Enhancing Teaching Skills through Digital Feedback in Microteaching: A Study with Prospective Primary Teachers

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***Abstract*—This study examined the effect of microteaching with digital feedback in improving teaching skills, its role in enhancing self-reflection and lesson planning, and its impact on classroom management. A quasi-experimental pre-test and post-test design is employed to compare the performance of an experimental group (engaging in microteaching with digital feedback) and a control group (following traditional microteaching methods) in a teacher education program. The study evaluates improvements in teaching competencies, self-reflection, and classroom management skills. The sample consists of 150 prospective primary school teachers from two universities in Kazakhstan: Abai Kazakh National Pedagogical University and Kazakh National Women's Teacher Training University. The experimental group, which received microteaching with digital feedback, demonstrated significant improvements in teaching performance. The findings strongly support the effectiveness of digital feedback in microteaching for enhancing teaching competencies, self-reflection, and classroom management. The substantial performance gains in the experimental group suggest that Kazakhstan's teacher training programs could benefit from the broader implementation of digital microteaching tools to enhance instructional quality and teacher preparedness. The results of this study can inform the development of standardized guidelines for integrating digital feedback into microteaching and aligning these practices with Kazakhstan's digital education strategy.**

***Keywords*—microteaching, digital feedback, teacher education, teaching competencies, self-reflection, lesson planning, classroom management, student engagement**

I. Introduction

The current state of educational practices, when combined with a critical understanding of past pedagogical conditions, encourages a reexamination of established pedagogical archetypes and the development of new scenarios in teacher education as key strategies for improving the quality of teacher preparation [1]. In response to new demands to address professional deficiencies, new 21st-century pedagogical competencies are developed and improved. Innovative methods are crucial for improving the quality of teacher preparation programs [2, 3].

Microteaching with digital feedback is one of the most effective methods [4–7]. This method meets the requirements of specificity of replenishment of existing professional deficiencies and minimization of time costs without loss of quality of educational result [8]. One such approach is microteaching with digital feedback, which combines structured teaching practice with technology-based assessment [9, 10]. However, there is a certain lack of discussion of this format among researchers [11, 12].

Microteaching is an innovative format for delivering quality professional training [13–18]. A strategy that addresses the needs of professionals in the twenty-first century while fostering ongoing organizational and career development is a form of digital learning rooted in artificial intelligence and a peer review system for effective teaching [19, 20]. The microteaching format involves a special pedagogical design of the material when the necessary educational information is divided into small fragments (blocks), during which to solve a specific didactic task [21–24].

However, researchers believe that microteaching is not a completely innovative format [25–27]. In this regard, the novelty is due only to the implementation of microteaching with the help of new technologies and appropriate software [28, 29]. Researchers have described an attempt to integrate learning using various electronic devices into a person's daily life [30–33].

Many researchers note changes in the psychology of human perception of information and acquisition of new knowledge in the context of the developing digital information society, information abundance, and information overload [34]. These changes are found in both the younger generation and adults.

A substantial body of research supports the influence of digital technologies on both the cognitive and emotional aspects of the human psyche, which are increasingly recognized as new tools for cognition [35, 36]. These studies emphasize how digital environments can shape cognitive processes such as attention and memory, as well as emotional engagement and reflective thinking, particularly in educational contexts.

Apling and Haryani [37] consider micro-learning with a modular organization of classes. The constituent components of the training module as an autonomous part of the educational material are related to the components of

microteaching and contain traditional didactic components for the module. Providing information in small portions over a short period creates optimal conditions for concentration and maintaining attention to the course materials. Thus, the recommended time for the video lecture format in a traditional e-learning course is usually 7–10 min. In the microteaching format, these can be 2–3-minute videos. After which a significant part of the time is spent on practicing the practical skills of future teachers. An equally important aspect is the solution to the problem of integrating training into the daily life of a future teacher by ensuring the availability of course materials from any point where there is Internet (training "here and now").

The availability of mobile versions on most educational platforms offers additional opportunities for accessing study materials at convenient times and locations, thereby promoting openness and mobility in learning [38].

Modularity and flexibility are widely recognized as key advantages of microteaching. This format involves acquiring knowledge through small, independent blocks that can be modified or reorganized to suit different learning needs. However, there is limited research on the effectiveness of microteaching across various academic disciplines—particularly in those requiring deep theoretical engagement—raising concerns about content sufficiency and cognitive demand [39]. Additionally, the optimal balance between learner autonomy and instructional scaffolding remains unclear. While micro-modules support self-paced learning, a lack of sufficient guidance may lead to cognitive overload or disengagement [40]. Although microteaching formats enhance flexibility, their accessibility for learners from diverse socio-economic and cognitive backgrounds has not been adequately explored. There is a pressing need for inclusive design strategies to ensure equitable learning opportunities [41]. Furthermore, the integration of microteaching into formal educational structures poses challenges related to curriculum coherence, alignment with learning outcomes, and compliance with institutional accreditation standards—issues that remain insufficiently addressed in the current literature [42, 43].

As practice shows, microteaching with digital feedback can successfully solve the problems of improving the quality of teacher training, allowing for quick responses to relevant practical requests, and developing and implementing programs aimed at the required educational result.

In the context of contemporary educational technologies, microteaching has emerged as a particularly effective method for enhancing teacher training programs. It ensures that future primary school teachers are equipped to meet the complex and evolving demands of the modern classroom. Beyond temporary solutions to crisis situations like the COVID-19 pandemic [44], microteaching with digital feedback serves as a sustainable and versatile pedagogical tool.

This approach is especially relevant in addressing ongoing challenges in education—such as managing digitally native students with shorter attention spans and increased demands for engagement and personalization. Digital microteaching facilitates repeated practice, enables personalized and timely feedback through AI or peer review, and allows for scalable implementation across face-to-face, hybrid, and fully online instructional modalities.

Thus, its integration is not only beneficial during periods of disruption but also essential for ongoing innovation and quality enhancement in teacher education. By embedding digital microteaching into routine pedagogical practice, teacher preparation programs can foster more reflective, adaptable, and competent educators equipped for diverse teaching environments.

Within educational technologies, microteaching has emerged as one of the most effective methods for enhancing teacher training programs, particularly in preparing future primary school teachers to meet evolving classroom expectations. As modern students display digital-native characteristics—such as reduced attention span and high visual engagement—teachers must adopt innovative teaching methods that both capture and sustain attention [45].

Microteaching with digital feedback addresses this challenge by offering a structured, reflective approach to improving teaching practices. The intervention involves short, focused teaching sessions followed by targeted feedback—often from peers, mentors, or artificial intelligence tools—that help teacher candidates reflect on their instructional strategies, classroom management techniques, and student engagement methods. Repeated cycles of teaching and feedback allow participants to make incremental improvements, develop effective lesson planning skills, and refine their management of the learning environment [46].

Digital feedback, in particular, supports personalized reflection by providing visual and data-driven insights into teaching behaviors, such as pacing, question distribution, and classroom interaction. These insights contribute directly to the development of teaching competencies, self-reflection, instructional improvement, and classroom management, making the intervention highly relevant to the core skills needed in contemporary classrooms. Therefore, integrating digital microteaching tools into teacher education programs offers a sustainable, scalable approach to fostering professional growth and readiness among prospective primary school teachers [47].

In Kazakhstan, knowledge management as a distinct scientific discipline offers various selective and analytical approaches to structuring elements of intellectual capital [48]. Within the realm of educational technologies, the microteaching method has emerged as particularly relevant for enhancing teacher training programs, ensuring that future primary school teachers are equipped to meet the evolving demands of modern classrooms. However, teachers today face a growing societal challenge: the rapid decline in students' attention span and ability to concentrate [49]. These characteristics, shaped by the digital thinking patterns of modern learners, pose a significant challenge for educators. The integration of innovative teaching methods is therefore not merely a desirable enhancement for increasing student motivation but a fundamental necessity for delivering educational content in an engaging and effective format. Knowledge, regardless of its complexity, can be segmented into smaller units to facilitate complete assimilation without compromising its core value [50].

This study is significant in that it provides empirical evidence on how microteaching supplemented with digital

feedback can enhance the quality of pre-service primary teacher education—an important yet underexplored area within Kazakhstan's primary education system. While previous studies have primarily focused on the overall effectiveness of the curriculum, this study examines how to integrate microteaching by incorporating digital feedback into pre-service primary teacher education programs. The novelty of this study lies in its focus on the relationship between microteaching and the enhancement of pedagogical competence, the impact of digital feedback on self-reflection, and the classroom management skills of pre-service primary teachers, an area that has been largely unexplored in Kazakhstan. By using microteaching to incorporate digital feedback into pre-service teacher education programs and survey analysis, this study provides a quantitative, evidence-based perspective for the development of a curriculum that combines traditional methods with microteaching with digital feedback. Therefore, the following research questions guide our study:

A. Research Questions

1) How does microteaching with digital feedback enhance prospective primary teachers' teaching competencies?
2) What is the impact of digital feedback on self-reflection and instructional improvement?
3) How does digital feedback influence classroom management skills?

B. Research Objectives

This study examines how microteaching and digital feedback can enhance teaching skills, aid in lesson planning and self-reflection, and impact classroom management.

II. Materials and Methods

This study employs a quantitative research approach to examine the impact of microteaching with digital feedback on improving the quality of education for prospective primary teachers. A quasi-experimental pre-test and post-test design is utilized to assess the effectiveness of microteaching with digital feedback in teacher education programs. The study compares the performance of an Experimental Group (EG) (engaged in microteaching with digital feedback) and a Control Group (CG) (following traditional microteaching methods) to measure improvements in teaching competencies, self-reflection, and classroom management skills.

A. Collection of Research Samples

This study involved 150 prospective primary school teachers, with 50% (n = 75) from Abai Kazakh National Pedagogical University and 50% (n = 75) from Kazakh National Women's Teacher Training University. Participants ranged in age from 18 to 27 years, with a mean age of 23.54 (SD = 4.2).

The EG consisted of students from Abai Kazakh National Pedagogical University, who participated in microteaching with digital feedback.

The CG comprised students from Kazakh National Women's Teacher Training University, who followed traditional microteaching methods without digital feedback.

To ensure a structured comparison, participants were selected based on the following criteria:

1) Specialization: Only prospective primary school teachers were included.
2) Age range: Participants were between 18 and 27 years old to maintain a relatively homogeneous sample of pre-service teachers.
3) Mean age balance: The groups were balanced in terms of age distribution, with a mean age of 23.54 ± 0.34 years (SD 4.2).
4) Educational background: All participants were enrolled in teacher education programs, ensuring comparability in pedagogical training.
5) Institutional affiliation: The EG and CG were assigned based on university enrollment, allowing for a comparative study between the two institutions. The demographic and educational backgrounds of participants are illustrated in Fig. 1 below.

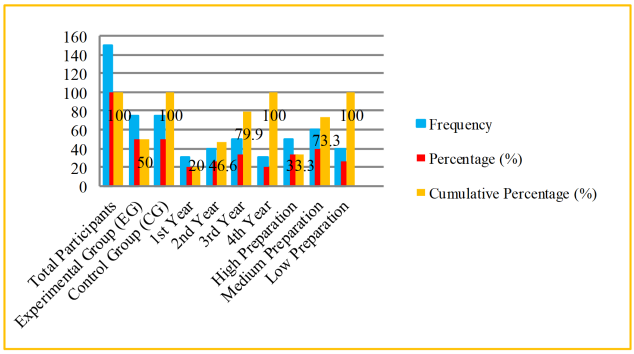

Fig. 1. Demographic and educational background of participants.

The demographic and educational background data provides insights into the composition of the study participants (see Table 1).

Table 1. Demographic and educational background of participants

Variable	Category	EG (n = 75)	CG (n = 75)	Total (n = 150)
Age	20–25 years	42	40	82
	26–30 years	28	30	58
	31+ years	5	5	10
Gender	Female	48	46	94
	Male	27	29	56
Academic Background	Education	60	58	118
	Humanities/Social Sciences	10	12	22
	STEM	5	5	10
Teaching Experience	None (Pre-service Teachers)	55	57	112
	1–3 years	15	13	28
	4+ years	5	5	10

B. Group Distribution (Experimental vs. Control)

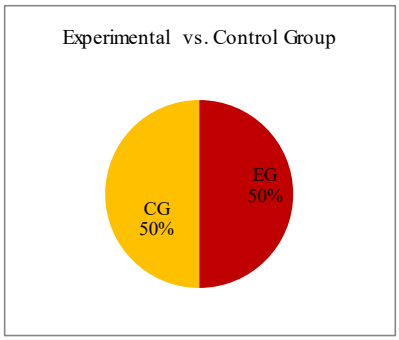

Fig. 2. The equal distribution of participants in the EG and CG.

The total number of participants is 150. The participants are evenly split between the EG and the CG, each consisting of 75 participants (50%). This even split suggests that the study design ensures a balanced comparison between the two groups, reducing bias in results (see Fig. 2).

C. Year of Study

The participants are distributed across four academic years:

1st year: 30 students (20%)
2nd year: 40 students (26.6%)
3rd year: 50 students (33.3%)
4th year: 30 students (20%)

The highest representation comes from 3rd-year students (33.3%), while 1st- and 4th-year students are equally represented (20% each).

This distribution suggests that most participants are in the middle of their academic journey, which may imply a higher level of experience or knowledge in the subject matter of the study (see Fig. 3).

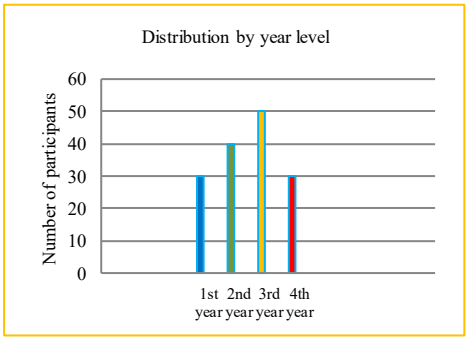

Fig. 3. The distribution across year levels.

The majority of students fall into the medium preparation category (40%), indicating that most participants have an average level of prior knowledge or skills. A significant proportion of students have high preparation (33.3%), which suggests a strong base of well-prepared individuals in the study. Low preparation students (26.6%) represent a smaller, but still notable, portion, which may affect overall performance results.

D. Experimental Research Design

1) Study phases

The study was conducted in four key phases to ensure a structured implementation and assessment process.

Phase 1: Preparation and participant selection.

Institutional approval was obtained from participating universities. A total of 150 prospective primary teachers were recruited based on eligibility criteria. Participants were divided into the EG and the CG. An initial orientation session on the study objectives and procedures was conducted.

Phase 2: Pre-test and initial microteaching sessions.

Pre-test assessments were administered to measure baseline teaching competencies. Initial microteaching sessions were conducted for both EG and CG. The EG used digital feedback tools, while the CG followed traditional methods. Observational data and performance recordings were collected.

Phase 3: Implementation of microteaching with digital feedback.

EG participants engaged in microteaching sessions supported by video recording, AI-driven feedback tools, and structured peer review. CG participants continued traditional sessions without digital feedback. Multiple feedback cycles were conducted, allowing EG participants to refine teaching skills based on insights.

Phase 4: Post-test, data analysis, and reporting.

Post-test assessments were administered, followed by data analysis and reporting of outcomes.

2) Intervention

The intervention consisted of digital microteaching for the EG and traditional microteaching for the CG, as outlined in Table 2 below:

Table 2. Intervention description

Component	EG (digital feedback)	CG (traditional microteaching)
Microteaching sessions	Short lessons delivered to peers	Same format
Session recording	Video-recorded sessions for analysis	No video recording
Feedback mechanism	AI-based and peer-reviewed feedback tools	Verbal feedback by instructors and peers
Feedback criteria	Rubric-based: clarity, engagement, non-verbal cues, voice modulation	Informal, without structured rubric
Feedback format	Structured digital platform	Verbal or written notes
Self-reflection	AI analytics + self-reflection journals	Encouraged but unstructured
Iterative improvement	Repeated cycles based on feedback	Improvements without digital tracking
Digital pedagogy training	Provided	Not provided
Post-assessment	AI-enhanced measures of competency growth	Standard post-test

3) Intervention design, validation, and implementation

Design of the intervention: The intervention was developed based on a synthesis of best practices in digital microteaching and formative assessment, drawing from peer-reviewed literature in teacher education and educational technology.

Validation process: The content and structure of the digital feedback-based microteaching program were reviewed by a panel of five experts in pedagogy, instructional design, and educational psychology. Based on their input, revisions were made to improve clarity, instructional alignment, and technical feasibility. A small-scale pilot study with 10 teacher candidates was conducted to assess usability and instructional effectiveness prior to full-scale implementation.

Implementation and experimental control: Before the experiment, participants in both groups completed a pre-test and were oriented on the process, expectations, and tools involved.

During the intervention, both the experimental and control groups received the same teaching content, but the experimental group additionally engaged in structured microteaching sessions with digital feedback (including peer and AI-assisted evaluations). To maintain fidelity, all sessions were recorded, and facilitators followed standardized protocols.

After the intervention, a post-test was administered, and all digital feedback interactions were reviewed to ensure consistency and completeness. Control mechanisms included

the use of common rubrics, observation checklists, and triangulated data from peer and AI sources.

4) Data collection methods

Pre-test and Post-test Assessments

To evaluate the effectiveness of the intervention, participants' teaching competencies were measured before and after the training using the Teaching Performance Assessment Rubric (TPAR). This rubric assessed multiple instructional domains, including lesson planning, classroom management, student engagement, content delivery, and communication skills. Teaching sessions were video-recorded and evaluated by trained raters using the standardized rubric. The pre- and post-test design enabled a direct comparison of performance gains resulting from the microteaching with digital feedback intervention.

Survey questionnaires (see Appendix A)

After the intervention, a structured survey was administered to gather participants' perceptions of the digital feedback process and its influence on their professional growth. The questionnaire included both closed- and open-ended items and was divided into three sections:

Section 1 explored participants' perceptions of the overall effectiveness of digital feedback and the usefulness of specific tools (e.g., Veo, GoReact, EdPuzzle, Kahoot!, Google Classroom).

Section II focused on participant experiences during different phases of the microteaching process, including the introduction to digital tools, engagement in digital feedback cycles, and opportunities for reflection.

Section III addressed the challenges encountered while using digital feedback tools and invited suggestions for improving future training programs.

The instrument was adapted from previously validated tools [51], reviewed by a panel of experts for content validity, and pilot-tested with a sample of participants to ensure reliability and clarity. Minor revisions were made based on feedback from the pilot.

Together, the pre/post assessments and post-intervention survey provided a robust and multifaceted evaluation of the impact of digital feedback on participants' teaching competencies and instructional practices.

E. Data Analysis

Inter-rater reliability for teaching evaluations: Multiple assessors (faculty members and peer reviewers) evaluated teaching performance using the same rubric to ensure consistency in scoring.

Test-retest reliability in pre-test/post-test: The same assessment tools were used before and after the intervention to ensure consistent measurement of teaching improvements [52].

1) Internal validity

Pre-test and post-test design: A quasi-experimental pre-test and post-test structure was used to assess changes in teaching competencies, ensuring a clear comparison of before and after intervention results.

Controlled participant selection: Participants were selected using strict inclusion criteria to reduce variability.

Use of standardized digital feedback tools: Feedback tools (Veo, GoReact, Google Classroom) used AI-driven analytics and structured rubrics, ensuring objective evaluation rather than subjective judgment.

Minimization of researcher bias: Data collection and analysis were conducted using predefined evaluation rubrics and statistical analysis to reduce subjectivity in scoring.

2) External validity

Multi-institutional study: The study included two major universities in Kazakhstan, making findings more generalizable to teacher education programs across the country.

Use of real classroom simulations: The microteaching sessions replicated real classroom environments, ensuring practical relevance of the results.

Diverse participants: Prospective teachers from different academic years (1st–4th year) were included, providing a broader perspective on digital feedback's impact.

3) Instrument reliability

Pilot testing of survey instruments: The survey questionnaire and assessment tools were pilot-tested with a small group of participants before the main study. Necessary modifications were made to improve clarity, question relevance, and response consistency.

Use of standardized rubrics for assessment: Teaching performance was evaluated using structured rubrics, reducing variability in assessor judgment.

4) Data reliability

Inter-rater reliability for teaching evaluations: Multiple assessors (faculty members and peer reviewers) evaluated teaching performance using the same rubric to ensure consistency in scoring.

Test-retest reliability in pre-test/post-test: The same assessment tools were used before and after the intervention to ensure consistent measurement of teaching improvements.

III. Result and Discussion

Table 3 shows descriptive statistics of teaching performance.

Table 3. Descriptive data on instructional effectiveness

Group	Pre-Test Mean (SD)	Post-Test Mean (SD)	Improvement (%)
EG	68.4 ± 4.5	85.2 ± 3.8	24.6%
CG	67.9 ± 4.7	74.1 ± 4.2	9.1%

Referring to Table 3, the EG, which received microteaching with digital feedback, showed a significant improvement in teaching performance. Their mean score increased from 68.4 (SD = 4.5) to 85.2 (SD = 3.8), reflecting a 24.6% improvement. In contrast, the CG, which followed traditional methods, had a more modest increase from 67.9 (SD = 4.7) to 74.1 (SD = 4.2), with only a 9.1% improvement. This suggests that digital feedback significantly enhances teaching competencies compared to traditional microteaching methods.

Table 4 presents the effectiveness of the intervention based on TPAR scores for both the EG and CG, pre- and post-intervention.

The TPAR provided a comprehensive evaluation of the teachers' performance across multiple dimensions, helping to capture the nuances of effective teaching. The significant improvement in the EG's performance, especially in lesson

planning, classroom management, and content delivery, highlights the positive impact of digital feedback in enhancing key teaching competencies. These findings suggest that microteaching with digital feedback is an effective method for improving specific aspects of teaching practice, which could ultimately lead to better student learning outcomes.

Table 4. Comparison of teaching competency scores—pre- and post-test results

Instructional Domain	Group	Pre-Test Mean (SD)	Post-Test Mean (SD)	Mean Gain	p-value (Effectiveness)
Lesson planning	EG	3.12 (0.47)	4.35 (0.39)	+1.23	<0.001
	CG	3.10 (0.45)	3.28 (0.50)	+0.18	
Classroom management	EG	3.05 (0.51)	4.20 (0.44)	+1.15	<0.001
	CG	3.08 (0.48)	3.25 (0.52)	+0.17	
Student engagement	EG	3.00 (0.49)	4.18 (0.42)	+1.18	<0.001
	CG	3.02 (0.50)	3.21 (0.53)	+0.19	
Content delivery	EG	3.20 (0.46)	4.30 (0.40)	+1.10	<0.001
	CG	3.22 (0.47)	3.33 (0.48)	+0.11	
Communication skills	EG	3.15 (0.50)	4.25 (0.41)	+1.10	<0.001
	CG	3.16 (0.48)	3.30 (0.49)	+0.14	
Overall TPAR score	EG	3.10 (0.49)	4.26 (0.41)	+1.16	<0.001
	CG	3.12 (0.46)	3.27 (0.50)	+0.15	

Table 5. The results of the ANOVA

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F-Value	P-Value
Between Groups	520.6	1	520.6	252.7	<0.001
Within Groups	304.8	148	2.06	-	-
Total	825.4	149	-	-	-

The ANOVA results as shown in Table 5 indicate a statistically significant difference in teaching competencies between the EG and CG after the intervention. The F-value (252.7, $p < 0.001$) confirms a highly significant effect of microteaching with digital feedback on teaching performance. The between-groups sum of squares (SS = 520.6) is significantly higher than the within-groups SS (304.8), indicating that the observed improvements are attributable to the intervention rather than random variation. Since $p < 0.001$, the null hypothesis is rejected, confirming that digital feedback significantly enhances teaching competencies compared to traditional methods.

A. Discussion

This study examined the effect of microteaching with digital feedback in improving teaching skills, its role in enhancing self-reflection and lesson planning, and its impact on classroom management. The findings from the descriptive statistics indicate that microteaching with digital feedback significantly enhances the teaching performance of prospective primary teachers compared to traditional microteaching methods. The EG, which utilized AI-powered video feedback, structured peer reviews, and self-reflection tools, demonstrated a substantial improvement in teaching performance, with mean scores increasing from 68.4 (SD = 4.5) to 85.2 (SD = 3.8), reflecting a 24.6% improvement. This suggests that the integration of technology-driven feedback mechanisms allows for more precise, data-informed improvements in instructional delivery, classroom engagement, and lesson structuring, consistent with findings from previous studies on digital feedback in teacher training [4, 5].

In contrast, the CG, which received conventional instructor-led feedback, experienced a more linear and less interactive process. This may explain the more modest gains in performance; traditional methods may lack the immediacy, individualization, and reusability of digital feedback. Participants in the CG had fewer opportunities to internalize feedback or adjust practices in a continuous, reflective manner [13, 14]. These findings are consistent with prior research showing that video-based and AI-driven feedback tools enhance preservice teachers' ability to self-assess and adjust instructional strategies [16, 17].

The results of the ANOVA analysis demonstrate a statistically significant difference in teaching competencies between the EG and the CG after the intervention. The F-value (252.7, $p < 0.001$) confirms that the improvements observed in the EG, which utilized microteaching with digital feedback, were not due to random variation but were instead a direct outcome of the intervention. These findings are consistent with previous studies that highlight the effectiveness of digital feedback in enhancing pedagogical competencies and instructional delivery through structured reflection and targeted feedback mechanisms [22, 23].

The significant performance gains observed in the EG support the theoretical premise that digital feedback mechanisms, particularly those enhanced by AI, can serve as catalysts for pedagogical transformation through increased self-awareness, critical reflection, and peer learning. Importantly, this research extends the application of digital microteaching beyond well-resourced, Western education systems and demonstrates its feasibility and impact in a developing Central Asian context. In doing so, it fills a critical gap in the literature by showcasing how scalable, technology-supported teacher training interventions can be adapted to local contexts without compromising instructional quality [53].

Furthermore, the study deepens theoretical understanding of how feedback loops—comprising self-reflection, peer assessment, and AI-powered evaluations—can be integrated into microteaching cycles to enhance metacognitive awareness and instructional adaptability. This aligns with contemporary constructivist theories of teacher development and adds practical evidence to the discourse on formative assessment and reflective practice in initial teacher education [54].

Finally, the results support policy-level considerations for embedding structured digital feedback into teacher training standards in Kazakhstan. They also lay the groundwork for future comparative studies that examine how culturally responsive adaptations of digital microteaching models perform across diverse educational systems. These insights are critical for developing sustainable, tech-enhanced teacher education frameworks aligned with 21st-century learning goals.

Furthermore, this study builds upon the work of Aptoula [55], whose feedback model emphasizes the importance of providing targeted and meaningful responses to relevant pedagogical questions. The digital tools employed in our research operationalize these principles by allowing pre-service teachers to track their own progress, benchmark their performance, and plan specific improvements—capabilities that are often limited in traditional microteaching settings.

One of the key benefits of digital microteaching lies in its ability to personalize professional learning. Participants receive targeted, non-intrusive feedback that they can revisit at their own pace. This asynchronous flexibility encourages autonomous learning, allowing preservice teachers to take greater ownership of their development.

Additionally, the visual and auditory feedback provided by AI tools supports multimodal reflection, which caters to diverse learner profiles. The structured peer feedback component also promoted a sense of community and collaborative learning, which is critical in developing reflective teaching cultures [19, 20].

Despite these advantages, several challenges emerged during implementation. Firstly, some participants initially found the technology interface intimidating or time-consuming, especially those less confident with digital tools. Secondly, ensuring consistency and accuracy in AI-generated feedback posed a concern; while the system provided real-time cues and suggestions, it occasionally required human moderation to contextualize feedback appropriately [6–9]. Furthermore, fostering genuine critical reflection—as opposed to superficial review—required sustained mentorship and training in reflective practice.

Although the study was conducted within the context of Kazakhstani teacher education, its implications are widely applicable. The use of digital microteaching tools addresses global challenges in teacher training, including large cohort sizes, limited mentor availability, and inconsistent assessment. The scalable and cost-effective nature of digital feedback tools makes them particularly attractive in low-resource educational settings, where personalized mentorship may be limited [10–12].

However, cultural and institutional contexts must be considered. The success of digital microteaching depends on a supportive infrastructure, teacher educator readiness, and policy alignment. Therefore, future research should explore cross-contextual validation, particularly in rural and multilingual education systems.

In summary, the study offers strong evidence that microteaching enhanced with digital feedback can significantly improve the teaching competencies of pre-service teachers. Beyond numerical gains, the intervention fostered deeper professional reflection, adaptive learning, and collaborative teaching cultures. The findings reinforce calls for the systematic integration of digital tools in teacher education programs—not as replacements for human mentorship, but as powerful complements that enrich teacher learning.

Going forward, institutions should consider not only investing in digital infrastructure but also developing frameworks for digital pedagogical mentorship, thereby ensuring that the benefits of technology-enhanced microteaching are both sustainable and inclusive.

B. Limitations of the Study

While survey responses provided quantitative perceptions, adding qualitative interviews or open-ended reflections could provide deeper insights into how and why digital feedback influenced teaching practices. The study measured immediate improvements, but it did not assess whether the observed benefits were sustained over time. The study included two universities in Kazakhstan, but the findings may not be generalizable to all teacher training institutions. The study focused on microteaching with digital feedback, but it could be beneficial to compare its effectiveness with other innovative teaching methods (e.g., flipped classrooms, problem-based learning, or blended learning) following.

IV. Conclusion

This study provides empirical evidence for the value of microteaching enhanced by digital feedback in preparing pre-service primary school teachers in Kazakhstan. By incorporating AI-supported evaluations and structured peer review, the approach significantly contributed to the development of key teaching competencies such as lesson planning, classroom management, and reflective practice. Participants gained greater insight into their instructional strategies, which in turn promoted more adaptive and student-focused teaching behaviors. These results add to the limited research base on the use of digital microteaching in the Kazakhstani context and support its integration into teacher education programs. Future research may expand on these findings by examining the long-term effects of such interventions on in-service teaching quality and student learning outcomes. Beyond its immediate practical benefits, this research contributes new empirical evidence to the emerging field of digital microteaching, particularly in underrepresented contexts such as Central Asia. The study also provides a foundation for developing evidence-based policies on the incorporation of microteaching into national teacher education standards. Future research should explore the long-term impacts of digital feedback on classroom performance, assess the retention and transfer of teaching competencies over time, and identify optimal strategies for implementation across diverse educational settings. Moreover, investigating the role of digital microteaching in supporting inclusive education and differentiated instruction may yield further insights into its transformative potential.

Ethical Considerations

Approval for this research was obtained from the Ethical Committee of the Academic Council at Abai Kazakh National Pedagogical University, Kazakhstan, on 14 October 2023 (Ref. No. 4). All participants were provided with an informed consent form outlining the purpose of the study, their right to withdraw at any time, and assurances of confidentiality and anonymity. Only those who voluntarily signed the consent form were included in the study. To ensure participant privacy, alphanumeric identifiers were used instead of names for all surveys and assessments, in compliance with data protection guidelines. These measures were implemented to guarantee full adherence to ethical research standards.

Appendix

Survey

Section 1: Perceptions of digital feedback

1) How effective do you think digital feedback improved your teaching skills?

(Very Effective, Effective, Neutral, Ineffective, Very Ineffective

2) To what extent did digital feedback help you in self-reflection and lesson improvement?
(To a great extent, Somewhat, Neutral, Very little, Not at all)
3) How helpful were the following digital tools in providing meaningful feedback?
(Rate on a scale of 1–5, where 1 = Not Helpful and 5 = Very Helpful)

Digital Tool	1	2	3	4	5
Veo (AI-powered video analysis)					
GoReact (Video-based feedback platform)					
EdPuzzle (Interactive video assessment)					
Kahoot! / Mentimeter (Engagement tools)					
Google Classroom (Peer-review and discussions)					

Section 2: Microteaching and feedback process
4) How useful were the different phases of digital feedback training in enhancing your teaching skills?
(Rate on a scale of 1-5, Where 1 = Not useful and 5 = Very Useful)

Training Focus	1	2	3	4	5
Introduction to digital tools and microteaching framework					
First cycle of microteaching with digital recording and AI feedback					
Reflection, peer feedback, and second cycle of improvement					
Final microteaching sessions, performance assessment					

5) How comfortable were you receiving feedback through digital tools? (Very Comfortable, Somewhat Comfortable, Neutral, Somewhat Uncomfortable, Very Uncomfortable)
6) Do you believe digital feedback is more effective than traditional feedback methods? Why? (Open-ended response)
Section 3: Challenges and recommendations
7) What were the biggest challenges you faced when using digital feedback tools? (Select all that apply)
Lack of familiarity with digital tools
Technical issues (e.g., internet access, software problems)
Difficulty in understanding AI-generated feedback
Insufficient time for lesson improvement
Other (please specify): _____
8) What improvements would you suggest to make digital feedback more effective for future teacher training programs? (Open-ended response)

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Conceptualization, ZZ and KZ; methodology, AO; software, EA; validation, MZ, ZZ and KZ; formal analysis, AO; investigation, EA; resources, KZ; data curation, AO; writing—original draft preparation, ZZ; writing—review and editing, MZ; visualization, KZ; supervision, EA; project administration, KZ; funding acquisition, ZZ. All authors have read and agreed to the published version of the manuscript.

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