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A comparative analysis of gamification tools in enhancing content retention in CLIL-based EFL classrooms

Abstract. In the digital age, integrating gamification into Content and Language Integrated Learning (CLIL) has become crucial for engaging EFL learners and enhancing pedagogical outcomes. This study aims to evaluate comparatively the impact of three widely used gamification platforms – Kahoot, Genially, and Quizizz – on content retention and learner experiences among university-level EFL students. Employing a quasi-experimental, mixed-methods design, 53 participants were assigned to one of the three tool conditions and assessed through retention tests, perception questionnaires, focus-group interviews, and structured classroom observations. Quantitative analysis via one-way ANOVA revealed a significant effect of tool type on retention scores ($F(2.50) = 5.67$, $p = .005$, $\eta^2 = .115$). Post hoc comparisons showed Quizizz users achieved the highest mean retention ($M = 85.6$, $SD = 5.9$), significantly outperforming Genially ($M = 78.2$, $SD = 7.4$; $p = .004$), with Kahoot ($M = 82.5$, $SD = 6.2$) yielding intermediate results. Qualitative findings indicated that Quizizz's self-paced format and immediate corrective feedback reduced anxiety, fostered autonomy, and promoted metacognitive reflection. Kahoot's competitive, time-pressured rounds drove high short-term engagement but sometimes imposed cognitive load that impeded deeper comprehension. Genially's rich multimedia interface enhanced initial motivation and visual immersion, yet learners required additional scaffolding and follow-up retrieval exercises to consolidate learning. These results underscore that design features – pacing controls, feedback immediacy, and interface complexity – must be strategically aligned with instructional goals to maximise both cognitive and affective outcomes. Educators and curriculum designers can apply these insights to select or combine gamified tools in CLIL settings, tailoring activities to balance engagement, comprehension, and long-term retention. The practical value of this research lies in its applicability for EFL instructors, curriculum designers, and educational technologists seeking evidence-based guidance on selecting and integrating gamified tools to enhance content retention in CLIL-based university language courses

Keywords: digital tools; Quizizz; Kahoot; Genially; language education; learner engagement

INTRODUCTION

In globalised world, mastering English as a Foreign Language (EFL) is crucial for academic success, professional development, and intercultural communication. However, traditional EFL classrooms often struggle with low student motivation and limited retention of knowledge. This has created a pressing need for innovative instructional strategies that can boost engagement and improve learning outcomes. One such approach gaining considerable attention is gamification – the application of game design elements in non-game contexts. By incorporating features such as points, challenges, and interactive tasks, gamification is increasingly being adopted in educational settings to enhance motivation, participation, and knowledge retention among EFL learners.

Recent studies have explored the role of gamification in enhancing learning outcomes in EFL and CLIL contexts. A.J. Arip & H. Hashim (2024) conducted a systematic review of 28 studies published between 2020 and 2024,

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concluding that game elements significantly improve student motivation, engagement, language proficiency, and critical thinking. Similarly, S. Zhang & Z. Hasim (2023), in their work published in *Frontiers in Psychology*, emphasised that gamification supports both English language development and emotional engagement, particularly through the fr ameworks of Self-Determination Theory and Flow Theory. N.K. Kalleny (2020) highlighted the widespread use of Kahoot!, noting that its more than 30 million users benefit from enhanced formative assessment practices, increased motivation, and stronger classroom interaction. Investigating its impact in vocational education, P. Sassmannová (2023) found that Kahoot! promotes memory retention and student participation. In a CLIL setting, T. Vo *et al*. (2023) integrated both Genially and Kahoot! in higher education, revealing notable improvements in learner motivation, language skills, comprehension of subject content, and retention. A variety of digital tools have been employed to gamify EFL instruction, with platforms like Kahoot, Genially, Quizizz, and Socrative among the most frequently studied. For instance, T. Vo *et al*. (2023) found that combining Genially and Kahoot in a CLIL framework significantly enhanced student motivation, language proficiency, and comprehension of subject-specific content. In a separate study, the sustained use of multiple gamified platforms over an eight-week period – Quizizz, Kahoot, Genially, and Socrative – was linked to improved communication skills and knowledge retention among university EFL students. Emerging technologies such as Augmented Reality (AR) have also been tested for gamification in EFL. P. Cabrera-Solano (2022) demonstrated that Genially supports differentiated instruction, effectively enhancing a range of language skills including grammar, vocabulary, reading, writing, speaking, and listening. Finally, I. Lopatynska *et al*. (2024) showed that incorporating games in CLIL instruction significantly boosts student motivation and fosters greater cultural awareness. Collectively, these findings highlight the growing evidence base supporting gamification as a powerful pedagogical tool in EFL and CLIL education.

Despite evidence supporting individual gamification tools, there remains a lack of comparative research on their relative strengths and limitations – especially regarding subject-content retention in CLIL-based EFL instruction. Existing literature does not adequately compare tools like Kahoot! and Genially, alone or combined, across critical pedagogical outcomes such as memory and engagement. F. Çelik & C.Y. Ersanlı (2023) conducted a quasi-experimental study showing that AR-based mobile apps not only improved language performance but also cultivated more positive learning attitudes among high school students. Despite promising results across these tools, few studies have directly compared their effectiveness. One exception is W. Ibad *et al*. (2023), who compared Kahoot, Quizizz, and Wordwall in EFL reading instruction, concluding that Quizizz yielded the most substantial learning gains. However, a significant gap remains: few investigations have examined the relative impact of different gamified tools on content retention in CLIL-based EFL classrooms. This lack of comparative evidence limits understanding of which tools are most effective for sustained knowledge acquisition, a critical factor in designing evidence-informed instruction.

The aim of this study was to comparatively analyse the effects of different gamified tools on retention of subject-specific content within EFL-CLIL classrooms.

MATERIALS AND METHODS

This study relied on a comparative quasi-experimental mixed-methods research design, combining quantitative and qualitative approaches to evaluate the effectiveness of various gamification tools – namely Kahoot, Genially, and Quizizz – in enhancing content retention among EFL learners within a CLIL framework. A mixed-methods approach, as supported by J.W. Creswell & J.D. Creswell (2022), allowed for both numerical analysis of learning outcomes and rich, contextual insights into learner experiences and perceptions, yielding a triangulated understanding of how different gamification tools affect retention in content-based language instruction. The primary dependent variable was content retention, operationalised through pre- and post-intervention tests aligned with the CLIL subject matter. Secondary variables included student motivation, engagement, participation, and perceived tool usability, captured via perception questionnaires, structured observations, and focus group discussions. These qualitative indicators complemented the quantitative data by revealing learner attitudes, behavioural patterns, and instructional dynamics within each gamified environment. The independent variable was the type of gamification tool used in instruction, with three levels: Kahoot, Genially, and Quizizz.

The study was conducted at the State University of Trade and Economics and involved 53 undergraduate students (aged between 18 and 22) majoring in Law, Economics, and International Relations and Economic Diplomacy. Participants were enrolled in three separate EFL course sections that implemented the CLIL methodology. Each academic group was treated as a distinct cohort and was randomly assigned one of the three gamification tools – Kahoot, Genially, or Quizizz – as the primary instructional aid over a 12-week period in the first semester of the 2024-2025 academic year. All three groups were taught by the same instructor – the author of this study – to ensure consistency in pedagogical delivery, minimise instructor-related bias, and maintain uniform implementation of the CLIL framework and gamification strategies. Participants had intermediate language proficiency (B1-B2 level) based on the Common European Framework of Reference for Languages (CEFR) (Council of Europe, 2020). All groups followed the same curriculum (discipline: Foreign language of speciality (English)), taught by instructors trained in CLIL pedagogy, ensuring consistency in content delivery across conditions.

Quantitative data were collected through pre- and post-intervention content retention tests, specifically designed around CLIL-integrated modules in history and environmental science. These tests, identical in content across all three groups, assessed learners' comprehension of subject-specific material in English. Two types of retention were measured: immediate retention, administered directly after instructional sessions, and delayed retention, assessed four weeks after the intervention to evaluate longer-term content recall. The dependent variable was content retention, while the independent variable was the gamification tool used (Kahoot, Genially, or Quizizz). Qualitative data focused on secondary variables such as student motivation, engagement, perceived tool usability, and overall learning experience. These were collected through:

1. Student perception questionnaires consisting of 24 items, including 18 five-point Likert-scale statements and 6 open-ended questions. The Likert-scale items targeted dimensions such as intrinsic motivation, perceived usefulness, ease of use, and engagement during gamified instruction. Open-ended responses allowed students to elaborate on strengths, challenges, and personal preferences regarding the tools used. The questionnaire underwent expert review by three specialists in EFL pedagogy and educational technology, followed by a pilot study with 15 students. Reliability was confirmed with a Cronbach's alpha of 0.91, indicating strong internal consistency.

2. Focus group interviews with 4-6 participants per group, guided by a semi-structured protocol addressing user experience, engagement, and instructional effectiveness. Each session lasted approximately 25-40 minutes and was conducted online via Zoom. Transcripts were thematically analysed to extract recurring perceptions across the different gamification conditions.

3. Structured classroom observations, documented using a standardised checklist featuring 12 binary items (yes/no) covering learner behaviours such as active participation, peer interaction, responsiveness to feedback, and attentiveness. Observers were trained to ensure inter-rater reliability, which reached 87%.

Quantitative data were analysed using Jamovi software (Version 2.5.5). A one-way ANOVA was conducted to compare content retention test scores across the three experimental groups. Variance was partitioned using Sum of Squares (SS): "Between Groups" reflects variance attributable to differences among the tools, "Within Groups" captures individual variability, and "Total" represents the overall variance. Degrees of freedom (*df*) indicate the number of values free to vary in the analysis. Mean Squares (MS) are obtained by dividing each SS by its corresponding df, yielding the average variance attributable to and within groups. The F-ratio – computed as the ratio of between-group variance to within-group variance – quantifies the relative magnitude of group differences, with larger values suggesting more pronounced between-group effects. Finally, the p-value falls below the conventional significance threshold, indicating that retention differs significantly among the three tools. ANOVA was followed by Tukey's post-hoc tests to identify statistically significant pairwise differences. Effect sizes were calculated using Eta-squared (η^2). Descriptive statistics provided a comprehensive overview of content retention scores across different groups. The sample size (*N*) indicated the number of participants in each group, reflecting the amount of data available for analysis. The *Mean* represented the average retention score within each group, serving as a measure of central tendency that summarised typical performance. The Standard Deviation *(SD*) quantified the spread or variability of scores around the mean, with larger values indicating greater dispersion in individual performances within the group. The Standard Error (*SE*) measured the precision of the sample mean as an estimate of the true population mean, with smaller values suggesting more reliable estimates. Together, these statistics allowed researchers to compare not only the average performance across groups but also the consistency and reliability of those performance measures. Qualitative data from focus groups and open responses were subjected to thematic analysis, identifying recurring themes related to user experience, motivation, and tool design features. Inter-rater reliability for coding exceeded 85%, ensuring consistency.

This study adhered to established ethical standards for educational research involving human participants. Informed consent was obtained from all students after they received full information about the study's objectives, procedures, voluntary nature, and their right to withdraw at any time without penalty. Confidentiality and privacy were ensured through anonymised data collection, secure data storage, and adherence to institutional data protection policies. The study protocol included comprehensive measures to safeguard participants' privacy and confidentiality – such as de-identifying participant data, encrypting digital files, and limiting access to master code lists – in accordance with IRB guidelines requiring secure handling of identifiable information (University of Nevada, 2025).

RESULTS

The results are presented in two parts: first, quantitative findings based on ANOVA and effect size analysis of retention scores, followed by qualitative insights from thematic analysis of focus group and questionnaire data. A one-way analysis of variance (ANOVA), presented in Table 1, was conducted to compare the effectiveness of three gamification tools – Kahoot, Genially, and Quizizz – on content retention scores among EFL learners in a CLIL-based instructional setting. The analysis revealed a statistically significant difference in mean retention scores among the groups, $F(2.50) = 5.67$, $p = .005$, $\eta^2 = .115$, indicating a medium-to-large effect size according to Cohen's guidelines. This suggests that the type of gamification tool used had a meaningful impact on students' ability to retain subject-specific content.

Table 1. One-way ANOVA summary table for content retention scores by gamification tool

Source	*SS*	*df*	*MS*	*F*	*p*
Between Groups	528.4	2	264.2	5.67	.005
Within Groups	4053.2	50	46.6	-	-
Total	4581.6	52	-	-	-

Source: developed by the author

Descriptive statistics, provided in Table 2, indicated that participants in the Quizizz group ($n = 18$) achieved the highest mean retention score ($M = 85.6$, $SD = 5.9$), followed by the Kahoot group ($n = 18$, $M = 82.5$, $SD = 6.2$), and the Genially group ($n = 17$, $M = 78.2$, $SD = 7.4$). Post-hoc analyses using Tukey's Honest Significant Difference (HSD) test revealed that the Quizizz group significantly outperformed the Genially group ($p = .004$), while the difference between the Kahoot and Genially groups approached significance ($p = .048$). No significant difference was observed between the Kahoot and Quizizz groups ($p = .210$), although the Quizizz group demonstrated a modestly higher mean score.

Table 2. Descriptive statistics for content retention scores

Group	*N*	*Mean*	*SD*	*SE*
Kahoot	18	82.5	6.2	1.46
Genially	17	78.2	7.4	1.79
Quizizz	18	85.6	5.9	1.39

Source: developed by the author

These findings, summarised in Table 1 and Table 2, suggest that while all three tools support learning within a CLIL framework, Quizizz may be particularly effective in enhancing long-term content retention. Its self-paced format, combined with immediate feedback and diverse question types, may contribute to deeper cognitive processing. In contrast, Genially, despite its interactive and visually engaging nature, might require more instructional scaffolding to achieve comparable retention outcomes.

The analysis of qualitative data provided deeper insight into secondary variables, including student motivation, engagement, perceived tool usability, and overall learning experience associated with the use of Kahoot, Genially, and Quizizz in CLIL-based EFL instruction. Thematic analysis revealed several converging and diverging patterns across the tools, enriching the interpretation of the quantitative findings. Students using Quizizz consistently highlighted its self-paced structure and instant feedback as key factors contributing to their intrinsic motivation and sustained engagement. Participants described the interface as "user-friendly" and "visually appealing," and appreciated the ability to revisit questions and track progress in real time. Focus group data indicated that Quizizz's format reduced performance anxiety by allowing learners to proceed at their own speed, thereby enhancing both engagement and comprehension. Observational data supported these claims, showing high levels of participation and peer interaction, particularly during collaborative quiz rounds.

In contrast, sampled student-users of Kahoot emphasised the tool's competitive and gamified atmosphere as highly motivating. The leaderboard feature and time-based scoring were frequently cited in open-ended responses as "exciting" and "energising." However, several students noted that the rapid pace sometimes led to stress and decreased focus on content comprehension. Despite this, classroom observations recorded consistent high energy levels and widespread active participation, confirming Kahoot's strength in boosting immediate engagement.

Participants exposed to Genially expressed appreciation for its multimedia-rich design and interactivity, which supported visual learning and made lessons more immersive. However, responses across all qualitative sources revealed mixed perceptions about its usability. While some students praised the creative and exploratory features, others reported difficulty navigating complex interfaces or technical delays that interrupted the learning flow. Genially was often seen as better suited for asynchronous activities or for supplementing rather than driving real-time classroom engagement.

Overall, the data suggest that Quizizz may offer the most balanced tool for sustained motivation, usability, and cognitive engagement, especially in formative assessment settings. Kahoot excels in fostering short-term excitement and classroom dynamism, but may require pacing adjustments for deeper learning. Genially offers a valuable platform for content delivery and visual reinforcement, yet may demand greater digital literacy and instructional scaffolding. These nuanced insights highlight the importance of aligning gamification tools not only with instructional goals but also with learners' technological preferences and cognitive needs.

DISCUSSION

This study breaks new ground by combining quantitative and qualitative methods to compare the learning effects of three gamification tools – Kahoot, Genially, and Quizizz – within a CLIL-based EFL classroom. The data reveal tool-specific differences not only in retention out-

comes but also in learner perceptions, motivation, and cognitive engagement. By triangulating statistical evidence with student-reported experiences and observed behaviours, the study provides a nuanced understanding of how design features like pacing, feedback, and interface usability shape the educational impact of gamified learning environments. These outcomes resonate strongly with the broader literature. S. Zhang & Z. Hasim (2023) emphasised that "timely feedback and user control" are linchpins of digital retention, and data confirm that giving learners autonomy over pacing fosters stronger recall. At the same time, Kahoot's timed rounds mirror A. Alawadhi & E.A.S. Abu-Ayyash's (2021) warning that too much pressure can overload working memory, a concern echoed by F. Çelik & C.Y. Ersanlı (2022) in their quasi-experimental study of speed-focused EFL games. Meanwhile, Genially's visual strengths – lauded by P. Cabrera-Solano (2022) – must be bolstered with immediate retrieval tasks, in line with M. Enríquez (2020), to translate engagement into lasting learning.

Findings align with a growing body of research emphasising the strategic value of gamification in CLIL-based EFL instruction. Prior studies have shown that integrating game-design features – such as points, leaderboards, and storytelling – into language learning environments enhances motivation, engagement, and content retention (Nozhovnik *et al.*, 2023; Zhang & Hasim, 2023). This is particularly relevant in CLIL contexts, which, as D. Marsh (2002) outlined in his foundational framework, aim to integrate both subject content and language acquisition in a cognitively demanding environment. Scholars such as C.J. Lai (2024), T. Vo *et al*. (2024) and J.J. Achivida (2025) have demonstrated that well-designed gamification strategies can effectively scaffold these demands – a conclusion that is corroborated by results.

From a pedagogical perspective, these insights suggest that the mere presence of gamification is not enough; rather, educators must thoughtfully match tool features to learning goals. In practice, this might mean using Quizizz to anchor key vocabulary or grammar points, supplementing Genially presentations with brief in-class quizzes, and reserving Kahoot for lively review sessions when rapid recall is the primary aim. Equally important is preparing both teachers and students: training instructors to recognise signs of cognitive overload, and guiding learners in managing self-paced activities to optimise metacognitive benefits. For example, D. Coyle (2007) emphasised that effective CLIL pedagogy requires cognitively engaging, well-structured tasks that simultaneously promote language and content mastery. Quizizz, with its capacity for metacognitive reflection and autonomy-supportive features, aligns well with these CLIL principles. In contrast, while Kahoot effectively boosts engagement, its reliance on speed and competition may not always support the deeper cognitive demands of CLIL, echoing M. Gebbels (2018) caution that such tools must be adapted to challenge learners meaningfully rather than superficially entertain. Furthermore, the formative potential of gamification tools like Kahoot has been positively documented in vocabulary learning contexts. A. Hamedi *et al*. (2022) found that using Kahoot significantly improved vocabulary knowledge and reduced learner burnout among intermediate EFL students. However, their findings also caution that tool effectiveness depends on how formative assessment is integrated into broader instructional design. Findings support this nuance: Kahoot is beneficial for short-term review, but without pacing adjustments or content scaffolding, it may not meet the cognitive load needs of CLIL students engaged with complex subject matter.

When situated within the broader landscape of gamification research, findings affirm and refine prior claims. I. Lopatynska *et al*. (2024) examined the integration of both Genially and Kahoot in a CLIL course and concluded that while the tools were effective in enhancing engagement and subject comprehension, their individual contributions to retention were not directly compared. Study fills this gap by explicitly contrasting tool-specific outcomes and identifying design factors – such as pacing, feedback immediacy, and competitive pressure – that mediate the effects of gamification on cognitive outcomes. W. Ibad *et al*. (2023) conducted a direct comparison of Quizizz, Kahoot, and Wordwall in EFL reading classes, concluding that Quizizz was most effective for retention. Findings reinforce their results, especially in highlighting how Quizizz's adaptive pace and immediate feedback help students self-correct in real-time and reduce working memory overload. Moreover, this study resonates with pedagogical principles from Self-Determination Theory (SDT), which emphasises autonomy, competence, and relatedness as key drivers of intrinsic motivation. Quizizz's format appears to satisfy these needs by allowing students to regulate their own learning pace, receive competence-affirming feedback, and compete in a low-pressure setting – conditions not fully met by Kahoot or Genially in this study's design.

While all three tools can enhance engagement, their cognitive effects vary based on how their features align with instructional goals. For instance, Quizizz is best suited for reinforcing grammar rules, terminology, or complex concepts that benefit from reflective processing. Kahoot may be strategically used for quick reviews or energising quiz sessions but should be moderated to avoid overwhelming learners, especially in content-heavy lessons. Genially, with its strong visual appeal, serves well as a pre-instructional tool or as part of a flipped classroom strategy, provided that post-lesson retrieval tasks are integrated to aid consolidation. Second, instructors must consider learner differences such as digital literacy, metacognitive awareness, and anxiety sensitivity when selecting gamified tools. As qualitative data suggest, students with lower tech confidence or slower processing speed may feel disadvantaged by fast-paced tools like Kahoot, whereas more autonomous learners thrive in self-paced environments like Quizizz. Therefore, blended or hybrid gamification models that offer both visual scaffolding (e.g., Genially) and retrieval practice (e.g., Quizizz) may offer the most inclusive and pedagogically

sound approach. Finally, teacher training is essential. Instructors need to be able to diagnose cognitive overload, adapt pacing, and guide students in using digital tools for reflection rather than passive interaction (Mykhailenko, 2024). As digital tools become more prevalent in language education, pedagogical competence must evolve to ensure that technology serves learning, not the reverse.

In conclusion, the Discussion highlights how the intersection of gamification design, learner needs, and instructional context shapes educational outcomes in CLIL-based EFL environments. This study contributes to both theory and practice by specifying when and why certain tools outperform others, offering educators a roadmap for intentional, evidence-based technology integration.

CONCLUSIONS

This study offered original empirical insights into CLIL-based EFL education by comparatively analysing the effectiveness of three popular gamification tools – Kahoot, Genially, and Quizizz – on students' content retention and learning experiences. Quantitative results from a one-way ANOVA ($F(2.50) = 5.67$, $p = .005$, $\eta^2 = .115$) indicated a medium-to-large effect size for the type of tool used, with Quizizz users achieving the highest mean score ($M = 85.6$, $SD = 5.9$), significantly outperforming Genially users ($M = 78.2$, $SD = 7.4$; $p = .004$), while the Kahoot–Genially comparison approached significance ($M = 82.5$, $SD = 6.2$; $p = .048$). Qualitative findings, based on thematic analysis of student questionnaires, focus group discussions, and classroom observations, revealed distinct patterns across the tools. Quizizz's self-paced structure and instant feedback minimised anxiety, fostered learner autonomy, and encouraged reflective learning – factors likely contributing to its superior retention outcomes. Kahoot, with its competitive, fast-paced format and real-time leaderboard, effectively heightened engagement and participation, though it sometimes induced cognitive overload that compromised deeper content processing.

Genially, characterised by its rich visual and interactive design, supported initial comprehension and classroom immersion; however, many students needed additional scaffolding and retrieval practice to convert this visual appeal into long-term retention. These findings highlight the importance of aligning specific design features – such as pacing, feedback immediacy, and interface complexity – with pedagogical goals and learner characteristics. Quizizz is best suited for promoting sustained knowledge retention, Kahoot is ideal for energising formative assessment moments, and Genially excels as an engaging introductory tool when paired with structured follow-up activities. By clarifying how cognitive load, motivation, and usability interact in gamified CLIL environments, this study provides language educators with evidence-based guidelines for selecting digital tools and designing effective, learner-centered instruction. Future research should use larger, more diverse samples, longitudinal designs, and explore hybrid models and learner differences – such as digital literacy – to refine gamification strategies in CLIL-based instruction.

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CONFLICT OF INTEREST

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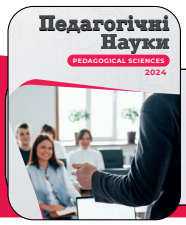
Порівняльний аналіз інструментів гейміфікації для покращення засвоєння навчального контенту в умовах CLIL-орієнтованого навчання англійської мови

Анотація. У сучасну цифрову епоху інтеграція елементів гейміфікації в підході навчання іноземної мови через зміст фахових дисциплін (Content and Language Integrated Learning (CLIL)) є надзвичайно важливою для підвищення мотивації та ефективності навчання студентів англійській мові як іноземній. Метою цього дослідження було порівняльне виявлення впливу трьох популярних платформ – Kahoot, Genially та Quizizz – на засвоєння навчального матеріалу та досвід студентів вищого навчального закладу. Для цього застосовано квазіекспериментальний змішаний дизайн: 53 учасники були розподілені на три групи, кожна з яких працювала з однією із платформ. Збір даних здійснювався за допомогою тестів на засвоєння змісту, опитувальників сприйняття, фокус-групових інтерв'ю та структурованих спостережень в навчальній аудиторії. Кількісний аналіз методом одновимірного дисперсійного аналізу (ANOVA) виявив статистично значущу різницю в результатах запам'ятовування між групами ($F(2,50) = 5,67$, $p = .005$, $\eta^2 = .115$). За результатами пост-hoc тесту Тьюкі, користувачі Quizizz досягли найвищого середнього показника (M = 85,6; $SD = 5,9$), що значуще перевищує Genially ($M = 78,2$; SD = 7,4; $p = .004$). Результати Kahoot ($M = 82,5$; $SD = 6,2$) виявилися проміжними й не відрізнялися статистично від Quizizz ($p = .210$). Якісний аналіз показав, що Quizizz завдяки можливості самостійно регулювати темп роботи та отримувати миттєвий зворотний зв'язок знижує тривожність, сприяє розвитку автономності та глибшому рефлексивному навчанню. Kahoot створює високу короткострокову мотивацію через змагання та лідерборд, але іноді навантажує когнітивні ресурси під тиском часу. Genially відзначається насиченими мультимедійними матеріалами, що підвищують початкове залучення, проте вимагає додаткового виконання вправ на відтворення інформації для закріплення знань. Практична значущість отриманих результатів полягає в тому, що викладачі та розробники навчальних програм можуть використовувати ці висновки для обґрунтованого вибору або комбінування гейміфікованих інструментів у CLIL-курси, враховуючи цілі навчання, потреби студентів і вимоги до інфраструктури. Практична цінність цього дослідження полягає в тому, що його результати можуть бути використані викладачами англійської мови професійного спрямування, розробниками навчальних програм і освітніми технологами як науково обґрунтовані орієнтири для вибору та інтеграції гейміфікованих інструментів з метою підвищення ефективності запам'ятовування навчального контенту в університетських мовних курсах, що реалізуються за підходом CLIL

Ключові слова: цифрові інструменти; Quizizz; Kahoot; Genially; мовна освіта; залучення учнів



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Implementation of Scrum methodology elements in the educational process in Ukraine: New horizons for the development of communication competences

Abstract. In the context of digitalisation and technological development, modern Generation Z students, who are accustomed to online learning and digital gadgets, need innovative approaches and a favourable environment for self-development. To effectively educate this generation, teachers should focus on developing communication skills, critical thinking, creativity, and other significant competences. The purpose of this study was to test the effectiveness of using the elements of the flexible Scrum methodology as a tool for developing students' communication skills through the integration of an interdisciplinary approach. The study employed the methods of theoretical generalisation and comparison (consideration of the essence and characterisation of the differences between flexible methods), analysis (questionnaires, self-analysis of the case participants), statistical method (compilation and grouping of data to determine the percentage of satisfaction of participants), synthesis (combination of various types of information). The study analysed the studies of Ukrainian and foreign researchers on the options for using the Scrum methodology. The study described the stages of practical use of elements of the flexible Scrum methodology in the educational process, with each of the proposed stages substantiated. The statistics of responses to the survey of second- and fourth-year students to understand the effectiveness of teamwork during an interdisciplinary practical training were presented. A pedagogical experiment was conducted using elements of the Scrum methodology to develop the communication competences of applicants, which enabled fourth-year students to assess their professional skills for their future profession, and second-year students to conduct a self-analysis of their level of competence and understand the areas for self-improvement. The experiment contributed to the development of key communication and self-development skills. The study developed an algorithm for using elements of the Scrum methodology in interdisciplinary practical classes. The findings of an empirical study of the development of students' communication competences using three diagnostic tools were presented. The practical value of this study lies in the possibility of implementing its findings in the educational process in the development of academic disciplines for various courses of higher education

Keywords: interdisciplinary case; teamwork; sprint; product owner; facilitator; retrospective

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INTRODUCTION

Understanding the significance of using interactive teaching methods that involve active engagement of students, teachers try to find special approaches to each student, because each student has their individual interests, learning style, perception, and assimilation of educational material, and therefore it is vital to provide tailored support. This leads to the search for modern practical teaching methods to develop not only theoretical skills but also practical ones. Such a methodology may be the Scrum methodology, which is predominantly used in EU countries. Therefore, it is vital to update the existing educational model with an emphasis on developing future-oriented competences.

It is widely known that the higher education system needs constant transformation. Various researchers have addressed this issue. Thus, V.V. Sychenko *et al.* (2022) proved that project management, specifically the use of agile methodologies, is a relevant tool for reforming the higher education system in Ukraine. This will enable more efficient implementation of educational projects and adaptation to changes in the external environment. Sharing concerns regarding the development of the necessary skills for students to work successfully in a dynamic world, L.V. Slipchyshyn (2020) noted that the Agile approach is an effective tool for modern education. S.G. Kisno *et al*. (2022) shared this opinion, emphasising that the Agile approach can be effective for active and project-based learning, enabling students to take an active part in the learning process. Furthermore, Agile methods can be applied to various subject areas, not just software engineering. The findings of the study revealed a considerable interest in investigating and applying flexible approaches to teaching to stimulate collaboration and effective student performance.

When considering the evaluation of the Scrum method in Brazilian federal universities, E. Rodrigues de Oliveira *et al*. (2023) indicated that despite some limitations, such as low level of technical maturity and high staff turnover, most of the surveyed employees positively assessed the use of Scrum. M.V. Kryva & A.-M.V. Lysko (2024) saw the great potential of introducing EduScrum in the educational process. It was proved that the use of the EduScrum methodology will increase students' involvement in the implementation of tasks, help them develop self-organisation and cooperation skills. S. Fernandes *et al.* (2021) investigated the potential of using Scrum to improve the efficiency and quality of project-based learning. The findings showed that using Scrum in project-based learning teams can greatly improve project and team management. The researchers identified the key benefits of Scrum for PBL teams: efficient task allocation, performance monitoring, visual management, and regular feedback. V. Pryimak & B. Korzh (2019) pointed out that agile methodologies such as Scrum and Kanban are more effective than conventional cascade models in engineering. Their application enables adaptability to change, improvement of team communication, and enhancement of the quality of the final product.

The purpose of the present study was to test the application of elements of the flexible Scrum methodology to develop students' communication competences using an interdisciplinary approach. To fulfil this purpose, the following tasks were set:

1. To substantiate the necessity of applying the elements of the Scrum methodology as a pedagogical methodology for conducting interdisciplinary practical training for second- and fourth-year students.

2. To use three methods of empirical research to assess the development of students' communication competences after the experiment.

3. To present the findings of an empirical study of the development of communication skills of management trainees through the application of elements of the Scrum methodology in the educational process.

LITERATURE REVIEW

The issue of applying the Scrum methodology, especially in the educational process, stays relevant to this day. Many researchers refer to this methodology and offer various options for its use. Yu.I. Minhalova (2018) considered current trends in the organisation of research activities of students of higher education institutions, outlined ways to solve the problem associated with the stereotypical thinking about the organisation of students' research work only in extracurricular time. The researcher pointed out that Scrum is a kind of work environment with flexible project management. Much is left to the discretion of the project team. And this is implemented for the simple reason that it is the project team that knows the best ways to solve problems that arise. Yu.I. Minhalova (2018) noted that research using agile Scrum management enables students to engage in scientific research, which contributes to the development of the necessary abilities of a modern researcher.

V.V. Sychenko *et al.* (2022) looked for the best ways to apply project management approaches in the higher education management system in Ukraine in the context of rapid socio-political changes, provided recommendations for the application of modern flexible management methodologies. Based on the analysis of the essence of the project-based approach, the researchers proposed ways to improve management mechanisms in the higher education system, involve state and regional authorities, business communities, and NGOs as customers of educational projects. The researchers focused on the need to adapt the project management methodology to the theory of public administration to ensure the innovative development of the higher education system as a whole, identified and analysed the key aspects to be considered when implementing project management models, improved the educational mechanism for implementing the project management methodology, considering the principles of systematicity, consistency in planning, organisation, execution, control, tracking progress and success dynamics, applying management decisions according to concrete

conditions, the ability to quickly adapt to new socio-economic conditions, and also considered in detail the stages of the project life cycle.

L.V. Slipchyshyn (2020) investigated the need to use an agile approach in education. The researcher found that the "information noise" in the educational process is overcome by fundamentalisation, which provides the scientific core of the educational material, around which the content is formed, factoring in the new skills and sources of learning. The researcher showed that to solve the educational problems in many countries of the world, the Agile approach is employed, which aims to help individuals gain knowledge through experience, facilitate the transition from conventional linear problem solving to iterative and group problem solving, which focuses on the abilities and skills of individuals and the significance of using them to benefit group processes. The ability to master the content of learning based on iteration is formed using the mechanisms of imaginative thinking and reflective activity, which will enable the training of competitive specialists.

M.V. Kryva & A.-M.V. Lysko (2024) identified the features of the implementation of the eduScrum methodology in the educational process of higher education institutions and investigated the attitude of students towards its use in organising project activities. The advantages of using flexible technologies in education, the disadvantages and difficulties of using eduScrum were considered, the need to prepare participants in the educational process for its wider application in the educational process, and the use of digital services for working with a scrum board were emphasised. In the study, the researchers substantiated the need to introduce the eduScrum methodology into the educational process of higher education institutions and proved that the introduction of the eduScrum methodology is a promising area of research, since this methodology in higher education institutions can be used in full-time, blended, and distance learning; adapted to the study of various academic disciplines.

A. Jurado-Navas & R. Munoz-Luna (2017) investigated the application of the Scrum methodology in teaching English at the University of Malaga. The findings revealed that this approach is effective and valuable for modern universities. Students were initially reluctant and apprehensive about working in teams, but with practice, their opinion changed. For instance, they positively noted that this methodology encouraged them to participate and change ideas with a deeper sense of empathy, self-organisation, and self-discovery. At the end of the training, most students said they would take part in an analogous event again. Thus, considering the opinions of students (as well as teachers), the researchers concluded that this method can be viewed as a good proposal for achieving high-quality educational process in universities for three key reasons: first, it improves the ability to use knowledge in a disciplined, critical, and creative way; second, it promotes coexistence in heterogeneous human groups; third, it develops the ability to think, live, and act with full autonomy.

S.G. Kisno *et al.* (2022) emphasised that the world of education is experiencing rapid change and uncertainty, which requires adaptability and flexibility from participants in the educational process. Scrum, as one of the agile development methods, offers the principles of transparency, inspection, and adaptation that can be applied in educational leadership to effectively manage change and solve complex problems. S. Fernandes *et al.* (2021) investigated the effectiveness of using Scrum to improve the performance of project-based learning (PBL) teams. The researchers showed that Scrum helps students develop crucial skills in project management, team management, leadership, time management, etc. Students are satisfied with using Scrum, especially because of the regular feedback and visual project management. The role of the Scrum Masters is critical to the successful use of Scrum, as they help teams stay on track.

E. Rodrigues de Oliveira *et al.* (2023) proved that Scrum promotes effective interaction between team members, which is crucial for projects carried out at universities. Thanks to Scrum, teams become more productive and can achieve their goals faster. Scrum helps to develop essential skills such as project management, leadership, and problem solving. The researchers proposed a set of attributes to measure Scrum effectiveness. This set can be useful for universities that plan to implement or are already using Scrum. M. Medrek (2018) demonstrated the effectiveness of using Agile methods for teaching e-business in a dynamic and interactive environment. The researcher noted that students get access to the necessary tools and platforms for developing and evaluating e-commerce solutions, can gain practical experience in applying Agile and Scrum to develop prototypes of e-commerce systems in collaboration with potential customers.

The analysis of scientific research revealed that Ukrainian and foreign authors have paid sufficient attention to the use of the Scrum methodology in education and research, but less so to the direct didactic and pedagogical developments in the disciplines for managers. The study considered the necessity of applying Scrum in students' research work, developing soft skills, increasing the transparency of the educational process and its organisation.

MATERIALS AND METHODS

The Department of Management of Alfred Nobel University (Dnipro), in implementing the educational and professional programme "Management" of the first (bachelor's) level of higher education, conducted a pedagogical experiment in the form of an interdisciplinary approach by introducing into the practical classes of second- and fourth-year students general cases in the disciplines "Business and Taxes" (taught in the 2nd year) and "Evaluation of the functioning of the enterprise" (taught in the 4th year) to solve interdisciplinary practical problems using elements of the The purpose of the proposed case was to develop students' communication competences, practical application of theoretical material, and to teach students to assess the

financial implications of various management decisions, such as optimisation of the payroll and changes in the number of staff. The interdisciplinary approach allowed the students to integrate knowledge from multiple disciplines, develop skills in making informed management decisions based on calculations, forecasting financial outcomes, and risk assessment.

To conduct the planned experimental event, the study used an auditorium with multimedia equipment with a large projection screen, which showed presentation materials about the course of the class; a magnetic marker flipchart for attaching coloured marker sheets with the relevant conclusions after the next sprint; and small tables on wheels, from which 8 tables were created as "islands" (1 for product owners, 1 for Scrum masters, 6 for teams). A fresh bouquet of yellow flowers with a pleasant aroma was used to create a positive atmosphere. During the workshop, 6 teams were formed. The experiment was attended by 40 students, of whom 20 were second-year students and 20 were fourth-year students.

The rules for conducting a practical lesson using elements of the agile Scrum methodology in the educational process were developed, which contained 9 points. Specifically:

1. The applicants were divided into teams of 5 people – each team member acted as a manager-optimiser of the production process at TechnoBud LLC.
2. Scrum masters were selected from among the applicants – facilitators of the Scrum team.
3. The applicants were also selected from among the product owners who decided to invest in optimising the production process at TechnoBud LLC. They gave tasks for the sprint to the Scrum master.
4. The Scrum Master passed on the task received from the product owner, set tasks to their team, and worked with them for 10 minutes to complete the task. Subsequently, the Scrum master demonstrated the decision made by the team during the sprint (2 minutes) to the product owner.
5. The deadline for one sprint was set at 10 minutes.
6. Sprint retrospective (2 min) – discussing how the team worked during the sprint and finding ways to improve the quality of its work in the future.
7. After presenting the outcomes of the production process optimisation, each team received the corresponding points, considering the labour impact factor as decided by the Scrum master.
8. Teachers are facilitators of the educational process.
9. Summarising the results of the interdisciplinary case.

The following *handouts* were prepared for the interdisciplinary case: job cards, numbers, scorecards, initial data, and case objectives, options for automation elements of TechnoBud LLC, staffing table of TechnoBud LLC, initial data for calculating deductions from the payroll, functional responsibilities of the staff units of the production department and the supply and logistics department of TechnoBud LLC, questions for discussion (content of sprints). When developing the content of the sprints, the knowledge and skills acquired by the students of different courses were considered. For example, second-year students focused on calculating personal income tax and changes in tax liability and its effects on the company's operations. Fourth-year students paid more attention to process management and analysis of possible risks for the company, and their elimination upon optimising labour resources. Based on the practices of conducting interdisciplinary cases using the Scrum methodology, the study offered a vision of the stages of using Scrum elements in interdisciplinary cases. Each Stage was considered in detail and an algorithm for conducting practical classes using an interdisciplinary approach was formed.

Conducting a pedagogical experiment involved not only achieving scientific results, but also compliance with ethical standards. The participants of the experiment were informed about the purpose of the study, its procedures, and possible risks. They were entitled to refuse to take part at any time without any negative consequences. All information obtained during the experiment is kept confidential. The experiment did not cause any physical or psychological harm to the participants. All necessary measures were taken to ensure the safety of the participants. There was no deception of the participants. The experiment had potential benefits for the participants and for society as a whole. Throughout the experiment, regular assessment of compliance with all ethical standards was carried out (American Sociological Association, n.d.).

The materials used for this study included valuable sources of information that helped to consider and analyse agile methodologies and approaches used in the educational process. The first method employed was the theoretical generalisation and comparison. This method helped to consider the essence and characterise the differences between flexible methods, compare them and substantiate the need for their application. The method of analysis was employed to reveal the results of the practical training, the analysis of the questionnaire, and the self-analysis of the case participants. Based on the analysis of concrete data, more generalised theoretical provisions were formulated to explain the findings. The statistical method was employed to collate and group the data, which helped to understand and analyse the percentage of satisfaction of the participants in the event. The next method was synthesis. This method enabled a systematic review by synthesising the findings of several studies, helped to identify general trends, discrepancies, and gaps in scientific knowledge about the use of agile methods. The method of synthesis was employed to articulate the key findings and principal aspects of the study.

RESULTS AND DISCUSSION

Implementation of the elements of the Scrum methodology in an interdisciplinary practical lesson

Communication competences play a vital role in the future profession of students of the Department of Management at Alfred Nobel University (Dnipro), and therefore their development was investigated through the interdisciplinary

use of the flexible Scrum methodology. V. Varenyk & Zh. Piskova (2024) noted that the European Commission ESCO (Official website of the European Commission (n.d.) provided a classification of skills that are relevant to the EU labour market, education and training. There is an entire block of cross-cutting skills and competences that can be attributed to universal, i.e., flexible skills to some extent. The researchers emphasised that the European Commission's ESCO focuses on the skills of the Social and Communication Skills and Competences group, which relate to the ability to interact positively and productively with others. This is manifested in communicating ideas effectively and empathetically, aligning one's personal goals and actions with those of others, acting according to values, promoting the well-being and progress of others, and demonstrating leadership. It includes the following components: adherence to an ethical code of conduct, leading others, supporting others, working in teams and communities, and communicating. From the employers' standpoint, soft skills are the most significant ones for entry-level success in the workplace. According to the publication on the Official Website of Osnova Publishing Group (2020), communication competence includes the following components: sociability (the ability to establish and maintain the necessary contacts with other people); possession of meaningful information and the ability to operate with it; the ability to partner and achieve mutual understanding.

Yu.I. Minhalova (2018) concluded that Scrum can be used as an effective tool in organising students' research work. It will contribute to the development of researcher skills, increase student engagement in research activities, and enable more effective problem solving, enhancing the abilities of students. M. Medrek (2018) expressed an analogous opinion, describing the successful implementation of Scrum in a master's programme in economics and management. A. Jurado-Navas & R. Munoz-Luna (2017) pointed out that the Scrum methodology promotes a deeper understanding of the material, critical thinking, and a creative approach to learning. Working in teams helps students develop communication skills, tolerance, and mutual understanding. This method prepares students for the challenges of the real world, where they often work in teams on complex projects.

I.V. Androshchuk (2022) investigated communicative competence and found that it is an integrated property of the personality of students, which ensures the accomplishment of educational, and later, in case of vocational education, professional tasks, and includes knowledge of speech culture, the ability to understand the interlocutor, to support the conversation using verbal and non-verbal means, to convey one's opinion reasonably, interpersonal communication skills, which are crucial factors of effective interaction. Furthermore, a future specialist, and now a student of vocational education, should have flexibility and critical thinking, be able to clearly and concretely express their opinion on a particular issue, adapt in a dynamic environment, taking into account the requirements of professional activity, work with information in the performance of professional tasks, and establish interaction in a professional environment. The author emphasises the importance of communicative interaction of participants in the educational process as a special type of pedagogical communication aimed at fulfilling educational tasks through establishing a favourable psychological climate and optimising the relationships between participants in the educational process.

Zh. Bohdan *et al.* (2020) stated the low level of communicative competence of students of higher education institutions. The researchers noted that modern students have certain challenges in expressing their thoughts, which complicates mutual understanding not only between teachers and students, but also between students themselves. Considering learning as a specially organised communication, during which social experience is formed and thus assimilated, which is the content of learning, it is emphasised that the need to develop the communicative competence of students exists in the process of teaching all disciplines, since the learning process is mostly communication between the teacher and the student, interaction between them, which is a significant factor in improving the quality of the educational process.

Many researchers have considered the development of communication skills in relation to various professions. Thus, Z.M. Gomeniuk (2012) investigated their development as a condition for successful professional activity of modern managers. S.Y. Dikhtyarenko (2017) focused on the study of future psychologists' communicative competence in the educational environment of a university. To test the acquisition of communicative competences, the researcher developed methodological materials in the form of an interdisciplinary case "The impact of automation of the production process on the structure of the company's labour resources and tax liabilities on personal income tax (PIT)" for the study of PIT by second-year students and fourth-year students of the company's labour resources analysis, using elements of the agile Scrum methodology with the possibility of introducing it into the educational process of higher education institutions. It is known that Scrum is a flexible methodology that allows adapting to changes. The team can modify its approach to work depending on the concrete circumstances of the project.

The key roles in Scrum were as follows:

- product owner – represented the client's interests and was responsible for the product backlog;
- scrum master – process facilitator, helped the team to follow the scrum rules;
- development team – a self-organised team that performed the work.

Stages of using the Scrum methodology in an interdisciplinary case:

Stage 1: Product definition (case study). During this stage, it is necessary to define the product, i.e., to clearly formulate and understand what exactly the team is creating. At this stage, the product owner must provide the

Scrum Master with a clear task for the team to complete. Each team member must understand the overall purpose of the project.

Stage 2. Creation of a team. This Stage requires a clear understanding of the number of case players. A prerequisite is to keep their number to 5 people in a Scrum team. This number (5 people) is explained by the fact that it is easier to maintain effective communication in teams with a small number of members. Each team member can easily express their opinion and be heard, the probability of internal conflicts and misunderstandings is reduced, and duplication of functions is more likely to be avoided. Each team member feels responsible for the result, which helps to increase the motivation and involvement of each participant. "Uncomfortable" teams were formed by randomly selecting a number from a "magic bag" that corresponded to the team number.

In the case of this study, the role of Scrum master was given to senior students (fourth year) because they have already mastered more management skills.

Stage 3. Creating a product backlog, i.e., creating a list of all the functionalities that the product should have. In the case under study, it was a list of tasks that teachers set for students to solve during the relevant sprint.

Stage 4. Planning of sprints. A sprint is the heart of a scrum, where ideas gain value. All the work necessary to achieve the goal is done within the sprint. Since there was a time limit (1 workshop – 1 hour and 20 minutes), the allotted time was divided into four sprints. At this stage, it was necessary to select tasks, i.e., from the product backlog, one had to select tasks that the team can complete in a single sprint. Also at this stage, it was necessary to distribute tasks among team members, determine deadlines, and determine the availability of necessary resources.

Stage 5. Demonstration of results. At the end of each sprint, the Scrum master of the team demonstrated the work done to the product owner, who decided whether to invest in the product or not.

Stage 6. Retrospection. During this stage, it was necessary to discuss how the team worked during the sprint and find ways to improve the quality of work in the future. All team members analysed which tasks were performed effectively and which could be improved.

Stage 7. Analysis of the case results. This Stage is mandatory and necessary for collective discussion, where applicants independently determined which aspects of teamwork needed to be improved to achieve synergy. In-depth self-analysis is mandatory, which will allow applicants to independently assess not only the overall result, but also each step on the way to the goal, enabling them to see and understand problem areas for further development. A necessary element of the last stage, stage 7, is to receive points for the work, considering the labour impact factor as decided by the Scrum Master, which, in opinion of the authors of the present study, will increase the motivation of applicants for teamwork and determine the significance and level of responsibility of the Scrum Master. Based on the proposed stages of using the elements of the flexible Scrum methodology in an interdisciplinary case, an algorithm for using the elements of the Scrum methodology in interdisciplinary cases was developed, which is presented in Figure 1.

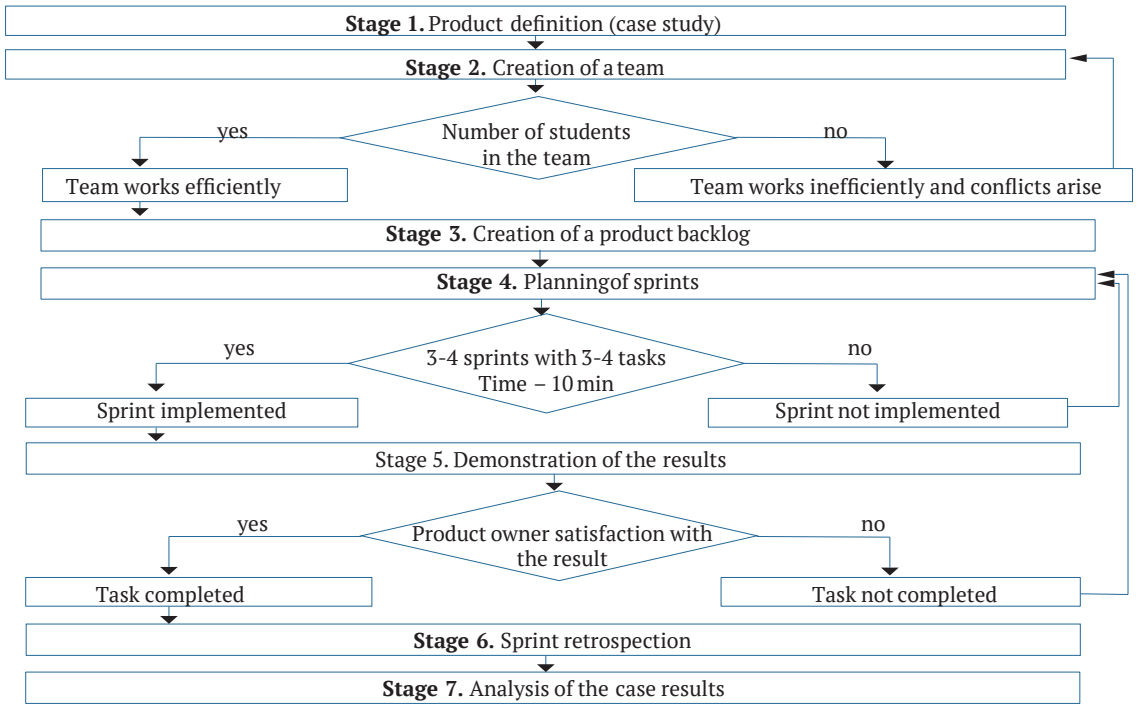

Figure 1. Algorithm for using the Scrum methodology in interdisciplinary cases

Source: developed by the authors of this study

Each group of stages has its individual semantic and logical load. The presented algorithm described in detail the process of conducting a Scrum case in a learning environment. It covers all the main stages of Scrum: from product definition to retrospection. The algorithm is logical, consistent, and adapted to the specifics of the educational process. The algorithm proposed can contribute to the development of such skills in students as ability to engage in partnerships, achieving mutual understanding, planning and organising work, teamwork, problem solving, adaptation to change, presentation of results, etc.

The teacher, as a facilitator of the educational process, can take an active part in the process, providing feedback and mentoring to the team. Furthermore, depending on the format of the training (offline or online), special digital tools can be used. If the practical training is conducted in an offline format, flashcards are developed to enable students to be more focused in their approach to solving problems. If the training is online, one can use tools such as Trello, Jira, Asana, or Miro to help students improve their digital skills. This will make it easier to plan, track progress, and communicate with team members. The resulting 3 stages of the interdisciplinary case are the final 3 stages: **Stage 5** – demonstration of results, **Stage 6** – retrospection, and **Stage 7** – analysis of the case results. By demonstrating the results at the end of each sprint (**Stage 5**), the Scrum master of each team reported to the product owner on the work done by their team. The results of the sprints in each team were quite interesting, reflecting the diversity of opinions, the level of empathy among the participants, the desire to take more or less risks, and the level of responsibility chosen. For example, one team "laid off" 30% of unskilled workers, replacing them with automated lines, while others were more loyal and only cut 6% of their staff in favour of machines.

Notably, when automating a company, one cannot completely abandon the employees of the production department, as specialists are needed to monitor the operation of machines, troubleshoot problems, organise power supply, and manage warehouse processes. These aspects became the subject of lively discussions during **Stage 6**, retrospection, where participants analysed the problems that had arisen and sought solutions. As the case study showed, there were more than enough discussion points. The results in each team were interesting, indicating the difference of opinions, the level of empathy among team members, the desire to take risks to a greater or lesser extent, and the level of responsibility chosen. For instance, one team "fired" 30% of unskilled workers and replaced them with automated lines. Other teams were more loyal to the company's staff members and replaced only 6% of people with machines. At the final stage, **Stage 7**, after the case study, the teachers conducted a survey on the results of the interdisciplinary case study, which helped to draw conclusions and analyse the responses of the case participants. The students made an in-depth self-analysis of their work and teamwork. Questions included in the questionnaire to the participants of the interdisciplinary case study:

1. How do you evaluate your work?
2. What knowledge did you lack during the case study?
3. In your opinion, how effective are interdisciplinary cases in the educational process?

Answers to the first question revealed that participants were generally satisfied with their teamwork, as presented in Figure 2

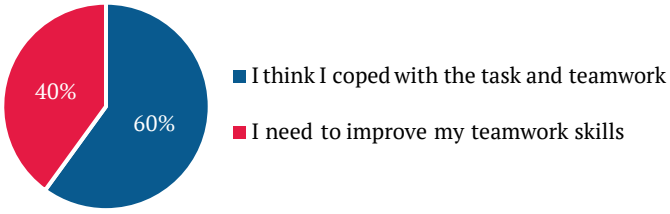

Figure 2. Results of answering the first question of the participants' questionnaire after the interdisciplinary case study
Source: developed by the authors of this study

Figure 2 shows that 60% of the participants believed that they coped with the tasks of the case, while 40% reported that they needed to improve their teamwork skills. An interesting fact was that 100% of the participants reported that they did not have enough time. This result suggests that they need to work on their time management. It may also indicate that the Scrum Masters have not correctly distributed roles among the team members. The answers to the second question of the questionnaire revealed that the participants lacked an understanding of the functional responsibilities of staff members of different departments of the company, especially the production department. Although the handout provided information on "Functional responsibilities of the staff of the production department and the supply and logistics department of the company" as a "hint". This may suggest a weak concentration of attention of the case study participants. In answering the third question of the questionnaire, the participants noted that they lacked such activities in the educational process. Thus, noting and acknowledging the complexities of the process, the participants reported that such activities enabled them to fully "engage" in the educational process, understand the significance of a "friend's" support and easily understand complex things. Another necessary element of this Stage was to assign points for the work of each team member, considering the labour impact factor. According

to the established rules, this decision was to be made by the Scrum master, which helped to increase the motivation of the participants to work together and determined the significance and level of responsibility Scrum master. This task was completed fairly, and the scores showed a true picture of what transpired in the process.

Results of an empirical study of the development of students' communicative competences after the experiment

Relying on the pedagogical practice of conducting empirical research, the study formed a diagnostic toolkit to determine the development of students' communication competences after a practical lesson using the flexible Scrum methodology. Particular attention was paid to such components of communication competences as improving sociability and increasing the ability to partner and achieve mutual understanding. Based on the empirical study of the communicative competence of students conducted by T. Shevchenko (2020), a separate diagnostic tool was considered. L.V. Plyaka & S.V. Ogar (2016) provided their view on methods for diagnosing personal and communicative qualities. S.M. Maximets (2017) investigated the communication and organisational skills of management students using the COS-2 methodology for assessing communication and organisational skills. O. Karabin & I. Vazarnytska (2005) highlighted the purpose of test control and noted that testing can provide prompt, reliable information about the readiness to perceive new material and knowledge gained in the learning process. G. Kralina (2022) investigated the role of testing in assessing the knowledge, skills, and abilities of a person. The researcher noted that testing is one of the sections of diagnostics for use in various fields, the test is considered as a standardised, short, time-limited test designed to establish quantitative and qualitative individual differences. L.K. Hrytsiuk & A.V. Liakisheva (2012) substantiated the essential characteristics of test control and identified the conditions for its effective use in the educational process of a higher education institution. A.B. Hryniak (2021) considered the specific features of the final control of law students' knowledge in the context of distance learning.

Having studied various methods, practices, and analysed the results of testing by various methods, several of them were selected and used as a basis. Thus, Thus, it is advisable to use the methodology for determining communication and organisational skills (COS-2), V. Sanzharovets & Y. Shatylo (2020), which aimed to study the communicative and organisational tendencies of the individual (ability to establish business and interpersonal relationships, desire to expand the scope of contacts, participation in public and group events, ability to influence people, desire to take initiative, etc.), which was also noted by O.M. Shelomovska (2015) in "Methodical instructions for independent work in the discipline Social Communications in Management". To test Scrum masters (fourth-year students) in their ability to draw conclusions after each sprint, the study chose the test to determine the ability to express their thoughts. The "Listening Skills" test by A.V. Kurova (2020) was also expedient, as teamwork involves the presence and development of this skill.

Thus, the experimental sample consisted of 40 second- and fourth-year management students of Alfred Nobel University aged 18-23. The study was conducted offline using Google forms. The availability of a gadget for each student allowed this to be done at the university. The following diagnostic tools were used for the empirical study:

1. Methodology for determining communication and organisational skills (COS-2);
2. Test to determine the ability to express one's thoughts;
3. Listening skills test.

The results of the study of applicants' communicative tendencies using the COS-2 methodology are presented in Table 1.

Table 1. Level of manifestation of applicants' communicative tendencies

Level of communication tendencies	Range of quantitative indicators	Assessment	Survey results, %	
			2nd year	4th year
Low	0.10-0.45	1	0	0
Below average	0.46-0.55	2	8	0
Medium	0.56-0.65	3	12	20
High	0.66-0.75	4	40	30
Very high	0.76-1.00	5	40	50

Source: calculated by the authors of this study

According to the data in Table 1, both second- and fourth-year students showed a fairly high level of communication aptitude. "High" and "very high" levels were achieved by 80% of students in both years. Half of the fourth-year students (50%) and 40% of the second-year students (40%) were characterised by quick orientation in challenging situations, relaxed behaviour in a new team, initiative, independent decision-making, and the ability to defend their personal opinions. These applicants easily adapted to an unfamiliar company and actively joined the game. However, those who did not get confused in the new situation quickly began to find friends, expanding their circle of acquaintances in the second year were more (40% – "high" level) compared to the fourth year (30%, respectively). Among the fourth-year students, there were no those who did not seek communication and felt constrained in the new company (no "low" or "below average" level). However, in the second year, 8% (below average) of applicants

had challenges establishing contacts with senior students, were afraid to speak in front of an audience and defend their opinions and were poorly oriented in unfamiliar situations. The results of the analysis also revealed that both in the second (12% – "average" level) and fourth year (20%, respectively) there are students whose potential for aptitude is not characterised by high stability. For example, they sought contact with other students, did not limit their circle of acquaintances, defended their opinions, and planned their work together with the team. However, they still need to seriously engage in the formation and development of communication skills. But it is vital to remember that the conditions for their manifestation and development may simply not have been created. Thus, fourth-year students demonstrate a greater level of development of communication skills, which suggests the effectiveness of teaching approaches and the natural improvement of competences with experience. The results of the diagnostics of the level of students' ability to listen and express their opinions are presented in Table 2.

Table 2. Students' level of listening skills and ability to express their opinions

Skills	Survey results, level, %.			Number of surveyed applicants
	Low	Medium	High	
Listening	25.0	50.0	25.0	40
Expressing thoughts	8.5	41.5	50.0	20

Source: calculated by the authors of this study

Table 2 shows the results of the survey of participants on the level of listening and expressing their opinions, assessed in three categories: low, medium, and high. It also shows the total number of respondents for each type of skill. Thus, a quarter of the applicants (25%) were argumentative, unable to listen, and were not oriented towards partnership in communication. This reflects a general trend among modern youth. Half (50%) were critical of what is said, often became offended and jumped to conclusions. These applicants lacked the traits of a good interlocutor and needed to work on their manner of speaking. Notably, 25% of applicants were excellent interlocutors and non-conflict people who knew how to listen. The communication style of such participants can be an example for other students.

The ability to express opinions was tested among senior students. The survey results revealed that 50% of the students are fluent in expressing their opinions and can formulate them promptly. However, a small proportion (8.5%) had not learnt to ask questions correctly to be understood, and did not speak politely and in a friendly manner. The ability to express their opinions is generally better developed than the ability to listen, which may be a consequence of an individual approach or the specifics of the training. More attention should be paid to improving listening skills through practical tasks that stimulate active perception of information.

CONCLUSIONS

An interdisciplinary approach is a crucial component of interactive teaching methods, which is fully correlated with the generally declared principles of higher education in Ukraine and the EU. It is the methods of active learning that activate the independence of students' opinions, involve them in information production, create an atmosphere of trust and mutual support, and make stakeholders active learning subjects. As the flexible Scrum methodology makes one feel more comfortable, it becomes possible to be more creative in organising the learning process. However, there are still some challenges that arise during the preparation and implementation of an interdisciplinary case scenario. The key problem that arises when applying interactive techniques is the lack of applied methodological developments for the development of economic thinking and studying complex educational material. The proposed methodological materials in the form of an interdisciplinary case study using elements of the Scrum methodology helped to observe one complex process divided into several smaller sprints. This approach aroused interest on both sides of the process and allowed work in teams (small groups of 5 people).

For the first time, the Department of Management launched a pedagogical experiment on the development of students' communication competences using elements of the flexible Scrum methodology in an interdisciplinary practical lesson, which enabled fourth-year students to assess the level of communication aptitudes, listening, and expressing their thoughts for their personal understanding of the degree of professional skills that can be demonstrated to an employer. Second-year students were given the opportunity to self-analyse their level of competence and assess the degree of its development. The findings of the study revealed that the use of elements of the agile Scrum methodology increases the ability to develop the communication skills of management students. Therefore, the authors of the present study see considerable potential in this area of research.

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Впровадження елементів методології Scrum в освітньому процесі в Україні: нові горизонти для розвитку комунікативних компетентностей

Анотація. В умовах цифровізації та розвитку технологій сучасні здобувачі покоління Z, які звикли до онлайн-навчання та цифрових гаджетів, потребують інноваційних підходів і сприятливого середовища для саморозвитку. Щоб ефективно навчати це покоління, викладачі мають акцентувати увагу на розвиток комунікаційних навичок, критичного мислення, креативності та інших важливих компетентностей. Дослідження мало на меті перевірити ефективність використання елементів гнучкої методології Scrum як інструменту розвитку комунікативних навичок у здобувачів через інтеграцію міждисциплінарного підходу. При проведенні дослідження були використані методи: теоретичного узагальнення і порівняння (розгляд суті та характеристика відмінностей між гнучкими методами), аналізу (анкетування, самоаналіз учасників кейсу), статистичний метод (зведення та групування даних для виявлення відсотку задоволеності учасників), синтезу (поєднання різних типів інформації). У результаті дослідження проаналізовано наукові праці українських та іноземних авторів щодо варіантів використання методології Scrum. Описано етапи практичного використання елементів гнучкої методології Scrum в освітньому процесі, обґрунтовано кожен із запропонованих етапів. Наведено статистику відповідей проведеного анкетування здобувачів другого та четвертого курсів для розуміння ефективності роботи в командах протягом міждисциплінарного практичного заняття. Проведено педагогічний експеримент із використанням елементів методології Scrum для розвитку комунікативних компетентностей здобувачів, що дало можливість здобувачам четвертого курсу оцінити свої професійні навички для майбутньої професії, а другокурсникам – провести самоаналіз рівня компетентності та зрозуміти напрямки для самовдосконалення. Експеримент сприяв формуванню ключових навичок спілкування й саморозвитку. Розроблено авторами алгоритм використання елементів методології Scrum у міждисциплінарних практичних заняттях. Продемонстровано результати емпіричного дослідження розвитку комунікативних компетентностей здобувачів із застосуванням трьох діагностичних інструментів. Практичною цінністю дослідження стало можливість запровадження його результатів у освітньому процесі при розробці навчальних дисциплін для різних курсів здобувачів вищої освіти

Ключові слова: міждисциплінарний кейс; робота в командах; спринт; власник продукту; фасилітатор; ретроспектива

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The use of digital microscopes for studying physical phenomena: New opportunities for school education

Abstract. The modern educational process requires the introduction of the latest technologies that contribute to a better understanding of complex scientific concepts. The use of digital microscopes opens up prospects for developing practical skills, improves students' analytical thinking, and supports the integration of physical phenomena with the real world. This study was devoted to the analysis of the possibilities of using digital microscopes in teaching physics at school. A series of experiments was conducted aimed at determining the dependence of the rate of chaotic motion of particles on the viscosity of the medium. The use of video analysis software established that as the milk concentration decreases, the particle velocity increases, which is consistent with the Stokes-Einstein model. In addition to the experimental part, a survey was conducted among students and teachers to assess the effectiveness of using digital microscopes in the educational process. The results showed that 85% of students suggest that digital microscopes have made studying physics more interesting, and 78% said that observing microscopic phenomena has contributed to a deeper understanding of theoretical material. The analysis of students' academic achievements showed an increase in the level of knowledge and improved academic performance in comparison with conventional teaching methods. The results confirmed the feasibility of integrating digital microscopes into physics curricula, especially in STEM education. It was proposed to develop methodological recommendations for the introduction of digital microscopy in the school physics course. The results of the study can be used by physics teachers of general education institutions to improve the effectiveness of teaching, developers of educational programmes for integrating digital microscopy into a school physics course, and in STEM centres and scientific communities to develop practical research skills in students

Keywords: Brownian motion; molecular kinetic theory; educational technologies; methodological recommendations; STEM education

INTRODUCTION

The modern education system requires the introduction of the latest technologies to improve the efficiency of the educational process. Conventional methods of teaching physics do not always allow students to have a deep understanding of complex physical phenomena and processes. One of the main problems is that many phenomena occur at the microscopic level, and therefore, they cannot be directly observed with the unaided eye. This significantly complicates the understanding of such branches of physics as molecular physics, thermodynamics, electricity, and optics.

The use of digital microscopes opens up new possibilities for visualising and analysing physical phenomena. As noted by S.J. Pennycook *et al*. (2024), they allow researchers to directly observe microscopic structures, processes, and interactions that contribute to shaping a scientific worldview. In addition, digital microscopy provides an opportunity to record, analyse, and compare the results of observations, which is an important aspect in the current research approach to learning. The use of digital microscopes in the school physics course remains poorly understood.

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However, there is a lack of developed guidelines for using digital microscopes in physical experiments, integrating them into curricula, and creating appropriate training materials. Especially important is the issue of effective organisation of practical classes using digital microscopy and their adaptation to different levels of training of students (Yurchenko *et al*., 2023). In the modern educational space, it is important to create an interactive learning environment that allows students to experimentally confirm theoretical knowledge and develop research skills. The use of digital microscopes can contribute to the development of critical thinking, the ability to analyse data, and skills in working with modern technologies. Given the global digitalisation of education, the integration of digital microscopy into the educational process is an important step in training future scientists and technicians.

In Ukraine and abroad, research related to the use of digital technologies in teaching academic subjects, including physics, is actively developing. R.L. Bell *et al*. (2008) proved that the use of digital microscopes contributes to better understanding by students of the molecular structure of substances. O.B. Budnyk *et al*. (2020) examined the use of digital technologies in inclusive education. The researchers analysed the current state of implementation of digital tools in the educational process for children with special educational needs, identified the main problems associated with this, and outlined the prospects for the development of such technologies in the future. Analysing the results of experimental implementation of digital microscopy in educational institutions, the researchers came to the conclusion that interactive learning increases the motivation of schoolchildren to study natural sciences. I. Doroshenko (2022) highlighted the integration of digital microscopes into optics training programmes. The researcher noted that the use of digital methods allows students to better understand the phenomena of interference and diffraction of light, and conduct experimental studies with high accuracy. The study by S. Hughes *et al*. (2019) examined the use of digital microscopes in STEM education. The researchers emphasised that their application contributes to the development of practical skills of students, helps them to apply theoretical knowledge in practice, and prepares them for future research activities.

The study by P. Whalley *et al*. (2010) analysed the possibilities of using digital microscopes in distance learning. The researchers proved that virtual laboratories based on digital microscopes help students to conduct experiments even in a remote format, while maintaining the quality of learning. O.V. Zholos (2020) examined the role of digital microscopes in the study of biophysics. The researcher noted that such technologies allow analysing the cellular structure in more detail, which is important for the integrated study of physics and biology.

The study by Y. Omelchenko (2024) examined the effectiveness of digital microscopes in the study of thermodynamics. The researcher argued that they can be used to demonstrate phase transitions and visualise the processes of evaporation and condensation. L. Potapiuk & O. Dymarchuk (2021) highlighted the adaptation of digital microscopes for students with visual impairments. The researchers offered special methods of image processing and increasing contrast, which makes teaching physics more accessible to all categories of students. Thus, researchers confirmed the effectiveness of using digital microscopes in teaching physics. However, the method of their application in the context of experimental physics remains insufficiently covered, which opens up opportunities for further research in this area. Thus, Y.T. Chien (2017) examined the effectiveness of digital microscopy in teaching natural sciences and confirmed that the integration of such technologies contributes to improving students' research skills and increases their motivation.

Despite the advantages of digital microscopes in teaching natural sciences, there is a lack of methodological developments for their effective use in physics lessons. It is necessary to determine which topics of the school physics course can be enhanced with a digital microscope, and develop specific methods for its application. Special attention should be paid to adapting digital microscopes to educational standards, preparing appropriate educational materials, and creating interactive tasks. The purpose of the study was to analyse the possibilities of using a digital microscope in physics lessons, and to develop methodological recommendations for its effective implementation in the educational process.

MATERIALS AND METHODS

The study used a comprehensive approach that included theoretical analysis of scientific sources, experimental investigation of physical phenomena using digital microscopes, sociological methods of collecting information (questionnaires), and a comparative analysis of student performance. The experiments were conducted as part of school laboratory classes in physics, where the influence of the viscosity of the medium on the speed of chaotic motion of particles (Brownian motion) was analysed. A digital microscope was used to provide video recording of particle trajectories, and the Tracker software for motion analysis. The study was conducted on milk solutions with distilled water in various concentrations (1:10, 1:15, 1:20). To assess the effectiveness of using digital microscopes in the educational process, an anonymous survey of students and teachers was conducted. The survey lasted from September to November 2024. Number of respondents: 150 students in grades 9-11 and 5 physics teachers from various educational institutions of the community. Questionnaire structure:

1. For students: the level of interest in physics before and after experiments, the impact of digital microscopy on understanding the material, the ease of use of equipment.

2. For teachers: assessment of the methodological convenience of digital microscopes, their impact on student performance, and the possibility of integration into curricula.

The study was conducted in compliance with ethical standards, including the principle of voluntary participation, anonymity, and confidentiality of responses. Prior to the survey, students and their parents received newsletters about the research objectives. The results of the survey helped to assess the feasibility of integrating digital microscopes into the educational process and their impact on students' motivation and understanding. To assess the impact of digital microscopes on the level of assimilation of the material, an experimental study was conducted, which included a comparison of two groups of students: the control group (conventional training) – studied according to the standard method, which provided for the use of textbooks, traditional demonstration experiments, and explanations of the teacher; the experimental group (digital microscopy) – worked with digital microscopes that allowed visualising and analysing physical phenomena.

Students of the control group mastered the topic of Brownian motion in the conventional way: explaining theoretical material, viewing diagrams and illustrations in the textbook, performing standard calculation tasks. Students in the experimental group additionally used digital microscopes to observe the chaotic movement of particles in solutions with different viscosities, and also analysed the data using the Tracker software. After completing the training cycle, students of both groups completed a test task that contained theoretical questions (determination of Brownian motion, factors affecting it); practical tasks (analysis of particle trajectories, calculation of their average speed based on the data obtained).

During the survey, all the necessary ethical standards specified in the Declaration of Helsinki (2013) were observed. In particular, the principle of voluntary participation was ensured – students and teachers participated in the survey at their own request. Anonymity and confidentiality of responses were guaranteed, which contributed to obtaining objective results. Before starting the survey, all respondents received newsletters explaining the goals and conditions of the survey. In addition, the students' parents were informed about the study, which allowed them to consider all aspects of ethical responsibility.

RESULTS AND DISCUSSION

Digital technologies are significantly changing the teaching methods of natural sciences, especially physics. One of the most effective tools for visual demonstration of physical phenomena is the digital microscope, which allows students to observe microscopic structures, analyse complex processes, and conduct their own research (Lavrova, 2013). The use of a digital microscope in teaching physics opens up new opportunities for improving the quality of learning, in particular: it increases the level of understanding of abstract concepts, because students can directly observe phenomena that were previously only read in textbooks; it stimulates interest in experimental work, since students can independently conduct research and analyse their results; it promotes the development of analytical thinking, because students not only observe phenomena, but also draw conclusions based on the data obtained; it increases the effectiveness of STEM education, because digital microscopy is integrated with other sciences, such as chemistry, biology, and computer science (Dickerson & Kubasko, 2007).

Conventional methods of teaching physics include the use of diagrams, illustrations, demonstration experiments, or watching videos. However, they do not always allow students to independently observe and analyse physical phenomena, which can reduce the level of understanding of the material (Banchi & Bell, 2008; Jonassen, 2011). The use of digital microscopes in the educational process allows conducting research experiments in physics lessons, combining theoretical material with practical work; involve students in active learning, because they directly interact with the material, and not just perceive it passively; use software to analyse the obtained images, which contributes to the development of skills in working with digital technologies; provide interactive learning that meets modern educational requirements (Rieber, 2005; Koehler & Mishra, 2009).

The use of digital microscopes can be effective in the following formats of the educational process: demonstration experiments (using a microscope when explaining new topics; displaying images on an interactive whiteboard or screen for analysing physical structures and phenomena; comparing the results of observations with theoretical calculations); laboratory work (visualisation of Brownian motion of particles in different environments; studying the structure and properties of thin films, optical lattices, materials; analysis of microstructures of conductors and semiconductors in the study of electricity and magnetism); project research (creating individual or group projects involving the use of digital microscopy for studying natural phenomena; study of changes in the microstructure of materials under the influence of various factors; use of digital microscopes in studies of environmental problems, such as the analysis of water micro-contamination, etc.) (Abdusselam & Kilis, 2021; Kozhevnikova & Kozhevnykov, 2024). The digital microscope was used to study physical phenomena, in particular, the Brownian motion of particles in liquids with different viscosities. Its application helped to observe microscopic processes and also quantify the movement of particles using special software (Levsheniuk & Tyshchuk, 2009). A digital microscope allowed directly observing the chaotic motion of suspended particles in each solution (Fig. 1).

1. At a high concentration of milk (1:10), the particles moved slowly, their trajectories were short due to the high viscosity of the medium.

2. At an average concentration (1:15), the movement of particles became more active, and their trajectories became longer.

3. At a low concentration (1:20), the particles moved rapidly, randomly changing direction.

Brownian motion at concentration 1:10 | Brownian motion at concentration 1:15 | Brownian motion at concentration 1:20

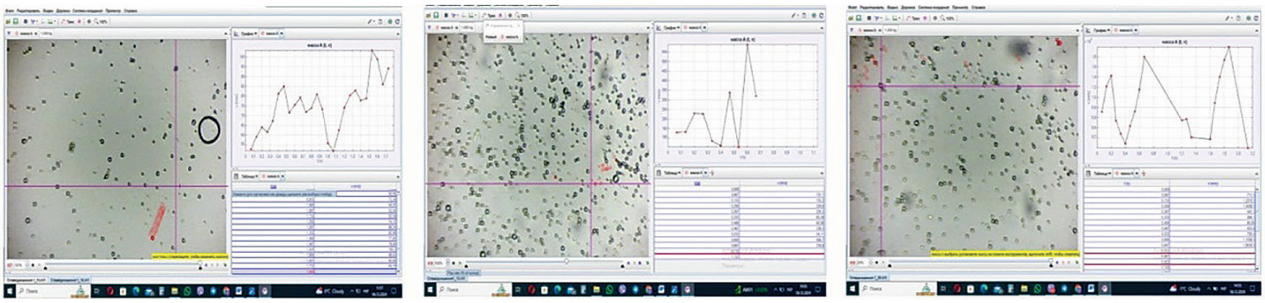

Figure 1. Visualisation of Brownian motion at different particle concentrations

Source: developed by the author based on the conducted research

The results of the study corresponded to the Stokes-Einstein model, according to which the velocity of particles in Brownian motion is inversely proportional to the viscosity of the medium. To assess the impact of a digital microscope on the educational process, a survey was conducted among students. Aspects such as the level of interest in physics before and after using a digital microscope; understanding of the topic "Molecular kinetic theory"; confidence in conducting laboratory research; ability to perform tasks for analysing experimental data were evaluated. The results are presented in Table 1.

Table 1. Influence of a digital microscope on the quality of learning material assimilation

Parameter	Before using a digital microscope (%)	After using a digital microscope (%)
Level of interest in physics	52	85
Understanding the topic "Molecular kinetic theory"	60	82
Confidence in laboratory work	45	78
Performing tasks for analysing experimental data	48	80

Source: developed by the author based on the survey conducted

The data show that after the integration of the digital microscope, the level of interest in physics increased by 33% – students began to perceive the subject not only as a set of formulas and theoretical concepts, but also as a science that can be directly studied. Understanding of the topic of molecular kinetic theory has improved by 22% – due to the ability to observe the chaotic motion of particles in different environments. Confidence in conducting laboratory tests increased by 33% – students were able to work with real experiments and analyse the results. The ability of students to analyse the results of experiments increased by 32%, which confirms the development of critical thinking skills and practical application of knowledge.

To evaluate the effectiveness of the digital microscope compared to other training methods, an additional study was conducted. Students were divided into two groups: control and experimental. After completing the study of the topic, students of both groups completed test tasks. The results obtained indicate a significant advantage of digital microscopy: conventional methods – 68 points, the use of a digital microscope – 86 points. The data confirm that students in the experimental group learned the material 26% better than those who studied in the conventional way. Student reviews confirmed the effectiveness of digital microscopy:

- "I never thought physics could be so interesting! We did not just learn theory, we explored the microcosm ourselves".
- "I did not like lab work before, because it seemed complicated. But the digital microscope has made them interesting and understandable".
- "It was very interesting to observe the chaotic movement of particles and draw conclusions yourself. Now I know exactly how molecular kinetic theory works".

Digital microscopes allow teachers to significantly improve the quality of teaching physics, as they provide visibility of educational material, make laboratory work more accessible, and help to increase students' motivation. Respondents noted the following key aspects of the impact of digital microscopes on the educational process: increasing student motivation (85% of respondents), because students showed a greater interest in performing experimental tasks, since they could directly observe physical phenomena; reducing the complexity of teaching physical topics (78%), when teachers noted that explaining complex topics, such as molecular kinetic theory or wave phenomena, became much easier due to visualisation; developing students' practical skills (80%), because the use of digital microscopes allowed students to acquire skills in working with scientific equipment, which is an important element

of STEM education; improving the ability to work with scientific equipment, which is an important element of STEM education; academic performance (75%), since students who worked with digital microscopes showed better results during tests, as they learned the material more deeply and at a practical level. To evaluate the effectiveness of digital microscopes in teaching physics, a comparative analysis of various teaching methods was performed (Table 2).

Table 2. Results of comparative analysis of various teaching methods

Training method	Improved understanding of the material (%)	Increased interest (%)
Conventional lectures	50	45
Demonstrations without interaction	60	55
Laboratory work without a digital microscope	70	65
Using a digital microscope	85	82

Source: developed by the author based on the survey conducted

These results show that the use of a digital microscope is the most effective method among those analysed. This is conditioned by the fact that students not only listen to theoretical material, but also have the opportunity to actively work with experimental data. In addition to statistics, comments were collected from teachers who implemented digital microscopes in their physics lessons:

- "Students became more attentive during laboratory work, as they were interested in observing microscopic processes with their own eyes".
- "Previously, it was difficult for scientists to imagine exactly how Brownian motion occurs, but now they can observe it independently. This greatly improved the understanding of the material".
- "Digital microscopes enable students to work with modern technologies, which is an important factor in preparing for future professions in science and technology".
- "I noticed that students who worked with digital microscopes became more confident in conducting research and analysing the results".

From a pedagogical standpoint, the digital microscope has the following advantages: simplification of the process of teaching complex topics (teachers can quickly demonstrate physical phenomena to students in real time; the use of interactive technologies increases the effectiveness of lessons); optimisation of laboratory work (digital microscopes allow for detailed analysis of the results obtained; teachers can record the results of experiments in digital format for further analysis); the possibility of individual and group training (students can work both independently and in groups, discussing the results obtained; this contributes to the development of communication and teamwork skills); compliance with modern educational standards (digital technologies are a key component of STEM education; the use of digital microscopes contributes to the preparation of students to modern technological challenges). Given the positive feedback from teachers and the high learning outcomes of students, digital microscopes have great potential for further development in the field of education.

For the effective implementation of digital microscopes, it is advisable to develop methodological recommendations for their use in school physics courses; conduct trainings and advanced training courses for teachers to help them use digital technologies effectively; integrate digital microscopes into STEM education, creating interdisciplinary projects that combine physics, biology, chemistry and computer science; provide schools with the necessary equipment and maintain its maintenance. The results of our study on the impact of digital microscopes on the quality of physics teaching demonstrate a significant improvement in understanding the material, increasing students' motivation, and developing their research skills. The data obtained correlate with the results of other researchers who also analysed the effectiveness of digital technologies in school education. Thus, this study showed that the level of interest of students in physics after using a digital microscope increased from 52% to 85%, which is consistent with the conclusions of R. Kuznetsov (2022), who analysed the impact of digital technologies on teaching physics in secondary schools. The researcher showed that the integration of interactive learning tools helps to increase students' motivation to study complex topics in physics.

The study by S. Hughes *et al*. (2019) also confirmed that the use of digital microscopes in STEM education encourages students' interest in experimental work. The researcher noted that the interaction of students with real physical processes contributes to their active participation in the educational process. The above results support this conclusion, as 85% of students indicated that observing phenomena through a digital microscope made physics lessons more interesting and accessible. The data obtained show that understanding of the topic "Molecular kinetic theory" improved by 22% (from 60% to 82%). Similar conclusions were obtained by E.S. Statnik *et al*. (2020) in the study of the effect of digital microscopy on the teaching of mechanical properties of materials. The researcher noted that visualisation of microstructures using a digital microscope contributed to an increase in the academic performance of students of technical specialities by 19-23%. J. Dickerson & D. Kubasko (2007) investigated the use of digital microscopes in the optics course and recorded an increase in the level of understanding of the topic by 20-25% due to the ability to visualise the phenomena of interference and diffraction of light, which correlates with the results of the current study and confirms the overall effectiveness of digital microscopes in explaining complex concepts of physics.

The study showed that students' confidence in conducting laboratory work increased from 45% to 78%, and their ability to analyse experimental data increased from 48% to 80%. The obtained indicators are consistent with the findings of I.S. Ivanenko (2021), who investigated methodological aspects of the use of digital microscopy in secondary schools. He recorded an increase in the level of practical skills of students by 30-35% compared to conventional teaching methods. L. Tarangul & S. Romaniuk (2022) confirmed that the use of digital technologies in the educational process contributes to the development of analytical thinking skills and independent research. The study supports this conclusion, as students who worked with digital microscopes performed 20% better on tests than their peers who were trained using conventional methods.

Despite the obvious advantages of digital microscopes, there are a number of limitations that require further research: not all schools are provided with a sufficient number of digital microscopes, which may limit their use; additional teacher training is required to effectively implement digital technologies in the educational process; further research should focus on integrating digital microscopy into cross-subject STEM projects.

CONCLUSIONS

The study confirmed the effectiveness of using digital microscopes in teaching physics. They significantly improve the assimilation of educational material, increase students' interest in the subject and develop their research skills. The main results of the study indicate an increase in students' motivation: 85% of respondents noted that learning has become more interesting due to the possibility of independent observation of microscopic processes. The level of understanding of complex physical topics (in particular, molecular kinetic theory) increased by 22%, which confirms the effectiveness of visualising physical phenomena. Students' practical skills improved significantly: their confidence in performing laboratory tests increased by 33%, which indicates an increase in competence in conducting experiments. The test results showed that students who used a digital microscope scored an average of 20% higher than those who studied using conventional methods. Teachers highly appreciated the methodology: 92% of teachers confirmed that digital microscopes help to make learning more visual, simplify the explanation of complex topics and increase student achievement.

There are also some challenges that require further study, such as the development of methodological recommendations for integrating digital microscopy into the educational process, training teachers to use digital technologies in teaching physics, expanding the scope of use of digital microscopes in cross-subject STEM projects, and technical support for schools for wider adoption of digital technologies. Thus, digital microscopy is a promising area in teaching physics, which not only improves the quality of the educational process, but also contributes to the development of students' research competencies, preparing them for future challenges in the field of science and technology. Further research should be aimed at developing methodological recommendations for integrating digital microscopy into the educational process and expanding the possibilities of using this method in STEM education.

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Використання цифрових мікроскопів для вивчення фізичних явищ: нові можливості для шкільного навчання

Анотація. Сучасний освітній процес вимагає впровадження новітніх технологій, які сприяють кращому розумінню складних наукових концепцій. Використання цифрових мікроскопів відкриває перспективи для розвитку практичних навичок, покращує аналітичне мислення учнів та підтримує інтеграцію фізичних явищ із реальним світом. Дане дослідження присвячене аналізу можливостей використання цифрових мікроскопів у викладанні фізики в школі. Було проведено серію досліджень, спрямованих на визначення залежності швидкості хаотичного руху частинок від в'язкості середовища. Використання програмного забезпечення для аналізу відеозаписів дозволило встановити, що зі зменшенням концентрації молока швидкість частинок зростає, що узгоджується з моделлю Стокса-Ейнштейна. Окрім експериментальної частини, було проведено анкетування серед учнів і вчителів для оцінки ефективності використання цифрових мікроскопів у навчальному процесі. Результати показали, що 85 % учнів вважають, що цифрові мікроскопи зробили вивчення фізики більш цікавим, а 78 % зазначили, що спостереження мікроскопічних явищ сприяло глибшому розумінню теоретичного матеріалу. Аналіз академічних досягнень учнів засвідчив підвищення рівня знань і покращення успішності в порівнянні з традиційними методами викладання. Отримані результати підтверджують доцільність інтеграції цифрових мікроскопів у навчальні програми з фізики, особливо в рамках STEM-освіти. Запропоновано розробити методичні рекомендації щодо впровадження цифрової мікроскопії у шкільний курс фізики. Отримані результати дослідження можуть бути використані вчителями фізики загальноосвітніх навчальних закладів для підвищення ефективності викладання, розробниками освітніх програм для інтеграції цифрової мікроскопії у шкільний курс фізики, а також у STEM-центрах та наукових гуртках для формування практичних дослідницьких навичок учнів

Ключові слова: Броунівський рух; молекулярно-кінетична теорія; освітні технології; методичні рекомендації; STEM-освіта

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Preparing future physical education teachers for inclusive education in secondary education institutions

Abstract. The relevance of the topic is due to the growth of public demand for inclusive education, the presence of an appropriate legislative basis and dynamic changes in the education system. The purpose of the study was to develop, scientifically substantiate and experimentally confirm the effectiveness of the author's model of training future physical education specialists to work in conditions of inclusion. To achieve the goal of the study, a set of theoretical methods was used: analysis and synthesis of professional literature, in particular, correctional and special pedagogy, physical education methodology, higher education pedagogy, etc.; logical and systemic analysis; comparison; classification; and modelling. The empirical methods included: pedagogical observation, questionnaires, and pedagogical experiment. The experiment confirmed the effectiveness of the author's model of training future physical education teachers for inclusive education in the synergistic unity of three blocks: conceptual-target, operational-content and control-result and pedagogical conditions: the formation of positive motivation for professional activity and psychological and pedagogical support for students; development and implementation of specially oriented training content, which requires the integration into the educational process of professionally oriented disciplines, in particular "Special Pedagogy in Physical Education" and "Inclusive Physical Education of Schoolchildren"; development of practical skills through production pedagogical practice. The implementation of the model yielded the following quantitative results: in the experimental group, a significant increase in students with high (+12.5%) and sufficient (+25.7%) levels of readiness was observed, while the number of applicants with average (-6.6%) and low (-32%) levels significantly decreased. This significantly exceeds the indicators of the control group, where the increase in high and sufficient levels was only 4.3% and 16.6%, respectively, and the decrease in average and low levels was 2.2% and 23.1%. The developed educational and methodological materials and scientific principles can be used by scientific and pedagogical workers of higher education institutions to prepare future physical education teachers for work in inclusion conditions

Keywords: professional training; physical education specialists; inclusive education; educational institutions; students with special educational needs; training model

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INTRODUCTION

The modern education system is actively changing, and one of the key areas is the implementation of inclusive education, which provides equal opportunities for all students. The effectiveness of this process largely depends on the readiness of teachers, especially physical education teachers, who influence the physical development, social competencies and integration of children with various educational needs. Working with students with special needs requires the teacher to have special knowledge, skills and flexibility in organising learning, as well as effective interaction with parents and colleagues. Therefore, research into the preparation of future physical education teachers for inclusive education is relevant and necessary for improving the quality of education and the formation of humanistic values.

Over the past decade, the issues of developing inclusive education, methods of its implementation and ensuring quality conditions for people with special educational needs (SEN) have been actively studied by both Ukrainian and foreign scientists. Analysis of international experience in implementing an inclusive approach in education has made it possible to identify significant scientific works that have made a significant contribution to the formation of its theoretical and methodological foundations. J.O. Aloka & A. Mamogobo (2025) studied the challenges faced by teachers in implementing inclusive education in a general education school in South Africa. The authors, relying on the social model of disability, found that the main obstacles are the negative attitude of teachers, insufficient knowledge of inclusive policies, low self-esteem of teachers and insufficient professional training. The study emphasises the need for priority attention to initial and continuous training of teachers in identifying the needs of students with disabilities and effectively managing them. M.J. Jardinez & L.R. Natividad (2024) devoted their research to analysing the advantages and problems of inclusive education, as well as ways to achieve equality in the classroom. The authors identify numerous barriers to successful implementation, including insufficient teacher training, limited resources and infrastructure, difficulties in building relationships with peers, and insufficient parental involvement. The study highlights the importance of adequate teacher training, as limited understanding and skills can make it difficult to create an inclusive environment.

S. Tsirantonaki & A. Vlachou (2025) provide a systematic review of school principals' attitudes towards inclusive education. The study analyses existing literature to summarise school principals' views and assessments of the implementation of inclusive practices, challenges and factors influencing their management decisions in an inclusive environment. The results of this analysis are important for understanding the role of administrative staff in shaping an inclusive culture in schools. A study by A.B. Llanes & M.C.L. Llanes (2023) was devoted to the analysis of the effectiveness of a capacity-building program for teachers working with students with special educational needs. The results showed that after completing the program, teachers' knowledge and experience in this area significantly increased. This indicates that targeted professional development programs are an effective way to provide teachers with the necessary tools and knowledge for successful work in inclusive classrooms. The article by N.V. Bezzlyudna & N.V. Dudnyk (2023) examined the theoretical foundations of preparing future primary school teachers for work in inclusive education. The author analyses the key components of teacher readiness, namely: motivational, cognitive, activity and reflective. The work emphasises the importance of forming a holistic understanding of inclusion in students and providing them with practical skills to create an adaptive and supportive learning environment.

H. Stambekova *et al.* (2021) analysed modern approaches to professional training of teachers in inclusive education. The author emphasises the need to implement innovative methods, such as co-teaching, universal design for learning (UDL), and interactive training, which allow teachers to effectively develop practical skills. The study emphasises that high-quality training should be based not only on theoretical knowledge, but also on the development of emotional resilience, empathy, and the ability to cooperate with other specialists. Despite the significant attention of scientists to various aspects of inclusive education and the preparation of future physical education teachers for work in inclusive settings, certain issues remain insufficiently covered. There is a lack of research on specific methods and approaches to adapting physical exercises, games, and motor activities for students with different types of disabilities (for example, with musculoskeletal disorders, sensory disorders, or intellectual disabilities).

The purpose of the study was to create, theoretically substantiate and experimentally verify the effectiveness of the author's model of training future physical education teachers for the organisation of inclusive education in secondary education institutions. The main tasks were as follows: to substantiate methodological approaches and pedagogical conditions for the formation of the readiness of future physical education teachers for inclusive education, to determine the criteria and levels of formation of this competence, and also to experimentally verify the effectiveness of the developed author's model of training.

MATERIALS AND METHODS

To solve the tasks and achieve the goal of the study, a set of theoretical and empirical methods was used. The theoretical methods included a review, analysis and synthesis of modern literature on special and correctional pedagogy, physical education methods, and vocational education, which allowed to outline key concepts and comprehend the content of the phenomenon. Logical and systematic analysis, classification, analogy, induction, deduction and generalisation were used to determine the basic pedagogical conditions necessary for preparing students for effective individual work in an inclusive environment. The

modelling method was used to develop a model for preparing future physical education teachers for work in inclusive education in secondary education institutions. Comparative analysis of data from the experimental and control groups before and after the experiment was used to identify causes, consequences and interdependencies between variables. The empirical methods included pedagogical observation, questionnaires and testing, which allowed to investigate and evaluate the effectiveness of pedagogical conditions and training models. The pedagogical experiment (confirmatory, formative and control stages) was aimed at assessing the level of readiness of future physical education teachers to work in an inclusive educational environment and checking the effectiveness of the proposed author's training model. In order to assess the level of readiness of students for professional activity, an open anonymous questionnaire was conducted, which contained three blocks: cognitive, motivational value and professional-practical. The cognitive block included the question:

1. What definition of inclusive education is, in your opinion, the most complete?

2. What are the main regulatory and legal documents of Ukraine that regulate inclusive education in the field of physical education?

3. Define the concepts of "individual development program" and "universal learning design".

4. What basic principles of adapting physical exercises for students with musculoskeletal disorders do you know?

5. Name three effective strategies for involving a child with autism spectrum disorders in team games.

6. What factors should be considered when choosing sports equipment for an inclusive class?

The responses were evaluated on a five-point scale, where 5 points corresponded to the most complete and correct answer, and 1 point to an incorrect one. The motivational and value block was aimed at identifying attitudes, beliefs and readiness for interaction. The Likert scale ("strongly agree", "agree", "hard to say", "disagree", "strongly disagree") was used for the assessment, which was converted into a five-point system (5 – "strongly agree", 1 – "strongly disagree"). The questions of this block were:

1. I believe that inclusive physical education lessons benefit all students, not just children with special needs.

2. I will be comfortable working with children who have visible physical disabilities.

3. Physical education teachers should take an active part in developing individual development programs.

4. I feel ready for the challenges of working in an inclusive classroom.

5. Having a child with a disability in the classroom will not complicate my work.

6. I am ready to independently study additional information and take courses to improve my qualifications.

The professional-practical block contained questions on practical skills and willingness to cooperate:

1. Describe in five sentences your own experience of communicating or interacting with people with disabilities.

2. Suggest options for adapting an outdoor game for a classroom with students with disabilities.

3. Which of the specialists (teacher assistant, correctional teacher, psychologist, parents) would you work with most closely and why?

4. Assess your level of skills in adapting motor tasks to the needs of students with special educational needs.

5. Assess your level of skills in interacting with parents of children with special educational needs.

The responses were assessed on a five-point scale. For each respondent, an average score was calculated for the block, after which the level of readiness was determined. Four levels were established:

- High (4.1-5.0 points): students have deep knowledge, high motivation and confidence in their practical skills, are aware of the importance of inclusion and are ready for innovative approaches.
- Sufficient (3.1-4.0 points): students have sufficient knowledge and a positive attitude, but need additional support and practical training.
- Average (2.1-3.0 points): characterised by fragmentary knowledge, an uncertain attitude towards inclusion, and the need to deepen theory and practice.
- Low (1.0-2.0 points): students demonstrate a low level of knowledge and motivation, and are unprepared to work in an inclusive environment.

To obtain a percentage distribution, it was determined what proportion of respondents belonged to each level. The pedagogical experiment was carried out in three stages. The ascertaining stage determined the criteria, indicators and levels of readiness of future teachers, and selected diagnostic methods (questionnaires, test papers, practical tasks, lesson plan-summaries, physical fitness tests). The formative stage involved the development, justification and implementation of a model for training future physical education teachers for professional activity in an inclusive environment. The control stage included repeated diagnostics and verification of the effectiveness of formative influences. The study was attended by second-year students: control group (n = 184) and experimental group (n = 200). 10% of respondents with the highest and lowest readiness indicators were excluded from the total sample to avoid extreme values. The experiment was conducted in the 3rd-4th semester of the 2024-2025 academic year. Based on Poltava National Pedagogical University, Kharkiv State Academy of Physical Culture, Hryhoriy Skovoroda University in Pereyaslav, Ivan Franko Zhytomyr State University and Poltava Institute of Business of the Yuriy Bugay International Scientific and Technical University. Diagnostics of students' readiness was carried out according to five criteria: motivational and value (attitude to inclusive education), cognitive (knowledge and understanding of methods), operational and activity (ability to organise lessons), reflective and evaluative (ability to analyse one's own activities) and socio-communicative (effectiveness of interaction with students, colleagues and parents). Additionally, the emotional and volitional criterion was taken

into account, reflecting the teacher's readiness to maintain a positive psycho-emotional climate.

Four levels of readiness were determined based on a set of criteria: high – students with deep knowledge, high motivation and developed practical skills; sufficient – with moderate motivation, sufficient level of knowledge and partial skills; medium – students with fragmentary knowledge and uncertainty in practice; low – with limited knowledge, insufficient motivation and lack of skills to work in an inclusive environment. The preparation of future physical education teachers for work in inclusive classes was carried out based on the principles of humanism, accessibility, equality, individualisation, integration, scientificity, practical orientation, complexity, continuity, partnership, activity and variability, which ensured the integrity and systematicity of the study. The study was conducted in accordance with the American Psychological Association (2010).

RESULTS AND DISCUSSION

To identify the preliminary state of formation of competence of future physical education teachers for professional activity in the inclusive environment of general secondary education institutions (GSSE), a pedagogical experiment was conducted, the results of which are presented in Tables 1 and 2.

Table 1. Initial state of readiness of future physical education teachers for professional activity in an inclusive environment of secondary education institutions

Level of formation	Experimental group (EG)		Control group (CG)	
	persons	%	persons	%
High	17	8,5	16	8,7
Sufficient	33	16,5	28	15,2
Average	61	30,5	59	31,8
Low	89	44,5	81	44,3
Total	**200**	**100**	**184**	**100**

Source: developed by the authors

Table 2. Results of preliminary diagnostics of EG and CG by levels and criteria

Criterion	High %		Sufficient, %		Average %		Low %	
	EG CG	CG	EG	CG	EG	CG	EG	CG
Motivational-value	10	11	20	18	30	32	40	39
Cognitive	9	8	19	20	31	34	41	38
Operational-activity	7	6	14	10	30	31	49	53
Reflective-evaluative	6	5	12	9	34	29	48	57
Social-communicative	9	11	15	17	27	32	49	40
Emotional-volitional	10	11	19	17	31	33	40	39
Average value	**8,5**	**8,7**	**16,5**	**15,2**	**30,5**	**31,8**	**44,5**	**44,3**

Source: developed by the authors

A generalised analysis of the results of the ascertaining experiment showed that according to the motivational and value criterion, most applicants have weak motivation for future professional activity with students with special needs, have a superficial understanding of the concept of inclusive education and insufficient awareness of the value of each child regardless of their abilities; have no interest in professional development in the field of inclusive education. The results of the study of the cognitive criterion showed insufficient knowledge among students of regulatory and legal documents regulating the activities of inclusive education, have limited knowledge about the features of the physical and cognitive development of children with special needs, weak orientation in methods of adapting physical activity, and have insufficient understanding of the need for social and psychological support for children with special educational needs.

According to the operational and activity criterion, partial ability to adapt curricula to the needs of students with inclusion is noted; lack of skills in applying special methods for working in inclusive classes, difficulty in organising inclusive sports events or outdoor games; students have fragmentary skills in collaborating with assistants and other teachers. According to the indicators of the reflective-evaluation criterion, it was found that most respondents have low reflection on their own professional activities, sometimes evaluate the successes and difficulties of students with SEN, do not conduct self-analysis and are unable to improve their own pedagogical activities. The indicators of the social-communicative criterion in future physical education teachers are mainly at an average and low level. This is manifested in a low level of communication with students, in unformed skills to involve students in activities, and weak mastery of skills of cooperation with colleagues, parents, etc. According to the emotional-volitional criterion, applicants have low emotional stability and the ability to empathise; students are unable to support other students emotionally in practice. The identified predominantly low level of professional competence of future physical education

teachers for activities in an inclusive educational environment prompted the development, theoretical substantiation, and experimental verification of the author's pedagogical model (Fig. 1).

Figure 1. Model of training future physical education teachers for inclusive education in secondary education institutions

Source: developed by the authors

The basis of this model is a system of interconnected stages that lead to the formation and development of professional qualities of teachers. According to the conceptual basis of the model, professionally significant qualities of the personality of the future teacher not only become visible but also actively develop in conditions that contribute to their growth, starting with adaptation and ending with the integration of the personality into the professional environment. The main component of the model is the conceptual-target block, which includes the goal, as an ideal image of the expected result of the functioning of the model, tasks, content of training, as well as the methodological basis (approaches and principles) for the implementation of tasks that act as intermediate goals, and the definition

of smaller actions to achieve these results. Professional training of specialists is a holistic, integral process based on a number of methodological approaches, the most significant of which are: systemic, competency-based, individual, integrative, activity-based, and practice-oriented (Sushchenko, 2003).

The systems approach is a research methodology that involves considering objects as holistic systems. It focuses on identifying the integrity of the object, analysing various relationships between its elements, and forming a single theoretical model. The use of a systems approach contributes to the effective design and implementation of the educational process through structuring the content of educational material and optimising the management of the process of its assimilation. The competency-based approach assumes that to successfully fulfil their professional duties, future physical education teachers must master the necessary knowledge, skills, abilities, and develop important personal qualities. They must be ready to carry out correctional and pedagogical, diagnostic and advisory, research, and cultural and educational work in educational and healthcare institutions (Chernichenko, 2017).

The basis of the concept of an individual approach is the principle of the interrelation of two levels of influence: external (procedural) and internal (psychological). The external, or procedural, level involves adapting the educational process to the needs of the student (for example, changing teaching methods, forms of work, pace of learning), while the internal, or psychological, level focuses on the student's personal perception (his motivation, emotional state, readiness for learning), which is crucial for the successful assimilation of the material. Important characteristics of this approach are reflection, dialogue and subjectivity. According to L.P. Sushchenko (2003), personally oriented professional training of future teachers is a scientifically substantiated system of interaction between students and teachers of a higher education institution, where the principle of a personalised approach is the basis. This system is rich in content, individualised in form, intensive in time, and aimed at forming a semantic paradigm of the future teacher's personality. An individual approach confirms the understanding of a person as an individuality, directs the organisation of the pedagogical process towards the individual, who is the goal, result and criterion of effectiveness, and requires recognition of the uniqueness of the individual, his or her right to freedom and respect.

The integrative approach reveals the intellectual potential of preparing a future physical education teacher for inclusive education in secondary education institutions, contributes to the formation of general and professional competencies, and also creates psychological and pedagogical conditions for the development of self-education, self-development, and socialisation (Babenko, 2008). This approach makes it possible to ensure the complexity and integrity of the knowledge of future physical education teachers, contributing to the development of systemic thinking and a rational worldview, and its use in the educational process of higher education institutions is aimed at training specialists with a high level of mastery of general cultural, general professional and professional competencies.

The activity approach is a complex of theoretical, methodological and empirical research that studies the psyche and consciousness, as well as their development and formation through various forms of subject activity. This approach is focused on acquiring deep systemic knowledge, improving general methods of action and their creative application in various situations. The main characteristics that distinguish educational activity from other types of activity are its focus on mastering educational material and solving educational tasks. The result of such activity is structured and updated knowledge, which becomes the basis for solving tasks that require its application in various fields of science and practice (Babych, 2010). The practice-oriented approach to training a future physical education teacher for inclusive education in secondary education institutions involves the active integration of theoretical knowledge and practical skills. This allows the future teacher to work effectively with students with different needs and abilities. The approach focuses on developing students' skills to adapt physical exercises, create an inclusive environment, and apply appropriate methods for organising physical education lessons (Chernichenko, 2017).

Pedagogical conditions play an important role in the model of formation of specialists. The first condition is the formation of positive motivation for professional activity and psychological and pedagogical support of students, which is fundamental in the process of preparing future physical education teachers for professional activity in an inclusive environment of secondary education institutions. It includes: the use of practice-oriented tasks to create a positive attitude towards working with children with SEN; the use of examples of successful inclusive practice, in particular, through the participation of students in open lectures or events dedicated to inclusive education; motivation for continuous professional growth in the field of working with children with SEN; the organisation of trainings, seminars and workshops aimed at developing empathy, tolerance, and communication skills; the involvement of psychologists and specialists in working with children with SEN to advise students; the creation of conditions for students to reflect on their own pedagogical activity and attitude to inclusive education.

The second condition is the development and implementation of specially oriented teaching content, which includes the development and implementation of two professionally oriented disciplines in the educational process: "Special Pedagogy in Physical Education" and "Inclusive Physical Education of Schoolchildren". In the process of teaching these OKs, it is important to: use modern forms and methods of organising the educational process, interactive teaching methods; use of the case method, situation modeling, role-playing games for teaching work in inclusive conditions; conduct discussions and master classes with the analysis of complex pedagogical situations; use

of modern technologies, in particular multimedia, to create individual and group educational tasks; use of tools for self-analysis and self-assessment of students regarding their readiness for inclusive learning; inclusion of tasks for the formation of reflection in the educational process; regular assessment of the level of formation of students' competencies using questionnaires, tests, portfolios, etc.; involving physical education teachers who have successful experience working in an inclusive environment in the educational process; conducting joint classes and seminars with specialists who work with children with special needs; taking into account the personal characteristics and abilities of each student during preparation for work in an inclusive environment; providing the opportunity to choose the topics of projects and practical tasks that meet their interests and future career goals. An important element in accordance with this pedagogical condition is the provision of a material and technical base, namely: equipping classrooms with special equipment for demonstrating and modelling physical education lessons in an inclusive environment; providing access to educational materials aimed at adaptive physical education; and creating a database of educational videos and other resources for training students.

The third condition is the development of practical skills through production pedagogical practice. According to this pedagogical condition, the organisation of production pedagogical practice should be carried out exclusively in inclusive classes or specialised schools to gain direct experience; mandatory cooperation with teacher assistants, correctional teachers and psychologists to understand the features of teamwork; ensuring that students are trained in the organisation and conduct of physical education lessons adapted to the needs of children with SEN (Demus, 2023). The operational-content block of the model is structured into three stages of preparation: adaptation-orientation, content-reflection and practical-transformation. At the adaptation-orientation stage, familiarisation with the basics of inclusion occurs, the study of the regulatory and legal framework of inclusive education, the formation of motivation to work with children with SEN, psychological adaptation to work with children with SEN, and the formation of professional ethics. At the content-reflective stage, the study of disciplines of practical orientation to deepen professional knowledge and skills, in particular, the practical development of professional skills, solving problem tasks, the formation of group support and team interaction. At the practical-transformational stage, special attention is paid to the integration of theoretical concepts with their practical application. Students are involved in solving real pedagogical tasks, including the management of educational activities, the development of programs and conducting classes, contributing to the awareness of the functional aspects of pedagogical methods and strategies, as well as their adaptation to the individual needs of students. This practical experience deepens the understanding of the educational process, the specifics of students' needs and contributes to the development of key skills. For future physical education teachers, this stage is of particular importance in the context of preparation for work in an inclusive environment. Students acquire the skills to adapt physical activities according to the various psychophysiological characteristics of students, which includes not only lesson planning, but also the formation of a safe and supportive environment for all participants in the educational process. Testing the acquired competencies in real conditions contributes to the awareness of the complexity of inclusive education, the development of empathy and flexibility in the pedagogical approach, which is critically important for ensuring equal access to quality education (Lyubarets *et al.*, 2017). Technological aspects of professional training of physical education teachers in inclusive education include adaptation to the future profession, the development of individual skills and competencies through gradual integration into the professional educational environment (Table 3).

Table 3. Organisational and methodological principles of professional activity of physical education teachers in conditions of inclusive education in secondary education institutions

Contents	Methods	Forms	Features
Planning and organising physical education lessons	Individualised Learning Method	Frontal forms of organisation	Adaptation of curricula
Adaptation of physical exercises and games	Group Work Method	Individual classes	Use of differentiated teaching methods
Creating an inclusive environment	Differentiated Instruction Method	Group classes	Psychological support and motivation
Monitoring and evaluation	Visualisation and Demonstration Method	Game classes	Collaboration with other specialists
Psychological and pedagogical support	Game Method	Complex classes	Correctional and developmental nature of physical exercises
Training and advanced training	Physical Therapy and Remedial Exercise Method	Classes using the blended learning method	Monitoring and evaluation
Overcoming stress factors	Feedback Method	Correctional, developmental, and extracurricular classes	Working with a group of students

Source: developed by the authors

Each technological stage is characterised by clearly defined tasks and methods of their implementation, which ensures deep assimilation of the material and the development of professional skills. The content of the professional activity of physical education teachers in inclusive education is a set of tasks, methods, approaches and competencies that ensure effective physical education of all students, including children with special educational needs. In such conditions, the teacher's activity is aimed at integrating children with different abilities into the educational process, taking into account their physical, intellectual and emotional characteristics. Individualisation of curricula in physical education is an important component of inclusive education. It allows you to take into account the individual needs of each student, adapting the educational process and ensuring equal participation of all children in physical activities.

Methods of professional activity of physical education teachers in inclusive education are a set of special pedagogical approaches that allow you to effectively teach physical education, taking into account the diverse educational and physical needs of students. These methods help to ensure equal access to physical education for all students, including children with SEN. The use of individualised, differentiated, and game methods contributes to the socialisation of students, the development of their physical and social skills, and increasing motivation for physical education classes. Forms of professional activity of physical education teachers in inclusive education in secondary education institutions include various organisational approaches and work models that are used to ensure effective learning of all students, including children with SEN. These forms involve an individual approach, adaptation of exercises and activities, as well as the integration of students into joint educational activities. They aim to ensure the active participation of all students, regardless of their physical or sensory capabilities. The use of various forms of classes – from individual to group and game – helps to adapt the educational process, taking into account the needs of each child, and promotes their physical, emotional and social development.

The specifics of the professional activities of physical education teachers in inclusive education in secondary education institutions are due to the need to ensure equal access to physical activity for all students, including children with disabilities. These features include individualisation of the approach, adaptation of programs and exercises, psychological support, as well as cooperation with specialists to ensure maximum involvement of children in the educational process. The main goal of the teacher's activity is to create conditions that promote the physical, social and emotional development of all students, regardless of their abilities (Demus, 2023). Therefore, the content, methods, forms and features of the professional activities of physical education teachers in inclusive education are of critical importance for ensuring equal access to education for all students, regardless of their physical abilities. Inclusive education is an important part of modern pedagogical activity, and for physical education teachers, this means responsibility for the physical development of each child, regardless of their abilities. The final stage of the training model is the control and results block, which involves determining the effectiveness of the proposed model of training future physical education teachers for professional activity in an inclusive environment of secondary education institutions. The introduction of the author's model into the process of professional training allowed to obtain control results of the study by levels and criteria, which are presented in Tables 4 and 5.

Table 4. Results of EG and CG diagnostics by levels and criteria at the control stage

Criterion	High %		Sufficient %		Average %		Low %	
	EG	CG	EG	CG	EG	CG	EG	CG
Motivational-value	22	15	44	33	25	35	9	17
Cognitive	20	12	42	30	25	34	13	24
Operational-activity	19	11	40	31	23	33	18	25
Reflective-evaluative	20	10	40	30	25	33	15	27
Social-communicative	23	16	44	34	24	35	9	15
Emotional-volitional	22	14	43	33	24	34	11	19
Average value	**21**	**13**	**42,2**	**31,8**	**24,3**	**34**	**12,5**	**21,2**

Source: developed by the authors

Table 5. Dynamics of the formation of competence of future physical education teachers for professional activity in the inclusive environment of secondary education institutions before and after the experiment

Level of formation	EG		Dynamics, %	CG		Dynamics, %
	At the ascertaining stage of the experiment, %	At the control stage of the experiment, %		At the ascertaining stage of the experiment, %	At the control stage of the experiment, %	
High	8,5	21	**+12,5**	8.7	13	**+4,3**
Sufficient	16,5	42,2	**+25,7**	15,2	31,8	**+16,6**
Average	30,5	24,3	**-6,6**	31,8	34	**-2,2**
Low	44,5	12,5	**-32**	44,3	21,2	**-23,1**

Source: developed by the authors

The result-criterion analysis of the final cut showed positive dynamics in the EG compared to the CG. The distribution of results demonstrated a significant shift in results towards high and sufficient levels of readiness. In particular, in the EG, there is a significant increase in the number of students at a high level according to all criteria. The most pronounced increase (by 7-8 percentage points) was recorded for the social-communicative (23% versus 16% in the CG), motivational-value (22% versus 15%) and emotional-volitional (22% versus 14%) criteria. This indicates the effectiveness of the program in forming a positive attitude, empathy and interaction skills. As for the sufficient level, the highest indicators are also observed in the EG. In particular, for the motivational-value and social-communicative criteria, the results in the EG are ahead of the CG by 11 percentage points (44% versus 33% and 34%, respectively). These criteria are considered the most informative regarding the effectiveness of the model, since their improvement contributed most to the overall increase in readiness. The distribution at the medium and low levels indicates a reverse trend: in the EG, the number of students at these levels is significantly lower than in the CG. According to the operational-activity criterion, only 18% were found at a low level in the EG, while in the CG, 25%. A generalised analysis of the results shows that the majority of EG students (42.2%) reached a sufficient level, and 21% – a high level, while in the CG, the majority (34%) remained at an average level, and 21.2% of students are at a low level. This confirms that the proposed training model is effective in forming the readiness of future physical education teachers for the conditions of inclusive activity. According to the results of the formative experiment, the developed training model showed high efficiency (Fig. 2).

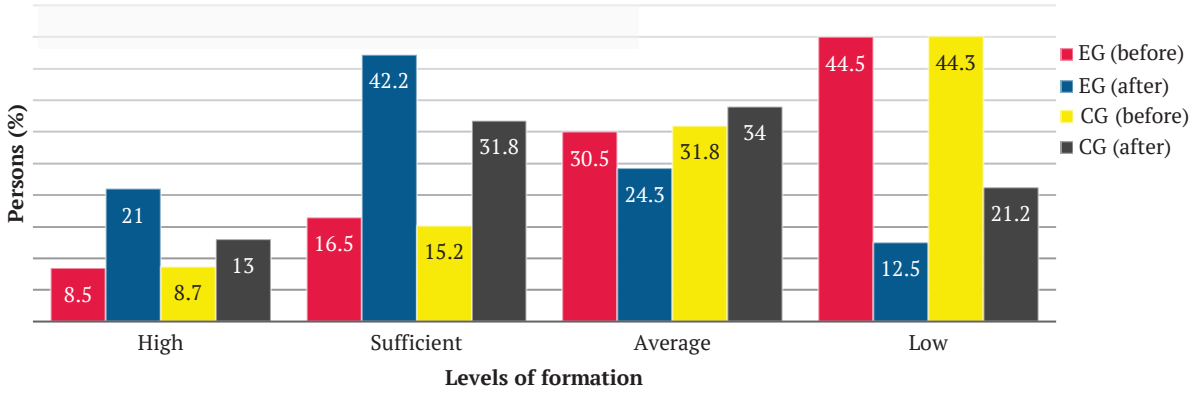

Figure 2. Comparative quantitative analysis of the readiness of future physical education teachers for professional activity in an inclusive environment in general secondary education institutions in EG and CG at the control stage of the experiment (developed by the authors)

Source: developed by the authors

Analysis of changes in the EG and CG showed that the implementation of the model caused a significant positive shift in the levels of readiness of future physical education teachers. In particular, a significant increase in students who reached high and sufficient levels was recorded in the experimental group. The number of students at a high level in the EG increased by 12.5%, which is almost three times higher than the increase in the CG (4.3%). Similarly, the increase in a sufficient level in the EG (25.7%) was almost twice as high as in the CG (16.6%). The effect of the model is also manifested in a significant reduction in the number of students at medium and low levels. The decrease in the percentage of students at a low level in the EG (-32%) is much greater than in the CG (-23.1%), which indicates the successful formation of professional qualities and competencies of applicants. The total increase in the percentage of students at high and sufficient levels in the EG (38.2%) is significantly higher than the similar indicator in the CG (20.9%). These results confirm that the developed model is effective in forming the readiness of future teachers to work in an inclusive environment. Thus, positive dynamics were found both in the EG, where purposeful work was carried out, and in the CG, where the training process took place according to the traditional system, but in the experimental group, the results are significantly higher.

The conducted study confirms its relevance and timeliness, which is consistent with the works of leading foreign authors, in particular with L.P. Ewe *et al.* (2023). Scientists emphasise the exceptional value and importance of using an individual approach in the system of inclusive education, which should adapt to the unique needs of students with different types of nosologies and aims not only to teach the material, but also to form positive self-esteem, social integration and development of all students. The importance of an individual approach also lies in the fact that it is the basis for the development of unique abilities, socio-emotional potential and competencies of each student. This opinion is supported by Ukrainian researchers. N.Z. Sofii (2007) analysed in detail the conceptual aspects of inclusive education, emphasising the need for the systematic implementation of individualised learning

strategies and pedagogical technologies that allow taking into account the psychophysical characteristics of each student. The author emphasises that inclusion is not only the adaptation of the material, but also a complex process of social integration, which involves the interaction of students, teachers and families, aimed at the formation of positive self-esteem and communicative competencies. Yu.M. Naida (2014) added to this the aspect of social activity and social responsibility, emphasising that an inclusive school should create conditions for involving all students in collective activities, which contributes to the development of cooperation skills, social empathy and the formation of a civic position. These studies together indicate that effective inclusion requires not only methodological knowledge, but also a high level of socio-psychological training of teachers who can organise the educational process, taking into account the diversity of the student contingent.

The opinion of scientists C. Steinert & S. Jurkowski (2023), who note that modern realities of the educational space require teachers to form basic competencies in individual support of students in inclusive classes, deserves attention. This sets the task of training future specialists capable of integrating knowledge in inclusive education, special pedagogy, general didactics, subject methods and industry sciences before the system of Ukrainian higher pedagogical education. In view of this, special courses "Special pedagogy in physical education" and "Inclusive physical education of schoolchildren" were developed, which directly form professional competencies in the implementation of physical education in general secondary education institutions of Ukraine. Developments and ideas of scientists S. Hopkins *et al*. (2023), who investigated the usefulness of tools for assessing the quality of training of future teachers for teaching students with intellectual disabilities, will be taken into account in further scientific research. These studies will be devoted to studying the behavioural characteristics of children with intellectual disabilities and preparing future teachers to work with them. This approach will allow for the development of effective technologies for professional training of physical education teachers aimed at overcoming the difficulties of interacting with people with intellectual disabilities and forming a positive attitude towards inclusion.

M.L. Boscardin (2005) presents a professional development model aimed at supporting secondary school teachers in inclusive settings. The model is based on Bandura's cognitive theory and includes key elements such as: collaborative problem-solving in the classroom; increasing self-esteem and a positive attitude towards inclusion; effective collaboration between general and special education teachers; and improving classroom management skills. The author emphasises that continuous, collaborative professional development is critical for successful inclusion. M.L. Boscardin's (2005) work formed the basis for the development of a questionnaire and criteria for assessing the readiness of future physical education teachers to work in an inclusive setting. Elements of this model, such as collaborative problem-solving, increasing self-esteem, collaboration, and improving classroom management skills, became key guidelines in the development of research tools. Ukrainian scholars, in particular A.A. Kolupaieva *et al*. (2012), are unanimous in their position that inclusive education is defined as a set of educational services. This set guarantees the basic right of every child to receive education in general secondary education institutions at the place of residence. Their scientific research has made it possible to understand that the key aspect is the formation of an educational environment capable of meeting the unique educational needs of each child, taking into account their individual psychophysical characteristics. This implies the openness of the educational system for all children and its adaptation to the diversity of the student contingent. An inclusive educational environment is a multi-component and dynamic system that ensures equal access to education for all students, going beyond physical adaptation alone.

According to the concept of I. Demchenko *et al.* (2021), the professional competence of physical education specialists should ensure not only the effective organisation of physical education of various social groups, but also successful professional activity in the field of sports that meets the current requirements of the labour market. The result of training is professional competence, which is a broader and deeper concept compared to the traditional categories of "readiness" or "preparedness". This approach emphasises the need to form in graduates not only knowledge and skills, but also a holistic ability to effectively solve professional tasks in the dynamic conditions of modernity. The author's model of professional training of future physical education teachers is based on a systemic approach to the formation of professional competence, integrating theoretical training, practical skills and personal qualities necessary for successful activity in an inclusive educational environment.

Within the scientific discourse of professional training of physical education teachers for activities in an inclusive environment, a key aspect is the teacher's ability to empathise and understand the psychological characteristics of students. Given the diverse challenges faced by students with special needs, the physical education teacher must be sensitive to their needs, provide emotional support, and ensure a safe environment for physical activity. This involves not only observation but also active listening to students to deeply understand their emotional state and adequately respond to their needs. Tolerance and flexibility are imperative components of effective work in an inclusive environment. The physical education teacher must be ready to adapt pedagogical approaches to the needs of different students, in particular those with physical limitations or cognitive difficulties. This may require adjusting training models, selecting specialised equipment, and developing adapted physical exercises that take into account the capabilities of each student. Flexibility of approaches and the ability to adapt to changing conditions are key to

ensuring equal opportunities for all students to participate in physical education classes, contributing to their overall physical and psychological development.

According to leading scientific concepts, in the process of preparing future physical education teachers to work in an inclusive environment, it is necessary to focus on the development of students' creative potential. It is important to provide them with opportunities for innovative application of acquired knowledge and skills, which will facilitate the transition from reproductive to productive levels of professional activity. This approach forms teachers who are able not only to reproduce the studied material but also to generate new ideas and effective solutions in dynamic and unpredictable conditions of inclusion, which is confirmed by the results of the criterion analysis.

CONCLUSIONS

Based on the conducted research, it can be stated that the developed model of training future physical education teachers for professional activity in an inclusive environment is timely, theoretically sound and practically significant. Its relevance is due to its compliance with state policy and European standards of inclusive education, which are actively implemented in Ukraine at all levels of education. The model meets modern requirements, ensuring the training of teachers who are able to effectively meet the educational needs of children with special educational needs. The developed model integrates leading pedagogical approaches, in particular, competency-based, systemic, activity-based and practice-oriented, which creates a holistic system of training future teachers.

It ensures the formation of cognitive, motivational-value, operational-activity, reflective-evaluative, social-communicative and emotional-volitional competencies in students that meet modern educational standards and labour market requirements. The pedagogical conditions provided by the model include the formation of positive motivation for professional activity, psychological and pedagogical support for students, specially oriented content of training and organisation of practical training in inclusive classes. This ensures active assimilation of knowledge, development of professional skills and the ability to effectively interact with students and colleagues. The operational-content block of the model is implemented in three stages: adaptive-orientational, content-reflective and practical-transformative, which contribute to the integration of theoretical knowledge with practical skills. Experimental verification of the model confirmed its high effectiveness. In the experimental group, a significant increase in the number of students at high and sufficient levels of readiness was observed (12.5% and 25.7%, respectively), which significantly exceeds the indicators of the control group. At the same time, the number of students at medium and low levels decreased, which indicates the successful formation of professional competencies and a positive attitude towards inclusive education. The results obtained allow using the model as a basis for developing methodological recommendations, teaching aids and training programs aimed at improving the professional competence of future physical education teachers and ensuring high-quality physical education for students with special educational needs. A promising direction for further research is the development of specialised physical training programs for children with special needs and the preparation of future teachers to work with students with intellectual spectrum disorders, which will contribute to their effective social development and integration into the educational process.

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CONFLICT OF INTEREST

None.

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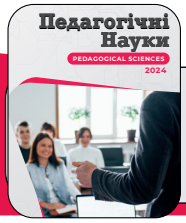
Підготовка майбутніх учителів фізичної культури до інклюзивного навчання в закладах загальної середньої освіти

Анотація. Актуальність теми зумовлена зростанням суспільного запиту на інклюзивну освіту, наявністю відповідного законодавчого підґрунтя та динамічними змінами в освітній системі. Мета дослідження полягала в розробці, науковому обґрунтуванні та експериментальному підтвердженні ефективності авторської моделі підготовки майбутніх фахівців фізичної культури до роботи в умовах інклюзії. Для досягнення мети дослідження було застосовано комплекс теоретичних методів: аналіз та синтез фахової літератури, зокрема з: корекційної та спеціальної педагогіки, методики фізичного виховання, педагогіки вищої школи тощо; логічний та системний аналіз; порівняння; класифікація; моделювання. До емпіричних методів належали: педагогічне спостереження, анкетування, педагогічний експеримент. Проведенням експерименту підтверджено ефективність авторської моделі підготовки майбутніх учителів фізичної культури до інклюзивного навчання у синергетичній єдності трьох блоків: концептуально-цільового, операційно-змістового та контрольно-результативного і педагогічних умов: формування позитивної мотивації до професійної діяльності та психолого-педагогічна підтримка студентів; розробка та впровадження спеціально орієнтованого змісту навчання, що вимагає інтеграцію в освітній процес професійно-орієнтованих дисциплін, зокрема «Спеціальна педагогіка у фізичному вихованні» та «Інклюзивне фізичне виховання школярів»; розвиток практичних навичок через виробничу педагогічну практику. Упровадження моделі дало такі кількісні результати: в експериментальній групі спостерігався значний приріст студентів із високим (+12,5 %) та достатнім (+25,7 %) рівнями готовності, тоді як кількість здобувачів із середнім (-6,6 %) і низьким (-32 %) рівнями суттєво зменшилася. Це значно перевищує показники контрольної групи, де зростання високого та достатнього рівнів становило лише 4,3 % та 16,6 % відповідно, а зниження середнього та низького – 2,2 % та 23,1 %. Розроблені навчально-методичні матеріали та наукові засади можуть бути використані науково-педагогічними працівниками закладів вищої освіти для підготовки майбутніх учителів фізичної культури до роботи в умовах інклюзії

Ключові слова: професійна підготовка; фахівці фізичної культури; інклюзивна освіта;освітні заклади; учні з особливими освітніми потребами; модель підготовки



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The integration of digital management platforms in teacher training: A practice of students

Abstract. The widespread introduction of digital educational platforms in higher education creates conditions for the modernisation of the educational process, increasing its interactivity and individualisation, which is of particular importance in the development of digital competence of philology students as a necessary component of their professional training. The purpose of the study was to analyse the results of monitoring the centralised educational platforms New Knowledge and Eddy by philology students during their teaching practice through their interaction with teachers and secondary school pupils. The methodology included a structured assessment of the functionality, usability, security, and other criteria of the platform using a questionnaire and a test programme, in which teachers, students, and pupils (134 people in total) participated. The survey results allowed comparing the assessments of the New Knowledge and Eddy educational management platforms by different user groups. The most significant differences were found in the assessments of the educational and communication capabilities of the platforms: for New Knowledge, the difference between teacher assessments and student assessments was 1.6 points, and for Eddy, it was 1.3 points. This is explained by students' desire to have a digital educational environment with various feedback channels. The criteria of reliability and ease of use of the Learning Management System (LMS) were identified as priorities for teachers. The technical capabilities of the New Knowledge platform were rated by teachers and students at 3.4 and 4.2 points, respectively. The reliability of the Eddy platform was rated significantly higher by teachers, 4.5 points. As Ukraine transitions to centralised management of secondary education, feedback from teachers and students on specific management platforms will help to identify optimal solutions for managing the educational process

Keywords: digitalisation; digital competence; teaching practice; Learning Management System; Eddy platform; New Knowledge platform

INTRODUCTION

Modernisation of the education system at all levels is impossible without changes in the training of future teachers, without them possessing real professional competencies, the improvement of which is directly related to the quality of university and school education. Quality education is one of the international sustainable development goals. Despite some progress, critical issues such as teacher shortages, limited professional training, and the need to improve students' reading skills remain unresolved, which highlights the importance of better teacher training. S. Lytvynova *et al.* (2024) analysed the All-Ukrainian Online School and determined that it provides video lessons, testing materials, and independent work resources covering 18 school subjects for grades 5-11. Researchers emphasised that this platform plays a critical role in maintaining access to education during emergencies, including the pandemic and ongoing wartime disruptions. Report on the Results of Studying the Issue of the Organised Start of the 2022/2023

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Academic Year in Preschool, General Secondary, and Out-of-School Educational Institutions (2022) examined the E-School platform as a centralised school management system. Approximately 5,000 schools nationwide use this tool, despite the presence of more than 10 similar systems, highlighting both its importance and its limitations compared to more popular platforms.

V.G. Kremen *et al.* (2023) investigated the challenges of Ukrainian higher education under martial law and recovery. The study emphasised the mismatch between graduate qualifications and labour market requirements, while also pointing to artificial intelligence as a promising area for improving teaching and learning quality. A. Bozkurt (2025) analysed the risks of over-digitalisation in education. The researcher warned that learning may be reduced to the management of automated tasks, which could leave students unprepared to meet the demands of a complex, critical, and constantly changing environment. A. Tkachenko (2024) analysed the advantages and risks of digital transformation in traditional education. The analysis included the use of MOOCs, augmented reality, and interactive platforms, showing that such tools increase motivation and accessibility but also require balanced implementation. M. Marienko & A. Sukhikh (2022) investigated the role of digitalisation through the lens of individualised learning. They concluded that digital tools allow tailoring of education to students' personal needs, thus enhancing cognitive motivation and student-centred approaches. M. Zhenchenko *et al.* (2022) examined open educational resources as a factor in the modernisation of the educational process. Their study showed that such resources contribute to equity in education, broaden access to quality materials, and support the development of global thinking skills.

A. Dagtas *et al.* (2024) emphasised the concept of "job crafting" in teacher education. Their research highlighted how adjustments in practices during professional training help to align future teachers' competencies with the expectations of both institutions and stakeholders. R. Sun & P. Du (2023) focused on the role of practice in fostering teacher creativity. Their study demonstrated that creative engagement during internships enhances the educational environment and directly contributes to the professional growth of future teachers. G. Wu *et al.* (2023) examined principals' motivational styles and their impact on preparing future teachers for work. The researchers found that supportive leadership significantly improves the work preparation climate, which is essential for effective integration of digital tools in education. Considering these aspects, it is clear that the integration of advanced digital learning tools into the pedagogical processes of universities is one of the pressing issues of contemporary education. Research confirms that centralised educational platforms and learning management systems (LMS) contribute to the development of information and digital competencies, global thinking, communication culture, and motivation for cognitive activity among students.

The purpose of this study was to examine the experience of philology students in using the centralised educational platforms New Knowledge and Eddy during their teaching practice, with an emphasis on assessing functional and technical characteristics of the systems and on differences in perception between teachers, pupils, and student interns.

MATERIALS AND METHODS

New Knowledge (n.d.) and Eddy (n.d.) platforms were analysed and characterised based on their official websites and functionalities as part of the AICOM system for centralised management of educational institutions. To evaluate the effectiveness of the New Knowledge and Eddy educational platforms, a survey method (Creswell & Creswell, 2022) was used, based on the assessments of teachers and students at schools and universities. The survey of users of educational platforms was descriptive and exploratory in nature, as all questions focused on the priority characteristics proposed by scientists in their research:

- dialogicity as the interaction of participants in the educational process in synchronous and asynchronous modes;
- interactivity of the educational process as a team activity during which there is an active exchange of thoughts, ideas, and suggestions (Morse *et al.*, 2021);
- atmosphere of educational cooperation, motivation to complete homework assignments, ease and success in mastering educational material (Kartashova & Plish, 2020; Illiashenko *et al.*, 2022):
- functional suitability, reliability, productivity, ease of use, security, compatibility, ease of maintenance, and portability (Ouadoud *et al.*, 2021).

To analyse the LMS used in schools in the Poltava Oblast, educational and technical characteristics were selected from the official websites of the New Knowledge and Eddy platforms, including criteria developed by the aforementioned researchers, which were used to create a questionnaire for subject teachers, administrators, students, and pupils. 26 school teachers, 15 university students, and 93 students of secondary general education institutions (grades 5-7) took part in the survey. Two academic groups of students (15 people) who were studying in the second educational semester of the 2024-2025 academic year were involved in preparing for the survey, and two teaching methodologists who helped to process and systematise the assessment results. During their internship at Poltava Secondary School No. 23 and Scientific Lyceum No. 3, philology students acquired skills in working with the platform and conducted anonymous individual surveys of teachers and students. The survey was conducted in writing in accordance with ethical standards for working with children (United Nations, 1948; Code of Academic Integrity of the V.G. Korolenko Poltava National Pedagogical University, 2022). Questions for teachers, pupils, and university students are listed in Table 1.

Table 1. Test programme for evaluating the educational platform for centralised management of an educational institution

1.	Evaluate the functionality of the educational platform for managing an educational institution:						
	➤ organisational	**0**	**1**	**2**	**3**	**4**	**5**
	➤ educational	**0**	**1**	**2**	**3**	**4**	**5**
	➤ communicative	**0**	**1**	**2**	**3**	**4**	**5**
	➤ analytical	**0**	**1**	**2**	**3**	**4**	**5**
2.	Evaluate the productivity of the digital platform in comparison with non-digital means of learning, assessment, analytics, communication	**0**	**1**	**2**	**3**	**4**	**5**
3.	Evaluate how compatible the school management platform is with other educational programmes for learning, knowledge testing, communication between students, and with parents	**0**	**1**	**2**	**3**	**4**	**5**
4.	Evaluate the ease of use of the educational platform for managing an educational institution	**0**	**1**	**2**	**3**	**4**	**5**
5.	Rate the reliability of the school educational platform with points from 1 to 5	**0**	**1**	**2**	**3**	**4**	**5**
6.	Rate the level of security of the educational platform in the educational process and educational work	**0**	**1**	**2**	**3**	**4**	**5**
7.	Evaluate the capabilities of the educational platform in terms of repair ability	**0**	**1**	**2**	**3**	**4**	**5**
8.	To what extent does the school educational platform meet the portability criterion	**0**	**1**	**2**	**3**	**4**	**5**
9.	Evaluate the platform as a whole on a five-point scale	**0**	**1**	**2**	**3**	**4**	**5**

Source: compiled by author

The survey results were analysed by the internship supervisor, and the responses of students and teachers were counted by university students. The effectiveness of educational software was measured on a five-point Likert scale with the following options: disagree, somewhat disagree, somewhere in the middle, somewhat agree, agree.

RESULTS

Platforms New Knowledge and Eddy have many standard features and are part of the Automated Information Complex for Education Management (AICOM). The New Knowledge LMS and Eddy are described in Table 2. This electronic education management system is designed to create a single integrated electronic environment that ensures uninterrupted electronic document flow in reporting, communication, notification, polling, voting, and data collection processes. Currently, 5 educational platforms are connected to the AICOM system for centralised management of educational institutions: New Knowledge, HUMAN School, Eddy, Unified School, and My School. The survey results for the New Knowledge platform are shown in Figure 1.

Table 2. Characteristics of educational management platforms for educational institutions selected for educational practice bases

No.	Title	Content	Users
1.	**New Knowledge** **NZ.UA**	Information and communication platform for centralised management of the institution. Electronic document flow. *Educational resources*: lesson creation, distance learning, feedback, and communication. Analysis of student, class, and school performance.	7,000 educational institutions in Ukraine (AIKOM)
2.	**Eddy**	Centralised institution management platform. Electronic document management. *Educational resources*: tools for distance and blended learning, creation of online courses, own online lesson module.	3,000 educational institutions in Ukraine (AIKOM)

Source: developed by the author based on Eddy School (n.d.), New Knowledge (n.d.)

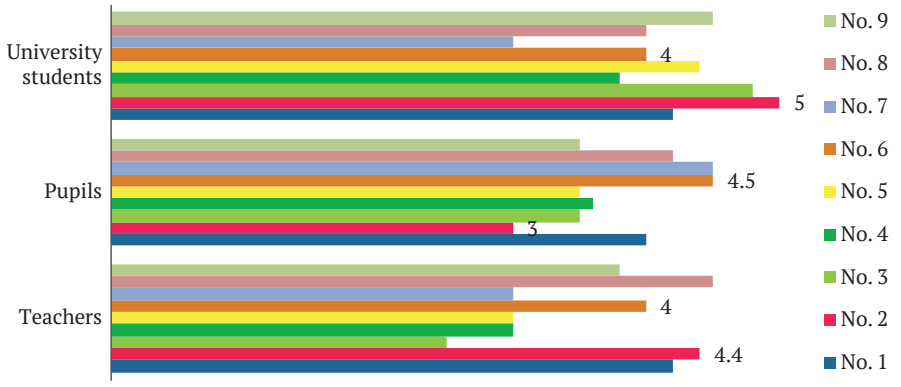

Figure 1. Monitoring results of the centralised management platform New Knowledge

Source: developed by the author

The functionality (organisational, educational, communicative, and analytical) of the New Knowledge platform was rated 4.2 by teachers, 4 by pupils, and 4.2 by student interns. Weighted average score for the functionality of LMS New Knowledge was 0.2 points higher among the organisers of the educational process than among its participants. Student interns were only theoretically familiar with the platform's functions, but they highly rated its organisational, educational, communicative, and analytical functions. Respondents' assessments of the productivity of the digital platform compared to non-digital means of teaching, assessment, analytics, and communication varied greatly. Teachers gave a score of 4.4, indicating the advantages of digital teaching tools over traditional ones, while university students gave the highest score of 5. Notably, digital management platforms are a completely new system for higher education students, which did not exist when they were in school. Therefore, the teachers consider the introduction of LMS to be a striking example of the digitalisation of education. Only 3 points were given for student perception of the advantages, which is explained by greater teacher and parental control over learning compared to previous years.

The compatibility of LMS New Knowledge with other educational programmes for learning, knowledge testing, and communication between students and parents was assessed by respondents with discrepancies: teachers – 2.5 points, university students and pupils – 4.8 and 3.5 points, respectively. Such large discrepancies are conditioned by the greater awareness of students, especially those in higher education, of digital educational platforms. The compatibility of the centralised school management platform with other educational resources was rated highly – 4.8 points, as the New Knowledge LMS has connections to interactive textbooks, distance learning platforms, competitions, projects, webinars, etc. Figure 2 shows the capabilities of the systems in terms of their potential for use in distance learning, and other multimedia platforms.

The ease of use, reliability, security, maintainability, and portability of the platform characterise the technical capabilities of the New Knowledge LMS. School teachers rated it 3.2 points, pupils – 4.5, and student interns – 4. The overall rating of the platform was: 3.8 points from teachers; 3.5 from pupils; and 4.5 from student interns. The reasons for the differences in the assessment results can be explained by the different levels of awareness of the functional and technical features of the platform among teachers and students, and the desire of students to have more diverse content for learning and communication within the LMS. The New Knowledge platform received more complaints about reliability, as its operation was often interrupted due to heavy loads on the system and external conditions related to military operations. In addition, teachers were more aware of these difficulties with grading and writing homework assignments than students, so technical problems with the platforms were rated lower by teachers than by students. The survey results for the Eddy platform are shown in Figure 3.

Figure 2. Interfaces of the New Knowledge and Eddy platforms

Source: developed by the author based on Eddy School (n.d.), New Knowledge (n.d.)

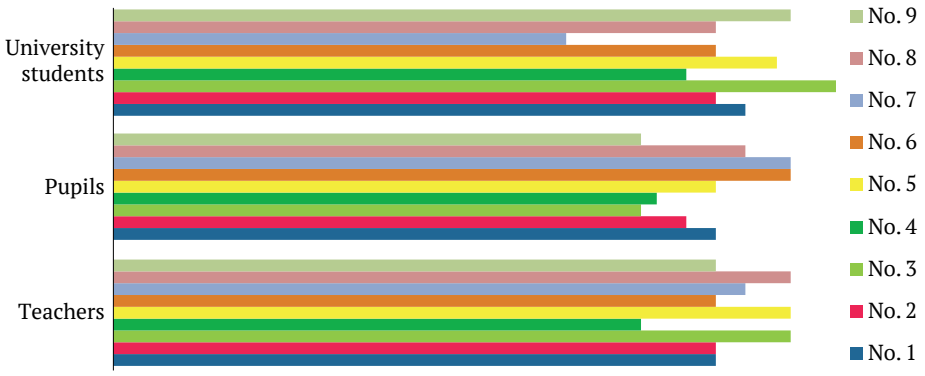

Figure 3. Monitoring results of the centralised management platform Eddy

Source: developed by the author

Monitoring of the Eddy platform differed in some respects from the New Knowledge platform, with most indicators deviating by an average of 0.4 points. Thus, the functionality (organisational, educational, communicative, and analytical) was rated 4.2 points by teachers and student interns and 3.8 points by students. The summary results of the survey on New Knowledge and Eddy are presented in Table 3.

Table 3. Summary table of LMS New Knowledge and Eddy monitoring results

		New Knowledge			Eddy		
		Teachers	**Pupils**	**University students**	**Teachers**	**Pupils**	**University students**
1.		4.2	4	4.2	4	4	4.2
2.		4.4	3	5	4	3.8	4
3.		2.5	3.5	4.8	3.5	3.5	4.8
4.		3	3.6	3.8	3.5	3.6	3.8
5.		3	3.5	4.4	4.5	4	4.4
6.		4	4.5	4	4	4.5	4
7.		3	4.5	3	4.2	4.5	3
8.		4.5	4.2	4	4.5	4.2	4
9.		3.8	3.5	4.5	3.8	4	4.5

Source: developed by the author

Using a questionnaire that assessed the functional characteristics of LMS, the degree of correspondence between the technological capabilities and educational prerequisites for learning on the New Knowledge and Eddy platforms was measured. The monitoring results demonstrated the greater reliability of the Eddy platform, which was rated 4.5 points against 3 for the New Knowledge platform in terms of convenience. Accordingly, in terms of ease of use, the score was 3.5 against 3; in terms of maintainability, 4.2 against 3. These results provide tools for higher education teachers and school administrators to select and develop programmes that improve learning management and LMS integration. The results also provide a strong rationale for conducting longitudinal studies aimed at examining the long-term impact of teaching practices on student learning outcomes.

DISCUSSION

While researching digitalisation processes, ways to integrate secondary and higher education through the use of LMS were identified. The study focused on two aspects: practical activities of university students and the analysis of centralised learning management systems. These aspects are often considered separately in scientific research, without being combined. In this study, points of contact were found between the integration of teaching practice and digital learning tools, as practical activities provide students with direct interaction with educational institution administration, teachers, and pupils. Such interactions not only support professional development but also allow for the practical testing of educational platforms in real educational environments.

The principle of relationships was considered essential to ensure that educators could respond effectively to changes in the educational environment, as highlighted by I. Kunnari *et al.* (2021). This approach is particularly relevant in teacher training programmes, where the ability to adapt to change constitutes one of the primary objectives. In this study, student teachers followed these principles while conducting surveys and interacting with teachers and pupils, which helped them to understand the dynamics of school environments and teaching practices. B. Dreer (2023) emphasised that teacher training programmes define the professional role of future specialists, and optional work constitutes a meaningful component of general education, reinforcing the importance of practical experience in forming professional competencies.

During the evaluation of centralised management platforms, N. Dhanpat (2022) highlighted the growing importance of professional training in adapting to technological changes in the workplace. The study emphasised that optional work allows future professionals to develop practical skills that correspond to 21st-century demands. In this study, student teachers' activities demonstrated that structured practical tasks help to strengthen professional competencies while simultaneously fostering the ability to navigate changes in educational environments. The influence of psychological factors such as self-efficacy and motivation was also evident, supporting X. Huang *et al.* (2023), who noted that engagement in practical activities increases structural resources and reduces obstacles when responding to changes in educational contexts. L. England (2023) explored the intersection of professional activity and higher education through analyses of educational programmes and interviews with teachers, current students, and graduates. The study addressed issues such as measuring success in professional careers, graduate outcomes, development of creative and technical skills, and engagement in professional development. These findings align with this study's results, which show that practical activities combined with

digital tools provide opportunities to develop both professional and digital competencies, an area often underrepresented in existing research.

A.V. Khomenko (2025) argued that integration of digital innovations into pedagogical practice supports a competency-based approach. Various educational technologies were examined, including LMS, MOOCs, AI tools, VR/AR, digital assessment and proctoring systems, blockchain technologies, learning analytics, mobile and microlearning tools, collaborative platforms, gamification, and simulations. In this study, LMS and related tools were applied in practical tasks, demonstrating how digital integration optimises learning, improves teaching effectiveness, enhances knowledge assessment, and supports the development of both general and professional competencies. Nonetheless, A.V. Khomenko noted that specific implementation strategies for educational platforms in secondary and higher education institutions remain underexplored, which this study partly addresses by examining student interactions with platforms in practice.

Digitisation processes in general secondary education were analysed by O.V. Ovcharuk (2023), who used surveys of teachers and educational specialists to identify popular digital tools, available resources, teachers' needs, self-assessed digital competence, and the specifics of organising education under challenging conditions. While O.V. Ovcharuk provided a broad overview of the educational environment, the study did not analyse specific LMSs in terms of their perception by teachers, student teachers, and pupils. This study extends those findings by evaluating both the use and perception of educational platforms in practical training. V.Yu. Bykov (2022) proposed an analysis of digital platforms in Ukrainian education, including types of learning management, content management, and communication/collaboration tools. V.Yu. Bykov highlighted difficulties with content importation and the lack of anti-plagiarism control, showing that platform evaluation often emphasises content rather than management functionality. In this study, attention was given not only to content but also to the effectiveness of platforms in supporting practical teaching activities and the quality of interaction between participants in the learning process. The implementation of digital literacy initiatives and monitoring of educational platforms at Poltava National Pedagogical University during the second academic year demonstrated that a comprehensive introduction of platforms in practical activities significantly improved student performance. Students showed higher levels of learning, independence, and creativity in presenting monitoring results.

CONCLUSIONS

Research into the integration of LMS into the teaching practice of students at pedagogical universities has demonstrated new approaches to pedagogical education, highlighting the importance of the interaction between the digitisation of education and the activities of secondary and higher education institutions. The results indicate that the development of digital competencies among student teachers is mediated by resources and databases of practices that will serve as students' workplaces in the future. The study also highlights the need to develop teacher training programmes through the monitoring of digital learning tools, in particular LMS. The integration of digital management platforms into the practical activities of higher education demonstrates practical ways of implementing professional skills through interaction with teachers and secondary school pupils. During a comprehensive introduction to educational platforms in practical activities, students achieved significantly better results, reflecting their learning outcomes, thorough independent work, and creative approach to presenting monitoring results.

The comparative monitoring of New Knowledge and Eddy platforms showed that although both systems provide basic organisational, educational, communicative, and analytical functions, Eddy demonstrated greater reliability, convenience, and maintainability. However, New Knowledge remains more widespread and better integrated into the centralised AICOM system, which explains its continued dominance in Ukrainian schools. The discrepancies in evaluations among teachers, students, and interns confirm the need for differentiated approaches to training future teachers in the effective use of digital platforms. Further research on this topic is planned, focusing on the quality of students' knowledge in learning, writing term papers, and scientific research, among other areas, with a particular emphasis on the use of various types of open educational resources in independent and practical activities. The topics of master's theses were also developed based on the implementation of educational platform resources in the theoretical and practical training of students.

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CONFLICT OF INTEREST

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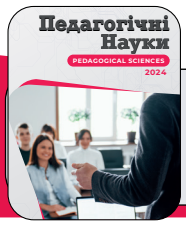
Інтеграція платформ цифрового управління в підготовку вчителів: практика студентів

Анотація. Широке впровадження цифрових освітніх платформ у вищій школі створює умови для модернізації освітнього процесу, підвищення його інтерактивності та індивідуалізації, що набуває особливої значущості у формуванні цифрової компетентності студентів-філологів як необхідної складової їхньої професійної підготовки. Метою дослідження був аналіз результатів моніторингу централізованих освітніх платформам New Knowledge та Eddy студентами-філологів під час педагогічної практики через їхню взаємодію з учителями та учнями середніх шкіл. Методологія включала структуровану оцінку функціональності, зручності використання, безпеки та інших критеріїв платформи за допомогою анкети та тестової програми, участь в яких брали учителі, студенти, учні (усього 134 особи). Результати опитування дозволили зіставити оцінювання освітніх платформ управління New Knowledge та Eddy різними групами користувачів – учителями, учнями шкіл та студентами університету. Найсуттєвіші розбіжності було виявлено в оцінках навчальних та комунікативних можливостей платформ цифрового управління навчальними закладами: для платформи New Knowledge відхилення між оцінками вчителів з одного боку та учнів і студентів – з другого, становило 1,6 балів, водночас для Eddy – 1,3 бали, що пояснюється бажанням учнів шкіл та студентів університету мати сучасне освітнє середовище з різноманітними каналами зворотного зв'язку. Критерії надійності та зручності користування системою управління навчанням (СУН) було визнано пріоритетними для вчителів: технічні можливості платформи New Knowledge, включаючи ремонтоздатність та портативність, була оцінена учителями, учнями шкіл та студентами університету в межах 3,4 та 4,2 балів відповідно. Надійність платформи Eddy була оцінена вчителями значно вище – 4,5 балами. Оскільки Україна переходить до централізованого управління середньою освітою, відгуки вчителів та учнів щодо конкретних платформ управління допоможуть визначити оптимальні рішення для управління навчальним процесом

Ключові слова: цифровізація; цифрова компетентність; педагогічна практика; система управління навчанням; платформа Eddy; платформа New Knowledge



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Application of diagnostic competency-based tasks as a means of mitigating educational losses of prospective geography teachers

Abstract. The problem of the emergence and overcoming of educational losses of future geography teachers in higher education institutions of Ukraine in the context of modern challenges is relevant: the consequences of the COVID-19 pandemic, military actions and martial law. The aim of the study was to provide a theoretical justification for the methodological principles of using diagnostic competence-oriented tasks as a means of minimising educational losses among students, based on empirical research. The study used methods of analysis, synthesis and systematisation in processing the source base. To identify the causes of educational losses and determine their scope and content, testing, pedagogical observation and interviews were used. The terms "educational losses", "learning gaps" and "learning gaps" were systematised as pedagogical categories; the causes of educational losses, the scale and duration of their impact, and ways to overcome them were analysed. A step-by-step algorithm for correcting educational losses and the need to use digital teaching aids were substantiated, and the positive and negative consequences of using artificial intelligence to overcome educational losses among applicants were characterised. The paper defines the essence of diagnostic competence-oriented tasks, conducts research on the scope and content of educational losses based on their application, provides examples of the author's diagnostic tasks in the discipline 'Methods of Teaching Geography,' and a graphical diagram of the process of awareness and correction of educational losses using these tasks. The result of the authors' research was the development of a methodological model for assessing and overcoming educational losses, which has practical significance and can be used by teachers in educational institutions

Keywords: higher education seekers; learning gaps; learning gaps; artificial intelligence; methodological model

INTRODUCTION

In the conditions of serious challenges faced by Ukrainians, education remains the stronghold that keeps its position. However, higher education students have limited access to the educational process compared to students in European countries, which is caused by martial law and air attacks on the territory of Ukraine. At the same time, the restoration of normal learning during the war is of a great value, as it is a process that gives young Ukrainians confidence, stability, and a sense of safety. O. Lokshyna *et al.* (2022) provided a review of the views of the international community on the functioning of education in wartime, as well as the support of the European Union for the integration of Ukrainian children and young people into the education systems of EU member states. It was noted by the authors that during the war the basic human right for education is violated, as the educational system becomes a target of military aggression,

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suffering attacks both on participants of the educational process and on the educational infrastructure.

In the methodological recommendations by O.M. Topuzova (2023), it is stated that during the full-scale war the education in Ukraine suffered significant losses and negative effects. Therefore, the increase and accumulation of educational losses is being caused by objective conditions. As highlighted in the international study by N. Jones *et al.* (2021), "gender, disability, and poverty intersect, deepening social inequality in access to distance learning", which prevents equal opportunities in times of crisis. Yu. Nazarenko (2022) determined the reasons for educational losses of learners and the consequences of their long-term impact in Ukraine, and described international experience in researching educational losses and approaches to their compensation. It was established that long-term educational losses may have serious consequences for the development of society and the economic well-being of the individual. A. Kendyukhova & O. Shylo (2024) defined "educational losses" as "losses of opportunities for comprehensive personal development – intellectual, social, emotional, psychological, etc." They state that educational losses affect the intellectual potential of the nation, economic situation, the readiness of learners for independent life, and in the future may negatively influence the scientific, technological, and socio-economic development of Ukraine over a long period of time.

S.O. Naumenko (2023), in an article devoted to the study of foreign experience in overcoming educational losses and the possibilities of using this experience in Ukrainian general secondary educational institutions (GSEI), identified directions of solving this problem, such as adjustment of training courses, re-study of the material, extended learning time, private lessons, and similar measures. In the article by P.V. Moroz (2023), potential mechanisms for overcoming educational losses in Ukraine are given. Among the ten suggested directions of activity, special attention is drawn to the following: "Development of high-quality digital educational content. The creation of e-textbooks and online platforms for learning different subjects will allow learners, regardless of their circumstances, to have broader access to educational services" and "Conducting fundamental and applied scientific research on the issue of educational losses with the aim of developing scientific and methodological framework for the compensation of educational losses".

S. Trubacheva *et al.* (2024) consider the lack of learners' independence (low learning motivation, lack of awareness of educational goals, and weak activity of students while distance mode) as the main reason of educational losses, and propose the technology of independent knowledge acquisition as an effective solution. O. Topuzov *et al.* (2023), analysing the processes taking place in Ukrainian education, state that prevention and minimisation of educational losses of learners "should be carried out on complex grounds, systematically and consistently, in accordance with the main components of the educational process". Thus, most researchers view the problem of educational losses as arising from limited access to education, instability of learning conditions, and changes of its formats. Educators cannot control the course of military actions or natural disasters, but they can influence the studying process and reduce the number of educational losses, thereby decreasing the extent of post-traumatic syndrome among learners.

Learners are in difficult life situations, forced to change places of residence, and remain in conditions of increased danger. All this leads to the fact that education in general secondary educational institutions (GSEI) is conducted in a combined online and offline mode, which is less effective, as it reduces the pedagogical influence of teachers on students' motivation towards learning. Accordingly, higher education students who enter the first year of the bachelor's degree have educational losses that need to be diagnosed and taken into account when designing the educational process in higher educational institutions (HEI). Despite the comprehensive implementation of offline learning conditions in HEI, the current realities of life in Ukraine and safety requirements for the organisation of the educational process also lead to the emergence of educational losses of higher education students. Thus, there arises the problem of determining the scope and content of these educational losses and developing ways to overcome them both in GSEI and HEI.

Therefore, the purpose of the article was to determine the theoretical foundations and applied aspects of the methodology for creating and using diagnostic competence-oriented tasks in order to overcome educational losses in the process of professional training of future geography teachers.

MATERIALS AND METHODS

To achieve the stated aim, both theoretical and empirical research methods were used. An analysis and generalisation of the source base related to the subject of the study were carried out; systematisation of the component structure of the concept "learning losses" was made. Existing definitions and approaches to the interpretation of educational losses were systematised. The component structure of the concept was arranged. Based on the synthesis of the results of theoretical analysis and data from previous studies, a methodological model for assessing educational losses of future geography teachers was developed. Owing to this step-by-step approach, methodological foundations were formed for designing diagnostic competence-oriented tasks to identify gaps in the professional training of students.

Among empirical methods, testing, pedagogical observation, and interviews were applied. The aim of the empirical stage was to identify the volume, content, and reasons for educational losses both quantitatively and qualitatively. Testing was conducted at Poltava V.G. Korolenko National Pedagogical University before the beginning of the courses "Physical Geography of Continents and Oceans" and "Physical Geography of Ukraine" in September of the third semester of study, using competence-oriented tasks of three levels of complexity using a 100-point grading scale. The research involved a group of 14 second-year students

and 15 students of the bachelor's level programme "Secondary Education (Geography)". Testing was conducted in the classroom during a lecture. Each student received tasks of all levels of complexity in order of increasing difficulty.

The first-level tasks were focused on controlling the acquisition of empirical knowledge, namely geographical facts, geographical nomenclature, and geographical representations. The second-level tasks were productive and required the application of geographical knowledge and skills. The third-level tasks were aimed at identifying the level of theoretical knowledge formation and its application for solving problem situations and creative-level tasks. Pedagogical observation was carried out during classroom lessons with fixation of students' activity at the beginning of the lesson. Interviews were conducted individually to clarify subjective reasons for educational losses (low motivation, lack of awareness of goals, difficulties of distance learning). All this made it possible to outline the main subjective barriers to learning and integrate them into corrective measures of the methodological model.

The use of all empirical methods was accompanied by clear rubrics of assessment criteria. The processing of test results involved the distribution of students' mistakes according to the levels of complexity of diagnostic competence-oriented tasks (COT), quantitative expression of mistakes in percentages, and visualisation in the form of a pie chart. The identified gaps were taken into account when refining the relevant training programmes. The qualitative analysis of observations and interviews consisted in classifying the factors causing learning losses. The results of applying empirical and theoretical research methods were the basis for creating a methodological model of assessing and overcoming educational losses of future geography teachers. The cyclic process "planning - testing - analysis - correction" made it possible to update the content and methods of teaching educational components promptly, guaranteeing that the educational programme meets the identified needs of students. Testing was conducted in written form in accordance with ethical standards of working with children (United Nations, 1948; Code of Academic Integrity of the Poltava V.G. Korolenko National Pedagogical University, 2022).

RESULTS AND DISCUSSION

Despite active research by scholars and teachers on educational losses, there is still a need to study this issue in relation to the professional training of future geography teachers. For lecturers of relevant educational programmes, it is important to seek new ways of organising students' learning activities, taking into account existing and potential educational losses, and to try to ensure a high-quality educational process by using innovative methods and technologies, digital tools, and advanced psychological and pedagogical approaches. On the other hand, the search for ways to overcome educational losses requires careful theoretical research of a didactic direction, the development of applied foundations and methodological recommendations for the organisation of learners' educational and cognitive activities and the evaluation of their learning outcomes.

V. Kovalchuk *et al.* (2022), after analysing the factors resulting from the threat of the pandemic and the imposition of martial law in Ukraine, emphasise that "the educational process in Ukraine is in a crisis situation: on the one hand, due to the threat of coronavirus spread, and on the other hand, due to the invasion of the Russian army into the territory of Ukraine". This double challenge highlights the need to adapt forms and methods of learning activities not only to the conditions of a particular institution but also to the individual needs of each learner. The authors underline that "a future qualified specialist should possess professional skills at a high level, be mobile, and able to respond flexibly to changes…", which in turn requires the future geography teacher to engage in constant self-development, professional growth, and the development of partnership skills.

In the manual prepared with the support of the International Foundation "Renaissance", it is noted that the specific feature of educational losses is that if effective measures are not taken in time to overcome them, they will accumulate and deepen (Zvynyatskivska, 2023). O. Malykhin *et al.* (2022) argue that creating a new model of education in the current conditions is practically impossible. Therefore, the way out of this critical situation should be a certain adaptation of the existing model of learning to current realities. It is worth noting that in the absence of reliable data on the scale of educational losses, the development of state policy aimed at systematic response becomes especially important. As Yu. Nazarenko (2022) emphasises: "the scale of existing challenges does not allow to expect that they will be solved by themselves without targeted state policy". This implies the creation of strategic documents, in particular the updating of the Educational Assessment Strategy and the introduction of compensatory measures. Her study also states that experiencing war at any age has a negative impact on both mental and physical health. Therefore, the support that learners can receive in the process of developing their professional competences is vital. Modern trends in education require forecasting the consequences of educational losses caused by the war, since these losses may significantly influence the social development of Ukraine in the future. Geographical education combines both natural and social directions in the formation of key and subject competences of learners at all educational levels. Moreover, it is aimed at the development of critical thinking, creativity, and innovativeness, which contributes to social progress and the development of a high-tech labour market. Accordingly, the professional training of future geography teachers should ensure their ability to educate and develop generations of students capable of solving complex economic, ecological, and environmental problems on which the future of Ukraine depends. At present, the effectiveness of professional training depends on the ability of lecturers and students of higher pedagogical education to overcome existing educational losses. Therefore, before analysing the corresponding processes in higher educational institutions

(HEI), it is necessary to determine the terminological basis of the studied phenomenon.

N. Bychko & V. Tereshchenko (2023) point out that in scientific literature there are many terms that, having entered Ukrainian practice through calquing, are sometimes inaccurate. This leads to the fact that in academic and informational space the same concepts may be used interchangeably: educational losses, learning gaps, learning losses, losses in learning, gaps in education, gaps in learning, learning disparities, achievement gaps, or missed knowledge. From their work it is known that the most widely used terms are "educational losses," "learning gaps," and "learning disparities". The term educational losses should be considered as a decrease in the level of knowledge, skills, and competences of learners due to disruptions of the educational process that arise as a result of emergencies such as war, pandemic, forced displacement, or prolonged distance learning. Learning gaps refer to the absence or insufficient acquisition of knowledge, concepts, or skills necessary for further successful learning. Learning disparities are a significant difference in the level of knowledge and learning outcomes between learners or groups of learners, caused by unequal access to educational resources or different learning conditions that emerged during the pandemic and the war. This term is often used to describe systemic disproportions in access to high-quality education (Fig. 1).

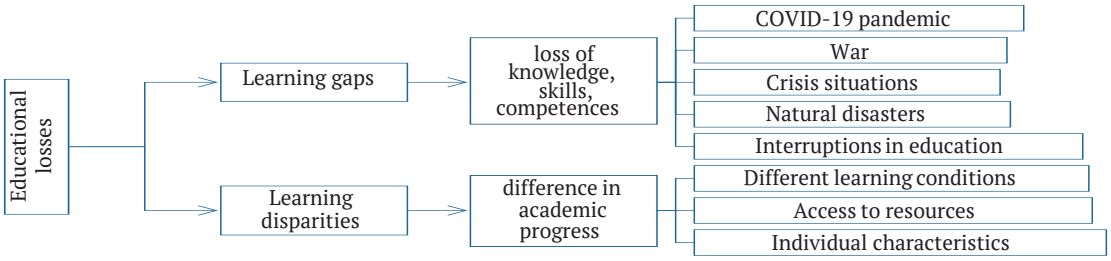

Figure 1. Scheme illustrating the distinctions between the concepts of "learning gaps" and "learning disparities"
Source: developed by the authors based on N. Bychko & V. Tereshchenko (2023)

The presented scheme clearly distinguishes two levels of educational losses: "learning gaps" as specific deficits in knowledge, skills and competences, and "learning disparities" as larger disproportions in academic progress. At the same time, the list of external and internal factors shows that both gaps and disparities have a multi-component nature. The awareness of this distinction helps to develop targeted strategies – from differentiated diagnostic COT to educational projects aimed at ensuring equal access to high-quality education. It is important to analyse the causes, scope, and duration of the impact, as well as the manifestations and strategies for overcoming educational losses, learning gaps, and disparities (Table 1).

Table 1. Educational losses, learning gaps, and learning disparities as pedagogical categories

Analysis criteria	Educational losses	Learning gaps	Learning disparities
Essence of the concept	General decrease in the level of knowledge and skills	Absence or weak acquisition of specific knowledge/skills	Difference in learning achievements between different students or groups
Causes	Emergencies: war, pandemic, displacement, technical difficulties, etc.	Insufficient explanation, missing topics, individual difficulties	Unequal access to resources, varying learning conditions, and differences in the quality of education
Scope of impact	Mass (whole institution, region, country)	Individual or a group of learners	Intergroup (between groups of learners, institutions, regions, categories of students)
Duration of impact	Medium or long-term	Can be short or long-term	Often long-term, accumulates over time
Manifestations	Significant lag behind curricula, loss of motivation	Learner does not understand a new topic due to unmastered previous material	Some learners systematically achieve much better results than others
Ways of overcoming	Additional learning, corrective programmei, psychosocial support	Individual work, revision of topics, teacher support	Systemic support for vulnerable groups, equal access to high-quality education for all

Source: developed by the authors based on Yu. Nazarenko (2022)

In Table 1 it is clearly shown that educational losses, learning gaps, and learning disparities overlap in their features but differ in the scope of impact. The given classification emphasises the need for combined strategies for their effective overcoming. In other words, it indicates the necessity of combining various solutions, pedagogical practices, and educational strategies. As A. Marchuk (2023) notes, under martial law HEI students lose and fail to acquire knowledge, skills, abilities, and competences that are essential for professional growth and career success. The digitalisation of higher education helps to reduce educational losses and creates safe conditions for lecturers and students, ensuring the effectiveness and functioning of the educational process.

The COVID-19 pandemic, during which education switched to a distance format, enabled the HEI system to adapt quickly to training during the war. Learning was resumed in online and blended formats. However, the educational process under martial law is complicated by air alarms and massive missile attacks. In addition, the psycho-emotional state of higher education students and lecturers influences the quality of organisation of learning and cognitive activities during classes. The above indicates the objective conditions for the emergence of educational losses of learners in HEI and the real need to determine an algorithm for solving the problem of overcoming educational losses, learning gaps, and disparities, which can be applied by pedagogical staff of HEI. Based on the analysis of authors' experience in overcoming educational losses of future geography teachers, an algorithm for solving the problem of overcoming educational losses, learning gaps, and disparities in HEI was proposed (Table 2).

Table 2. Algorithm for solving the problem of overcoming educational losses, learning gaps and disparities in HEI

1. Assessment of losses	**Conducting diagnostics. Detailed analysis to determine the quality of the educational process.**
2. Plan for restoring lost knowledge, skills, and competences	Development of individual learning plans taking into account learners' educational gaps. Identification of the main learning material that requires special attention. Setting deadlines to compensate for learning losses
3. Adaptation	Changing forms of organisation of learning activities to reduce overload and facilitate knowledge acquisition. Use of digital learning tools. Increase of motivation and interest of learners.
4. Support and opportunities	Providing learners with technical equipment for online classes. Psycho-emotional support for learners and lecturers during the war. Organisation of seminars, webinars, and trainings for lecturers to improve their readiness to work in this direction.
5. Support from the state	Development of model programmes to compensate for educational losses among higher education students. Development of technologies and methods to eliminate learning gaps. Ensuring funding for the implementation of educational goals.
6. Cooperation with international organisations	Use of relevant international experience in the educational process of HEI.
7. Innovations	Development of new curricula and syllabi, improvement of study programmes. Application of modern digital resources to improve the quality of the educational process.
8. Monitoring, evaluation	Continuous monitoring of educational progress. Regular evaluation of the effectiveness of implemented algorithms and adjustment of strategies.
9. Communication	Open dialogue among all participants of the educational process. Public discussion of the issue of educational losses and appeals to educational institutions for the necessary support.
10. Preparation for the future	Development of a set of strategies to prevent similar educational losses in the future. Creation of resilient and flexible educational systems capable of adapting to unpredictable situations.

Source: developed by the authors

The availability of psycho-emotional support and technical resources for solving the problem is aimed at providing comprehensive assistance to learners and lecturers in difficult conditions. State support and cooperation with international organisations will help to exchange best practices, which will contribute to the sustainability of initiatives. Constant monitoring and communication create feedback that allows prompt adjustment of strategies and guarantees continuous improvement of the educational process. A relevant problem in the development of physical geography, as a component of the natural science educational field, is the occurrence of the greatest educational losses in the formation of experimental skills. This is especially important in distance learning conditions, where students do not have real access to equipment, and the main source of information is textbooks and study manuals. At the same time, in the current conditions of digitalisation of education, the experience of countries that introduce e-learning as a tool for ensuring educational resilience during crises becomes particularly important. International practice shows that "e-learning is not inferior in quality to face-to-face learning, and under conditions of warfare it is relevant and critically important for the provision of educational services" (Nosachenko, 2022; Bakhmat *et al.*, 2023).

Among the digital tools that have become an obligatory component of the modern educational process, a special place is occupied by the use of Artificial Intelligence (AI) both by lecturers and learners. The use of AI in blended learning has become an important element of learning activity. The use of chatbots such as ChatGPT, GIMINI, and others can currently both assist in the formation of professional competences of future geography teachers and contribute to increasing their educational losses. AI chatbots can explain complex topics in simple words, act as personal tutors, answer questions, provide examples, etc. (Table 3).

Table 3. Positive and negative consequences of using Artificial Intelligence to overcome educational losses of learners

Positive consequences	***Negative consequences***
Individual approach to learning	Decrease of critical thinking
Increase of efficiency and saving of time	Risk of academic dishonesty (cheating, plagiarism)

Table 3. Continue

Positive consequences	*Negative consequences*
Access to knowledge 24/7	Excessive dependence on AI
Support of inclusive education	Possible mistakes or unreliable information
Development of digital skills	Issues of confidentiality and data security

Source: developed by the authors

AI adapts to the level of knowledge and learning pace of the learner, helping to focus on the main aspects and saving time. In addition, AI can be useful for learners with special educational needs, as they are able to access it at any time, without being limited by a lecturer's schedule. On the other hand, if future geography teachers mindlessly copy AI answers without paying attention to possible geographical or psychological-pedagogical mistakes, they lose skills of independent analysis, text writing, problem-solving, and so on. Finally, systematic and thoughtless use of AI may slow down the development of critical thinking and increase the volume of educational losses. To avoid negative consequences, lecturers should reconsider the design of learning tasks and requirements for their implementation. In this sense, the use of AI as a universal learning tool requires new approaches to the organisation of the educational process. AI should not imitate learners' intellectual activity, but rather stimulate it. As L.D. Zelenska & T.S. Kopteva (2024) note, the development of digital competence of geography teachers by means of Artificial Intelligence is a promising and in-demand direction of professionalisation of teachers in the context of digitalisation of society and the spread of blended and distance learning during the war of russia against Ukraine.

Therefore, AI is a powerful educational tool which, when used in a balanced and ethical way, can ensure the overcoming of educational losses rather than their accumulation. In addition, in the context of reducing educational losses of future geography teachers, the use of geoinformation models in the educational process is quite effective. They may serve not only as a tool for visualising geographical data but also as a means of stimulating cognitive activity. As researchers point out, geoinformation learning models are a tool for organising independent cognitive activity of students, allowing them to explore the geographical environment (Topuzov *et al.*, 2019). Such models can be integrated into the structure of diagnostic competence-oriented tasks, particularly in the assessment of learners' spatial thinking, in the development of skills of cartographic data analysis, and in solving problem situations in a geoinformation environment.

Another means that can be used to reduce educational losses is the application of various digital educational platforms. As O. Bondarenko *et al.* (2023) state, digital platforms create conditions for targeted support of students' spatial thinking, which is critically important for the formation of geographical literacy. Thus, digital platforms serve not only as a technical resource but also as a pedagogical environment capable of integrating diagnostics, reflection, and competence development into a single educational trajectory of future geography teachers.

The tendency toward a decrease in the level of future teachers' geographical subject competencies, caused by learning gaps, negatively influences the quality of their professional training. In higher education conditions, the diagnostics of educational losses should be based on the principles of effectiveness, as well as taking into account learners' individual cognitive characteristics. A key aspect of the training of future geography teachers is the formation of professional competences, among which knowledge and the ability to apply it play an important role. Considering this, pedagogical research was conducted, aimed at assessing the level of knowledge and skills necessary for high-quality teaching of geography in general secondary educational institutions (GSEI). In order to diagnose learning gaps in the educational achievements of future geography teachers, competence-oriented tasks (COT) were used. COT are tasks that model problematic (contradictory) situations and require intellectual search from contradiction to new knowledge, for the development and diagnosis of key competences.

Scholars prove that assessment is a key element of the learning process. It increases the effectiveness of learning and guides educational processes (Grynyov *et al.*, 2024). In the context of using diagnostic COT, assessment becomes not only a tool for measuring results but also a means of timely identification of learning gaps and guiding the educational process towards overcoming them. This is especially important for the training of future teachers, where the ability to reflect and think analytically is the basis of professional maturity. The use of diagnostic COT is part of "building back better" (Lennox *et al.*, 2021), as they allow identifying educational losses and designing learning that meets the real needs of future teachers.

Therefore, COT can, on the one hand, serve as a tool for diagnosing and identifying learning gaps, and on the other hand, motivating and encouraging learners to self-assess and overcome such gaps. According to the research results among students, it was found that the largest number of mistakes (67%) were in the tasks of the third level of complexity, which according to the national ECTS scale correspond to the level "excellent". This highlights the challenges learners face in comprehending geographical causal relationships and regularities. The insufficient formation of the conceptual apparatus negatively affects the structuring of scientific concepts and their application in new contexts (Fig. 2).

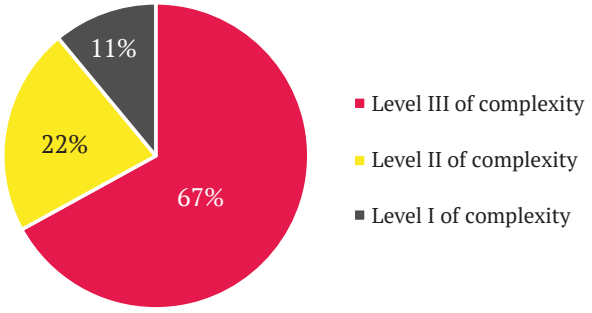

Figure 2. Distribution of students' mistakes by levels of complexity of diagnostic COT
Source: developed by the authors

22% of mistakes were made by participants while completing tasks of the second level of complexity, which indicates educational losses related to the formation of their geographical skills and the ability to apply knowledge to solve applied problems. While performing the first-level tasks, learners completed the largest number of tasks correctly. These tasks accounted for the smallest number of mistakes (11%), which indicates some progress in school geography learning regarding the use of visualisation tools, as well as achievements in the formation of geographical concepts, nomenclature, and facts.

Therefore, the results of testing demonstrated that educational losses are most evident in complex analytical tasks, which require a systematic approach, critical thinking, and integration of geographical knowledge. According to the testing results, lecturers, when designing curricula of the specified disciplines, considered the identified learning gaps and disparities of learners, as well as the potential possibilities of overcoming them. According to the needs of improving the mechanisms of diagnostics, assessment, and overcoming of educational losses of future geography teachers, a comprehensive methodological model was developed. The model defines and specifies its conceptual foundations and the set of tools for assessing educational losses. In addition, it presents the content of the stages of educational loss assessment: primary diagnostics; in-depth analysis of learning gaps and disparities; and development of corrective measures. The step-by-step algorithm of overcoming educational losses presented in the model will allow lecturers of the relevant disciplines to form effective corrective technologies, which will contribute to improving the professional training of learners (Fig. 3).

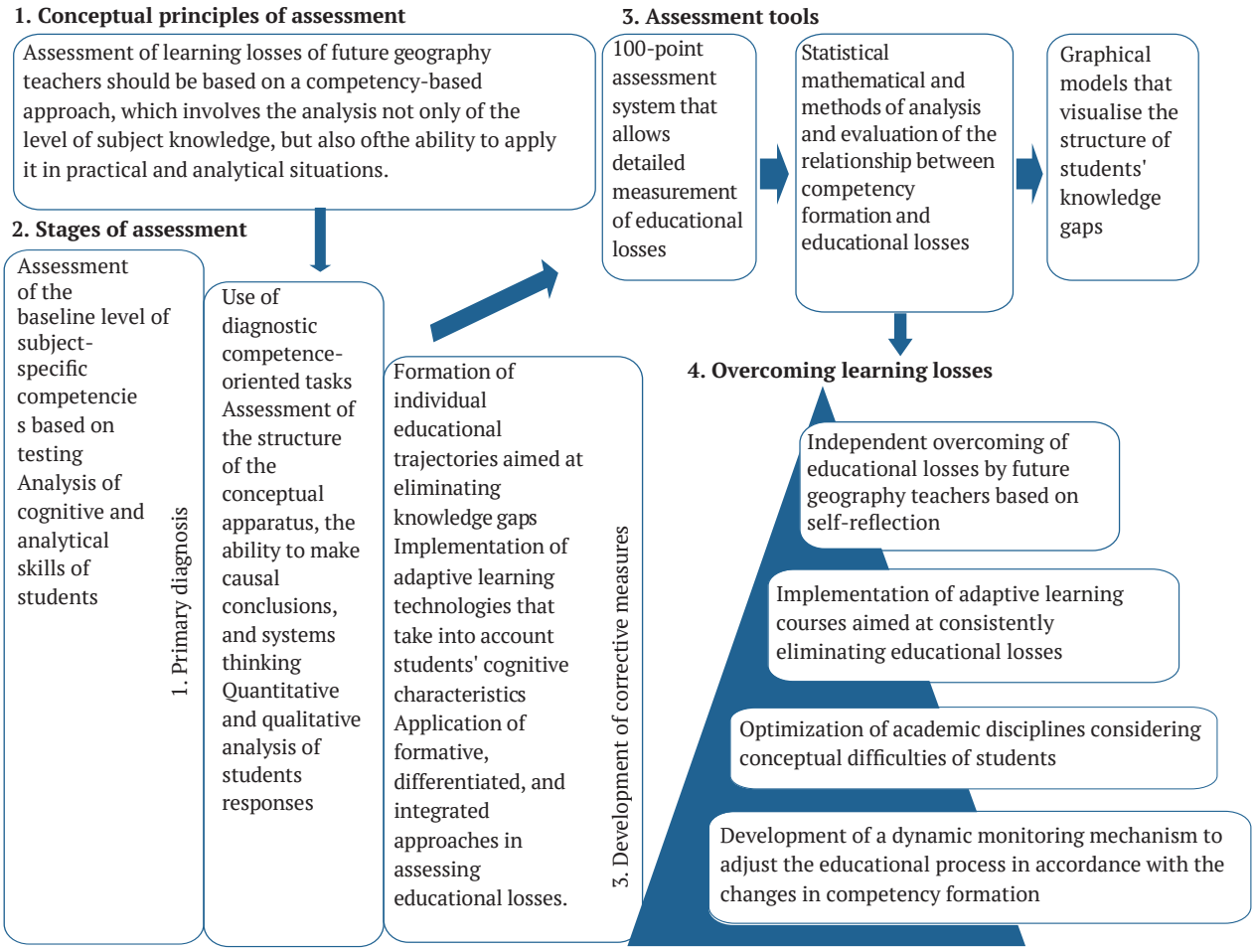

Figure 3. Comprehensive methodological model for assessing and overcoming educational losses of future geography teachers
Source: developed by the authors

To conduct monitoring research on the training of future geography teachers, it is advisable to involve lecturers who understand the specifics of geographical and psycho-pedagogical disciplines within the relevant educational programmes. Collective monitoring work carried out by lecturers will help comprehensively determine the content and extent of educational losses, as well as the methods for overcoming them. Considering the identified learning gaps and disparities during the design of the educational process will make it possible to provide individual support to students who experience difficulties. It is advisable to assess their academic progress at the beginning and at the end of the semester. A set of such procedures, combined with formative assessment, will enable lecturers to adjust their teaching activities and provide timely assistance to students who need support.

The advantage of this approach is the reduction of educational losses and the possibility of creating a supportive and positive atmosphere. It is important not to forget about academic integrity, the promotion of which will help learners to focus on learning and personal development rather than fear of results. If there is a need to make up academic hours, this can be done by providing additional learning materials and self-study assignments online. The amount of such hours depends on the number of students and the volume of missed learning material. There is no perfect strategy; therefore, it is necessary to take into account individual needs and circumstances when choosing the right compensation algorithm and making decisions for each student separately.

The effectiveness of using the above-mentioned diagnostic COT lies in their ability to measure the level of students' mastery of professional competences. Since COT are performed individually, both lecturers and students can jointly determine the scope and content of learning gaps that require additional work. It is important that the identification of such gaps takes place in a stress-free environment and contributes to overcoming the disparities that need to be filled, taking into account the individual circumstances of students - such as the inability to study during air raids, being in occupied territories, lack of internet access, relocation, evacuation, or power outages.

The design of diagnostic COT involves clear definition of the goals of diagnostic assessment and the creation of tasks based on real-life situations. At the first stage of designing diagnostic COT, the target learning outcomes are determined, and then tasks are developed based on realistic life scenarios. This approach makes it possible to ensure the connection between theoretical content and practical activities, which is especially important in the process of reducing educational losses during the professional training of future geography teachers. COT are multifunctional. Their functions include: objective identification of gaps in students' knowledge, skills, and abilities; providing lecturers with opportunities to adjust the educational process; enabling an individual approach to solving students' problems; preventing the emergence of further learning gaps; and guiding students toward continuous academic progress (Fig. 4).

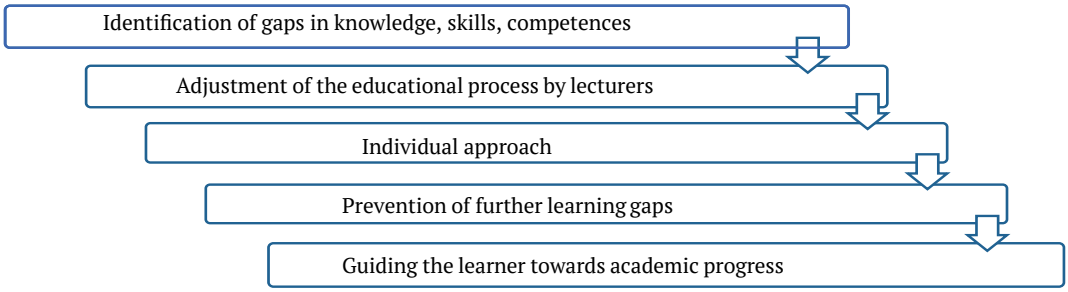

Figure 4. Features of diagnostic COT

Source: developed by the authors

Figure 4 illustrates a closed cycle in which diagnostics becomes the starting point for continuous improvement of the educational process. The transition from analysing current results to making corrections allows a quick response to students' individual needs. Timely prevention of new learning gaps simultaneously strengthens motivation and confidence in the ability to overcome challenging tasks. The vector of all stages is directed toward the steady growth of each student's academic achievements. The formation of methodological competences is a key component of the professional training of future teachers, as the quality of geography education depends on their ability to organise students' learning and cognitive activities both during lessons and in extracurricular contexts. Accordingly, a set of diagnostic COT has been developed, which can be used to identify educational gaps in the course "Methods of Teaching Geography" (Table 4).

After completing diagnostic COT, learners review the correct answers that helps them to adequately evaluate their own achievements and gaps in knowledge, skills, and competences. During this research it was found that diagnostic COT, both in distance learning and in classroom settings, help future teachers to understand their own learning gaps, while enabling the lecturer to determine the level of complexity of the problem that needs to be solved. The scheme presented in Figure 5 illustrates the process of awareness of educational losses by future geography teachers with the help of diagnostic COT.

Table 4. Diagnostic COT in the professional training of future geography teachers

Topic of practical classes, discipline "Methods of Teaching Geography"	Formulation of diagnostic COT
Formation of subject-specific geographical competences	It is well known that one of the priority tasks of geography education in secondary schools is the development of various types of skills. Imagine that you are currently conducting a lesson for 6th-grade pupils and need to develop their intellectual skills. How would you do this? Design a fragment of a geography lesson (the topic of the lesson is chosen by the student).
Verbal teaching methods in geography	You probably all have memories of school when a teacher explained something in such a way that you still remember their story. They create a mental representation of a geographical object, process, or phenomenon. A vivid description of nature, not overloaded with facts, is easy to remember. Try to design a 7th-grade lesson segment in which storytelling and explanation are applied. The duration should be up to 10 minutes (the lesson topic is at the learner's discretion).
Practical teaching methods in geography	Creating a weather calendar by pupils requires new methodological approaches, taking into account their access to modern information sources. At the same time, the systematic observation of weather details encourages pupils to compare and analyse results, overcoming potential challenges. Provide interesting examples of motivating and encouraging pupils to organise weather observations (5 examples).
Methodology for working with outline maps	A geographical map is both a language and a source of information in geography. The creativity of a geography teacher is revealed in the innovative design of engaging tasks that correspond to the current level of scientific development. The teacher should derive satisfaction from designing unconventional lessons that serve as didactic discoveries. Therefore, design two tasks for pupils of 6–9 grades using an outline map. Primitive or well-known tasks are not accepted.

Source: developed by the authors

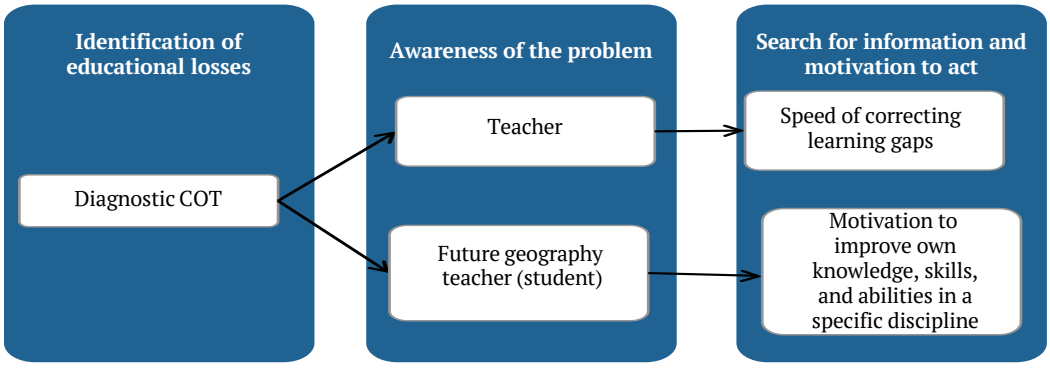

Figure 5. The process of identifying and remediation educational losses through diagnostic competence-oriented tasks
Source: developed by the authors

The sequence of transforming the results of applying diagnostic COT into practical corrective steps is determined by the close connection between the identification of gaps and the targeted search for information. Through the involvement of both participants, both lecturer and learner, an interaction arises that increases the accuracy of assessment and the promptness of further changes in the learning process. The emphasis on the speed of implementing corrections and the students' internal motivation shows that the effectiveness of the process largely depends not only on methodological tools but also on the students' readiness to take responsibility for their own development. Overall, this approach strengthens the cyclical nature of the educational process, where each stage becomes an impulse for continuous improvement. The analysis of completed tasks contributes to the formation of the ability for reflection and self-correction of learning achievements. This, in turn, positively influences learners' educational progress and motivation for further learning activities.

CONCLUSIONS

In the conditions of modern global challenges, particularly the combination of the pandemic and the war, educational losses have become a serious challenge for learners. Future geography teachers, as key participants in the educational process, require effective tools to minimise such losses. One of such a tool is COT, which, on the one hand, are a component of the assessment-analytical element of the educational process, and on the other hand, an effective means of reducing educational losses of future geography teachers. However, it is difficult to implement new models of overcoming educational losses at the state level during martial law. To solve this task, cooperation of lecturers from different HEI is required. A comprehensive system of educational

measurement should be created within the relevant educational programmes, using standardised testing based on the combination of diagnostic competence-oriented tasks. Special attention should be paid to the integration of adaptive digital educational platforms, which, based on the results of diagnostic testing, will form individual learning trajectories for learners. Without a system of objective measurement of educational losses, it is impossible to build a strategy for overcoming them. In addition, it is advisable to study and adopt the experience of foreign countries in overcoming educational losses more attentively.

The presented study does not exhaust the essence of the problem of applying diagnostic COT as a means of overcoming educational losses of future geography teachers, since it requires recognising the problem of educational losses in HEI as one that needs urgent solution on the basis of systematic methodological reflection. There is also a need for further development of applied aspects of the proposed methodological model for assessing and overcoming such losses. A lecturer of HEI should see the real picture of students' educational losses in order to overcome them in time. The application of diagnostic COT contributes to the development of reflection and self-assessment skills, to the identification of gaps and their subsequent elimination. This allows future teachers to adapt more effectively to the conditions of the educational process and to achieve the planned results envisaged by the curricula. Future research should focus on determining the impact of diagnostic COT on the correction and reduction of educational losses of future geography teachers and on assessing the long-term effects of their use.

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CONFLICT OF INTEREST

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Застосування діагностичних компетентнісно орієнтованих завдань як засіб подолання освітніх втрат майбутніх учителів географії

Анотація. Актуальною є проблема виникнення та подолання освітніх втрат майбутніх вчителів географії у закладах вищої освіти України за умов сучасних викликів: наслідків пандемії COVID-19, військових дій та воєнного стану. Метою дослідження було теоретичне обґрунтування методичних засад застосування діагностичних компетентнісно орієнтованих завдань як засобу мінімізації освітніх втрат здобувачів на основі емпіричного дослідження. У дослідженні застосовано методи аналізу, синтезу та систематизування при опрацюванні джерельної бази. Задля з'ясування причин виникнення освітніх втрат, визначення їх обсягу і змісту використовувались методи тестування, педагогічного спостереження та бесіди. Здійснено систематизування термінів «освітні втрати», «навчальні прогалини», «навчальні розриви» як педагогічних категорій; проаналізовано причини виникнення освітніх втрат, масштаб і тривалість їхнього впливу, способи їх подолання. Обґрунтували поетапний алгоритм корегування освітніх втрат, необхідність використання цифрових засобів навчання, схарактеризували позитивні й негативні наслідки застосування штучного інтелекту задля подолання освітніх втрат здобувачів. У роботі визначено сутність діагностичних компетентнісно орієнтованих завдань, проведенню дослідження обсягу і змісту освітніх втрат на основі їх застосування, наведено приклади авторських діагностичних завдань з дисципліни «Методика навчання географії», розроблено графічну схему процесу усвідомлення та корекції освітніх втрат за допомогою цих завдань. Результатом дослідження авторів стала розроблена методична модель оцінювання й подолання освітніх втрат, яка має прикладне значення і може бути використана викладачами закладів освіти

Ключові слова: здобувачі вищої освіти; навчальні прогалини; навчальні розриви; штучний інтелект; методична модель

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