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Environmental education as an innovative pedagogical strategy for sustainable development: A case study of teacher training

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Abstract. The article presented the results of an empirical study examining the potential of environmental education as an innovative pedagogical strategy for sustainable development within the system of training future teachers. The aim of the study was to analyse the effectiveness of a series of guest lectures involving international (European Union countries and the United Kingdom) and Ukrainian practitioners and researchers as a tool for implementing the principles of education for sustainable development, lifelong learning, and universal design for learning. The research was grounded in a mixed qualitative-quantitative approach, employing a case study as the primary methodological design. The empirical basis was an educational case study conducted by the Department of Botany, Ecology and Horticulture at Bohdan Khmelnytsky Melitopol State Pedagogical University (Ukraine), within a series of ten hybrid-format guest lectures was implemented during 2025. The study involved 350 participants, including students of pedagogical specialities, academic staff, and representatives of other educational institutions. To assess the impact of the educational intervention, a pre-test/post-test questionnaire design based on a five-point Likert scale was applied. The results were analysed using descriptive statistics and Wilcoxon's non-parametric signed-rank test for dependent samples. The findings demonstrated statistically significant positive dynamics in participants' awareness of environmental education and sustainable development, their attitudes towards lifelong learning, and their readiness to implement inclusive and innovative pedagogical practices. Comparative analysis revealed that students showed greater increases in motivation and knowledge, whereas teachers demonstrated a higher level of readiness to integrate the acquired experience into their professional practice. The practical value of the study lies in the possibility of applying its results by higher education institutions and teacher training centres for designing and implementing sustainable, inclusive, and innovation-oriented professional development programmes

Keywords: education for sustainable development; universal design for learning (UDL); lifelong learning; guest lectures; training of future teachers; pedagogical innovations

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Introduction

Global environmental changes, climate instability and growing social risks are transforming the role of education in modern society. Educational systems can no longer be limited to the transfer of knowledge – they must develop sustainable development competencies, critical thinking skills, adaptability, and readiness to act in conditions of uncertainty. This issue is particularly relevant in the training of future teachers, as they are the conduits of environmental and social values in the school environment. In the context of crisis transformations and the digitalisation of the educational space, environmental education is emerging not only as a substantive component of teacher training, but also as an innovative pedagogical strategy capable of ensuring the integration of the principles of sustainable development, inclusiveness and flexibility in learning.

Contemporary international research confirms the need for the systematic integration of education for sustainable development (ESD) into higher education. J. Holst *et al.* (2024), analysing the implementation of SDG 4.7, found that teacher training is a critical factor for the successful implementation of sustainable development, but in most countries the integration of ESD remains fragmented. The authors emphasise the need to move from declarative programmes to practice-oriented learning models. H. Bui *et al.* (2024), researching the capacity of universities to implement the Sustainable Development Goals, concluded that the effectiveness of ESD depends on institutional support, interdisciplinarity and the use of innovative educational formats. The researchers emphasise the importance of active learning methods for the formation of long-term competencies.

The issue of forming sustainable development competencies in higher education was also considered by A. Annelin & G.-O. Boström (2024). In their proposed model for supporting sustainability competence, they demonstrated that inter-institutional interaction and reflective educational practices contribute to the transformation of the professional attitudes of future specialists. Similar results were presented by X. Qu & B. Cross (2024), who showed that inclusive learning design increases student engagement and promotes deeper learning. Contemporary research pays particular attention to universal design for learning (UDL) as a tool for ensuring inclusiveness. J. Griful-Freixenet *et al.* (2020) empirically proved that the implementation of UDL principles in teacher training programmes has a positive effect on teachers' readiness to work with diverse groups of learners. The research confirms that the integration of UDL promotes the development of pedagogical flexibility and professional reflection.

Research by N. Ullah *et al.* (2021) shows that digital learning environments increase student engagement when integrated into a sustainable development strategy. Empirical studies of interactive learning formats also confirm their effectiveness. A. Alshahrani (2024) proved that involving guest experts in the learning process increases motivation and promotes the connection between theory and professional practice. M. Ma (2025), analysing the strategic use of guest lectures, found an increase in students' academic activity and communication skills. The pedagogical value of guest lectures in strengthening professional readiness has also been confirmed by D. Pepple *et al.* (2025), who, drawing on Self-Determination Theory, demonstrate that structured interaction with external professionals enhances students' intrinsic motivation, employability skills, and professional self-efficacy. Their empirical findings indicate that exposure to real-world expertise contributes to the development of communication competencies and applied knowledge, which directly correlates with the increased readiness for professional practice observed in the present study.

In the Ukrainian scientific community, the issues of sustainable development and digital transformation of education are also being actively researched. O. Kovalenko & I. Kutelmah (2025) justified the need to update the system of professional development of teachers in accordance

with UNESCO's international recommendations and emphasises the importance of continuing education. T. Odintsova (2024) argues that the formation of ESG competencies is a key condition for the professional sustainability of educators in the context of global challenges. An analysis of educational practices in crisis conditions, presented by L. Gutierrez-Bucheli *et al.* (2022), confirms that the integration of environmental issues with inclusive approaches increases the adaptability of educational systems.

Despite the significant number of contemporary studies, most of them are conceptual or review in nature. There are still only a limited number of empirical studies that combine environmental education, universal design for learning principles, and interactive educational formats in the training of future teachers. In particular, there is a lack of research that records quantifiable changes in the knowledge, motivation, and professional readiness of different groups of participants in the educational process. Therefore, there is a need for a comprehensive empirical analysis of the integration of environmental education as an innovative pedagogical strategy into the system of training future teachers.

The aim of the study was to empirically determine the impact of integrating environmental education, universal design principles, and interactive educational formats on the formation of sustainable development competencies in future teachers in the context of contemporary socio-educational transformations. The objectives of the study were: to analyse the educational potential of guest lectures in the system of training future teachers; assess changes in the perceptions of students and teachers regarding environmental education and sustainable development; identify opportunities for integrating universal design principles into informal and innovative educational practices.

Literature Review

ESD is seen as a key tool for shaping the values, competencies and behaviours needed to address global social, economic and environmental challenges. In contemporary scientific discourse, environmental education is seen not only as a component of education for sustainable development, but also as an independent pedagogical strategy aimed at shaping environmental awareness and responsible behaviour. Its key objective is to develop environmental literacy, the ability to analyse environmental problems and make informed decisions in the context of complex socio-environmental interactions (UNESCO, 2020). It is precisely this pedagogical strategy that is now seen as a factor in educational innovation, as it combines content, methods and values for the training of future teachers.

At the international level, education for sustainable development is increasingly linked to the idea of transformative learning, which involves changing the ways of thinking of learners, rather than just transferring knowledge. In this context, emphasis is placed on the need to develop critical thinking, the ability to analyse systems and make decisions in conditions of uncertainty (Lotz-Sisitka *et al.*, 2015). This approach differs from traditional learning in that it focuses on reflection, social impact and active participation in projects, which is an essential element of 21st century teaching practice. For example, ESD programmes in the European Union integrate transformative components into teacher training programmes through project-based tasks and collaboration with local communities, which promotes the practical application of knowledge (Hadjiachilleos & Zachariou, 2022). In this context, environmental education is increasingly interpreted as an innovative pedagogical response to the challenges of climate change and environmental instability. Innovative approaches allow for the integration of environmental knowledge, values, and practical actions into the learning process, which is especially important for training future teachers who are able to work in conditions of uncertainty and social transformation (Barth *et al.*, 2007). Thus, innovative environmental education is becoming not only a substantive component of teacher training, but also a

strategic educational practice that shapes readiness for action in the modern world.

Researchers pay particular attention to the link between ESD and Sustainable Development Goal 4.7, which emphasises the need to integrate sustainable development, human rights and global citizenship into educational policies and practices. Monitoring the implementation of this goal shows significant variation in approaches across countries and the need for unified indicators for assessing educational outcomes (Wiek *et al.*, 2011; Linnerud *et al.*, 2021). Comparative studies show that some countries (e.g. the Netherlands, Finland, Sweden) have more systematic approaches to integrating ESD into teacher training, while other countries are only just beginning their reforms. In teacher education, environmental training for future teachers should be considered an integrated component of professional competence, rather than an additional or optional element. Researchers emphasise that it is the systematic inclusion of environmental issues in teacher training programmes that creates the conditions for the formation of innovative pedagogical practices focused on sustainable development (Leicht *et al.*, 2018). These practices not only expand the professional arsenal of future educators, but also shape their ability to be agents of change in their own communities.

The development of digital technologies is significantly transforming education systems, creating new opportunities for implementing the principles of sustainable development. O. Zawacki-Richter *et al.* (2019) and F. Ferri *et al.* (2020) proved that in scientific literature, the digitalisation of education is seen as a factor in increasing the accessibility, inclusiveness and effectiveness of learning, especially in crisis and post-conflict situations. Smart learning environments based on the use of big data, artificial intelligence and blockchain technologies are increasingly being positioned as tools for ensuring transparency, security and personalisation of the educational process. Research N. Ullah *et al.* (2021) shows that the implementation of blockchain solutions in education contributes to increasing trust in educational outcomes and optimising management processes, which is consistent with sustainable development goals. At the same time, researchers emphasise that technological innovation is not an end in itself. Their effectiveness directly depends on pedagogical design and the ability of educational institutions to integrate digital solutions into the broader context of social responsibility and ethical standards (Punie, 2017). Thus, digital technologies should be seen as a means of supporting sustainable educational practices, rather than as an autonomous factor of change.

Inclusive education is an integral part of sustainable development, as it ensures equal access to quality education for all categories of learners. In contemporary research, inclusiveness is interpreted not only as the adaptation of the educational environment to the needs of persons with disabilities, but as a broader approach aimed at taking into account the diversity of educational needs and learning styles (Florian, 2015). The concept of universal design for learning is central to the development of inclusive educational practices. It involves designing the learning process in such a way as to minimise barriers and ensure flexibility in the ways in which material is presented, learners are engaged and learning outcomes are assessed (Rose, 2000). Research shows that the implementation of UDL principles has a positive impact on academic achievement and student motivation in various educational contexts. The application of the principles of inclusive pedagogy and universal design for learning in environmental education expands the opportunities for engaging different groups of learners in understanding sustainable development issues. For teacher training, this means developing the ability to adapt environmental content and teaching methods to different educational contexts, which enhances the innovative potential of environmental education was also considered by M. Priestley *et al.* (2015) and J. Griful-Freixenet *et al.* (2020). In addition, the use of digital technologies significantly expands the

possibilities for implementing inclusive education. The use of adaptive platforms, assistive technologies and multimodal resources allows the creation of educational environments that comply with the principles of equity and social sustainability (Punie, 2017; Ullah *et al.*, 2021).

The concept of lifelong learning is an important element of the theoretical basis for sustainable development in education. It involves the continuous updating of knowledge and skills throughout life in order to adapt to changes in society and the labour market. At the same time, the development of sustainable learning competencies includes self-regulation of learning activities and the ability to work effectively in different professional contexts, as confirmed by research on self-regulated sustainable learning (Taranto & Buchanan, 2020). In addition, conceptual approaches to adult education emphasise the importance of ESG competencies (environmental, social and governance), which are part of sustainable professional development considered by T. Odintsova (2024). Scientific publications emphasise that lifelong learning is closely linked to the development of key competences, in particular digital literacy, social responsibility and environmental awareness. Such competencies are necessary for the formation of the innovative potential of future educators and the effective integration of environmental education into the educational process (Barth *et al.*, 2007).

In the context of higher education, lifelong learning is seen as a strategic direction for the development of universities, which should act as centres of knowledge open to different age and social groups. V. Yahupov *et al.* (2023) argue that this strengthens the role of universities in achieving sustainable development goals and promotes social cohesion. An analysis of international research shows a growing scientific interest in environmental education as a factor in sustainable development and educational innovation. At the same time, most publications focus on conceptual models, policy documents or general recommendations. Empirical studies analysing specific cases of teacher training remain limited (Bui *et al.*, 2024). This necessitates further development of empirical research in the field of teacher training for sustainable development. The combination of environmental education with inclusive and innovative approaches in the context of social and educational crises is particularly under-researched. Contemporary challenges related to wars, migration and the transformation of education systems require an analysis of real educational practices capable of ensuring the sustainability and flexibility of teacher education (Lambrechts *et al.*, 2018; Gutierrez-Bucheli *et al.*, 2022).

The combination of environmental education, inclusiveness and technological innovation provides a comprehensive approach to developing sustainable thinking and behaviour in students, shaping future educators as agents of change. Thus, innovative environmental education acts not only as a substantive component, but also as a strategic pedagogical concept that integrates knowledge, values and practical actions to ensure sustainable development. The application of the principles of innovative environmental education in teacher training creates the potential for the transformation of education systems and the formation of a generation of educators capable of effectively implementing sustainable development concepts in the educational process.

Materials and Methods

The study was conducted using a mixed-methods research design combining qualitative and quantitative approaches. A case study methodology was selected as the main research strategy, as it enables a comprehensive analysis of educational practices within their real institutional and social context. This methodological approach allowed for an in-depth examination of the pedagogical potential of guest lectures as an innovative educational format for integrating the principles of ESD, lifelong learning, and UDL into the system of teacher training.

The empirical basis of the research was an institutional educational case implemented by

the Department of Botany, Ecology and Horticulture at Melitopol State Pedagogical University named after Bohdan Khmelnytsky (Ukraine). Between September and December 2025, a series of ten guest lectures was organised in a hybrid format, combining face-to-face and online participation. The lectures involved international practitioners and researchers from European Union countries and the United Kingdom, as well as domestic experts from Ukraine, specialising in environmental education, sustainable development, inclusive pedagogy, and innovative teaching methodologies. All lectures were officially announced through the university's website and digital communication channels, ensuring openness, transparency, and equal access to participation. The hybrid format made it possible to engage participants regardless of geographical location, which corresponds to the principles of inclusiveness and lifelong learning.

A total of 350 individuals participated in the study. The sample consisted of 220 bachelor's degree students enrolled in pedagogical specialities and 130 educators, including university academic staff, college instructors, and secondary school teachers. The age of student participants ranged from 18 to 23 years (mean age 20.4 years), while the age of educators ranged from 27 to 59 years (mean age 41.7 years). In terms of gender distribution, 68% of respondents were female and 32% male, reflecting the typical demographic structure of pedagogical education programmes in Ukraine. Participants represented several higher and secondary education institutions, which ensured inter-institutional diversity and strengthened the interdisciplinary and intergenerational character of the case study.

Data collection was carried out using a pre-test/post-test survey design. The questionnaire included ten items grouped into four thematic blocks addressing participants' knowledge of environmental education and sustainable development, their attitudes towards lifelong learning, their readiness to implement inclusive and innovative pedagogical practices, and their evaluation of the educational value of the guest lecture series. Responses were measured using a five-point Likert scale. Quantitative data were processed using descriptive statistics and the Wilcoxon signed-rank test for dependent samples to determine the statistical significance of changes between the pre-test and post-test results. In addition, elements of qualitative observation were used to analyse the organisation of educational interaction and participants' reflective engagement during the lectures.

The study was conducted in accordance with fundamental ethical principles of educational research. Participation was voluntary and based on informed consent obtained prior to data collection. Respondents were informed about the purpose of the study, the anonymity and confidentiality of their responses, and their right to withdraw from participation at any stage without any negative consequences. No personal identifying information was collected, and all data were analysed in aggregated form exclusively for research purposes. The research design complied with institutional academic integrity standards and data protection requirements. The study was conducted in accordance with ethical standards American Sociological Association's Code of Ethics (2018).

Guest lectures were held in a hybrid format and combined presentation materials, examples of practical experience from experts, interactive elements such as Mentimeter and Kahoot, and question and answer sessions, which contributed to the active involvement of participants and the development of reflective thinking. The format and content of the lectures were in line with the key principles of universal design for learning, in particular through the use of different ways of presenting information, varying forms of interaction, and creating conditions for reflection and discussion of the knowledge gained.

Lecture topics included environmental education and sustainable development with a focus on contemporary concepts and practical implementation; pedagogical innovations in teaching

natural sciences; the development of sustainable learning competencies among students of pedagogical specialities; inclusive practices in education for sustainable development; the application of digital technologies and smart learning environments in environmental education; the formation of critical thinking and systematic analytical skills in students; education for global citizenship and international approaches to its implementation; the role of universities in responding to social and educational crises while fostering sustainability; practical cases and international experience in implementing ESD programmes; and the integration of environmental and inclusive content into the professional training of future teachers.

The research methodology included the analysis of the educational content of the guest lectures with regard to their thematic structure and alignment with ESD and UDL principles; systematic observation of the organisation, format, and interactive components of educational interaction during the lecture cycle; and the administration of questionnaire surveys to participants before and after the completion of the lecture series in order to identify changes in knowledge, attitudes, and readiness to implement innovative and inclusive pedagogical practices. To assess the impact of the educational case study, a pre-test/post-test questionnaire design was used. The pre-test was conducted immediately before the first lecture in September 2025. The post-test was conducted after the completion of the lecture cycle in December 2025. This made it possible to record the dynamics of changes in the attitudes, level of awareness and self-assessment of participants regarding environmental education, sustainable development and lifelong learning.

Empirical data was collected using an anonymous questionnaire. The questionnaire was structured into four thematic blocks. The first block focused on the level of knowledge about environmental education and sustainable development and included statements assessing respondents' self-evaluation of their knowledge of sustainable development concepts on a five-point scale; their understanding of the principles of ESD on a five-point scale; and their awareness of current international practices in environmental education on a five-point scale. The second block addressed attitudes towards lifelong learning and included statements evaluating whether respondents considered lifelong learning important for their professional development on a five-point scale; and their readiness to independently seek new knowledge and professional experience beyond the formal curriculum on a five-point scale.

The third block examined readiness to integrate innovative and inclusive methods into professional practice and included statements assessing respondents' readiness to apply inclusive teaching methods on a five-point scale; their willingness to use digital technologies in teaching on a five-point scale; and their intention to participate in inter-institutional and international educational events on a five-point scale. The fourth block was aimed at evaluating the perceived value of the guest lectures and case studies and included statements measuring whether respondents considered guest lectures useful for broadening their professional horizons on a five-point scale; and whether the lectures contributed to a deeper understanding of the importance of environmental education and sustainable development on a five-point scale.

The questionnaire's scale questions were based on participants' self-assessment and used a five-point Likert scale, which allowed for a comparative analysis of the results before and after the lecture series. The data obtained was processed using descriptive statistics and comparative analysis to identify significant changes in participants' attitudes and self-assessment. A comparison of the results before and after the lecture cycle made it possible to record the dynamics of increasing the level of knowledge, readiness to apply innovative and inclusive methods, and the value of participating in international educational events. The approach used is research-descriptive in nature and aims to identify

the potential of educational innovations in the training of future teachers, rather than to statistically generalise the results to a wider population.

To assess the statistical significance of changes in participants' perceptions, knowledge and self-assessment before and after the series of guest lectures, the Wilcoxon signed-rank test for paired samples was used. This non-parametric test allows for the comparison of pre-test and post-test survey results, even if the data does not follow a normal distribution. The use of the Wilcoxon test made it possible to identify statistically significant changes in participants' assessments of their level of knowledge about environmental education and sustainable development, their willingness to apply inclusive methods, and their motivation to participate in international educational initiatives. This approach strengthens the analytical component of the study, allowing not only to describe the dynamics of changes, but also to confirm their statistical validity. The uniqueness and innovation of the case study lay in the combination of different educational approaches and tasks: the involvement of international and inter-institutional experts, the use of UDL principles, and the active implementation of the concept of lifelong learning through a series of guest lectures.

The limitations of the study are the local nature of the case and the limited sample of participants, which is compensated by the depth of analysis, practical orientation and relevance of the educational practice under study in the context of the transformation of teacher education. Thus, the case study allows for assessing the effectiveness of guest lectures as a tool for implementing ESD, integrating universal design principles and developing lifelong learning competencies in future teachers. For a more detailed assessment of the effect of the educational case study, the sample was divided into two main groups: students of pedagogical specialities (n = 220) – higher education seekers; teachers and other educators (n = 130) – scientific and pedagogical staff of the university, teachers and representatives of colleges and other educational institutions. The analysis was conducted in three key areas: knowledge of sustainable development and environmental education; attitudes towards lifelong learning; willingness to apply inclusive and innovative practices (UDL, digital tools, interactive methods).

Results and Discussion

Empirical research has shown that a series of guest lectures had a significant impact on the knowledge, attitudes and readiness of participants to apply the principles of sustainable development, innovative pedagogical practices and the principles of universal design for learning.

Changes in participants' knowledge. The average pre-test score for students in the knowledge block was 3.1 out of 5, while the post-test showed 4.0, indicating a significant increase in knowledge of sustainable development concepts, ESD principles and international practices. For teachers, the average pre-test score was 3.4, while the post-test score was 4.2, demonstrating a significant increase in competence, especially in understanding methodological approaches and practical cases. A detailed presentation of the pre-test and post-test results for both groups, including the values of the Wilcoxon signed-rank test for dependent samples, is provided in Table 1.

Table 1. *Pre-test/post-test results for the knowledge block (Wilcoxon signed-rank test)*

No.	Question	Students pre	Students post	Δ	W (students)	Teachers pre	Teachers post	Δ	W (teachers)
1	Knowledge of sustainable development concepts	3.0	3.9	+0.9	180	3.3	4.2	+0.9	75
2	Understanding of ESD principles	3.1	4	+0.9	185	3.4	4.3	+0.9	80

Table 1. *Continued*

No.	Question	Students pre	Students post	Δ	W (students)	Teachers pre	Teachers post	Δ	W (teachers)
3	International practices in environmental education	3.2	4	+0.8	170	3.5	4.2	+0.7	78

Source: *author's development*

Changes in attitudes towards lifelong learning. The results showed that guest lectures encouraged participants to make more active use of opportunities for continuing professional development. The average pre-test score for students was 3.2, post-test – 4.1, while for teachers – 3.5 and 4.2, respectively. Both groups showed positive dynamics in motivation to participate in international educational programmes and open online events. A detailed comparison of pre-test and post-test indicators for this block, including the results of the Wilcoxon signed-rank test for dependent samples, is presented in Table 2.

Table 2. *Pre-test/post-test results for the attitude block (Wilcoxon signed-rank test)*

No.	Question	Students pre	Students post	Δ	W (students)	Teachers pre	Teachers post	Δ	W (teachers)
4	Attitude towards lifelong learning	3.2	4	+0.9	190	3.5	4.2	+0.7	77
5	Motivation to participate in international programmes	3	3.9	+0.9	180	3	4.1	+0.8	75

Source: *author's development*

Readiness to apply inclusive and innovative practices. The block assessing readiness to integrate UDL, digital technologies and innovative methodologies showed significant improvements. Students increased their average score from 3.1 to 4.0, while teachers increased theirs from 3.4 to 4.2. The most significant changes were recorded in questions regarding the use of multimodal materials and interactive platforms (Mentimeter, Kahoot) in the learning process. A detailed presentation of the comparative pre-test and post-test results for this block, including the Wilcoxon signed-rank test statistics for dependent samples, is provided in Table 3.

Table 3. *Pre-test/post-test results for the innovation readiness block (Wilcoxon signed-rank test)*

No.	Question	Students pre	Students post	Δ	W (students)	Teachers pre	Teachers post	Δ	W (teachers)
6	Willingness to apply inclusive methods	3	3	+0.9	185	3	4.2	+0.9	78
7	Integration of environmental and inclusive content	3.1	4	+0.9	180	3.4	4.1	+0.7	75
8	Use of digital technologies	3.2	4	+0.8	175	3.5	4.2	+0.7	77

Source: *author's development*

Assessment of the value of lectures and case studies. The results of the analysis of block 4 showed that guest lectures significantly contributed to increasing participants' awareness of the value of the educational case study and broadening their professional horizons. The average pre-test score for students on the question "Lectures are useful for professional horizons" was 3.0, while the post-test showed 4.3, indicating a noticeable positive trend (+1.3). For teachers, the corresponding figures were 3.2 and 4.4 (+1.2), demonstrating a significant increase in the assessment of the value of lectures for their own professional activities.

Regarding the question "The lectures helped to realise the importance of environmental education", the average score for students increased from 3.1 to 4.4 (+1.3), while for teachers it increased from 3.3 to 4.5 (+1.2). The data obtained confirm that the series of guest lectures not only increases knowledge and motivation to apply innovative methods, but also contributes to a deeper understanding of the importance of environmental education and sustainable development. A detailed comparison of the pre-test and post-test results for this evaluation block, including the Wilcoxon signed-rank test statistics for dependent samples, is presented in Table 4.

Table 4. *Pre-test/post-test results for the lecture and case study evaluation block (Wilcoxon signed-rank test)*

No.	Question	Students pre	Post students	Δ	W (students)	Teachers pre	Teachers post	Δ	W (teachers)
9	Lectures useful for professional horizons	3	4	+1.3	190	3.2	4.4	+1.2	80
10	The lectures helped me realise the importance of environmental education	3.1	4	+1.3	192	3.3	4.5	+1.2	82

Source: *author's development*

The data obtained demonstrate statistically significant positive dynamics in all four blocks for both groups of participants ($p < 0.01$, Wilcoxon signed-rank test), which indicates the effectiveness of guest lectures as a tool for developing competencies in the field of sustainable development, integrating the principles of UDL and stimulating lifelong learning. For a comprehensive visual representation of the comparative pre-test and post-test mean values, together with the corresponding Wilcoxon test results (Fig. 1).

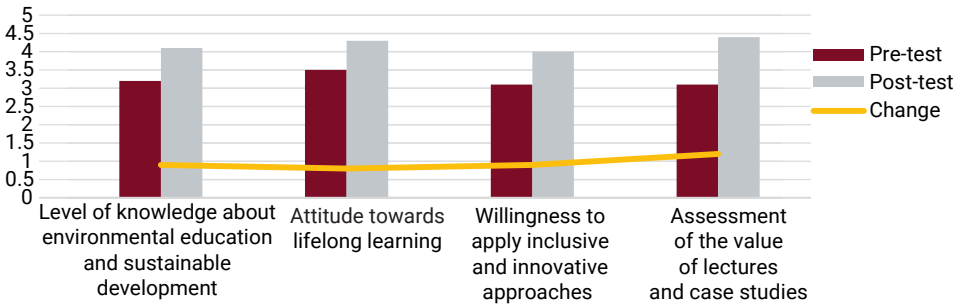

Figure 1. *Mean values for pre-test, post-test, and Wilcoxon test*

Source: *author's development*

A more detailed examination reveals specific characteristics of the responses of different groups: students demonstrated more pronounced dynamics in the blocks of knowledge and motivation for lifelong learning, which can be explained by their openness to new digital platforms and interactive methods (Mentimeter, Kahoot). They actively absorbed examples of international cases and digital resources, which was reflected in an increase in average scores of +0.9 in the knowledge block and +0.9 in the motivation block; teachers showed more noticeable changes in the blocks of readiness to apply innovative practices and UDL integration. This confirms the value of inter-institutional exchange of experience and practical training: teachers had the opportunity to try out tools for activating learning, adapt examples to their own courses, and improve their pedagogical competence in the field of sustainable development. The average increase in the block of readiness to apply innovations was +0.8-0.9 points, which is a high indicator for a group with teaching experience.

Guest lectures were held in a hybrid format, which ensured the active participation of participants from various educational institutions. The use of the interactive platforms Mentimeter and Kahoot contributed to increased engagement and reflective thinking. During the lectures, participants had the opportunity to evaluate practical case studies, discuss their own ideas and ask questions to experts. A survey showed that 82% of students acknowledged that interactive elements significantly increased their motivation and activity, and 78% of teachers noted that the lecture format provided valuable experience for integrating innovative methods into their own teaching.

The results of the present study are consistent with contemporary international research examining the pedagogical impact of guest lectures and inter-institutional collaboration in higher education. In particular, A. Alshahrani (2024), in a systematic review devoted to the use of guest speakers in university teaching, demonstrates that structured interaction with external experts significantly enhances student engagement, strengthens the connection between theoretical knowledge and professional practice, and improves learning outcomes. The author emphasises that exposure to authentic professional contexts contributes to the development of applied competencies and professional readiness. A similar position is articulated by M. Ma (2025), who analyses the strategic integration of guest speakers into academic programmes. M. Ma concludes that guest lectures function as a mechanism of practice-oriented learning, facilitating deeper comprehension of disciplinary content and increasing student motivation. The positive dynamics recorded in the study – particularly the statistically significant growth in knowledge and motivation for lifelong learning – correspond to these findings. The broader institutional dimension of sustainability education has been substantiated by A. Annelin & G.-O. Boström (2024). In their model of sustainability competence support, the authors demonstrate that inter-institutional collaboration and interdisciplinary exchange contribute to transformative learning and foster the development of sustainable thinking patterns. Likewise, X. Qu & B. Cross (2024), investigating inclusive higher education practices, show that collaborative and inclusive learning environments increase student participation and academic engagement. The inter-institutional composition of participants in the present case study aligns with these conclusions, as professional exchange between universities and colleges strengthened reflective dialogue and competence development.

The role of universal design for learning in teacher education has been empirically validated by J. Griful-Freixenet *et al.* (2020), who demonstrate that the systematic implementation of UDL principles enhances preservice teachers' readiness to apply inclusive methodologies. Their findings confirm that UDL not only ensures accessibility but also supports pedagogical flexibility and professional confidence. The observed increase in participants' readiness to apply inclusive and multimodal approaches in the present study corresponds

with these empirical results. The integration of digital technologies within sustainability-oriented education has also been explored in recent research. O. Zawacki-Richter *et al.* (2019) highlight that digital transformation in higher education strengthens personalisation and accessibility when grounded in sound pedagogical design. Complementary evidence provided by N. Ullah *et al.* (2021) indicates that technology-enhanced learning environments contribute to engagement and institutional transparency when aligned with strategic sustainability goals. The hybrid format and use of interactive platforms in the present study reflect these evidence-based approaches.

Inclusive and innovative strategies in contemporary education have additionally been examined by W.-K. Giera (2025), who demonstrates that inclusive learning communities foster communication skills and collaborative competencies. In the Ukrainian context, O. Kovalenko & I. Kutelmah (2025) argue that digital transformation and internationalisation of teacher professional development enhance institutional adaptability and lifelong learning orientation. Furthermore, M. Stevkovska *et al.* (2025) emphasise that active learning formats support critical thinking and long-term competence formation, reinforcing the importance of structured interactive engagement in higher education. Earlier analytical work by S. Gallagher & P. Murphy (2024), devoted to inter-institutional lifelong sustainability education initiatives, underscores that collaborative e-learning models strengthen knowledge exchange and support sustained professional growth. The outcomes of the present case study – particularly the statistically significant improvements across all analytical blocks – confirm these broader theoretical and empirical trends.

Taken together, the international and national evidence demonstrates that the strategic combination of guest lectures, universal design for learning principles, digital technologies, and inter-institutional cooperation creates a multidimensional pedagogical environment conducive to competence-based teacher education. The findings of this study not only correspond with existing research but also extend it by providing quantitative confirmation of measurable changes in knowledge, motivation, and professional readiness within a structured case study framework. Despite the local scope of the research, the results indicate the scalability of similar initiatives in other higher education institutions and confirm that hybrid and inclusive educational formats can significantly enhance accessibility, sustainability, and innovation in teacher training systems.

Conclusions

The aim of this study was to analyse environmental education as an innovative pedagogical strategy for sustainable development based on the case study of training future teachers at a higher education institution using guest lectures, universal design for learning principles and the concept of lifelong learning. The results obtained give grounds to assert that the set goal was fully achieved. Empirical data obtained from preliminary and final questionnaires showed statistically significant positive dynamics in all areas studied: level of knowledge of environmental education and sustainable development, attitude to lifelong learning, readiness to apply inclusive and innovative pedagogical practices, as well as assessment of the value of guest lectures as an educational format. The application of the Wilcoxon test for dependent samples confirmed the significance of the changes identified among both students and teachers, which indicates the effectiveness of the chosen educational approach regardless of the level of professional experience of the participants.

A comparative analysis of the results of the two groups of participants revealed differences in the nature of educational dynamics. Students demonstrated more pronounced growth in knowledge and motivation, which may be due to their openness to digital technologies, interactive formats, and international educational experience. At the same time, teachers showed significant positive changes in their readiness to integrate environmental, inclusive and innovative

content into their own teaching practice, which emphasises the importance of inter-institutional and inter-professional exchange of experience. An important result of the study is the confirmation that a series of guest lectures, implemented in a hybrid format and using the principles of universal design for learning, contributes to broadening the professional horizons of participants, raising awareness of the role of environmental education and forming a sustainable motivation for lifelong learning. The combination of international experience, practical cases and interactive methods has created an inclusive educational environment capable of responding to the current challenges of teacher education.

Thus, the results of the study confirm the feasibility of integrating environmental education, universal design principles, and innovative forms of informal education into the training of future teachers. Despite the local nature of the case study, the conclusions are of practical value and can be used to develop and scale similar educational initiatives in higher pedagogical education institutions. Prospects for further research are related to expanding the sample of participants, applying long-term (longitudinal) research designs, and studying the impact of digital and international educational environments on the formation of sustainable development competencies in the context of the transformation of teacher education.

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Conflict of Interest

None.

References

[1] Alshahrani, A. (2024). The use of guest speakers in higher education and implications for pharmaceutical teaching: A systematic review of literature. *F1000Research*, 13, article number 862. doi: 10.12688/f1000research.153968.1.

[2] American Sociological Association's Code of Ethics. (2018, June). Retrieved from https://www.asanet.org/wp-content/uploads/asa_code_of_ethics-june2018a.pdf.

[3] Annelin, A., & Boström, G.-O. (2024). Interdisciplinary perspectives on sustainability in higher education: A sustainability competence support model. *Frontiers in Sustainability*, 5, article number 1416498. doi: 10.3389/frsus.2024.1416498.

[4] Barth, M., Godemann, J., Rieckmann, M., & Stoltenberg, U. (2007). Developing key competencies for sustainable development in higher education. *International Journal of Sustainability in Higher Education*, 8(4), 416-430. doi: 10.1108/14676370710823582.

[5] Bui, H.T.M., Bui, T., & Pham, B.T. (2024). The role of higher education in achieving sustainable development goals: An evaluation of motivation and capacity of Vietnamese institutions. *The International Journal of Management Education*, 22(3), article number 101088. doi: 10.1016/j.ijme.2024.101088.

[6] Ferri, F., Grifoni, P., & Guzzo, T. (2020). Online learning and emergency remote teaching: Opportunities and challenges in emergency situations. *Societies*, 10(4), article number 86. doi: 10.3390/soc10040086.

[7] Florian, L. (2015). Inclusive pedagogy: A transformative approach to individual differences but can it help reduce educational inequalities? *Scottish Educational Review*, 47(1), 5-14. doi: 10.1163/27730840-04701003.

[8] Gallagher, S., & Murphy, P. (2024). Implementing inter-institutional lifelong sustainability education: The UNI-ECO e-learning case study. *Irish Journal of Academic Practice*, 11(2), article number 5. doi: 10.21427/6kt7-bm13.

[9] Giera, W.-K. (2025). The inclusive learning community: Theoretical arguments and practical insights in five school projects. *Sustainability*, 17(17), article number 8016. doi: 10.3390/su17178016.

[10] Griful-Freixenet, J., Struyven, K., & Vantieghem, W. (2020). Toward more inclusive education: An empirical test of the universal design for learning conceptual model among preservice teachers. *Journal of Teacher Education*, 72(3), 381-395. doi: 10.1177/0022487120965525.
[11] Gutierrez-Bucheli, L., Reid, A., & Kidman, G. (2022). Scoping reviews: Their development and application in environmental and sustainability education research. *Environmental Education Research*, 28(5), 645-673. doi: 10.1080/13504622.2022.2047896.
[12] Hadjiachilleos, S., & Zachariou, A. (2022). *Implementation of the UNECE strategy for ESD across the ECE region (2015-2018)*. Geneva: UNECE.
[13] Holst, J., Singer-Brodowski, M., Brock, A., & de Haan, G. (2024). Monitoring SDG 4.7: Assessing education for sustainable development in policies, curricula, training of educators and student assessment (input-indicator). *Sustainable Development*, 32(4), 3908-3923. doi: 10.1002/sd.2865.
[14] Kovalenko, O., & Kutelmah, I. (2025). Digital transformation of teacher professional development in UNESCO policy: International guidelines and the Ukrainian context. *UNESCO Chair Journal "Lifelong Professional Education in the XXI Century"*, 1(11), 7-21. doi: 10.35387/ucj.1(11).2025.0001.
[15] Lambrechts, W., Liedekerke, L.V., & Petegem, P.V. (2018). Higher education for sustainable development in Flanders: Balancing between normative and transformative approaches. *Environmental Education Research*, 24(9), 1284-1300. doi: 10.1080/13504622.2017.1378622.
[16] Leicht, A., Heiss, J., & Byun, W.J. (Eds.). (2018). *Issues and trends in education for sustainable development*. Paris: UNESCO Publishing. doi: 10.54675/YELO2332.
[17] Linnerud, K., Holden, E., & Simonsen, M. (2021). Closing the sustainable development gap: A global study of goal interactions. *Sustainable Development*, 29(4), 738-753. doi: 10.1002/sd.2171.
[18] Lotz-Sisitka, H., Wals, A.E., Kronlid, D., & McGarry, D. (2015). Transformative, transgressive social learning: Rethinking higher education pedagogy in times of systemic global dysfunction. *Current Opinion in Environmental Sustainability*, 16, 73-80. doi: 10.1016/j.cosust.2015.07.018.
[19] Ma, M. (2025). Enhancing student engagement and learning outcomes through strategic use of guest speakers in advertising education. *Journal of Advertising Education*, 29(1), 41-52. doi: 10.1177/10980482251325495.
[20] Odintsova, T. (2024). ESG competences and skills in lifelong education for sustainability. environment. In *Environment. Technology. Resources. Proceedings of the 15th international scientific and practical conference* (pp. 453-459). Rezekne: Rezekne Academy of Technologies. doi: 10.17770/etr2024vol2.8091.
[21] Pepple, D.G., Akaighe, G.O., Sambo, A., George-Aremu, O., Bosah, G., & Trollman, H. (2025). Using guest lectures to enhance student employability: Pedagogical considerations. *Cogent Education*, 12(1), article number 2452076. doi: 10.1080/2331186X.2025.2452076.
[22] Priestley, M., Biesta, G., & Robinson, S. (2015). *Teacher agency: An ecological approach*. London: Bloomsbury Academic. doi: 10.5040/9781474219426.
[23] Punie, Y. (Ed.). (2017). *European framework for the digital competence of educators: DigCompEdu*. Luxembourg: EU Publications. doi: 10.2760/159770.
[24] Qu, X., & Cross, B. (2024). UDL for inclusive higher education – what makes group work effective for diverse international students in UK? *International Journal of Educational Research*, 123, article number 102277. doi: 10.1016/j.ijer.2023.102277.
[25] Rose, D. (2000). Universal design for learning. *Journal of Special Education Technology*, 15(3), 45-49. doi: 10.1177/016264340001500307.
[26] Stevkovska, M., Klemenchich, M., Petrusheva, K.M., & Kurt, O. (2025). *Active learning in higher education*. Skopje: Balkan University Press. doi: 10.69648/PJKN7980.
[27] Taranto, D., & Buchanan, M.T. (2020). Sustaining lifelong learning: A self-regulated learning (SRL) approach. *Discourse and Communication for Sustainable Education*, 11(1), 5-15. doi: 10.2478/dcse-2020-0002.
[28] Ullah, N., Al-Rahmi, W.M., Alzahrani, A.I., Alfarraj, O., & Alblehai, F.M. (2021). Blockchain technology adoption in smart learning environments. *Sustainability*, 13(4), article number 1801. doi: 10.3390/su13041801.

[29] UNESCO. (2020). *Education for sustainable development: A roadmap*. Paris: UNESCO Publishing. doi: 10.54675/YFRE1448.
[30] Wiek, A., Withycombe, L., & Redman, C.L. (2011). Key competencies in sustainability: A reference framework for academic program development. *Sustainability Science*, 6, 203-218. doi: 10.1007/s11625-011-0132-6.
[31] Yahupov, V., *et al.* (2023). *Lifelong learning: Models and methods of implementation*. Kharkiv: PC Technology Center. doi: 10.15587/978-617-7319-70-1.
[32] Zawacki-Richter, O., Marín, V.I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, 16, article number 39. doi: 10.1186/s41239-019-0171-0.

Екологічна освіта як інноваційна педагогічна стратегія сталого розвитку: кейс-дослідження підготовки вчителів

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Анотація. У статті представлено результати емпіричного дослідження потенціалу екологічної освіти як інноваційної педагогічної стратегії сталого розвитку в системі підготовки майбутніх учителів. Метою дослідження був аналіз ефективності серії гостьових лекцій за участю міжнародних країн (Європейського Союзу та Великої Британії) і українських практиків та дослідників як інструменту впровадження принципів освіти для сталого розвитку, навчання впродовж життя та універсального дизайну навчання. Дослідження ґрунтувалося на змішаному якісно-кількісному підході із застосуванням кейс-стаді як основного методологічного дизайну. Емпіричною базою стало освітнє кейс-дослідження, проведене кафедрою ботаніки, екології та садівництва Мелітопольського державного педагогічного університету імені Богдана Хмельницького, у межах якого протягом 2025 року було реалізовано серію з десяти гостьових лекцій у гібридному форматі. У дослідженні взяли участь 350 учасників, зокрема студенти педагогічних спеціальностей, науково-педагогічні працівники та представники інших закладів освіти. Для оцінювання впливу освітнього втручання застосовано дизайн анкетування до і після (pre-test/post-test) на основі п'ятибальної шкали Лайкерта. Результати проаналізовано за допомогою описової статистики та непараметричного критерію знакових рангів Вілкоксона для залежних вибірок. Отримані результати продемонстрували статистично значущу позитивну динаміку обізнаності учасників щодо екологічної освіти та сталого розвитку, їх ставлення до навчання впродовж життя, а також готовності впроваджувати інклюзивні та інноваційні педагогічні практики. Порівняльний аналіз засвідчив, що студенти продемонстрували більш відчутне зростання мотивації та рівня знань, тоді як викладачі показали вищий рівень готовності інтегрувати набутий досвід у професійну діяльність. Практична цінність дослідження полягає у можливості використання його результатів закладами вищої освіти та центрами підготовки вчителів для розроблення й упровадження сталих, інклюзивних та інноваційно орієнтованих програм професійного розвитку

Ключові слова: освіта для сталого розвитку; універсальний дизайн для навчання (UDL); навчання впродовж життя; гостьові лекції; підготовка майбутніх вчителів; педагогічні інновації