

Regional Biodiversity and Environmental Education: Preliminary Outputs of the EFFUSE-win Project

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Abstract The EFFUSE-win project develops a cross-border model of field-based environmental education in the Slovak-Ukrainian border region. It connects universities, schools, experts and local communities through inquiry-based outdoor learning, laboratory activities, biodiversity documentation and digital educational tools. Pupils and students encounter scientific work directly: they observe organisms, use field and laboratory equipment, record data and interpret findings from their own region. Teachers gain methodological support and materials that can be transferred into school practice. Since April 2025, the project has involved more than 720 students from 12 schools through school events, field trips, a three-day educational programme and expert activities. Its preliminary outputs include a developing database of 183 documented organisms and a network of young scientists' laboratories supporting environmental awareness, scientific competencies and cross-border cooperation.

Keywords Environmental education, field-based learning, cross-border cooperation

1. INTRODUCTION

Environmental education is an important part of education for sustainable development, as it helps learners understand the relationship between human activities, natural processes and the condition of the environment. Cross-curricular topics such as environmental education require students to develop critical and creative thinking, including the ability to analyze problems and propose their own solutions (Sandanusová and Schlarmannová, 2020). This ability should be systematically cultivated if students are to engage in environmental protection later in life. Current challenges such as biodiversity loss, pollution, climate change, ecosystem degradation and the spread of invasive species require not only scientific and technical solutions, but also an informed society capable of responsible decision-making. Environmental education should therefore develop not only knowledge, but also attitudes, practical skills and responsibility toward nature.

This is particularly important for children and young people, whose direct contact with nature may be limited in a highly digital and technology-oriented society. If nature is experienced mainly through textbooks, screens or abstract examples, environmental problems can appear distant and unrelated to everyday life. Educational activities that bring pupils into direct contact with living organisms, habitats and local environmental issues can make nature protection more concrete, understandable and personally relevant.

Inquiry-based and field-based learning offer valuable opportunities in this context. Through observation, data collection, work with field and laboratory equipment, interpretation of findings and formulation of conclusions, pupils and students encounter science as an active process. At the same time, such activities develop broader competencies, including critical thinking, cooperation, communication, problem-solving and the ability to present one's own observations. These skills are especially relevant in environmental education, where complex problems require both knowledge and collaboration.

Cross-border regions provide a meaningful setting for this type of education. Rivers, watersheds, pollution, species distribution and ecosystem changes do not follow national borders, which creates shared environmental challenges and a need for cooperation. In the Slovak-Ukrainian border region, the Latorica and Bodrog river basin represents such a connected ecological space, where biodiversity, water quality, invasive species and human activities are relevant from scientific, educational and social perspectives.

Universities can play an important role in connecting scientific expertise with school education and public awareness. They provide access to current knowledge, laboratory infrastructure, scientific methods and methodological support for teachers. At the same time, they educate future teachers and scientists, which allows them to transform scientific knowledge into educational activities that are both accurate and applicable in school practice.

The EFFUSE-win project, *Environment For the Future by Scientific Education – work in nature*, responds to these needs by developing a cross-border model of field-based environmental education in the

Slovak-Ukrainian border region. The project connects universities, schools, experts and local communities through outdoor learning, laboratory activities, biodiversity documentation, digital educational tools and awareness-raising events.

The aim of this paper is to present the EFFUSE-win project as a case study of field-based environmental education in a cross-border region. The paper focuses on the project's educational concept, implementation process and preliminary outputs, with attention to inquiry-based learning, living laboratories, biodiversity documentation, teacher support and Slovak-Ukrainian cooperation. Since the project is still ongoing and formal evaluation of learning outcomes has not yet been conducted, the paper does not measure educational impact statistically, but analyses the project design, early implementation experience and educational potential of the model.

2. PROJECT CONTEXT AND CASE DESCRIPTION

The EFFUSE-win project is implemented as a cross-border educational and environmental initiative focused on biodiversity, environmental awareness and knowledge sharing in the Slovak-Ukrainian border region. The project belongs to the priority area of a resilient and green border region and addresses biodiversity protection and pollution reduction through joint education activities, awareness raising and cooperation between scientific, educational and regional institutions.

The project partnership is formed by Pavol Jozef Šafárik University in Košice as the Lead Partner, State University "Uzhhorod National University" and the Institute of Development of Carpathian Region. The partnership builds on previous cross-border cooperation, especially the earlier EFFUSE project, which focused on environmental protection through the study of bioindicators and their habitats in the border regions of Slovakia and Ukraine. EFFUSE-win extends this cooperation by placing stronger emphasis on educational activities, public awareness, field-based learning and the development of tools that can be used by schools and teachers.

2.1 Regional and environmental context

The regional context of the project is defined mainly by the shared natural environment of the Latorica and Bodrog river basin. River landscapes represent connected ecological systems in which changes in water quality, land use, biodiversity or the spread of invasive species can affect wider territories beyond national borders. For this reason, the project approaches the Slovak-Ukrainian border region not only as an administrative space, but also as a common ecological and educational area. This creates a meaningful basis for cooperation between institutions from both countries and for the development of shared educational content.

The project responds to several interconnected needs. From the environmental perspective, the region faces pressures related to pollution, biodiversity loss, invasive species, climate-related changes and human impact on river and landscape systems. From the educational perspective, pupils and students need more opportunities to experience nature directly, understand environmental problems in their local context and encounter scientific work in a practical and accessible way. Teachers also need methodological support, educational materials and examples that can help them connect school biology and environmental education with regional biodiversity.

2.2 Target groups and educational needs

The main target groups of the project are pupils, teachers, university students, future teachers, future scientists, experts and the wider public. Pupils and students participate in school events, field trips, laboratory activities and awareness-raising events. Teachers are involved as important mediators who can transfer selected methods, materials and experiences into school practice. University students and young researchers benefit from the connection between scientific work, educational practice and communication with non-specialist audiences. The wider public is addressed through project outputs, digital resources and activities aimed at increasing environmental awareness.

3. EDUCATIONAL MODEL OF THE EFFUSE-WIN PROJECT

The educational model of the EFFUSE-win project is built around the connection of four components: direct work in nature, laboratory-based activities, digital biodiversity resources and teacher support. These components are not implemented separately, but as linked parts of one educational process. Pupils first encounter environmental topics through observation and practical activity, then continue by working with collected or demonstrated material, interpreting findings and connecting them with broader questions of biodiversity, pollution and nature protection.

The model is designed to move learners from experience to understanding. Instead of presenting environmental problems only through explanation, the project creates situations in which pupils can observe organisms, habitats or selected environmental phenomena directly. This is followed by guided discussion, simple scientific description and interpretation. In this way, project activities connect sensory experience, scientific procedure and environmental meaning.

3.1 Direct contact with scientific work

A central element of the model is the opportunity for pupils and students to experience selected aspects of scientific work. During project activities, participants work with microscopes, field equipment, laboratory tools and biological material. They observe organisms, compare visible structures, record information and describe what they see. These activities help transform science from an abstract school subject into a practical activity based on observation, evidence and interpretation.

The educational value of this approach lies in its accessibility. Pupils are not expected to perform advanced research tasks, but they are introduced to the basic logic of scientific work. They learn that scientific knowledge begins with careful observation, precise description and questions about relationships in nature. This experience can support their understanding of biology and environmental topics, while also helping them recognize science as a possible part of their future studies or professional interests.

3.2 Development of scientific and transferable skills

EFFUSE-win activities support the development of scientific competencies such as observation, comparison, classification, work with data, use of instruments and formulation of simple conclusions. These skills are developed through concrete tasks rather than through theoretical instruction alone. For example, when pupils observe selected organisms or environmental samples, they must

focus attention, distinguish relevant features and communicate their findings.

The ability to identify organisms is considered one of the basic prerequisites for understanding biological diversity and ecological relationships (Randler, 2008). Since understanding the importance of biodiversity is one of the key goals of biology education, activities focused on observation and identification can help pupils connect practical work with broader ecological knowledge.

At the same time, many activities are organized in a way that supports transferable skills. Pupils often work in groups, divide tasks, discuss observations and present results. This strengthens communication, cooperation, responsibility within a team and the ability to explain one's own reasoning. These skills are important in environmental education because environmental problems are rarely solved individually; they require shared understanding, discussion and cooperation.

Topics related to biodiversity and organismal diversity are often difficult for students to understand because of their complexity. They include not only the taxonomic classification of organisms, but also ecological relationships and adaptations to the environment. For this reason, effective and innovative approaches are needed to make these topics more accessible to students (Gafur et al., 2024).

3.3 Role of teachers and transfer into school practice

Teachers are important participants in the project model, not only accompanying persons. Their presence allows project activities to become part of a wider educational process that can continue after a single event. During school events, field trips and laboratory activities, teachers can observe methods, tasks and forms of explanation that may be adapted for their own teaching.

The project also supports teachers through educational materials, video tutorials and examples connected with regional biodiversity. These resources are intended to make field-based and practical environmental education easier to implement in school conditions. They can help teachers introduce local organisms, field observation or simple scientific procedures into lessons, even when schools have limited equipment or time for outdoor activities.

3.4 Living laboratories for young learners

The planned network of young scientists' laboratories strengthens the practical dimension of the project. The biology living lab, environmental solution lab and science lab are designed as spaces where pupils and students can encounter scientific work in a more direct and structured way than is usually possible in regular classrooms. The laboratories provide access to equipment, expert guidance and activities that connect school knowledge with practical investigation.

Their function is not only technical, but also motivational. For many pupils, such laboratories may represent one of the first opportunities to work in an environment associated with real science. This can help reduce the distance between school biology and scientific practice. By involving students in activities where they can apply theoretical knowledge to real-world situations, laboratories can support the development of critical thinking and foster a sense of discovery and inquiry (Asad and Kramer, 2024). They also create conditions for repeated activities, teacher cooperation and the future development of educational programmes focused on biodiversity, environmental quality and nature protection.

3.5 Digital database as a bridge between fieldwork and education

Technological advancements and lifestyle changes increasingly influence educational practice, including the ways in which students encounter biological and environmental topics. An effective approach can combine experiential outdoor learning with instruction in specialized biology classrooms, while also using engaging elements such as computer technology (Sudzinová, 2021). In this context, digital tools can extend the value of field and laboratory activities by making collected information accessible for further teaching and learning.

The organism database developed within the project connects biodiversity documentation with educational use. Its purpose is not only to collect records of organisms from the studied cross-border region, but also to make regional biodiversity accessible to pupils, students and teachers. The database can serve as a source of examples for lessons, field activities and project-based school work.

By working with organisms documented in their own region, pupils can better understand the diversity of local nature. For teachers, the database provides practical support in preparing educational content that is regionally relevant and connected with real environmental surroundings. It extends the educational impact of field and laboratory activities beyond individual events. The use of digital technologies can improve and develop students' skills, increase motivation and engagement, and help them connect what they learn with the real world (Bartošovič and Tamášková, 2023). In this way, the database extends the educational impact of field and laboratory activities beyond individual events.

3.6 Linking environmental education with regional responsibility

The educational model of EFFUSE-win combines scientific experience with the idea of regional responsibility. Pupils are encouraged to see nature not as a distant object of study, but as part of the environment in which they live. By connecting observation, practical work, local biodiversity and cross-border cooperation, the project helps create conditions for a more informed and responsible relationship with nature.

This model does not depend on one isolated activity. Its strength lies in the combination of repeated school events, field experiences, laboratory infrastructure, teacher support and digital outputs. In science education, hands-on, student-centered instruction is essential because it enables a better understanding of natural phenomena through direct experience and supports a deeper grasp of biological concepts (Šorgo and Špernjak, 2012).

Together, these elements form a practical educational framework that can support environmental awareness and scientific competencies while remaining connected to the real environmental context of the Slovak-Ukrainian border region.

4. IMPLEMENTATION AND PRELIMINARY OUTPUTS

The EFFUSE-win project started its implementation on 15 April 2025. Since then, several types of educational, field-based and expert activities have been carried out in Slovakia and Ukraine. These activities were designed to connect school education with practical experience in nature, scientific observation and environmental awareness.

By the current stage of implementation, the project has organized 15 school events, including 3 events in Ukraine, 4 field trips, including 2 in Ukraine, 1 three-day outdoor educational event and 7 expert field trips. The activities differed in their specific content and setting, but they shared a common aim: to bring environmental topics closer to pupils and students through direct experience, practical tasks and contact with scientific methods.

School events focused mainly on introducing pupils to selected biological and environmental topics in an accessible and practical form. Field trips allowed participants to observe organisms, habitats and environmental relationships outside the classroom. Expert field trips supported the documentation of biodiversity and contributed to the preparation of educational content and database materials. The three-day educational programme combined several forms of learning, including field activities, scientific tasks and experiential contact with the aquatic environment.

4.1 Participation of schools and students

The project has so far involved more than 720 students from 12 schools in Slovakia and Ukraine. This participation indicates the educational reach of the project and its ability to involve pupils from different parts of the cross-border region. The activities were implemented with the participation of teachers, who played an important role in connecting project events with the school environment.

The involvement of schools from both countries is important for the cross-border character of the project. It allows environmental education to be connected with a shared regional context and supports the idea that river landscapes, biodiversity and environmental problems should be understood beyond national borders. Although the current outputs do not yet measure changes in students' knowledge or attitudes, the number and diversity of implemented activities show that the project has created a functional platform for further educational work.

4.2 Biodiversity documentation and database development

An important preliminary output of the project is the documentation of organisms in the studied cross-border region. So far, 183 organisms have been documented. This number includes 13 microorganisms, 30 higher plant species, 116 invertebrate species and 24 vertebrate species. The collected data provide valuable visual material that can support organism identification. This is consistent with studies on the effectiveness of visual identification guides; for example, Wäldchen et al. (2022) pointed out that recognition based on visual elements may be more successful than recognition based on verbal descriptions.

The organism database has both educational and informational value. From an educational perspective, it provides teachers and pupils with regional examples that can be used in lessons, field activities and project-based learning. From a broader perspective, it contributes to raising awareness of the biodiversity present in the Slovak-Ukrainian border region. The database also supports digital education, as it makes information about local organisms accessible through the project website and related educational materials.

4.3 Educational materials and digital outputs

In addition to field and school activities, the project develops educational materials intended to support teachers and students.

These include resources available through the project website and video tutorials focused on selected methods and organism groups. Some materials demonstrate how to capture, observe and present selected invertebrates and other organisms in a way that can be adapted to school conditions.

These outputs are important because they extend the project beyond individual events. Teachers can return to the materials after the activities and use them as support for their own teaching. Digital resources also help make the project outputs more accessible to schools that may not be able to participate directly in every field or laboratory activity. In this way, the project strengthens the sustainability and transferability of its educational approach.

4.4 Preliminary educational observations

Formal evaluation of learning outcomes has not yet been conducted; therefore, the project's educational impact cannot be interpreted statistically at this stage. However, informal responses from participating students and teachers suggest that practical work with organisms, scientific tools and field activities is perceived positively. Teachers have particularly appreciated the practical character of the activities and the possibility of using selected methods, materials and regional examples in school education.

These observations should be understood as preliminary implementation experience rather than verified research results. They nevertheless indicate that the project model has potential to support students' interest in biology, environmental topics and scientific work. Future stages of the project should include systematic evaluation, for example through questionnaires, interviews, observation protocols or analysis of student outputs.

4.5 Cross-border implementation experience

The implementation of project activities has also confirmed the importance and complexity of cross-border cooperation. Slovak and Ukrainian partners contribute complementary expertise, methodological approaches and institutional capacities. The joint development of the organism database, educational activities and project outputs supports the creation of a shared educational space focused on regional biodiversity and environmental awareness.

At the same time, the project has been influenced by practical constraints. Direct travel from the Slovak university side to Ukraine is currently restricted, which limits opportunities for in-person observation of partner activities in Ukraine. Part of the cooperation has therefore moved to online communication. In-person meetings remain possible mainly on the Slovak side, where Ukrainian partners have already participated and where further joint meetings are planned. This experience shows that flexible forms of cooperation are necessary for maintaining cross-border educational projects under changing external conditions.

Overall, the preliminary outputs of the EFFUSE-win project demonstrate progress in three connected areas: educational outreach, biodiversity documentation and institutional cooperation. The implemented activities have created a basis for further development of field-based environmental education, while the database, laboratory infrastructure and teaching materials provide tools that can continue to support schools and teachers in the next stages of the project.

5. CONCLUSIONS

The EFFUSE-win project demonstrates how environmental education can be strengthened when it is connected with direct experience, scientific practice and regional relevance. Its main value lies in creating an educational model in which pupils do not encounter nature only as curriculum content, but as a living environment that can be observed, studied and understood through practical activity. Fieldwork, laboratory tasks, biodiversity documentation and digital resources together create conditions for more active and meaningful learning.

The project also shows the importance of cooperation between universities and schools. Universities provide scientific expertise, equipment, methodological support and access to current knowledge, while schools bring this knowledge into the educational reality of pupils and teachers. This connection is especially valuable in biology and environmental education, where practical experience is often limited by school infrastructure, time or available resources.

A significant strength of the project is its cross-border dimension. The Slovak-Ukrainian border region shares environmental systems and challenges that cannot be understood only from a national perspective. By focusing on regional biodiversity and river landscapes, the project helps present environmental protection as a shared responsibility. The developing organism database, educational materials and planned laboratory network create outputs that can remain useful beyond individual events.

At the current stage, the project results should be interpreted as preliminary implementation outputs, not as evidence of measured educational impact. The number of involved students, schools and activities confirms the project's educational reach, while informal feedback suggests positive reception among participants and teachers. However, future work should include systematic evaluation of learning outcomes, changes in environmental attitudes, motivation toward science and the practical use of project materials in schools.

Despite implementation challenges, including limited mobility and administrative processes, EFFUSE-win provides a transferable example of environmental education based on cooperation, local biodiversity and active learning. Its experience suggests that bringing scientific work closer to pupils can support environmental

awareness, strengthen scientific competencies and help build a more responsible relationship with nature in cross-border regions.

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