PEDAGOGICAL ACADEMY:
SCIENTIFIC NOTES

THEORY AND METHODOLOGY OF VOCATIONAL EDUCATION

UDC 502/504:004.9:378

DOI https://doi.org/10.5281/zenodo.17757234

# Popularization of environmental culture through digital education and online courses in phytodesign

**Yevheniia Brovarna,**

Founder, Zeleno House, C/Historiador Rafael Altamira, 8, Alicante, Spain,

https://orcid.org/0009-0000-4486-9881

**Accepted: 09.11.2025 | Published: 29.11.2025**

***Abstract.*** *The study's relevance stems from the growing need to foster an ecological culture among the population, in the context of urbanisation and increased public demand for biophilic and greening practices. The* ***article aims*** *to substantiate holistic scientific approaches and digital educational solutions that can ensure the effective popularisation of ecological culture through online courses and integrated programs in phytodesign, interior landscaping, and plant therapy. The* ***research methods*** *include content analysis of digital educational platforms, comparative analysis of eco-education models, generalisation of pedagogical, ecological, and psychological sources, and systematisation of data on the use of virtual laboratories, augmented reality (AR), and virtual reality (VR) technologies in modelling green spaces.* ***Results.*** *It has been established that digital formats – microlearning, video modules, AR/VR modelling, interactive cases, virtual laboratories – are suitable for providing practice-oriented learning, reproducing real care scenarios, and developing students' cognitive, activity, and value-behavioural competencies. It has been found that combining phytodesign with elements of plant therapy enhances students' psycho-emotional involvement and*

*contributes to the formation of sustainable environmental habits. It has been proven that digital programs become effective only when they feature modular, scientifically verified content, personalised tasks, and the ability to track educational progress analytically.* ***Conclusions.*** *Digital eco-education is a promising tool for scaling ecological culture, as it reaches a broad audience and creates conditions for the systematic development of environmentally friendly behaviour. Comprehensive phytodesign programs that combine ecological, design, and therapeutic components clarify the mechanisms of perception and the practical application of ecological knowledge, facilitating the transition from theoretical awareness to real, sustainable actions in everyday life. Prospects for further research are related to the creation of standardised requirements for the quality of digital eco-courses, the development of intelligent adaptive educational platforms, the expansion of AR/VR environments for modeling complex biophysical processes in educational programs, as well as conducting longitudinal pedagogical studies aimed at assessing the impact of digital ecological education on sustainable behavioral practices of different population groups.*

***Keywords:*** *environmental awareness, digital learning, interior landscaping, plant therapy, virtual labs, AR/VR technologies, sustainable design.*

## Популяризація екологічної культури засобами цифрової освіти та онлайн-курсів з фітодизайну

**Броварна Євгенія Сергіївна**,
засновник, Zeleno House, вул. Історика Рафаеля Альтаміра, 8, м. Аліканте, Іспанія, https://orcid.org/0009-0000-4486-9881

***Анотація.*** *Актуальність дослідження зумовлено зростанням потреби у формуванні екологічної культури населення в умовах урбанізації та підвищеного суспільного запиту на біофільні й озеленювальні практики.*

***Метою статті*** *є обґрунтування цілісних наукових підходів і цифрових освітніх рішень, здатних забезпечити результативну популяризацію екологічної культури засобами онлайн-курсів та інтегрованих програм з фітодизайну, інтер'єрного озеленення і рослинотерапії.* ***Методи*** *дослідження включають контент-аналіз цифрових освітніх платформ, порівняльний аналіз моделей еко-освіти, узагальнення педагогічних, екологічних та психологічних джерел, а також систематизацію даних щодо застосування віртуальних лабораторій, технологій доповненої реальності (AR) і віртуальної реальності (VR) у моделюванні озеленених просторів.* ***Результати.*** *Встановлено, що цифрові формати – мікронавчання, відеомодулі, AR/VR-моделювання, інтерактивні кейси, віртуальні лабораторії – є придатними для забезпечення практикоорієнтованого навчання, відтворення реальних доглядових сценаріїв та формування когнітивних, діяльнісних і ціннісно-поведінкових компетенцій здобувачів освіти. Виявлено, що поєднання фітодизайну з елементами рослинотерапії підсилює психоемоційну залученість здобувачів освіти та сприяє формуванню стійких екологічних звичок. Доведено, що цифрові програми стають ефективними лише за умови їх модульності, наукової верифікованості контенту, персоналізації завдань і можливості аналітичного відстеження навчального прогресу.* ***Висновки****. Цифрова еко-освіта є перспективним інструментом масштабування екологічної культури, оскільки забезпечує широке охоплення аудиторій і створює умови для системного формування екологічно відповідної поведінки. Комплексні програми з фітодизайну, які поєднують екологічні, дизайнерські та терапевтичні складові, дозволяють уточнити механізми сприйняття та практичного застосування екологічних знань, сприяючи переходу від теоретичної обізнаності до реальних сталих дій у повсякденному житті. Перспективи подальших досліджень пов'язані зі створенням стандартизованих вимог до якості цифрових еко-курсів, розробленням інтелектуальних адаптивних освітніх платформ, розширенням AR/VR-*

*середовищ для моделювання складних біофізичних процесів у навчальних програмах, а також із проведенням лонгітюдних педагогічних досліджень, спрямованих на оцінку впливу цифрової екологічної освіти на стійкі поведінкові практики різних груп населення.*

***Ключові слова:*** *екологічна обізнаність, цифрове навчання, інтер'єрне озеленення, рослинотерапія, віртуальні лабораторії, AR/VR-технології, сталий дизайн.*

**Problem statement.** The spread of ecological culture through digital education is driven by the need to develop sustainable models of ecological behaviour amid increasing anthropogenic pressure and the transition of the educational sphere to digital learning formats. In a broad sense, the difficulties in forming a responsible culture stem from the insufficient integration of environmentally oriented knowledge into modern educational programs, which hinders the development of environmental awareness and proper practical preparedness among students for the economic use of natural resources.

The scientific dimension requires developing a methodology for digital learning, identifying practical pedagogical tools for visualising biological processes, modelling sustainable solutions in phytodesign, and researching mechanisms for developing ecological competencies in the digital environment. In the applied context, the relevance of the topic is enhanced by the need to create accessible, adaptable online courses that enable students to master environmentally safe phytodesign technologies, support urban greening, improve the indoor environment of buildings, and implement environmentally responsible design practices.

The shortage of high-quality digital educational materials and the limited capacity for interactive adaptation deepen the gap between public demand for sustainable practices and the actual level of environmental education among the population. It necessitates the search for new digital pedagogical approaches to enhance the effectiveness of environmental education in phytodesign.

**Analysis of recent research and publications.** A review of modern research on the popularisation of environmental culture through digital education and online courses in phytodesign identifies four interrelated scientific areas. The first area covers the development of environmental awareness through educational approaches to phytodesign and ecological spatial thinking. The study by T. M. Kushniruk and co-authors defines the structure of an extracurricular course in phytodesign, which fosters environmentally motivated behaviour, develops plant care skills, and creates green interiors [1]. The work of V. Radomska et al. emphasises the importance of cultural reflection and ecological sensitivity in the education of designers, which is relevant for digital courses in phytodesign, focused on the formation of emotional and value-based attitudes towards nature [2]. The work of T. Tkachenko et al. highlights the importance of environmental safety within buildings' internal environments in the context of spatial organisation, thereby enhancing the value of plant compositions and enabling adaptation in digital learning models [3]. The study by N. Pasichnyk et al. demonstrates the feasibility of using digital environmental monitoring systems for educational and practical tasks in phytodesign, thereby enhancing students' ability to assess the ecological parameters of space [4]. Further research in this direction should aim to integrate ecological design, phytodesign, and digital environmental monitoring into unified learning models.

The second direction concerns digital tools for environmental education that can shape environmental attitudes and behavioural practices. The study by E. E. Şimşek demonstrates the effectiveness of augmented reality in fostering environmental awareness in children, thereby highlighting the possibility of adapting such technologies to phytodesign courses [5]. F. Douglas et al. establish the positive impact of online formats of education for sustainable development on environmental beliefs and well-being of students, emphasising the importance of experiential learning in a digital environment [6]. The work of S. K. Yadav et al. systematises a model of environmental education for sustainable development,

which includes cognitive, emotional, and behavioural components that can be incorporated into online phytodesign courses [7]. The study by V. Kioupi and N. Voulvoulis analyses the role of university programs in developing sustainable development competencies, substantiating the importance of digital platforms as an effective tool for translating environmental knowledge [8]. Further research should aim to develop interactive digital models of environmental education for phytodesign using immersive technologies, gamification, and behavioural indicators of environmental responsibility.

The third direction concerns the development of botanical literacy and the overcoming of the «plant awareness disparity» in the context of the digitalisation of education. The work of C. Rodosthenous et al. demonstrated the effectiveness of combining IoT and gamification in fostering ecological awareness, providing a basis for digital tools for studying plants [9]. The study by J. Marcos-Walias et al. indicates significant differences in plant awareness among individuals of different educational levels, underscoring the need for digital methods to address this gap [10]. A systematic review by W. P. Arif et al. structures the main domains of botanical literacy (knowledge, attitude, behaviour) that can constitute the content of digital courses on phytodesign [11]. A study by N. Pernat et al. showed that engaging students in citizen science through digital applications not only develops plant recognition skills but also environmentally responsible behaviours [12]. Further research should aim to integrate digital botanical laboratories and open ecological data into online courses on phytodesign.

The fourth direction covers the application of augmented reality (AR) and virtual reality (VR) technologies in the formation of an ecological culture and in increasing interest in studying the plant world. The work of C. Y. Huang et al. shows that using AR in the natural sciences increases motivation and knowledge acquisition, and that this approach can be adapted to phytodesign courses [13]. K. H. Cheng demonstrates the effectiveness of VR environments for emotionally coloured, immersive plant learning, which contributes to the formation of a

sustainable interest in natural systems [14]. The study by S. J. Lu et al. showed that AR-integrated game modules increase both learning motivation and the depth of interaction with natural objects [15]. Further research should aim to develop immersive AR/VR platforms for online phytodesign courses that enable modelling green spaces and assessing the environmental consequences of design decisions in virtual environments.

**Highlighting previously unresolved parts of the general problem.** Despite recent developments in digital eco-education, several key aspects remain unresolved. The structural components of ecological culture in digital learning environments are insufficiently defined, making it difficult to determine the intended outcomes of educational programs. The mechanisms of transferring the therapeutic and psycho-emotional impact of phytodesign and plant therapy to the digital environment, as well as their impact on different age and professional groups, remain unstudied. There is no holistic assessment of the effectiveness of digital formats – from virtual laboratories to AR/VR modelling in the formation of sustainable environmental skills. Methodological gaps, unequal access to technologies, and the lack of integrated assessment systems limit the quality and scalability of online courses in phytodesign. The proposed study aims to fill these gaps by clarifying the content elements of ecological culture, analysing the educational potential of phytodesign and plant therapy, scientifically evaluating digital technologies, and identifying barriers to their implementation. The results obtained will form the basis for scientifically based approaches to the development of effective digital programs capable of increasing students' environmental awareness and practical involvement in sustainable environmental actions.

**Formulation of the article objectives (task statement).** The article aims to establish scientifically based principles and digital solutions that ensure the effective popularisation of ecological culture through online courses and educational programs in phytodesign, integrated with interior landscaping and the therapeutic effect of plants.

Objectives of the article:

1. To determine the content and structural components of ecological culture and to clarify the educational potential of phytodesign, interior landscaping and plant therapy in digital learning.

2. To analyse digital formats and technologies that ensure the practice-oriented formation of ecological knowledge, plant care skills and the creation of sustainable green spaces.

3. Identify scientific and practical barriers to the implementation of digital eco-education and develop recommendations for increasing the effectiveness of online courses and programs in phytodesign and plant therapy.

**Presentation of the main research material.** Approaches to the formation of the content and structural components of ecological culture in the digital environment of phytodesign are based on the understanding that modern educational practices should ensure not only the transfer of knowledge but also the development of value orientations and behavioural models necessary for a responsible attitude toward the natural environment. The conditions of intensive urbanisation and digitalisation of society necessitate a rethinking of ecological culture as an integrated category encompassing cognitive, emotional value, and activity components that can be effectively formed through online education. Digital courses in the field of phytodesign can combine scientifically based knowledge of plants, landscaping technologies, and their psycho-emotional impact with modern multimedia tools, creating a new quality of educational experience. It opens up the possibility for the structured formation of ecological culture in an accessible, visually rich and adaptive format (table 1).

**Table 1**

*Structural components of ecological culture and possibilities of their formation in digital education in phytodesign*

| Ecoculture component | Content description | Tool |
|---|---|---|


ISSN: 2786-9458

| | | |
|---|---|---|
| *Cognitive* | System of ecological knowledge about nature, plants, biodiversity, and relationships in ecosystems | Video lectures, 3D models of plants, interactive schemes, virtual greenhouses |
| *Value-motivational* | Awareness of the significance of ecological behaviour, formation of eco-oriented beliefs | Practical cases, digital stories, and visualisation of the impact of landscaping on well-being |
| *Active* | Plant care skills, creation of a green environment, and use of eco-technologies | Online master classes, care simulations, step-by-step video instructions |
| *Emotional-behavioral* | Emotional involvement, environmental responsibility, and development of environmentally sustainable behaviour | Therapeutic herbal practices, interactive exercises, and VR visualisation for interior modelling |

Source: created by the author based on [1, p. 147–148; 6, p. 2259; 10, p. 236; 13; 14]

In modern conditions, the structural components of ecological culture are implemented in digital education through a combination of scientifically proven approaches and practical phytodesign tools, enabling the development of sustainable ecological competencies even in a distance format. The cognitive component is manifested through a systematic digital representation of knowledge: 3D models and interactive greenhouses not only reproduce plant morphology but also allow modelling changes in growing conditions, which is particularly important in cities where access to real green spaces is limited. In online education, virtual laboratories for caring for indoor plants are already widely used, where students analyse plant needs for light, humidity, and substrate, practising making environmentally sound decisions [14].

The value-motivational component is formed through digital narratives that demonstrate the proven impact of green spaces on psychological well-being, concentration, and productivity. For example, corporate online well-being programs use AR «before/after» visualisation to show the effects of biophilic design, which stimulates the transition from academic knowledge to personally meaningful environmental beliefs. Interactive stories about ecosystem restoration are used for school and family education, fostering emotional involvement and motivation for environmentally responsible actions.

The activity component in digital courses is implemented through simulation and video instruction, which provide practice in plant care skills in the «learning by doing» format [6, p. 2259]. Phytodesign platforms offer students to virtually plant plants, select compositions and test the resistance of green solutions to different microclimatic conditions. Practical tasks often include modelling the landscaping of real spaces – from offices to educational institutions – which allows you to form practical environmental competence relevant to the modern market of landscaping services and interior design. The integration of digital tools of plant therapy enhances the emotional-behavioural component. Several online courses use audiovisual practices using plant patterns and microvideos «plant mindfulness», which contribute to stress reduction and the formation of a connection between plants and emotional resilience. AR models allow students to experiment with plant arrangements in their own living spaces, translating environmental beliefs into specific behavioural solutions: the choice of safe materials, the creation of a biophilic working environment, and systematic plant care.

The educational potential of phytodesign, interior gardening, and plant therapy in professional training is determined by their ability to combine natural mechanisms of psycho-emotional regulation with interactive educational tools that contribute to the formation of environmental competence, the development of professional skills, and the improvement of students' pedagogical, design, or environmental culture. In both digital and practical dimensions, phytodesign provides a holistic integration of knowledge about plant properties and the principles of creating a healthy and functional environment, and interior landscaping is an applied professional practice that demonstrates real ecological effects in the design, arrangement, and organisation of educational space.

Plant therapy, based on the psychological and physiological mechanisms of human interaction with vegetation, enhances the motivational and emotional impact of educational programs, contributing to the development of professional resilience, reducing stress reactions and forming skills for caring for living objects. Thanks to

this, digital courses, trainings and practical classes using plant material are easily adapted to the needs of different categories of learners – from students of vocational and professional pre-higher education institutions to future designers, teachers, ecologists or specialists in the field of well-being. It ensures a combination of cognitive development, emotional involvement, and the formation of professionally significant behavioural competencies (table 2).

**Table 2**

*Educational potential of phytodesign areas and their impact on the professional training of education seekers*

| Area | Educational potential | Expected impact on learners |
|---|---|---|
| *Phytodesign* | Formation of understanding of the principles of ecological design, biophilic solutions, and sustainable use of plants | Increasing the environmental literacy of future designers, developing spatial thinking, and forming professional design competencies |
| *Interior landscaping* | Teaching to create a healthy microclimate, introducing plants to improve air quality and psychological comfort | Preparation for professional activity in the field of ecological environmental design, forming skills for implementing sustainable solutions in educational institutions, workspaces and public interiors |
| *Plant therapy* | Development of emotional self-regulation, reduction of stress reactions, formation of empathy and mindfulness through interaction with plants | Increasing students' emotional resilience, reducing the risk of professional burnout, and developing skills for working with biophilic health practices in professional activities |

Source: formed by the author based on [1, p. 150; 2, p. 558; 6, p. 2261–2262; 12, p. 12986]

The practical application of these areas in digital professional education demonstrates their high effectiveness in fostering environmental awareness and increasing students' psycho-emotional resilience, as they simultaneously work at the levels of knowledge, professional skills, and psychological reactions. In modern online courses on phytodesign, students not only receive theoretical information, but also simulate interior design in virtual spaces, selecting plants for specific microclimatic conditions. It allows us to identify the relationship between

landscaping structures and environmental quality, which is an essential element of professional training. Interior landscaping programs use digital microclimate simulators to demonstrate the impact of plants on air parameters, humidity, and visual comfort, forming in students a demonstrable understanding of the role of green solutions in professional activities [2, p. 558].

Phytotherapy in digital formats is presented as a system of guided learning practices: short video sessions on plant care, mindfulness exercises through observation of growth or leaf texture, and interactive tasks to create individual biophilic zones. In vocational education, such elements perform the function of psychoemotional support for students, contribute to the development of self-regulation, empathy and mindfulness – competencies critical for further pedagogical, design or social professional activities. The use of digital practices in phytotherapy also contributes to reducing educational stress, increasing motivation, and maintaining cognitive activity, thereby positively affecting the quality of content assimilation in professional training.

Digital formats and training technologies in phytodesign enable the reproduction of real plant care processes and the creation of green spaces in a virtual environment, significantly expanding the accessibility and practicality of environmental education. The use of multimedia tools, such as video modules and step-by-step microlearning systems, simulation platforms and virtual labs (VL), AR and VR technologies, as well as interactive learning scenarios, allows for the integration of visualisation, experimentation, and skill development. Thanks to this, digital learning becomes an effective tool for developing sustainable environmental competencies (table 3).

**Table 3**

*Digital formats and technologies of practice-oriented training in phytodesign*

| Digital format/technology | Educational opportunities | Educational outcome |
|---|---|---|
| *Video modules and ML* | Clear demonstration of care techniques and typical errors | Quick mastery of algorithms and correct operations |

| | | |
|---|---|---|
| *VL* | Modelling of growing conditions and plant reactions in changed microfactors | Reasoned care decision-making |
| *AR/VR technologies* | Spatial modelling of compositions and «trying on» landscaping | Formation of skills for creating balanced green interiors |
| *Interactive cases* | Solving realistic care and landscaping problems | Development of environmentally responsible behaviour |
| *Online workshops* | Practical actions with expert support in real time | Improving the accuracy and quality of practical operations |

Source: formed by the author based on [5; 9, p.660; 13; 15, p. 455–456]

In modern environmental education, these formats create a multi-level learning environment that combines visualisation, modeling, and direct interaction with plant scenarios. Video modules and microlearning (ML) systems provide the transfer of action algorithms in a concise, technologically optimised form: for example, phytodesign platforms demonstrate correct watering, rooting cuttings, or caring for moisture-loving species in the format of step-by-step microvideos. Thanks to the ML structure, users can quickly reproduce operations at home, thereby enhancing the effectiveness of transferring knowledge into practice [5]. VL are used to model plant reactions to changes in microclimatic parameters – humidity, light intensity, substrate composition [15, p.456]. In VL, the student analyses how plant condition indicators change in response to various actions, such as waterlogging, light deficiency, or soil salinity. It creates a safe space for experimentation, which is often impossible or too risky in a real environment. AR and VR technologies provide spatial modeling of green compositions. A student can «move» a plant in his own interior, evaluate lighting, compatibility with furniture or colour scheme, and also predict changes in visual and microclimatic effects. In professional phytodesign studios, AR and VR are used to prepare design projects, demonstrate landscaping options to clients, and optimise costs during implementation. Interactive cases simulate typical problem situations in domestic and commercial landscaping: diagnosing fungal infections, determining the optimal watering frequency, or adjusting the composition to restore visual balance. Thanks to this, students acquire

the ability to make decisions based on proven ecological principles, rather than intuitive assumptions. Online workshops that combine video communication and expert support provide real-time learning. The instructor corrects movements, demonstrates techniques for transplanting, pruning, and forming compositions, and the student immediately repeats the operations. In professional programs and corporate courses, such workshops serve as a key tool for developing the precision of operations that is necessary when working with valuable or rare plants [13]. Together, ML, VL, AR, VR, and interactive practices create an environment in which learning moves from passive perception to practical modeling and action. It allows learners – from beginners to professional designers – to effectively form sustainable ecological skills, develop spatial thinking, and make informed decisions about care and landscaping in different types of spaces.

The development of environmental education in the digital environment is accompanied by several scientific and practical problems that affect the quality and effectiveness of online courses in phytodesign. First of all, there is methodological fragmentation: educational programs often do not contain standardised requirements for the structure of content, levels of complexity, the logic of practical tasks and criteria for assessing environmental competencies, which is indirectly confirmed by the conclusions about the lack of coherence of educational approaches in a design-oriented environment [2, p.558–559]. There is a problem of insufficient scientific verification of educational materials, as recommendations for plant care are based on popular sources rather than on botanical or ecological research, which contradicts the results of assessments of the quality of online environmental education [6].

Another difficulty is the lack of adapted methods for different age and professional groups, which reduces the personalisation of the educational process. Technological barriers are manifested in unequal access of education seekers to digital tools, unstable operation of simulation platforms, insufficient interactivity of modules and limited use of augmented reality and virtual modeling technologies,

which is consistent with data on the limitations of digital solutions identified in studies of the use of IoT and gamification in environmental education [9, p.660].

A significant problem is the weak integration of environmental courses with analytical systems for tracking educational progress, which prevents accurate assessment of the skills developed. In addition, some platforms do not support the complex visualisation formats necessary for demonstrating the microprocesses of plant growth or the influence of microclimatic parameters, which correlates with the conclusions about the insufficient level of formation of botanical literacy among students at different educational levels [10, p. 236].

Organisational barriers include a shortage of specialists capable of combining knowledge of ecology, phytodesign, and digital pedagogy, leading to the creation of educational products with a low degree of practicality. An additional problem is the lack of sustainable financing and support models for digital eco-courses, which means curricula are not updated in line with changes in scientific approaches and technologies. Also widespread is the lack of quality assurance systems that ensure the reliability of information, the compliance of practical recommendations with environmental standards, and the safety of advice for beginners.

Effective development of online courses and digital programs in phytodesign and plant therapy requires implementing structured, scientifically based, and technologically progressive approaches that ensure the quality of content and fundamental change in users' behavioural patterns. First of all, it is advisable to develop training programs based on verified botanical, ecological and psychological sources, ensuring the scientific accuracy of the material and the correctness of practical recommendations. It is essential to design content according to the modular principle, with a consistent level of task complexity, which allows for the consideration of the different levels of training of target groups and maintains the adaptability of learning. Within each module, it is worth combining video instructions, interactive simulations, analytical tasks and self-testing tools, which ensures a balanced development of knowledge and skills. The effectiveness of

digital courses is increased by using augmented and virtual reality technologies for spatial modelling of plant compositions, demonstrating the influence of lighting, humidity, and other parameters on plant condition. Virtual laboratories and simulators should be integrated with analytical panels that allow you to track progress, record typical errors and provide personalised recommendations for their elimination. It is advisable to include cases from authentic interiors, microenvironments and life scenarios in practical blocks, allowing users to learn to make decisions based on data and environmental criteria. It is essential to ensure the courses are interdisciplinary, combining phytodesign with the fundamentals of plant therapy to foster a deeper understanding of plants therapeutic effects and their role in supporting well-being and emotional resilience. It is advisable to include micro-practices of mindfulness, exercises involving interaction with vegetation, and tasks to foster biophilic habits in the course structure, which will contribute to the transfer of environmental beliefs into everyday activities. Organisational support for online courses should be based on a quality assurance system that includes regular updates of materials in accordance with scientific data, the involvement of specialists in ecology, psychology, and design, and the creation of channels for communication with users who need consultations. It is advisable to develop communities of practice where students can exchange results, ask questions, and receive professional advice, thereby strengthening motivation and increasing the sustainability of learning outcomes. Provided these recommendations are implemented, online courses in phytodesign and plant therapy can play a key role in spreading ecological culture and fostering environmentally responsible actions among broad segments of the population.

**Conclusions.** The study found that digital education and online courses in phytodesign are an effective tool for fostering ecological culture, provided that the knowledge, value, activity, and emotional-behavioural components of learning are combined. It is proven that multimedia and simulation technologies not only facilitate the transfer of knowledge about plants and ecological processes but also

create conditions for reproducing real care situations, developing design thinking, and transitioning from theoretical perception to practical ecological behaviour. Key scientific and practical problems of digital eco-education are identified: the methodological lack of standardised models of material presentation, lack of assessment of ecological competencies, insufficient scientific verification of content, technological limitations of simulation platforms and AR/VR solutions; organisational difficulties associated with the lack of interdisciplinary specialists and the instability of digital course support. These factors hinder the scaling of high-quality eco-education and reduce its effectiveness. Based on the analysis, recommendations were made for the development of digital educational programs in phytodesign and plant therapy: the use of modular content design, the expansion of AR/VR modeling, the integration of virtual laboratories, the use of learning progress analytics, and the inclusion of therapeutic plant practices to support well-being. It was substantiated that the combination of educational, psycho-emotional, and practical components ensures the sustainability of environmental skills. Prospects for further research include the creation of quality standards for digital eco-courses, the development of intelligent, adaptive platforms, the strengthening of AR/VR environments for modelling complex biological processes, and the study of the long-term impact of digital eco-education on real behavioural environmental practices across different population groups.

## References

1. Кушнірук Т. М., М’ялковський Р. О., Безвіконний П. В. Планування й організація позааудиторного курсу з фітодизайну в закладах вищої освіти. *Вісник Міжнародного економіко-гуманітарного університету імені академіка Степана Дем’янчука. Серія: Педагогіка та психологія*. 2025. № 3. С. 146–152. DOI: https://doi.org/10.32782/3041-2021/2025-3-20.

2. Radomska V., Ponkalo S. Reflections on war in creative context of design education in Ukraine. *Journal of Education Culture and Society*. 2023. Vol. 14, № 1.

P. 551–567. URL: https://www.ceeol.com/search/article-detail?id=1167773 (date access: 08.09.2025).

3. Tkachenko T., Mileikovskyi V., Dziubenko V., Tkachenko O. Improvement of the safety of multi-floor housing. *IOP Conference Series: Materials Science and Engineering*. 2020. Vol. 907, № 1. Article 012064. DOI: https://doi.org/10.1088/1757-899X/907/1/012064.

4. Pasichnyk N., Komarchuk D., Opryshko O., Shvorov S., Reshetiuk V., Bahatska O. Technologies for environmental monitoring of the city. *2021 IEEE 16th International Conference on the Experience of Designing and Application of CAD Systems*. Lviv, Ukraine, 2021. P. 40–43. DOI: https://doi.org/10.1109/CADSM52681.2021.9385213.

5. Şimşek E. E. The use of augmented reality-supported activities in environmental education for early childhood: a quasi-experimental study. *Sustainability*. 2024. Vol. 16, № 23. Article 10374. DOI: https://doi.org/10.3390/su162310374.

6. Douglas F., Beasy K., Sollis K., Flies E. J. Online, experiential sustainability education can improve students' self-reported environmental attitudes, behaviours and wellbeing. *Sustainability*. 2024. Vol. 16, № 6. Article 2258. DOI: https://doi.org/10.3390/su16062258.

7. Yadav S. K., Banerjee A., Jhariya M. K., Meena R. S., Raj A., Khan N., Sheoran S. Environmental education for sustainable development. Natural resources conservation and advances for sustainability. Elsevier, 2022. P. 415–431. DOI: https://doi.org/10.1016/B978-0-12-822976-7.00010-7.

8. Kioupi V., Voulvoulis N. Sustainable development goals (SDGs): assessing the contribution of higher education programmes. *Sustainability*. 2020. Vol. 12, № 17. Article 6701. DOI: https://doi.org/10.3390/su12176701.

9. Rodosthenous C., Mavrotheris E., Greller W., Tabuenca B. Creating environmental awareness in education through IoT and gamification. *International*

*Conference on Interactive Collaborative Learning*. 2022. P. 657–668. DOI: https://doi.org/10.1007/978-3-031-26190-9_69.

10. Marcos-Walias J., Bobo-Pinilla J., Delgado Iglesias J., Reinoso Tapia R. Plant Awareness disparity among students of different educational levels in Spain. *European Journal of Science and Mathematics Education*. 2023. Vol. 11, № 2. P. 234–248. DOI: https://doi.org/10.30935/scimath/12570.

11. Arif W. P., Sari M. S., Lestari S. R. Unveiling the roots of botanical literacy: a systematic literature review on its concepts and domains. *EURASIA Journal of Mathematics, Science and Technology Education*. 2025. Vol. 21, № 4. Article em2612. DOI: https://doi.org/10.29333/ejmste/16121.

12. Pernat N., Gathof A. K., Herrmann J., Seitz B., Buchholz S. Citizen science apps in a higher education botany course: data quality and learning effects. *Sustainability*. 2023. Vol. 15, № 17. Article 12984. DOI: https://doi.org/10.3390/su151712984.

13. Huang C. Y., Chou Y. Y., Chen C. H., Tsai Y. H. Applying activity system-based process model in augmented reality-based learning for natural science course in elementary school. *Mobile Information Systems*. 2022. Vol. 2022. Article 9579766. DOI: https://doi.org/10.1155/2022/9579766.

14. Cheng K. H. Development of an immersive virtual reality system for learning about plants in primary education: Evaluation of teachers' perceptions and learners' flow experiences and learning attitudes. *Educational Technology Research and Development*. 2024. Vol. 72, № 2. P. 845–867. DOI: https://doi.org/10.1007/s11423-023-10300-6.

15. Lu S. J., Liu Y. C., Chen P. J., Hsieh M. R. Evaluation of AR embedded physical puzzle game on students' learning achievement and motivation on elementary natural science. *Interactive Learning Environments*. 2020. Vol. 28, № 4. P. 451–463. DOI: https://doi.org/10.1080/10494820.2018.1541908.