) are presented in Table 2. Gender was self-reported and coded as male or female. The inclusion of multiple cohorts made it possible not only to assess the immediate effect of the intervention but also to examine the stability of findings across academic years and to account for potential contextual influences.

**Table 2: Structure of the research sample**

Variable	Category	2021/2022	2022/2023	2023/2024	2024/2025	Total
		Pre/Post	Pre/Post	Pre/Post	Pre/Post	Pre/Post
Gender	Male	116/61	96/40	86/54	82/40	380/195
	Female	238/159	249/173	300/192	270/152	1057/676
Age	Up to 20	226/127	237/138	250/144	226/116	939/525
	21–30 years	100/78	83/60	93/73	82/57	358/268
	31–40 years	20/13	12/9	26/17	30/10	88/49
	41–50 years	8/2	12/6	15/12	13/8	48/28
	Over 50 years	0/0	1/0	2/0	1/1	4/1
Focus of pedagogical education	Kindergartens	15/9	21/11	11/10	23/10	70/40
	Primary schools (1st stage)	70/51	90/21	122/70	102/14	384/156
	Primary schools (2nd stage)	141/87	121/116	149/95	119/93	530/391
	Secondary schools	128/73	113/65	104/71	108/75	453/284
Form of study	Regular learning	287/183	285/175	303/191	268/150	1143/699
	Distance learning	67/37	60/38	83/55	84/42	294/172

The intervention consisted of a fully online microlearning course structured into modular units composed of short, task-oriented segments (2–10 minutes), in accordance with the defining characteristics of microlearning described in the literature (Buchem and Hamelmann, 2010). The microlearning course *Information Technology in Education* was developed and delivered within the Moodle learning management system (LMS) as a compulsory component of all teacher education programmes at the Faculty of Education, University of Ostrava. Cílem předmětu bylo poskytnout budoucím učitelům obecný základ pro praktické a pedagogické využívání digitálních technologií ve vzdělávání, zatímco oborově specifické aplikace jsou rozvíjeny v navazujících didakticky orientovaných předmětech. The individual modules focused on specific domains of digital competences relevant to instructional practice: **(1)** Text processing and worksheet design, **(2)** Image and graphic editing, **(3)** Multimedia production, **(4)** Online tools and digital sharing, **(5)** Mobile technologies and applications. The course was not designed as discipline-specific training, but as a shared foundation of transversal digital competences relevant to pre-service teachers across educational levels and subject areas.

To ensure that the microlearning units did not function merely as short fragments of instructional content, each module followed a recurring instructional sequence. A typical unit began with a concise introduction to the tool, concept, or pedagogical problem, followed by a short demonstration or guided example. Students then completed an application task in which they created a concrete educational output, such as a worksheet, digital

poster, video material, or electronic questionnaire. These tasks were embedded in pedagogically situated scenarios to connect technical skill acquisition with instructional use.

The modules also incorporated elements supporting recall, reflection, consolidation, and feedback. After selected activities, students checked their understanding through short verification tasks, compared their outputs with stated criteria, or reflected on how the created digital material could be used in teaching practice. Feedback was provided through automated Moodle activities, task completion criteria, model examples, or teacher comments on submitted outputs. Through this sequence, the course combined content segmentation, modular progression, self-paced learning, active application, and immediate feedback, thereby reinforcing mastery experiences as a core mechanism underlying the development of perceived self-efficacy (Bandura, Freeman and Lightsey, 1999).

Perceived self-efficacy was measured using a structured questionnaire targeting the specific domains of digital competences aligned with the course objectives. The use of a self-report instrument is grounded in the theoretical conceptualization of self-efficacy as an individual's subjective belief in their capability to perform specific tasks (Bandura, Freeman and Lightsey, 1999). Items were rated on a Likert scale and included the response option "N – unable to assess," enabling the identification of areas in which respondents lacked prior experience. The questionnaire was administratively identical in both the pre-survey and post-survey, ensuring full comparability of measurements. The internal consistency of the instrument across cohorts was high (Cronbach's  $\alpha = .83-.95$ ; see Table 3), confirming its reliability.

**Table 3: Cronbach's alpha for pre-survey and post-survey questionnaires in 2021/2022 to 2024/2025**

Academic year	Pre-survey	Post-survey
2021/2022	0.88	0.95
2022/2023	0.85	0.95
2023/2024	0.83	0.94
2024/2025	0.86	0.92

The pre-survey was administered prior to the commencement of instruction, and the post-survey immediately after its completion. Due to the anonymous nature of data collection, it was not possible to match individual responses; consequently, a paired (dependent) statistical model could not be employed. The analysis was therefore conducted at the level of independent samples. This approach is methodologically appropriate in contexts where anonymity precludes longitudinal tracking of individuals, while still permitting the assessment of change at the group level. Non-parametric tests for independent samples were employed due to the ordinal nature of Likert-scale data.

The data were analyzed using descriptive and inferential statistics, with pre- and post-survey differences tested at  $\alpha = .05$  in NCSS 2023 statistical software (64-bit), version 23.0.2. Responses to the two open-ended items were analyzed using Braun and Clarke's (2012) open-ended response coding and analysis methodology. Participation was voluntary and anonymous, no personally identifiable data were collected, and the study followed institutional ethical standards.

## 4. Results

The results are presented according to the research questions: changes in self-efficacy across digital skill areas, their statistical significance, the role of demographic variables, and cohort effects across four academic years.

### 4.1 Differences in the Self-efficacy Ratings of Student Teachers Before and After Completing the Microlearning Course

Aggregated data across all observed academic years provide an overview of students' perceived self-efficacy in specific areas of digital technology use before and after completing the microlearning course (Table 4). Three indicators were used in the analysis: mean (M), median (Mdn), and standard deviation (SD).

Before completing the course, students reported the highest levels of confidence in word processing ( $M = 1.76$ ) and creating presentations ( $M = 1.73$ ). These results indicate that commonly used office tools were already familiar to most participants prior to the intervention. In contrast, creating an interactive worksheet ( $M = 3.03$ ) and editing a video ( $M = 3.07$ ) were evaluated as the most demanding activities. Higher variability of responses in these areas ( $SD > 1.2$ ) suggests considerable differences in students' prior experience with more advanced digital tasks.

Following completion of the microlearning course, mean values decreased in almost all skill domains, indicating higher perceived competence. The most visible improvements were observed in creating a worksheet (M = 2.31 to M = 1.67) and creating a poster or flyer (M = 2.38 to M = 1.62). Although editing a video and creating an interactive worksheet remained among the more challenging activities, both domains showed substantial improvement (e.g., 3.07 to 1.98). In addition, slightly lower SD values across most areas indicate more consistent levels of confidence among students after completing the course. Changes in the relative ranking of individual digital skills before and after the course are summarised in Table 5.

A further indicator of change is the frequency of the response option “N – unable to assess.” In the pre-survey this option was selected 1,445 times, whereas in the post-survey it appeared only 42 times. This substantial reduction suggests that students developed greater awareness of the assessed competence domains and were better able to evaluate their own skills after completing the course.

**Table 4: Results of the self-efficacy assessment in each area of digital skills before and after the course for the entire observation period**

Digital skill area	Pre-survey			Post-survey		
	M	Mdn	SD	M	Mdn	SD
Word processing in a word processor	1.76	2	0.74	1.58	1	0.95
Data processing in a spreadsheet editor	2.80	3	0.99	2.48	2	0.97
Creating a presentation	1.74	2	0.76	1.53	1	0.97
Creating a worksheet	2.31	2	0.95	1.67	1	0.95
Creating an interactive worksheet	3.03	3	1.04	1.85	2	0.94
Creating an educational infographic	2.60	3	1.04	1.91	2	0.98
Creating a poster/flyer	2.38	2	1.08	1.62	1	0.99
Editing a video	3.07	3	1.23	1.98	2	1.00
Using shared documents	2.15	2	1.01	1.65	1	0.97
Creating an electronic questionnaire or test	2.40	2	1.08	1.53	1	0.97
Navigating an educational application	2.44	2	1.00	1.92	2	0.93

M – Mean, Mdn – Median, SD – Standard deviation

**Table 5: Changes in the ranking of digital skills before and after the microlearning course**

Digital skill area	Pre-survey M	Pre-survey rank	Post-survey M	Post-survey rank	Rank change
Creating a presentation	1.74	1	1.53	1	0
Word processing in a word processor	1.76	2	1.58	3	+1
Using shared documents	2.15	3	1.65	5	+2
Creating a worksheet	2.31	4	1.67	6	+2
Creating a poster/flyer	2.38	5	1.62	4	-1
Creating an electronic questionnaire or test	2.40	6	1.53	2	-4
Navigating an educational application	2.44	7	1.92	9	+2
Creating an educational infographic	2.60	8	1.91	8	0
Data processing in a spreadsheet editor	2.79	9	2.48	11	+2
Creating an interactive worksheet	3.03	10	1.85	7	-3
Editing a video	3.07	11	1.98	10	-1

M – Mean

#### 4.2 Impact of the Microlearning Course on Students' Self-efficacy in Digital Skills

To determine whether participation in the microlearning course was associated with changes in students' self-efficacy, responses from the pre-survey and post-survey were compared using the Mann–Whitney U test (Table 6). Statistically significant differences were identified in all examined areas ( $p < .001$ ).

The most pronounced changes were observed in creating an interactive worksheet ( $U = 186,812$ ;  $Z = -23.51$ ), creating an electronic questionnaire or test ( $U = 278,438$ ;  $Z = -20.78$ ), and editing a video ( $U = 268,990$ ;  $Z = -19.84$ ). These results indicate that the microlearning course was particularly associated with improvements in areas involving the creation of interactive and multimedia educational materials, which students initially perceived as more demanding tasks.

Smaller, although still statistically significant, differences were observed in word processing ( $U = 499,477$ ;  $Z = -9.25$ ) and data processing in spreadsheets ( $U = 509,125$ ;  $Z = -7.16$ ). These domains already showed relatively high levels of confidence in the pre-survey, leaving less room for substantial improvement.

Overall, the results indicate that participation in the microlearning course was associated with improvements in self-efficacy across all examined digital skill domains, although the magnitude of change varied depending on the complexity of the activity and students' prior experience.

**Table 6: Analysis of differences in students' self-efficacy before and after the microlearning course using Mann-Whitney U test**

Digital skill area	Pre-survey		Post-survey		U	Z	p-value
	M	Mdn	M	Mdn			
Word processing in a word processor	1.76	2	1.58	1	499477	-9.2543	$p < .001$
Data processing in a spreadsheet editor	2.80	3	2.48	2	509125	-7.1593	$p < .001$
Creating a presentation	1.74	2	1.53	1	486593.5	-10.141	$p < .001$
Creating a worksheet	2.31	2	1.67	1	329173	-17.13	$p < .001$
Creating an interactive worksheet	3.03	3	1.85	2	186812	-23.507	$p < .001$
Creating an educational infographic	2.60	3	1.91	2	333552.5	-15.414	$p < .001$
Creating a poster/flyer	2.38	2	1.62	1	330940.5	-18.057	$p < .001$
Editing a video	3.07	3	1.98	2	268990.5	-19.843	$p < .001$
Using shared documents	2.15	2	1.65	1	411659	-13.429	$p < .001$
Creating an electronic questionnaire or test	2.40	2	1.53	1	278438	-20.779	$p < .001$
Navigating an educational application	2.44	2	1.92	2	398576	-12.696	$p < .001$

M – Mean, Mdn – Median, U – U-value of the statistic, Z – Z-value of the statistic, Significance level  $\alpha = 0.01$

#### 4.3 Impact of Gender, Age, and Form of Study on the Development of Self-Efficacy

The subsequent analysis examined potential differences in self-efficacy development in relation to gender, age, and form of study (regular or distance learning). Statistical testing using the Kruskal–Wallis One-Way ANOVA identified several statistically significant differences between groups (Table 7).

**Table 7: Statistically significant differences in self-efficacy of student teachers by gender, age and form of study (Kruskal-Wallis One-Way ANOVA)**

Digital skill area	Pre-survey			Post-survey		
	Gender <sup>1</sup>	Age <sup>2</sup>	Form of study <sup>3</sup>	Gender	Age	Form of study
Word processing in a word processor	.00876 (F)	—	—	.00002 (F)	—	—
Data processing in a spreadsheet editor	.00000 (M)	.00088 (31-40)	.00000 (DL)	—	.02599 (41-50)	.00159 (DL)
Creating a presentation	.00001 (F)	.00000 (<20)	.00000 (RL)	.00001 (F)	.00001 (<20)	.00001 (RL)

Digital skill area	Pre-survey			Post-survey		
	Gender <sup>1</sup>	Age <sup>2</sup>	Form of study <sup>3</sup>	Gender	Age	Form of study
Creating a worksheet	.00061 (F)	—	—	.00000 (F)	—	—
Creating an interactive worksheet	—	—	—	.00184 (F)	.02112 (<20)	.01969 (RL)
Developing an educational infographic	—	.002479 (<20)	—	.00507 (F)	—	—
Creating a poster/flyer	.00085 (F)	—	—	.00001 (F)	—	—
Editing a video	.00281 (M)	.00281 (31-40)	—	.03784 (F)	—	—
Using shared documents	—	—	.00179 (RL)	.01132 (F)	—	—
Creating an electronic questionnaire or test	—	.00099 (<20)	.00131 (RL)	.02348 (F)	—	—
Navigating an educational application	—	.00001 (<20)	.00358 (RL)	.01175 (F)	—	—

<sup>1</sup>Female, male (self-reported)

<sup>2</sup>Up to 20 years of age, 21-30 years of age, 31-40 years of age, 41-50 years of age, over 50 years of age

<sup>3</sup>Regular learning (RL), distance learning (DL)

In the pre-survey, women reported higher self-efficacy in tasks related to commonly used productivity tools, including word processing, creating presentations, creating worksheets, and creating posters or flyers. In contrast, men reported higher self-efficacy in spreadsheet processing and video editing, which may reflect different prior technological experiences.

After completing the course, women showed significant increases in confidence particularly in creating an interactive worksheet and editing a video, suggesting that gender-related differences in these domains were partially reduced during the course. This pattern indicates that structured training in digital competences may contribute to reducing gender disparities in perceived technological abilities.

Age differences were primarily observed in the pre-survey phase. Younger students (below 20 years of age) reported higher self-efficacy in creating presentations, developing infographics, and navigating educational applications, whereas students aged 31–40 years showed higher confidence in spreadsheet processing and video editing. After the course, the number of statistically significant differences between age groups decreased, suggesting a partial levelling of self-efficacy across generations.

A similar pattern was observed in the comparison between forms of study. Before the course, regular students reported higher confidence in presentation creation, whereas distance students reported higher confidence in spreadsheet processing. After course completion, these differences became less pronounced, which may reflect the homogenising influence of exposure to the same instructional content.

#### 4.4 Four-Year Comparison of Student Teachers' Self-efficacy in the Use of Digital Technologies

To examine potential cohort effects, self-efficacy levels were compared across four academic years (2021/2022–2024/2025). Differences between cohorts were analysed using the Kruskal–Wallis One-Way ANOVA test.

In the pre-survey, statistically significant differences between academic years were identified in two skill areas: data processing in spreadsheets ( $p = 0.02$ ) and creating posters or flyers ( $p = 0.004$ ). Students in the academic year 2021/2022 reported higher self-efficacy in spreadsheet processing, while students in 2024/2025 reported higher confidence in poster and flyer creation.

However, no statistically significant differences between cohorts were observed in the post-survey results. This finding suggests that the structure and design of the microlearning course contributed to reducing differences between student cohorts and resulted in more uniform levels of perceived self-efficacy across groups.

Overall, the four-year comparison indicates that the microlearning course produced consistent outcomes across different student cohorts, suggesting that the instructional design maintained comparable effectiveness over time.

#### 4.5 Open-ended Responses

Responses to the open-ended questions complemented the quantitative findings and provided deeper insight into students' perceived strengths and weaknesses in the use of digital technologies.

In the pre-survey, many respondents indicated limited confidence in their digital abilities and were often unable to identify specific strengths. When strengths were mentioned, they most frequently related to commonly used tools such as MS Word, PowerPoint, Canva, or basic graphic editing, reflecting a relatively basic level of digital competence prior to the course.

In contrast, post-survey responses demonstrated both an increase in the number of reported strengths and greater diversity in the technologies mentioned. Students frequently referred to multimedia creation, interactive educational tools, and the pedagogical integration of digital technologies, including the use of AI tools, virtual reality, augmented reality, and digital content creation for personalised learning.

Despite the overall improvement, several areas remained challenging. Students frequently mentioned databases, programming, video editing, and web design as weaker areas both before and after the course. These topics were only marginally represented in the course structure, which may explain their continued presence among perceived weaknesses. Artificial intelligence also appeared as a newly mentioned area in the post-survey responses, indicating increased awareness of the topic while simultaneously reflecting uncertainty regarding its pedagogical application.

Overall, the qualitative findings support the quantitative results by illustrating a shift from basic operational familiarity with digital tools toward a broader and more pedagogically oriented understanding of digital technology use in education.

## 5. Discussion

This study found statistically significant improvements in pre-service teachers' self-efficacy across all examined digital skill domains after completing a microlearning course.

The most pronounced improvements were observed in areas initially perceived as the most challenging, particularly in the creation of interactive worksheets, instructional video materials, and electronic assessments. These tasks are complex pedagogical–technological activities because they require students to use digital tools to create instructional artefacts with a clear pedagogical function. Comparable findings have been reported in microlearning research across educational and professional contexts, where participation in short, structured modules resulted in improvements in both learning outcomes and self-efficacy (Rahbar, Zarifsanaiey and Mehrabi, 2024; Richardson et al., 2023; Zarshenas et al., 2022;). Similar effects have been documented in medical and professional education, including the training of healthcare professionals (Janssen et al., 2023; Zarshenas et al., 2022), supporting the theoretical assumption that mastery experiences constitute a central mechanism in the development of self-efficacy (Bandura, Freeman and Lightsey, 1999).

The substantial reduction in responses marked "N – unable to assess" further indicates enhanced metacognitive awareness and greater confidence in evaluating one's own competences. At the same time, isolated decreases in post-survey self-efficacy scores may be interpreted as a process of recalibration rather than regression. As students develop a deeper understanding of task complexity, they may reassess previously overestimated perceptions of their own competence. This interpretation aligns with research highlighting discrepancies between perceived and externally evaluated competence among pre-service teachers (Dassa and Nichols, 2019) and with models of reflective professional development in digital competence (Ertmer and Ottenbreit-Leftwich, 2010; Tondeur et al., 2017).

With respect to demographic variables, gender differences were evident in the pre-survey but became partially attenuated following course completion. Women initially reported higher self-efficacy in traditional productive tasks, whereas men demonstrated greater confidence in more technically demanding domains. The equalizing effect observed after the intervention suggests that structured development of digital competences may

contribute to reducing gender disparities. The literature on academic self-efficacy presents mixed findings: some studies report higher confidence among men, while others indicate higher academic self-efficacy among women or emphasize women's stronger emotional competences supporting performance (Kurniawan et al., 2022; Salavera, Usán and Jarie, 2017; Webb-Williams, 2014). These inconsistent results reinforce the view that self-efficacy is context-dependent and shaped by learning experiences rather than by fixed personal characteristics.

Age and mode of study also influenced baseline levels of self-efficacy. Older students and those enrolled in part-time programmes reported higher confidence in certain domains in the pre-survey, possibly reflecting accumulated experience and more developed coping strategies (Bausch, Michel and Sonntag, 2014; Doba et al., 2016). Conversely, younger individuals—particularly women—may exhibit lower initial self-efficacy (Szota et al., 2024). Post-survey findings, however, revealed an equalizing effect across age groups and modes of study, suggesting that appropriately designed online educational interventions can significantly strengthen self-efficacy (Blazer et al., 2012). Nevertheless, research in practice-based training contexts (e.g., cardiopulmonary resuscitation instruction) indicates that face-to-face instruction may, in some cases, produce stronger increases in confidence for highly procedural skills (Ko, Kim and Cho, 2023), underscoring the importance of instructional design.

Longitudinal comparisons across four academic years further support the homogenizing effect of the microlearning course. Although differences in baseline self-efficacy were observed among cohorts in the pre-survey—likely influenced by prior educational quality, learning environments, and other contextual factors (Duraku et al., 2022)—these differences were no longer apparent in the post-survey. This finding suggests that the systematic implementation of microlearning may stabilize competence development across diverse student populations.

Several limitations should be acknowledged. Because the surveys were anonymous, individual responses could not be paired across measurement points, limiting causal interpretation at the individual level. Differences in the number of respondents between the pre- and post-survey may also indicate attrition bias. Furthermore, the study measured perceived self-efficacy rather than objectively assessed digital performance; the findings should therefore be interpreted as evidence of changes in students' confidence, not as direct evidence of demonstrated mastery of digital competences. Since the post-survey was administered immediately after course completion, the study also does not allow conclusions about the long-term stability of the observed gains. Future research should therefore incorporate performance-based measures, analysis of student-created digital artefacts, delayed post-tests, and evidence of transfer into authentic pedagogical practice.

Overall, the results confirm that microlearning can substantially enhance the digital self-efficacy of pre-service teachers while simultaneously contributing to the reduction of disparities associated with gender, age, mode of study, and cohort differences. When systematically integrated into teacher education, microlearning represents a promising strategy for fostering both competence development and the formation of professional confidence within digitally enriched educational environments.

## **6. Conclusion**

This study provides longitudinal empirical evidence that a systematically designed microlearning course can significantly enhance the digital self-efficacy of pre-service teachers across multiple domains of digital skills. The most substantial gains were observed in areas initially perceived as the most challenging, suggesting that microlearning may be particularly effective in fostering complex pedagogical–technological competences.

The findings further indicate a homogenizing effect of the intervention, as differences associated with gender, age, mode of study, and cohort affiliation were reduced or fully eliminated following course completion. This suggests that a structured, modular approach to digital competence development can contribute to stabilizing and equalizing competence levels across heterogeneous groups of pre-service teachers.

The results support the theoretical assumptions of the social-cognitive conceptualization of self-efficacy and confirm the importance of mastery experiences as a central mechanism in the development of professional confidence. Microlearning thus emerges not only as an effective tool for the acquisition of discrete skills but also as a strategy that supports the formation of professional identity within a digitally transformed educational environment.

Despite limitations arising from the use of self-report instruments and the absence of paired individual-level tracking, the study indicates that the systematic integration of microlearning into teacher education represents a promising pathway for strengthening the digital readiness of future teachers. Future research should examine

the long-term transfer of perceived competences into authentic pedagogical practice and combine self-report data with performance-based indicators.

**AI Statement:** ChatGPT was used solely for language editing and grammatical refinement. The ideas, structure, interpretations, and conclusions presented in this manuscript are entirely the authors' original work.

**Ethics Statement:** The study was approved by the Ethics Committee of the Faculty of Education, University of Ostrava. Participants were informed about the purpose of the study and their inclusion in the research and participated voluntarily. All data were collected and analysed anonymously.

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