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Modern environmental education requires innovative approaches to teaching for several reasons. First, environmental issues are becoming increasingly complex and multifaceted. Traditional methods that focus only on the transfer of knowledge may not be sufficient to understand these problems and develop skills to solve them. Second, today's youth are more inclined to visual and digital learning formats. Innovative interactive methods based on multimedia technologies may be more effective for this generation. Third, such methods help make environmental education more relevant and meaningful. They allow us to demonstrate the impact of environmental issues on the lives of students and the possibilities of personal contribution to their solution. The use of podcasts as part of modern educational technologies in the field of ecology complements traditional teaching methods, offering flexibility and accessibility to education, and can play a key role in expanding knowledge and building an informed public on environmental issues. However, despite the growing popularity of podcasts in the educational process, there is still limited evidence on their effectiveness in improving environmental learning. In our study, we focused on analysing the comparative perception of information by students in different formats – podcasts, presentations and text documents – using such methods as experimental research and surveys. The analysis included an assessment of the quality of learning, retention, usability, student preferences, flexibility of learning and suitability for practical application. Our experimental study with students revealed that podcast users achieved the highest test score (84.7%) compared with presentation (82.5%) and text document groups (81.2%). Survey results showed that 97% of students valued learning flexibility with podcasts, 87% reported increased engagement, and 80% considered podcasts effective learning tools. Additionally, 99% of students agreed that podcasts improved their understanding of lectures. The findings help to develop recommendations for integrating different learning formats into the educational process and adapting teaching methods to the needs of students. As an innovative teaching tool, eco-podcasts offer considerable flexibility in disseminating science-based information, ease of use, and the ability to reach a wider audience, contributing to the development of communication skills in the environmental community.

Keywords: environmental education, eco-podcast, environmental policy, sustainable development, environmental safety, environmental information.

Introduction

Environmental education plays a crucial role in shaping individuals' environmental culture, awareness, and behaviour. It encompasses a wide range of topics related to the environment, including natural processes, environmental issues, and potential solutions. Scientists offer various definitions of environmental education, emphasising its role in fostering understanding of human-nature relationships, promoting sustainable development values, and developing skills for responsible environmental interaction (Rieckmann, 2018).

In Ukraine, legal documents define environmental education as a process aimed at forming environmental culture, awareness, and behaviour among citizens. The Law of Ukraine "On Environmental Protection" (Verkhovna Rada of Ukraine, 1991) and the Concept of Environmental Education in Ukraine (Verkhovna Rada of Ukraine, 2001) highlight the importance of environmental education as a system of measures and a process that contributes to the development of environmental knowledge, skills, and abilities necessary for understanding and preserving the environment. Recent years have witnessed a growing interest in environmental education and upbringing, with scientists studying various aspects such as environmental outlook, consciousness, responsibility, and behaviour. However, traditional teaching methods that focus only on knowledge transfer may not be sufficient to help students comprehend the increasingly complex and multifaceted environmental issues and develop the necessary skills to address them (Strickland et al., 2021).

Modern environmental education requires innovative approaches to teaching that incorporate multimedia technologies and interactive methods more suitable for current generations of students. Today's youth are more inclined toward visual and digital learning formats, making innovative approaches based on audio-visual media potentially more effective (Ahmad and Halim, 2024; Bawamenewi et al., 2024). Such methods help make environmental education more relevant and meaningful by demonstrating the impact of environmental issues on students' lives and the possibilities for personal contribution to solving these issues (Novitri et al., 2023).

International research demonstrates the significant potential of podcasts as an innovative educational tool across various educational contexts and disciplines. Studies from the United States highlight the substantial impact of podcasts on student engagement and skill development (Besser et al., 2021; Sevnarayan, 2022). Research indicates that podcasts are particularly effective in developing critical media evaluation skills in environmental studies courses (Vatovec and Balser, 2009; Gunderson and Cumming, 2022) and providing flexible learning opportunities in online conservation education (Strickland et al., 2021; Che, 2023). The audio format of podcasts enhances student motivation, ensures active participation, and creates a better learning atmosphere while encouraging teacher innovation and creativity (Gipson and Richards, 2011; Marheni et al., 2020). However, international experience has also revealed certain challenges in podcast implementation, including technical difficulties and varying levels of student engagement (Hall and Jones, 2021).

In the Ukrainian context, scholars have made significant contributions to understanding and developing environmental education methodologies. Dmytrovskyi (2015) has contributed to understanding the evolution of podcasting in Ukraine, noting its rapid growth and intersection with traditional media forms. Innovative approaches involving audio content in the educational process have been further explored by Ukrainian researchers (Mund et al., 2023), highlighting their potential in maintaining educational continuity during challenging circumstances. These domestic studies complement international research while addressing the specific context of environmental education in Ukraine. Additionally, research on modern teaching technologies and methods (Lebedik et al., 2020) emphasises the importance of implementing innovative approaches that meet the needs of today's students and promote better assimilation of educational material.

The integration of STEM education with sustainable development goals in Ukraine also provides a supportive framework for innovative educational approaches (Buturlina et al., 2021), while research on education for sustainable development in Ukrainian higher education institutions highlights both opportunities and challenges in implementing new pedagogical methods (Chaikovska, 2023). The importance of ecological education in Ukraine has gained additional relevance

in the context of post-war recovery, emphasising the need for innovative approaches that can address environmental challenges while rebuilding educational systems (Zamula et al., 2024; Kireitseva et al., 2023).

The use of environmental podcasts in the educational process in Ukraine is gaining considerable relevance due to their accessibility, flexibility, and potential for engaging modern learners (Santo, 2023; Dmytrovskyi, 2015). Popular environmental podcasts, such as 'Outrage + Optimism' (Global Optimism, n.d.) and 'The Energy Gang' (Greentech Media, n.d.), demonstrate how the audio format can effectively disseminate environmental knowledge and raise awareness about environmental issues among a broad audience. Despite the growing use of podcasts in education, there is limited information on their effectiveness in improving students' environmental learning (Vatovec and Balser, 2009; Hall and Jones, 2021). This study aims to compare the perception of information for educating students in different forms, such as podcasts, presentations, and text documents, by assessing parameters like overall learning, information retention, usability, student preferences, flexibility in learning, and practical application. The findings will contribute to the development of recommendations for integrating different learning formats into the educational process and adapting teaching methods to students' needs and preferences.

Materials and Methods

A comparative study was conducted to investigate the perception and effectiveness of different educational formats, namely podcasts, presentations, and text documents, in the context of environmental education. The study aimed to assess various parameters, including overall learning, information retention, usability, student preferences, flexibility in learning, and practical application. The research employed a mixed-methods approach, combining an experimental study and a questionnaire survey. The participants consisted of 90 third- and fourth-year students majoring in Ecology and Environmental Protection Technologies. They were divided into three groups of 30 students each, and each group was assigned a different format of educational material on the topic of environmental policy. The content of the material was identical across all formats to ensure comparability.

The study was conducted at the Department of Ecology and Environmental Protection Technologies at Zhytomyr Polytechnic State University, involving two associate professors with over 15 years of teaching experience and their PhD students in their second and first years of study. The research implementation was preceded by the participation of the teaching staff in a specialised workshop at a German university for sustainable development, which was part of the Ukrainian-German educational project funded by DAAD (Deutscher Akademischer Austauschdienst), focusing on the digital transformation of environmental education.

The combination of experienced faculty members and PhD students in the research team provided a valuable mix of established pedagogical expertise and innovative approaches to educational technology implementation. The educational setting utilised the university's existing infrastructure, enhanced by the knowledge and skills gained through the international workshop. This systematic approach to implementation created a robust framework for the research while reflecting realistic conditions in Ukrainian higher education settings during wartime.

The experimental study involved the following steps:

1 Each group of students was provided with the educational material in their assigned format (podcast, presentation, or text document).

2 The students were given time to study the material independently.

3 One week after studying the material, the students were administered a test to assess their comprehension and retention of the information. The test consisted of two levels of difficulty:

- Level 1: 10 multiple-choice questions with "yes" or "no" answers;
- Level 2: 5 open-ended questions requiring detailed answers.

4 The test results were analysed to compare the performance of the three groups and determine the effectiveness of each educational format in terms of overall learning and information retention.

In addition to the experimental study, a questionnaire survey was conducted using 1Google Forms. The survey was administered to the participants immediately after the experiment and again after taking the test. The

questionnaire aimed to gather feedback on the benefits, ease of use, and general perception of each learning format. The survey data were analysed to identify student preferences, perceived usability, and the suitability of each format for different learning styles and practical applications. The combination of the experimental study and questionnaire survey allowed for a comprehensive evaluation of the different educational formats. The experimental study provided objective data on learning outcomes, while the survey offered insights into students' subjective experiences and preferences.

The data collected from both the experimental study and the survey were subjected to statistical analysis using appropriate methods, such as analysis of variance (ANOVA) for comparing test scores and descriptive statistics for survey responses. Statistical analyses, including one-factor analysis of variance (ANOVA), were performed using Microsoft Excel 2021 software, with the significance level set at $\alpha = 0.05$. The results were interpreted in the context of environmental education and the potential benefits and limitations of each educational format.

Different formats of educational material can have a different impact on information assimilation, retention, and application in practice. Each format has its own advantages and disadvantages, and studying them can help determine the most effective methods of environmental education. For example, podcasts may be more effective for auditory learners who absorb information better by listening, while visual learners may prefer presentations with visual elements such as diagrams and illustrations. Text documents can be useful for students who are better at absorbing written information and prefer to be able to return to the text for repeated review. The findings of this study contribute to the understanding of how different educational formats, particularly podcasts, can be effectively integrated into environmental education curricula. The insights gained can inform the development of recommendations for optimising the use of various formats in teaching and learning, taking into account student needs, preferences, and the specific context of environmental education.

Results and Discussion

The study aimed to compare the perception and effectiveness of different educational formats (podcast, presentation, and text document) in the context of environmental education. The results of the experiment showed that there was no significant difference in test scores between the three groups of students, but the answers to the open-ended questions were more meaningful for the group that listened to and worked with eco-podcasts.

To further analyse the differences between the groups, a one-way analysis of variance (ANOVA) was conducted. The descriptive statistics and ANOVA results are presented in *Table 1* and *Table 2*, respectively.

Table 1. *Descriptive statistics for test scores by educational format group*

Group	Mean (M)	Standard deviation (SD)	Sample size (n)
Podcast	84.7	6.9	30
Presentation	82.5	7.5	30
Text	81.2	7.1	30

Table 1 presents descriptive statistics for test scores across three groups of students who studied the material in different educational formats: podcast, presentation, and text. For each group, the mean (M), standard deviation (SD), and sample size (n) are provided. The mean test scores slightly differ between the groups, with the podcast group having the highest mean score (M = 84.7) and the text document group having the lowest (M = 81.2). However, the standard deviations and sample sizes are the same for all three groups (SD = 6.9–7.5; n = 30).

The one-way ANOVA results (*Table 2*) indicate that there is no statistically significant difference between the three groups of students (podcast, presentation, and text document) in terms of test scores ($F(2, 87) = 1.72$, $P = 0.185$). The F value of 1.72 is the ratio of the between-groups mean square (90.43) to the within-groups mean square (52.62). The *P* value of 0.185 is greater than the chosen significance level ($\alpha = 0.05$), suggesting that the null hypothesis (no difference between the groups) cannot be rejected. The degrees of freedom (df) for the between-groups variation is 2, which is the number of groups minus one ($k-1 = 3-1 = 2$). The degrees of freedom for the within-groups variation is 87, which is the total number of observations minus the number of groups ($N-k = 90-3 = 87$). These degrees of freedom are used to calculate the mean squares and the F value.

Table 2. *ANOVA summary table for the effect of educational format on test scores*

Source of variation	Sum of squares	Degrees of freedom (df)	Mean square (Mean Sq. or MS)	F (F value or F ratio)	Probability value (P value)
Between groups	180.87	2	90.43	1.72	0.185
Within groups	4578.30	87	52.62	-	-
Total	4759.17	89	-	-	-

The mean test scores for the podcast group (M = 84.7, SD = 6.9), presentation group (M = 82.5, SD = 7.5), and text document group (M = 81.2, SD = 7.1) suggest that students who received the material through the podcast format had slightly higher test scores, but this difference is not statistically significant, as indicated by the ANOVA results.

These findings support the initial observation that there was no substantial difference in test scores between the three groups. However, considering the observation that the answers to the open-ended questions were more meaningful for the group that listened to and worked with eco-podcasts, it can be hypothesised that the podcast format may facilitate a deeper understanding of the material, even if this is not reflected in the overall test scores.

We generated several possible explanations for why the group that listened to the eco-podcast had more meaningful detailed answers than the other two groups:

- Ecopodcasts can be more engaging and interesting for students than presentations or text documents, which could lead to students listening more attentively to the podcast and remembering the information better. Podcasts often use a narrative format, which can attract and retain listeners' attention better than text documents or presentations.

- The audio format of an eco-podcast can help to improve understanding of complex concepts, as it includes explanations, examples, and discussions that help learners to understand the material more deeply. When listening to an eco-podcast, learners may find it easier to visualise concepts, which can contribute to better learning.

- Eco-podcasts require active listening, which can increase concentration and understanding of the material.

- Learners could listen to an eco-podcast anytime and anywhere, which could lead to better learning.

Several factors may contribute to the potential benefits of podcasts in promoting a deeper understanding of the subject matter. First, podcasts can be more engaging and interesting for students compared with presentations or text documents. The narrative format and audio delivery of podcasts can capture and maintain listeners' attention more effectively than written text or static presentations. Second, the audio format of podcasts may enhance the comprehension of complex concepts by providing explanations, examples, and discussions that help learners grasp the material more thoroughly. When listening to a podcast, learners may find it easier to visualise concepts, which can contribute to better understanding. Third, podcasts require active listening, which can increase focus and engagement with the content, leading to improved retention and comprehension.

Results of the survey for eco-podcast listeners

Immediately after the experiment, we conducted a survey for a group of 30 students who had been working on environmental policy information in the podcast format to find out their perceptions of the usefulness of eco-podcasts.

Figs. 1, 2, and *3* show the processed data of responses on the perception of students (N = 30) of the usefulness of environmental podcasts as learning tools, aids to memorisation, and promotion of understanding of information. Students rated the usefulness of podcasts on a 5-point Likert scale, where 1 point is very useful and 5 points is very unhelpful (wasted time).

Students were asked to assess the overall usefulness of eco-podcasts as a learning resource. Twenty-nine out of 30 respondents rated the podcasts as useful or very useful information resources for learning (*Fig. 1*). When asked to elaborate on eco-podcasts, all students agreed that they could listen to them anytime, 29 said they could listen to podcasts anywhere, and 24 said that podcasts allowed them to learn at their own pace.

Fig. 1. *Perception of students (N = 30) of environmental podcasts usefulness as a learning tool*
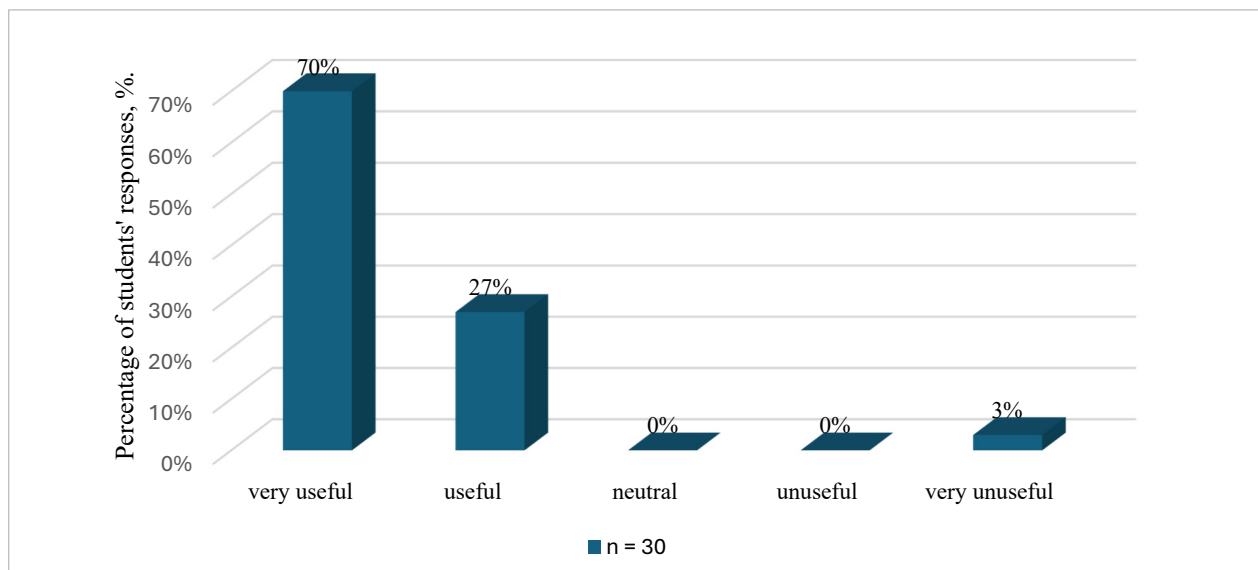
Fig. 2. *Perception of students (N = 30) on the usefulness of environmental podcasts as aids to memorising information*
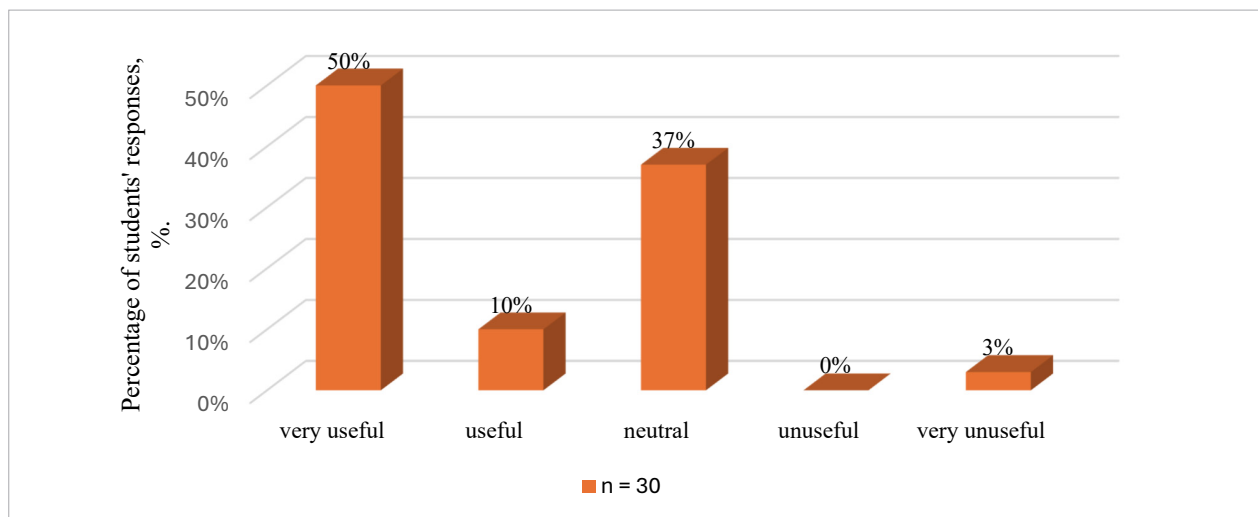
In the questionnaire, students were asked to identify the extent to which podcasts helped them with specific aspects of their studies. They responded positively to the extent that eco-podcasts helped them memorise facts. Eighteen students agreed with this statement "completely" and 11 agreed "partially" (*Fig. 2*).

The students' perception of the usefulness of environmental podcasts as tools that help them understand information also received more positive responses. Six students agreed with the statement that the eco-podcast helped them understand environmental policy

processes and was "useful" for them, three students were "partially satisfied", and 20 students strongly agreed that the eco-podcast contributed to a better understanding of environmental policy information and helped them to actively engage in learning (*Fig. 3*).

The respondents generally agreed that the podcast was interesting and informative (29 out of 30 answers to the questionnaire, one student expressed a negative attitude towards podcasts).

Further, after taking the test and completing the survey, students had the opportunity to compare

Fig. 3. *Perception of students (N = 30) on the usefulness of environmental podcasts as tools for better understanding of information*
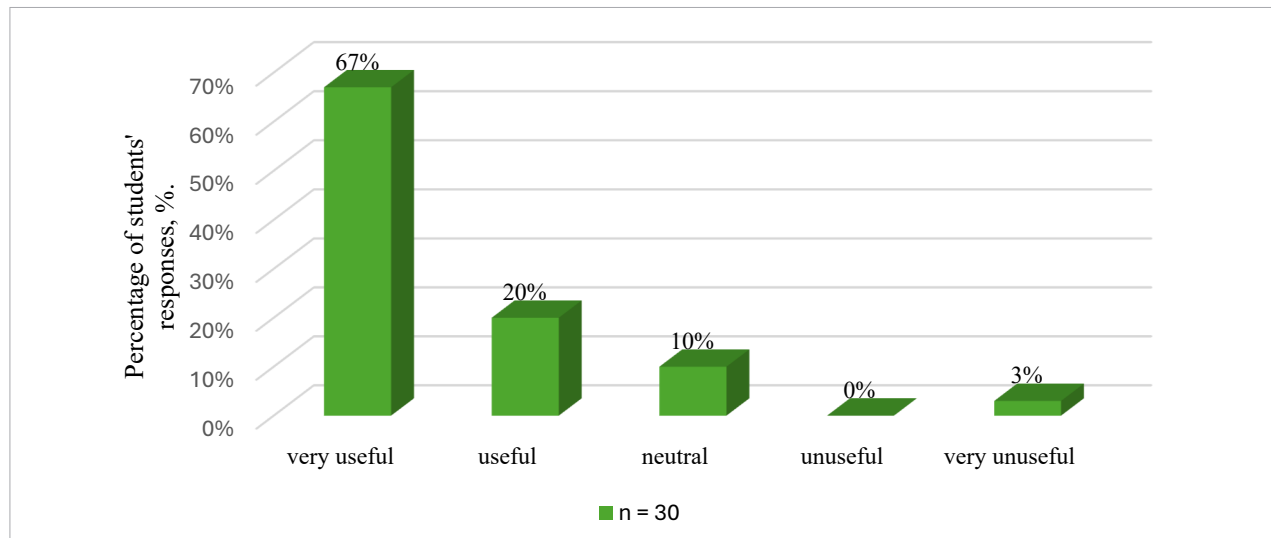

eco-podcasts with other learning methods and provide answers about the educational usefulness of eco-podcasts as learning tools, memory aids, and tools that help them understand information. The survey was conducted for the entire group of 90 students. This made it possible to collect data from students who had studied the material using all three methods (podcast, presentation, text document) and provided a more objective and comprehensive assessment of the effectiveness of each format. The inclusion of all study participants in the survey helped to avoid bias and provide a more complete understanding of the benefits of eco-podcasts and the overall experience of listening to podcasts.

The data from the survey of students on the perception of certain aspects of learning through eco-podcasts are shown in *Fig. 4*. Students evaluated the educational usefulness of the eco-podcast on a 5-point Likert scale, where 1 point means "strongly agree" and 5 points means "strongly disagree".

Fig. 4. *Students' perception of the educational usefulness of eco-podcasts*
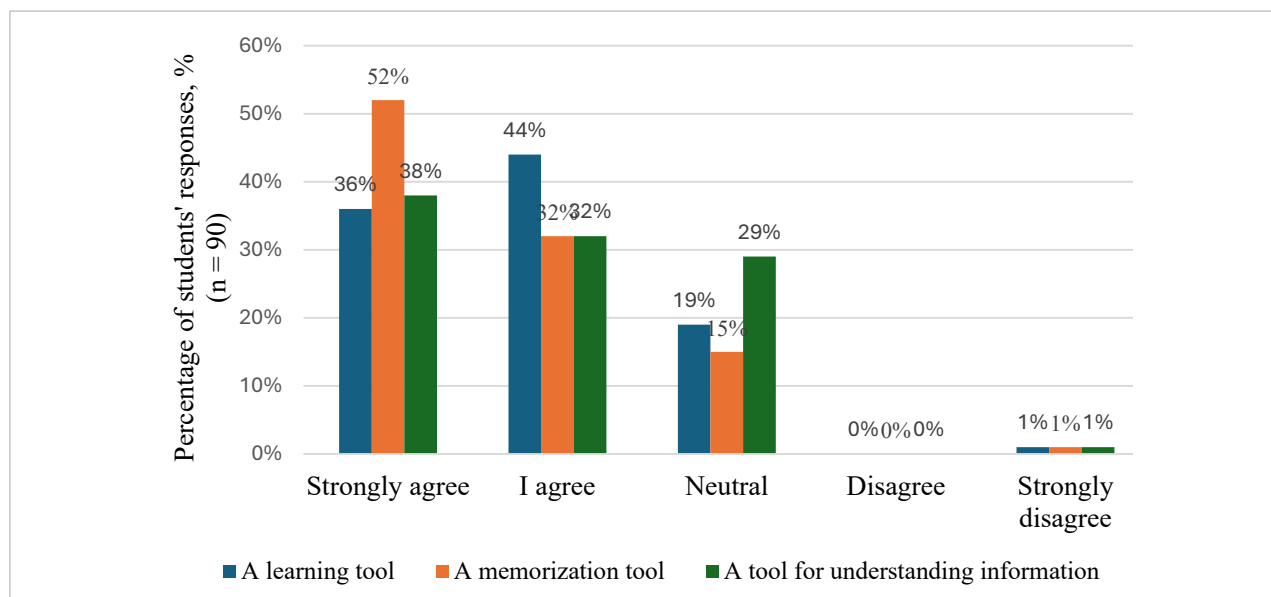
As can be seen from *Fig. 4*, the majority of students (80% or more) consider eco-podcasts to be tools for learning and memorising information, and 70% of respondents consider eco-podcasts to be tools for understanding information. In general, students believe that eco-podcasts are effective in learning, easy to use, and help them better understand the topic. It was also noted that it would be useful to create video podcasts or textual accompaniment to audio podcasts for people who perceive visual information better. Many believed that podcasts were more useful than seminars, but not as effective as lectures delivered through presentations. Students expressed the opinion that podcasts should be used as a supplement to lectures, not instead of them.

Of the 90 students surveyed, 89 agreed that eco-podcasts helped them understand lectures and improve their overall learning. However, some students noted the repetition of information between the lecture presentation and the podcast as a problem with eco-podcasts, while others found these repetitions useful for memorisation. Based on the results of the analysis, recommendations were developed for the introduction of different learning formats in the educational process, as well as the adaptation of teaching methods to the needs and preferences of students.

The survey results further support the potential benefits of eco-podcasts in environmental education. The majority of students (80% or more) perceived eco-podcasts as effective tools for learning, memorising, and understanding information. Students also noted the convenience and flexibility of podcasts, allowing them to access educational content anytime and anywhere. These findings suggest that eco-podcasts can be a valuable addition to traditional teaching methods, providing students with an engaging and accessible learning resource.

However, it is important to acknowledge the limitations of this study. The relatively small sample size (N = 90) may limit the generalisability of the findings. Additionally, the study focused on a specific topic (Environmental Policy) and a particular group of students (third- and fourth-year students majoring in Ecology and Environmental Protection Technologies). Further research is needed to investigate the effectiveness of eco-podcasts across different environmental topics and student populations.

Moreover, while podcasts show promise as a supplementary learning tool, they should not be considered a replacement for traditional teaching methods. As some students mentioned in the survey, podcasts can be most effective when used in conjunction with lectures and other educational formats. The repetition of information between lectures and podcasts can be beneficial for reinforcing key concepts and promoting retention.

In conclusion, this study provides valuable insights into the potential of eco-podcasts as a modern educational technology in environmental education. Although no statistically significant differences were found in test scores between the podcast, presentation, and text document groups, the more meaningful answers to open-ended questions and the positive student perceptions suggest that podcasts may facilitate a deeper understanding of the material. As an innovative teaching tool, eco-podcasts offer considerable flexibility, accessibility, and the ability to engage learners, making them a promising complement to traditional educational methods.

The comparison of our findings with international research reveals significant parallels while highlighting unique aspects specific to the Ukrainian educational context *(Table 3)*. Our results demonstrate notable alignment with previous international studies across several key dimensions. The observed 87% student engagement rate with eco-podcasts corresponds closely with the 82–90% engagement rates reported in international studies (Besser et al., 2021). Similarly, our finding that 97% of students valued learning flexibility aligns with research in distance learning contexts, where approximately 95% of students reported similar benefits (Sevnarayan, 2022). The deeper understanding demonstrated by students in open-ended questions parallels the enhanced comprehension reported across multiple studies (Vatovec and Balser, 2009). Technical challenges reported by 23% of our participants align with global findings where 25–30% of users encountered similar issues (Hall and Jones, 2021). The preference for podcasts as a supplementary rather than replacement tool for traditional learning methods mirrors findings in other international contexts (Gunderson and Cumming, 2022).

The Ukrainian context presents several distinctive features in podcast implementation. The integration occurs within the framework of ongoing educational reforms and recent shifts to online learning necessitated by external factors. This situation creates unique

Table 3. *Comparison of research findings with international studies*

Aspect	Our research findings	International research results	Alignment
Student engagement	87% of students reported increased engagement with eco-podcasts	82–90% engagement rates reported in international studies (Besser et al., 2021)	High
Learning flexibility	97% appreciated the ability to learn at their own pace	Similar findings (95%) in distance learning contexts (Sevnarayan, 2022)	High
Content understanding	A deeper understanding demonstrated in open-ended questions	Enhanced comprehension reported across multiple studies (Vatovec and Balser, 2009)	Moderate
Technical challenges	23% reported technical difficulties	25–30% reported similar issues globally (Hall and Jones, 2021)	High
Integration with traditional learning	Preferred as a supplementary tool rather than replacement	Similar preference noted in international contexts (Gunderson and Cumming, 2022)	High

implementation challenges and opportunities that differ from those reported in international studies. Specifically, the adaptation of podcast use during periods of mandated distance learning, the focused integration within Ukraine's developing environmental education framework, and the emphasis on environmental policy and sustainability within the Ukrainian context distinguish our findings from international studies. Additionally, podcasts play a crucial role in maintaining educational continuity during challenging circumstances, a factor not prominently featured in international research.

These comparative findings suggest that while the fundamental benefits of podcast-based learning demonstrate universal applicability, implementation strategies require careful adaptation to local educational contexts and needs. The Ukrainian experience contributes valuable insights to the global understanding of podcast-based environmental education implementation in diverse educational settings, particularly in contexts of educational system transformation and adaptation to external challenges.

This comparative analysis not only validates the effectiveness of podcasts as educational tools but also emphasises the importance of considering local educational contexts in their implementation. The findings provide valuable insights for future research and practical applications in both Ukrainian and international educational contexts, particularly in addressing the specific challenges and opportunities presented by different educational systems and circumstances.

Despite these encouraging findings, it is important to acknowledge several limitations of our research. The primary limitation is the sample size (N = 90), which, while sufficient for initial analysis, would benefit from expansion in future research. This study serves as a pilot investigation that establishes foundational understanding and methodology for broader implementation. Our research development strategy encompasses two phases. The completed initial phase focused on developing and validating the research methodology, establishing preliminary findings, testing hypotheses, and identifying key variables for podcast effectiveness in environmental education. Building on these findings, we envision an expanded second phase involving a significantly larger sample size of over 400 students from multiple universities. This phase will implement a longitudinal study design spanning a full academic year, allowing for the investigation of additional variables including different academic levels, various environmental topics, multiple podcast formats, and diverse teaching approaches.

Through this expansion of research scope, we aim to address the current limitations while building upon the promising initial results, ultimately contributing to a more comprehensive understanding of podcast effectiveness in environmental education and providing evidence-based recommendations for their implementation in various educational contexts. Through the multi-level teaching perspective, eco-podcasts can be effectively integrated at different educational stages and for various learning needs. At the undergraduate level, podcasts can serve as introductory material for foundational environmental concepts, while at the graduate level, they can facilitate deeper analysis and critical discussions of complex environmental issues.

For advanced learners, podcasts can be used to explore specialised topics and current research developments, while beginning students can benefit from basic concept explanations and practical examples. Additionally, podcasts support differentiated instruction by allowing students to engage with content at their own pace and level of understanding. The asynchronous nature of podcast learning enables instructors to address diverse learning needs simultaneously, providing additional support for struggling students while offering enrichment opportunities for advanced learners. This flexibility in content delivery and engagement makes podcasts particularly valuable in multi-level educational settings where students with varying levels of knowledge and expertise need to be accommodated within the same learning environment.

Conclusions

The present investigation examined the comparative efficacy of diverse educational formats in environmental education while analysing students' perceptions of eco-podcasts as pedagogical instruments. The empirical findings yielded several significant quantitative results. The experimental study demonstrated that participants utilising podcasts achieved a mean score of 84.7% (SD = 6.9), whereas those employing presentations and text documents attained means of 82.5% (SD = 7.5) and 81.2% (SD = 7.1), respectively. Although these variations did not reach statistical significance (F(2, 87) = 1.72, P = 0.185), they suggest a modest trend favouring podcast-based instruction. Quantitative analysis of survey data (N = 90) revealed substantial support for podcast efficacy, with 80% of participants affirming effectiveness of podcasts as educational tools (36% indicating strong agreement, 44% expressing agreement). Furthermore, 84% reported enhanced retention through podcast utilisation (52% strongly agreeing, 32% agreeing), while 70% demonstrated improved comprehension (38% strongly agreeing, 32% agreeing). Notably, 97% of participants endorsed the pedagogical flexibility afforded by podcasts, and 99% acknowledged podcasts' contribution to lecture comprehension. While statistical analyses did not indicate significant differences in quantitative assessment scores across formats, qualitative evaluation revealed that podcast users demonstrated superior capacity for detailed, nuanced responses to open-ended inquiries. This observation suggests that podcast-based instruction may facilitate enhanced conceptual understanding of environmental topics, despite comparable performance on standardised assessments. The findings substantiate the efficacy of eco-podcasts as complementary pedagogical instruments in environmental education, offering enhanced accessibility and flexibility while fostering active engagement. However, these tools should be integrated within existing educational frameworks rather than supplanting traditional methodologies. Further research involving expanded sample populations across multiple institutions is warranted to validate these preliminary findings and optimise podcast implementation in environmental education curricula.

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