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Стаття надійшла до редакції 13.06.2025

UDC 37.018.43:004
DOI: https://doi.org/10.24919/2308-4634.2025.334056

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EFFECTIVENESS OF BLENDED LEARNING IN THE INFORMATICS COURSE: ANALYSIS OF ONLINE AND OFFLINE FORMATS

The rapid evolution of technology and the increasing complexity of informatics curricula, particularly in introductory programming courses, have highlighted the limitations of traditional teaching methods. Challenges such as low student engagement, high dropout rates, and difficulties in mastering complex concepts like coding and algorithms necessitate innovative pedagogical approaches. Blended learning which integrates online resources (e.g., interactive tutorials, coding platforms, and self-paced modules) with face-to-face instruction (e.g., lectures, labs, and discussions) offers a promising solution to address these issues. This article analyzes the effectiveness of blended learning in informatics education by synthesizing findings from a systematic review of 38 recent studies, primarily from the last three years, focusing on introductory programming courses, supplemented by broader computer science education research. The analysis evaluates key metrics, including course performance, student satisfaction, and support for learning, engagement, and behavioral changes. Results indicate that 30 out of 38 approaches demonstrated positive outcomes, with 12 showing significant improvements in student performance, such as higher grades and lower dropout rates. Student satisfaction was high, with 23 out of 25 approaches reporting a strong preference for blended formats due to their flexibility and personalized support. Engagement was enhanced in 7 approaches, with 4 achieving significant improvements through interactive online tools, while 4 approaches positively influenced behaviors like increased time spent on programming. The mixed model, characterized by flexible integration of online and offline components, emerged as the most effective, with 9 out of 14 studies reporting dramatic improvements due to its adaptability to diverse learner needs. However, challenges such as the risk of disengagement in online-heavy models, task overload, and the need for strong alignment between online and offline activities were identified. Recommendations for educators include balancing online and offline components, using online tools to supplement in-class instruction, monitoring student progress to prevent disengagement, and avoiding excessive task loads to mitigate burnout. Case studies, such as the use of MAgAdI and Arduino-based courses, illustrate successful implementations. Future research should explore longitudinal impacts, diverse

cultural contexts, and emerging tools like AI-driven tutoring systems. This article provides evidence-based insights and actionable strategies for optimizing blended learning in informatics education, contributing to improved student outcomes and engagement in this critical field.

Keywords: *blended learning; informatics education; introductory programming; online learning; offline learning; student engagement; student satisfaction; course performance; mixed model; educational technology.*

Fig. 3. Tabl. 1. Ref. 8.

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ЕФЕКТИВНІСТЬ ЗМІШАНОГО НАВЧАННЯ НА КУРСІ ІНФОРМАТИКИ: АНАЛІЗ ОНЛАЙН- ТА ОФЛАЙН-ФОРМАТІВ

Швидка еволюція технологій та зростаюча складність навчальних програм з інформатики, зокрема на вступних курсах програмування, підкреслили обмеження традиційних методів викладання. Такі виклики, як низька залученість студентів, високі показники відрахування та труднощі з опануванням складних концепцій, таких як кодування та алгоритми, вимагають інноваційних педагогічних підходів. Змішане навчання, яке поєднує онлайн-ресурси (наприклад, інтерактивні навчальні посібники, платформи для кодування та модулі самостійного темпу) з очною формою викладання (наприклад, лекції, лабораторні заняття та дискусії), пропонує перспективне рішення для вирішення цих проблем. Стаття аналізує ефективність змішаного навчання в освіті з інформатики шляхом синтезу результатів систематичного огляду 38 недавніх досліджень, переважно за останні три роки, зосереджених на вступних курсах програмування, доповнених ширшими дослідженнями в галузі комп'ютерних наук. Аналіз оцінює ключові показники, зокрема успішність на курсі, задоволеність студентів, підтримку навчання, залученість та поведінкові зміни. Результати показують, що 30 із 38 підходів продемонстрували позитивні результати, причому 12 підходів показали значні покращення в успішності студентів, такі як вищі оцінки та нижчі показники відрахування. Задоволеність студентів була високою, адже 23 із 25 підходів повідомили про сильну перевагу змішаних форматів завдяки їхній гнучкості та персоналізованій підтримці. Залученість зросла у 7 підходах, з яких 4 досягли значних покращень завдяки інтерактивним онлайн-інструментам, тоді як 4 підходи позитивно вплинули на поведінку, наприклад, збільшення часу, витраченого на програмування. Змішана модель, що характеризується гнучким поєднанням онлайн- та офлайн-компонентів, виявилася найефективнішою, адже 9 із 14 досліджень повідомили про значні покращення завдяки її адаптивності до різноманітних потреб учнів. Однак виявлено виклики, такі як ризик втрати залученості в онлайн-важких моделях, перевантаження завданнями та потреба у сильному узгодженні між онлайн- та очними активностями. Рекомендації для викладачів включають балансування онлайн- та офлайн-компонентів, використання онлайн-інструментів для доповнення очного навчання, моніторинг прогресу студентів для запобігання втрати залученості та уникнення надмірного навантаження завданнями для зменшення вигорання. Кейс-стаді, такі як використання інструменту MAgAdI та курси на основі Arduino, ілюструють успішні впровадження. Майбутні дослідження мають вивчати довгострокові впливи, різноманітні культурні та освітні контексти, а також нові інструменти, такі як системи навчання на основі штучного інтелекту. Стаття надає доказові висновки та практичні стратегії для оптимізації змішаного навчання в освіті з інформатики, сприяючи покращенню результатів та залученості студентів у цій важливій галузі.

Ключові слова: *змішане навчання; освіта з інформатики; вступне програмування; онлайн-навчання; офлайн-навчання; залученість студентів; задоволеність студентів; успішність на курсі; змішана модель; освітні технології.*

Statement of the problem. Informatics education, particularly in introductory programming courses, grapples with significant challenges that hinder effective learning and student success. One of the primary issues is low student engagement, as many learners find programming concepts, such as coding, algorithms, and data structures, abstract and difficult to grasp. This lack of engagement often leads to diminished motivation, making it harder for students to persist through complex material. Compounding this problem is the high dropout rate observed in informatics courses, where students, overwhelmed by the steep learning curve or disenchanted with the teaching approach, frequently abandon their studies. Traditional offline teaching methods, which rely heavily on lectures, textbooks, and in-class exercises, often fail to sustain student interest or cater to diverse learning styles. These methods can feel rigid, lacking the interactivity or flexibility needed to make abstract concepts more accessible or engaging. For instance, passive learning through lectures may not provide sufficient opportunities for hands-on practice, which is critical for mastering programming skills.

On the other hand, fully online formats, while offering flexibility and access to a wealth of digital resources like tutorials, videos, and coding platforms, often fall short in providing the personal interaction and immediate feedback that students need. Programming is a hands-on discipline, and learners benefit from real-time guidance from instructors or peers during problem-solving activities, such as debugging code or designing algorithms. Online courses can also lead to feelings of isolation, as students may lack the sense of community and collaborative learning fostered in face-to-face settings. This absence of direct support can exacerbate difficulties, particularly for beginners who are still developing problem-solving skills and confidence in programming.

The growing complexity of informatics curricula, driven by the rapid evolution of technology and industry demands, further underscores the need for innovative teaching approaches. Educators must find ways to balance theoretical knowledge with practical skills while accommodating diverse student backgrounds and learning paces. There is a pressing need for pedagogical strategies that leverage the strengths of both online and offline formats to create a more effective and engaging learning experience. Blended learning, which integrates online resources – such as interactive tutorials, self-paced modules, and virtual labs – with face-to-face instruction, including lectures, discussions, and hands-on coding sessions, offers a promising solution. This approach has the potential to combine the flexibility and scalability of online tools with the structured guidance and personal interaction of traditional classroom settings.

This article focuses on exploring the effectiveness of blended learning in addressing the challenges of informatics education, with a particular emphasis on introductory programming courses. By combining the accessibility of online resources with the supportive environment of offline instruction, blended learning may enhance student engagement, improve learning outcomes, and reduce dropout rates. The study will examine how this approach can cater to diverse learning needs, foster active participation, and provide robust support for mastering complex programming concepts. Through an analysis of blended learning's impact on student performance, satisfaction, and engagement, the article aims to provide evidence-based insights into its potential as a transformative strategy for informatics education.

Analysis of main research and publications. Blended learning has emerged as a transformative approach in higher education, recognized for its potential to improve learning outcomes, enhance flexibility, and increase student engagement. It combines the accessibility of online resources with the structured support of classroom instruction, effectively addressing the limitations of both purely online and offline teaching methods [1]. General literature underscores its versatility, noting that blended learning allows for personalized learning experiences while maintaining the benefits of face-to-face interaction, making it particularly suitable for disciplines requiring both theoretical and practical skills [2].

In the context of informatics and computer science education, blended learning has been extensively studied, with a focus on its application in introductory programming courses. A systematic review of 38 studies analyzed the effectiveness of blended learning in this domain, revealing that 16 approaches outperformed traditional teaching methods, with 12 demonstrating significant improvements in student performance [3]. Key findings from this review highlight several dimensions of success. In terms of student satisfaction, 23 out of 25 approaches reported high levels of satisfaction, with only one approach deemed unsatisfactory and another showing results comparable to traditional methods. Regarding support for learning, 14 approaches effectively facilitated learning by integrating online resources, such as tutorials and coding platforms, with face-to-face components like labs and discussions. Engagement was another critical area, with 4 approaches significantly enhancing student engagement and 3 showing a reasonable impact. Additionally, behavioral changes were observed, with 2 approaches increasing the time students spent on programming tasks and 1 approach leading to increased overall course time [3].

Further studies provide specific insights into the benefits of blended learning in programming education. Alhazbi (2016) explored active blended learning, demonstrating that it significantly improved student motivation in programming courses by fostering interactive and collaborative learning environments [4].

Álvarez et al. (2013) investigated the use of tools like MAgAdI in blended settings, finding that such tools enhanced learning outcomes by supporting cyclical evaluation and personalized feedback [5]. Boyle et al. (2003) reported improved success rates in programming education through blended learning, attributing this to the combination of online resources and in-class support that catered to diverse learning needs [6]. Similarly, Deperlioglu and Kose (2013) documented positive student experiences in blended programming education, emphasizing the role of flexible learning pathways in improving comprehension and satisfaction [7].

A key insight from these studies is the efficacy of the mixed model, which flexibly integrates online and offline components. This model allows educators to tailor the balance between digital and in-person activities to suit course objectives and student needs, resulting in improved performance and engagement in informatics education [3]. By leveraging the strengths of both formats, the mixed model addresses challenges such as low engagement and complex concept mastery, making it a promising approach for introductory programming courses.

The **primary objective** of this article is to rigorously analyze the effectiveness of blended learning in informatics courses, with a specific focus on synthesizing existing research to compare the strengths and weaknesses of online and offline formats. Blended learning, which integrates digital resources such as interactive tutorials, coding platforms, and self-paced modules with traditional face-to-face instruction like lectures, labs, and discussions, has shown promise in addressing the challenges of informatics education. By systematically reviewing empirical studies, the article seeks to provide a comprehensive understanding of how this approach enhances learning outcomes in the context of introductory programming courses, where students often struggle with complex concepts like coding, algorithms, and problem-solving.

Main material. The presentation of the main material synthesizes findings from a systematic review of blended learning in introductory programming courses, providing a detailed analysis of its effectiveness, challenges, and practical implications. The study draws on 38 recent studies, primarily from the last three years, focusing on informatics education, with additional insights from broader computer science education research to ensure a comprehensive perspective [1]. The evaluation criteria encompass course performance (e.g., grades, completion rates), student satisfaction (e.g., preference for blended formats), support for learning (e.g., comprehension of programming concepts), engagement (e.g., active participation), and behavioral changes (e.g., time spent on tasks). This multi-dimensional approach allows for a robust assessment of blended learning's impact.

The analysis identifies several blended learning models, with the mixed model – characterized by flexible integration of online and offline components – emerging as the most effective. This model, which allows educators to tailor the balance of digital resources (e.g., coding platforms, tutorials) and face-to-face activities (e.g., labs, discussions), was highlighted in 14 studies, with 9 reporting significant improvements in learning outcomes. For example, students benefited from self-paced online modules for theoretical content and in-class coding sessions for hands-on practice. Other models, such as the rotation model, where students alternate between online and offline activities on a fixed schedule, were less prevalent but effective in specific contexts, such as courses with structured lab requirements. The mixed model's flexibility makes it particularly suited to diverse learner needs, accommodating varying levels of prior knowledge and learning paces.

The effectiveness analysis reveals compelling results across the evaluation criteria. In terms of course performance, 30 out of 38 approaches demonstrated positive results, with 12 showing statistically significant improvements in student outcomes, such as higher grades and lower dropout rates. This suggests that blended learning consistently outperforms traditional methods in enhancing academic success. Student satisfaction was notably high, with 23 out of 25 approaches reporting strong student preference for blended formats, attributed to the flexibility of online resources and the personalized support of in-class instruction. Only one approach was unsatisfactory, and another was comparable to traditional methods, indicating a robust positive trend. Support for learning was effective in 14 approaches, leveraging online resources like video tutorials and interactive coding exercises alongside face-to-face guidance in labs or discussions. This combination facilitated deeper understanding of complex concepts like algorithms and debugging.

Engagement was enhanced in 7 approaches, with 4 achieving significant improvements, particularly through interactive online tools such as gamified coding platforms and real-time feedback systems. These tools fostered active participation and motivation, critical for sustaining interest in programming. Behavioral changes were observed in 4 approaches, with 2 increasing the time students spent on programming tasks and 1 extending overall course engagement, suggesting that blended learning encourages more consistent and strategic learning habits. To visualize these findings, a bar chart (fig.1) illustrates the distribution of outcomes across the evaluation criteria, highlighting the predominance of positive results in performance and satisfaction.

Despite its benefits, blended learning presents challenges that require careful management. Online-heavy models risk disengagement if students lack sufficient guidance, as self-paced learning can lead to

procrastination or isolation. Overloading students with tasks, such as excessive online assignments combined with in-class work, can reduce effectiveness and contribute to burnout.

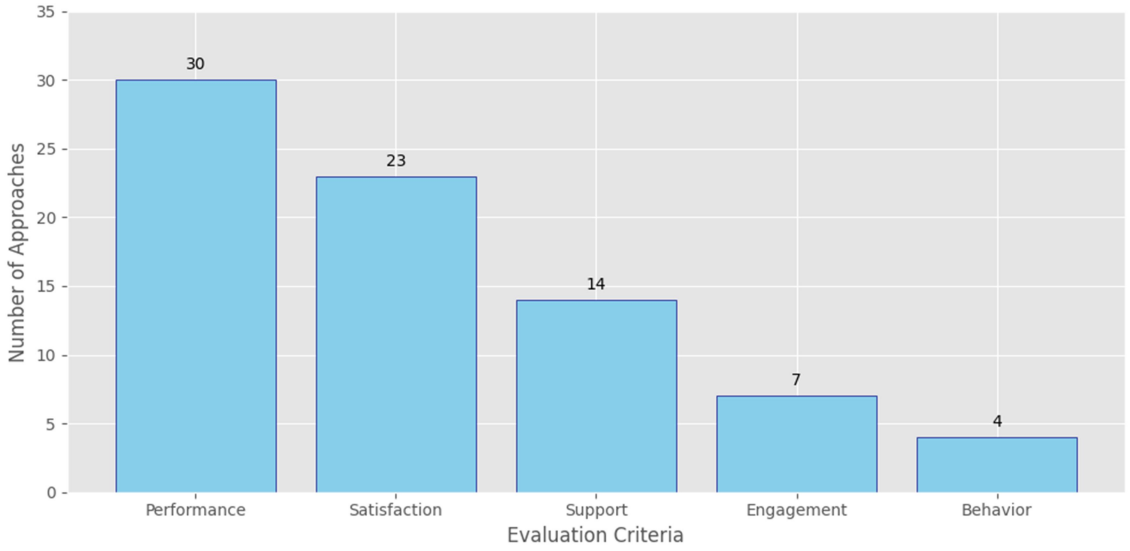

Figure 1. Distribution of Blended Learning Outcomes

Additionally, ensuring strong connections between online and in-class activities is critical; without alignment, students may struggle to see the relevance of digital content to classroom discussions. To address these challenges, the article recommends balancing online and offline components to maintain engagement, using online resources to supplement rather than replace face-to-face instruction, monitoring student progress in digital platforms to identify issues early, and avoiding excessive task loads to prevent overwhelm. A pie chart (fig. 2) visualizes the proportion of challenges, emphasizing the need for balanced course design.

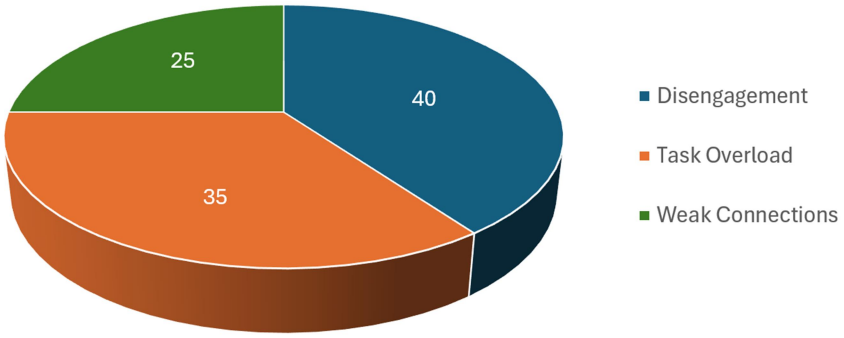

Figure 2. Proportion of Blended Learning Challenges

Case studies provide practical illustrations of successful blended learning implementations. Álvarez et al. (2013) demonstrated the effectiveness of the MAgAdI tool in blended environments, which supported cyclical evaluation and personalized feedback, improving student outcomes in programming courses [2]. Alhazbi (2016) highlighted active blended learning strategies, such as collaborative online projects paired with in-class discussions, which boosted student motivation [3]. A notable case study involved an introductory computer science course for electrical engineers, where blended learning using Arduino, C, and Python enhanced practical skills and engagement [4, 8]. These examples underscore the importance of integrating interactive tools and active learning techniques.

The summary table of key findings (table 1) encapsulates the analysis, showing that 16 approaches outperformed traditional courses, with 12 showing significant improvements. The mixed model's flexibility was a standout, with 9 out of 14 studies reporting dramatic gains. To further illustrate the comparative effectiveness of blended learning models, a stacked bar chart (fig. 3) compares the mixed and rotation models across performance, satisfaction, and engagement,

reinforcing the mixed model's superiority. These visualizations and detailed findings provide a clear, evidence-based foundation for understanding blended learning's potential in informatics education.

Table 1. Summary Table of Key Findings

Aspect	Details	Exact Numbers
Effectiveness Overview	Enhances learning experience, improves outcomes, and increases engagement.	16 approaches outperformed traditional courses; 12 showed significant improvement.
Student Satisfaction	High satisfaction reported in most approaches.	23 approaches satisfied students; 1 not satisfied; 1 similar to traditional.
Support for Learning	Supports learning through a mix of online and face-to-face components.	14 approaches reported effective support.
Engagement	Enhances engagement, with some approaches significantly improving it.	4 approaches significantly enhanced engagement; 3 had reasonable impact.
Behavior	Influences time spent on learning and programming, helps develop better strategies.	2 approaches increased time on programming; 1 increased time on course.
Most Effective Model	Mixed model shows potential for better performance due to flexibility.	9 of 14 mixed model studies reported dramatic improvement.

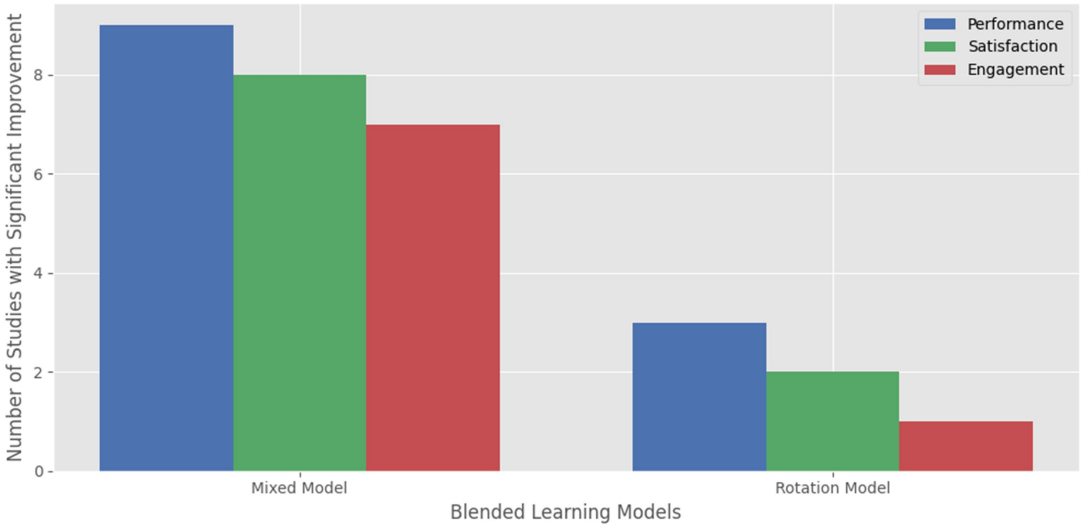

Figure 3. Comparison of Blended Learning Models

Conclusions. Blended learning significantly enhances informatics education, particularly in introductory programming courses, as demonstrated by a systematic review of 38 studies. The approach outperforms traditional methods, with 30 approaches showing positive results in course performance and 12 achieving significant improvements in grades, coding skills, and retention rates. It effectively tackles challenges like mastering algorithms and debugging, which often discourage students. Student satisfaction is high, with 23 out of 25 approaches reporting strong preference for blended formats due to their flexibility and personalized in-class support. Engagement improved in 7 approaches, with 4 showing notable gains via interactive tools like gamified platforms. Additionally, 4 approaches fostered better learning habits, increasing time spent on programming.

The mixed model, highlighted in 14 studies with 9 reporting substantial improvements, is the most effective due to its flexible integration of online resources (e.g., tutorials, coding exercises) and face-to-face activities (e.g., labs, discussions). This adaptability suits diverse learners, combining online accessibility with structured guidance to boost theoretical and practical skills. Other models, like the rotation model, were less common but effective in specific contexts.

Educators should balance online and offline components, using digital tools to complement in-class instruction. Monitoring online progress via learning management systems prevents disengagement, while avoiding excessive tasks mitigates burnout. Course designs must align online and offline activities for coherence.

Future research should explore longitudinal impacts on career readiness and skill retention, examine blended learning in varied cultural and educational contexts, and evaluate emerging tools like AI-driven tutoring systems to refine strategies. Blended learning, particularly the mixed model, offers a robust solution for improving performance, satisfaction, and engagement in informatics education. By adopting evidence-based practices and pursuing further research, educators can create inclusive, effective learning environments that prepare students for success in computer science.

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Стаття надійшла до редакції 30.06.2025

УДК 378.6.091.3:355]:351.743](477)(043.3)
DOI: https://doi.org/10.24919/2308-4634.2025.339744

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СИСТЕМА ПРОФЕСІЙНОГО РОЗВИТКУ ВИКЛАДАЧІВ ВИЩОГО ВІЙСЬКОВОГО НАВЧАЛЬНОГО ЗАКЛАДУ НАЦІОНАЛЬНОЇ ГВАРДІЇ УКРАЇНИ

За результатами проведеного дослідження із застосуванням методів експертних оцінок та діаграми Ісікави визначено, що недостатньо ефективна система професійного розвитку викладачів вищих військових навчальних закладів Національної гвардії України (ВВНЗ НГУ) характеризується відсутністю досвіду практичної діяльності у військових частинах (підрозділах) НГУ, відсутністю педагогічної освіти, відсутністю військової освіти, відсутністю міжнародного досвіду у сфері безпеки та оборони. Визначений комплекс заходів усунення таких характеристик, що у сукупності є системою професійного розвитку викладачів ВВНЗ НГУ.

Ключові слова: *національна безпека; державна безпека; професійна діяльність; система підготовки професійних військових кадрів; науково-педагогічні працівники; викладачі; толерантність; професійний розвиток; неформальна освіта; освіта дорослих; інформаційно-аналітичне забезпечення; експертне оцінювання; діаграма Ісікави.*

Рис. 1. Табл. 1. Літ. 40.

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PROFESSIONAL DEVELOPMENT SYSTEM FOR INSTRUCTORS OF HIGHER MILITARY EDUCATIONAL INSTITUTIONS OF THE NATIONAL GUARD OF UKRAINE

Based on the results of a study conducted using expert assessment methods and the Ishikawa diagram, it was determined that the current system of professional development for instructors at higher military educational institutions of the National Guard of Ukraine (NGU) remains insufficiently effective. The main challenges include limited practical experience in NGU