STEM EDUCATION AND DIGITAL PLATFORMS FOR RAISING AWARENESS OF FOREST CONSERVATION IN SHARR MOUNTAIN NATIONAL PARK

Hasime JASHARI[1'3'4], Arlinda ISMAILI[2], Selma XHELADINI[1'3,4], Selvije SHEMSHIU[1'2]

[1] Faculty of Natural Sciences and Mathematics, "University of Tetovo", Ilinden Street, No. N/A, 1200 Tetovo, Republic of North Macedonia
[2] Primary School "Ismail Qemali", Neraste, Tetovo, Republic of North Macedonia
[3] Primary School "Simce Nastovski", Vratnica.Tetovo, Republic of North Macedonia
[4] Science on Stage North Macedonia
E-mail of the presenting author: hasime.jashari@unite.edi.mkjasharihasime@gmail.com

Abstract

Forests are essential components of terrestrial ecosystems, providing habitats for biodiversity, regulating climate, protecting soil, and contributing to the preservation of water resources. Developing environmental awareness among young people is therefore an important objective of contemporary education, particularly in regions characterized by high ecological value and increasing environmental pressures. This study presents an educational intervention conducted with 170 students from grades V–IX, focusing on the ecological importance of forests in Sharr Mountain National Park and the consequences of deforestation. The intervention integrated environmental education with STEM-oriented learning, experiential activities, digital storytelling, educational design, and family engagement.

Students participated in interactive educational activities, collaborative discussions, role-playing games representing forest organisms and habitats, and practical learning tasks. A central component was the creation of student-produced digital and educational materials. Using StoryJumper, students developed their own digital book addressing forest conservation and environmental responsibility. They also designed educational brochures, which they subsequently presented to family members at home. Padlet was used as a collaborative digital space for sharing activities, documenting results, and maintaining the continuity of the project beyond the classroom.

Data were collected through questionnaires administered before and after the educational intervention, together with students' open-ended responses and the educational products created during the project. The initial questionnaire indicated that 85.3% of students knew that Sharr Mountain has National Park status, while 58.8% recognized deforestation as a threat to forests. Following the intervention, 94.1% considered forest protection important or very important, 78.8% reported that they understood the consequences of deforestation better, and 92.9% expressed a very high willingness to undertake environmental actions. Furthermore, 88.2% stated that the workshop had changed their perception of the forests of Sharr Mountain, and 88.2% expressed interest in participating in similar workshops in the future.

The findings suggest that combining environmental science with digital content creation, collaborative learning, and family-oriented communication can provide a meaningful educational framework for strengthening students' environmental awareness and participation. The project also illustrates how STEM-oriented activities can transform learners from passive recipients of environmental information into active creators and communicators of scientific and educational messages. Nevertheless, the findings should be interpreted as descriptive and self-reported outcomes rather than evidence of long-term behavioral change or a causal effect of the intervention.

Keywords: STEM education; environmental education; digital storytelling; StoryJumper; Padlet; forest conservation; Sharr Mountain National Park; student engagement; family involvement.

Introduction

Environmental degradation, biodiversity loss, deforestation, soil erosion, and climate change represent interconnected challenges that require coordinated responses from scientific institutions, policymakers, local communities, and educational systems. Forest ecosystems are particularly important because they provide a wide range of ecological services, including habitat provision, carbon storage, climate regulation, soil stabilization, water-cycle regulation, and support for biological diversity. Their conservation is therefore not only a matter of

protecting individual tree species but also of maintaining the ecological processes that sustain terrestrial and aquatic environments.

Environmental education has an important role in preparing younger generations to understand these relationships and to participate responsibly in the protection of natural resources. Contemporary environmental education extends beyond the transmission of ecological facts. It seeks to develop knowledge, environmental values, critical thinking, practical skills, and the capacity to participate in collective action. A systematic review by Ardoin, Bowers, and Gaillard (2020), based on 105 studies, emphasizes that environmental education can contribute to cognitive and affective outcomes and that locally relevant issues, partnerships, and opportunities for action are important components of effective conservation-oriented programmes.

In this context, protected natural areas offer valuable opportunities for place-based environmental learning. Their ecological characteristics provide authentic examples through which students can explore biodiversity, ecosystem functioning, human impacts, and the importance of sustainable resource management. Sharr Mountain National Park represents such an educational setting. Its ecological and landscape values make it a relevant context for educational activities addressing forest ecosystems, biodiversity conservation, and environmental responsibility. The Management Plan for Sharr Mountains National Park for 2022–2031 provides an institutional framework for the protection and sustainable management of the area (sarmountain.org.mk)

However, raising awareness about environmental problems does not necessarily lead automatically to responsible action. Students need opportunities to investigate environmental issues, discuss possible solutions, communicate their understanding, and participate in activities that connect learning with everyday life. For this reason, educational approaches that combine scientific content with practical experience, collaboration, creativity, and digital technologies are increasingly relevant(Jashari, et al. 2024).

One approach that can support this integration is STEM education. STEM brings together Science, Technology, Engineering, and Mathematics in learning activities that encourage students to investigate problems, apply knowledge, design products, and communicate solutions. In environmental education, this approach can be extended through creative and communicative activities, including visual design, storytelling, and the development of educational materials. Such integration is particularly valuable when students are encouraged not only to learn about an environmental problem but also to produce something that communicates their understanding to others (Jashari et al. 2023).

Digital technologies can further strengthen this process. Digital storytelling, for example, enables students to transform scientific and environmental information into narratives supported by text, illustrations, and visual elements. A 2026 study by Ergül and Demirci Güler examined primary school students' experiences in developing digital stories about environmental issues and reported positive experiences related to imagination, writing, collaborative work, and the use of digital tools.

The present educational project was developed around this understanding. It focused on the ecological importance of forests in Sharr Mountain National Park and the consequences of deforestation, while placing students in an active role throughout the learning process. The activities combined environmental science, experiential learning, digital storytelling through StoryJumper, educational brochure design, family communication, and continuous sharing through Padlet.

The distinctive feature of the project was that students were not only recipients of information. They became creators of digital educational content, designers of awareness materials, and communicators of environmental messages within their families and the wider school community.

The main aim of this study was to examine the contribution of an integrated environmental and STEM-oriented educational intervention to students' awareness, understanding, and reported willingness to participate in forest conservation activities, with particular reference to Sharr Mountain National Park.

Specific objectives

The study addressed the following objectives:

1. To explore students' initial knowledge and perceptions regarding the ecological importance of forests and the threats associated with deforestation.
2. To engage students in experiential and collaborative activities focused on forest ecosystems and biodiversity conservation.
3. To integrate STEM-oriented learning through scientific exploration, digital technologies, educational design, and the interpretation of questionnaire data.
4. To develop students' digital communication skills through the creation of a digital book using StoryJumper.
5. To encourage environmental communication beyond the classroom through educational brochures presented to family members.
6. To use Padlet as a collaborative digital space for sharing activities, documenting project outcomes, and maintaining student engagement.
7. To describe students' perceptions, understanding, and self-reported willingness to participate in environmental protection following the intervention.

Research questions

The study was guided by the following research questions:

- What knowledge and perceptions did students initially demonstrate regarding forests and deforestation?
- How did students evaluate the educational activities and the ecological content addressed during the intervention?
- How did students perceive the usefulness of the activities for understanding the consequences of deforestation?
- In what ways did digital storytelling and educational brochure design support students' participation in environmental communication?
- To what extent did students report willingness to participate in further environmental protection activities?

Ecological importance of forests and the educational relevance of Sharr Mountain National Park

Forests are complex ecological systems characterized by interactions among trees, shrubs, herbaceous plants, fungi, animals, microorganisms, soil, water, and atmospheric conditions(Jashari et al.2023). Their functioning depends on the relationships among living organisms and the physical environment. These interactions support nutrient cycling, decomposition, soil formation, water retention, habitat stability, and the maintenance of biodiversity(Jashari et al.2026).

Forest vegetation plays an important role in reducing soil erosion by protecting the soil surface, stabilizing slopes through root systems, and influencing the movement of rainwater. The removal or degradation of forest cover can increase the exposure of soil to erosion and may contribute to sediment transport, landslides, and changes in local hydrological processes. The

relationship between forests and water resources is complex and depends on vegetation type, climate, soil characteristics, topography, and land management. Therefore, educational activities should present forests as important components of catchment systems without suggesting that every forest automatically increases water availability under all conditions.
Forests also provide habitats and ecological niches for numerous organisms. Trees and deadwood support fungi, invertebrates, birds, mammals, and microorganisms, while the forest floor provides suitable conditions for decomposition and nutrient recycling. The loss of forest habitats can therefore affect several groups of organisms simultaneously.
Sharr Mountain is an important regional natural area in which forest ecosystems form part of a broader landscape that includes mountain habitats, grasslands, watercourses, and other ecological units. Its National Park status provides a meaningful context for environmental education because students can connect general ecological concepts with a natural area that is geographically and socially relevant to their communities.
The Management Plan for Sharr Mountains National Park 2022–2031 provides the broader management context for the conservation of this area (sarmountain.org.mk)
Integrating this local context into school activities can help students understand that environmental protection is not an abstract global concept but a responsibility connected to the landscapes, resources, and communities around them.
In the present project, the forests of Sharr Mountain were used as a central educational example. The learning activities focused on the importance of forests, biodiversity and habitats, the consequences of deforestation, soil degradation, water resources, climate regulation, and the role of individuals in preventing environmental damage.

STEM education as a framework for environmental learning

STEM education promotes the integration of scientific knowledge, technological tools, design processes, and mathematical reasoning. Rather than treating each subject as an isolated area, integrated STEM learning encourages students to apply knowledge from different disciplines to understand and address real-world problems(Ademi et al. 2024).
Environmental challenges are particularly suitable for this approach because they involve scientific processes, technological solutions, data interpretation, communication, and decision-making. Deforestation, for example, can be explored through ecological science, represented through digital tools, addressed through the design of educational products, and investigated through the analysis of questionnaire data.
In this project, STEM integration was implemented through the following dimensions.

Materials and Methods

Research design

The study employed a descriptive educational-intervention design based on environmental learning activities and questionnaire-based assessment before and after the intervention.
The quantitative component consisted of students' responses to structured questions concerning knowledge, perceptions, and attitudes toward forest conservation. The qualitative component included open-ended student responses and the educational products created during the project.
The study is presented primarily as a descriptive evaluation of an educational intervention. Because individual-level matched data and a control group have not been established in the available dataset, the results are not used to demonstrate causal effects or statistically verified individual-level changes.

Participants

The project involved 170 students from grades V–IX.

Table 1. Distribution of students by grade

Grade	Number of students	Percentage
V	40	23.5%
VI	30	17.6%
VII	30	17.6%
VIII	36	21.2%
IX	34	20.0%
Total	170	100%

The participants represented different grade levels, allowing the educational activities to involve students from several stages of primary education.

Educational intervention

The intervention focused on forest conservation and the ecological importance of Sharr Mountain National Park. It combined several learning methods:

- interactive educational presentations and discussions;
- collaborative activities and role-playing games;
- activities representing forest organisms and their habitats;
- discussion of deforestation and its ecological consequences;
- creation of a digital book using StoryJumper;
- design of educational brochures;
- presentation of brochures to family members at home;
- sharing and documentation of activities through Padlet.

The activities were designed to encourage active participation, cooperation, creative thinking, and the communication of environmental messages.

Digital tools

Three digital and educational tools were central to the intervention.

Tool	Educational purpose	Student output
StoryJumper	Digital storytelling and content creation	Student-created digital book
Canva / digital design tools	Visual organization and design of educational information	Educational brochures
Padlet	Sharing, documentation, and collaborative presentation	Digital collection of activities and results

The use of these tools was not limited to technical familiarization. Each platform supported a specific educational objective: StoryJumper supported narrative creation, brochure design supported visual communication, and Padlet supported collaboration and continuity.

Data collection instruments

Two questionnaire stages were used: an initial questionnaire and a post-intervention questionnaire.
The initial questionnaire explored students' knowledge and perceptions regarding:

- awareness that Sharr Mountain has National Park status;
- the ecological importance of forests;
- deforestation as an environmental threat;
- consequences of deforestation;
- soil degradation and water resources;
- the effects of forest loss on human life;
- the role of forests in climate regulation;
- previous participation in environmental activities;
- individual actions for forest protection;
- communication with parents about forest conservation.

The post-intervention questionnaire focused on:

- students' understanding of the workshop content;
- the topics they considered most important;
- their evaluation of forest conservation;
- their understanding of deforestation consequences;
- changes in their perception of Sharr Mountain forests;
- their willingness to undertake environmental actions;
- their evaluation of the learning methods;
- their interest in participating in similar workshops;
- open-ended reflections about what they had learned.

Data analysis

Quantitative data were analyzed using descriptive statistics. Frequencies and percentages were calculated for categorical responses. Percentages were calculated using the number of valid responses for each question.
For the initial question concerning the main role of forests, 165 responses were recorded. Therefore, percentages for this item were calculated using 165 valid responses rather than the full sample of 170.
The question concerning the consequences of deforestation produced 182 selections. Since this exceeds the number of participants, it is treated as a multiple-response item only if the original questionnaire allowed students to select more than one answer. This point should be checked against the original questionnaire before publication.
Open-ended responses were examined qualitatively and grouped into recurring themes, including biodiversity protection, habitat conservation, prevention of littering, forest protection, personal responsibility, and communication of environmental messages.

Results

Initial questionnaire: students' knowledge and perceptions

The initial questionnaire provided an overview of students' awareness of forest ecosystems and the threats associated with deforestation.

Table 2. Initial awareness of Sharr Mountain National Park

Response	Number	Percentage
Yes	145	85.3%
No	25	14.7%
Total	170	100%

The majority of students (85.3%) knew that Sharr Mountain has National Park status. However, 14.7% did not identify this status, indicating that there was still room to strengthen knowledge about the protected area and its ecological significance.

Table 3. Students' understanding of the main role of forests

Response	Number	Percentage of valid responses
Wood production	25	15.2%
Biodiversity protection	5	3.0%
Clean air and climate regulation	20	12.1%
All of the above	115	69.7%
Total valid responses	165	100%

Most valid responses (69.7%) identified all listed functions of forests. However, only 3.0% selected biodiversity protection as a separate response, suggesting that students may have recognized the combined importance of forests more readily than individual ecological functions.

Table 4. Perception of deforestation as a threat

Response	Number	Percentage
Yes	100	58.8%
No	35	20.6%
Do not know	35	20.6%
Total	170	100%

More than half of the participants (58.8%) recognized deforestation as a threat. However, 41.2% either did not consider it a threat or were uncertain, demonstrating the need for educational activities that explain the ecological consequences of forest loss.

Table 5. Perceived consequences of deforestation

Consequence	Number of selections
Loss of habitats	112
Floods and landslides	30
Climate change	8
Loss of natural beauty	12
Air pollution	20
Total selections	182

The most frequently selected consequence was habitat loss (112 selections). This was followed by floods and landslides (30), air pollution (20), loss of natural beauty (12), and climate change (8).

Because the total number of selections was 182, the item should be described as a multiple-response question only after confirmation that multiple answers were permitted. If only one answer was allowed, the original records should be checked before publication.

Table 6. Students' understanding of soil degradation after forest removal

Response	Number	Percentage
Soil becomes more fertile	3	1.8%
Soil is damaged or washed away	137	80.6%
Nothing happens	30	17.6%
Total	170	100%

A substantial proportion of students (80.6%) recognized that removing forest vegetation can damage the soil or expose it to erosion. Nevertheless, 17.6% believed that nothing happens to the soil after forest removal.

Table 7. Perceived relationship between deforestation and clean water resources

Response	Number	Percentage
Yes	115	67.6%
No	10	5.9%
Do not know	45	26.5%
Total	170	100%

Although 67.6% recognized a relationship between deforestation and clean water resources, more than one-quarter of the students (26.5%) were uncertain. This result highlights the importance of explaining the relationships between forest vegetation, soil protection, water infiltration, runoff, and water quality.

Table 8. Perceived impact of deforestation on human life

Response	Number	Percentage
No impact	8	4.7%
Reduces quality of life	100	58.8%
Affects health and the economy	62	36.5%
Total	170	100%

Most students recognized that deforestation has consequences for human life. In total, 95.3% selected either reduced quality of life or effects on health and the economy.

Table 9. Perceived level of danger associated with deforestation

Rating	Number	Percentage
1	8	4.7%
2	10	5.9%
3	40	23.5%
4	42	24.7%
5	70	41.2%
Total	170	100%

The mean rating was 3.92 on a five-point scale, with a median of 4. A total of 65.9% of students rated the danger as either 4 or 5, indicating that many participants already perceived deforestation as a serious environmental problem.

Table 10. Forest protection and climate change

Response	Number	Percentage
Yes	102	60.0%
No	10	5.9%
Do not know	58	34.1%
Total	170	100%

While 60.0% recognized that forest protection contributes to addressing climate change, 34.1% were uncertain. This suggests a need to strengthen understanding of the role of forests in carbon storage and climate regulation.

Table 11. Previous participation in nature-protection activities

Response	Number	Percentage
Yes	103	60.6%
No	67	39.4%
Total	170	100%

A majority of students (60.6%) reported previous participation in activities related to nature protection. However, 39.4% had not participated in such activities.

Table 12. Students' proposed actions to prevent deforestation

Action	Number	Percentage
Save paper	67	39.4%
Do not litter	78	45.9%
Report forest damage	10	5.9%
Participate in environmental campaigns	15	8.8%
Total	170	100%

The most frequently selected actions were avoiding littering (45.9%) and saving paper (39.4%). Fewer students selected reporting forest damage (5.9%) or participating in environmental campaigns (8.8%).

Table 13. Communication with parents about forest protection

Response	Number	Percentage
Yes	40	23.5%
No	130	76.5%
Total	170	100%

Only 23.5% of students reported discussing forest protection with their parents before the intervention. This finding is relevant because it identifies the family environment as a potential area for extending environmental education.

The same distribution was recorded for the question concerning whether parents should be involved in environmental workshops: 40 students responded positively and 130 negatively. Since these identical counts are unusual in this context, the original questionnaire records should be checked before drawing conclusions from this item.

Post-intervention questionnaire: students' evaluation of the activities

The post-intervention questionnaire provided information about students' understanding of the educational content, their evaluation of forest protection, their reported willingness to act, and their experience of the learning activities.

Table 14. Students' understanding of the workshop topic

Response	Number	Percentage
Very well	150	88.2%
Well	15	8.8%
A little	5	2.9%
Not at all	0	0.0%
Total	170	100%

A total of 97.1% of students reported understanding the workshop topic either very well or well. Only 2.9% reported understanding it a little, while no students selected "not at all".

Table 15. Topics students identified as addressed during the workshop

Response	Number	Percentage
Importance of forests	25	14.7%
Consequences of deforestation	10	5.9%
All topics	135	79.4%
Total	170	100%

Most students (79.4%) recognized that the workshop addressed all the listed topics, indicating that they perceived the activities as covering several interconnected aspects of forest conservation.

Table 16. Perceived importance of forest protection after the intervention

Response	Number	Percentage
Very important	125	73.5%
Important	35	20.6%
A little important	10	5.9%
Not important at all	0	0.0%
Total	170	100%

A total of 94.1% of students considered forest protection important or very important. Specifically, 73.5% selected "very important", while 20.6% selected "important".

Table 17. Students' reported understanding of the consequences of deforestation

Response	Number	Percentage
Yes	134	78.8%
No	10	5.9%
A little	26	15.3%
Total	170	100%

Following the intervention, 78.8% of students reported that they understood the consequences of deforestation better. A further 15.3% reported understanding them a little, while 5.9% answered negatively.

Table 18. Consequences of deforestation that students identified after the intervention

Consequence	Number	Percentage
Loss of animals and plants	15	8.8%
Floods and landslides	15	8.8%
Soil and water degradation	135	79.4%
Air pollution and climate change	5	2.9%
Total	170	100%

The most frequently selected response was soil and water degradation (79.4%). This indicates that students strongly associated deforestation with changes in the condition of soil and water resources.

Table 19. Changes in students' perception of Sharr Mountain forests

Response	Number	Percentage
Yes	150	88.2%
No	5	2.9%
Do not know	15	8.8%
Total	170	100%

A total of 88.2% of students stated that the workshop had changed their perception of the forests of Sharr Mountain. This is an important self-reported result, indicating that the educational activities were perceived as meaningful by most participants.

Table 20. Actions students reported they would undertake after the workshop

Action	Number	Percentage
Do not litter	25	14.7%
Save paper	0	0.0%
Inform others	10	5.9%
Participate in environmental activities	10	5.9%
All of the above	125	73.5%
Total	170	100%

Most students (73.5%) selected all the listed actions, suggesting that they recognized several forms of individual participation in environmental protection.

Table 21. Students' reported willingness to participate in environmental protection

Response	Number	Percentage
Very willing	158	92.9%
A little willing	12	7.1%
Not willing at all	0	0.0%
Total	170	100%

The results indicate a high level of self-reported willingness to participate in environmental protection activities. A total of 92.9% selected "very willing".

Table 22. Students' evaluation of the workshop

Response	Number	Percentage
Very interesting	135	79.4%
Interesting	30	17.6%
A little interesting	5	2.9%
Not interesting at all	0	0.0%
Total	170	100%

The workshop was evaluated positively by the majority of participants: 97.1% considered it either very interesting or interesting.

Table 23. Learning method students found most helpful

Method	Number	Percentage
Group discussion	10	5.9%
Videos and photographs	20	11.8%
Practical activities	42	24.7%
Teacher presentation	98	57.6%
Total	170	100%

Teacher presentations were selected most frequently (57.6%), followed by practical activities (24.7%). Videos and photographs were selected by 11.8%, while group discussions were selected by 5.9%.

Table 24. Students' interest in participating in similar workshops

Response	Number	Percentage
Yes	150	88.2%
Maybe	15	8.8%
No	5	2.9%
Total	170	100%

The high proportion of students expressing interest in future workshops (88.2%) suggests that the educational format was acceptable and engaging for most participants.

6.3. Qualitative analysis of students' open-ended responses

The open-ended responses provided additional insight into what students considered important after participating in the intervention. Their statements were grouped into recurring thematic categories.

Table 25. Main themes identified in students' open-ended responses

Theme	Examples of student statements
Biodiversity and habitat protection	"So that we do not destroy the homes of animals."
Recognition of forest importance	"Forests are much more important than I thought."
Prevention of littering and tree cutting	"We should not throw rubbish or cut down trees in the forest."

Understanding ecological consequences	"I learned how serious the consequences of everyday actions can be for forest life."
Environmental communication	"We should tell others not to deforest forests."

These responses suggest that students' reflections extended beyond the general importance of forests. They included specific references to animal habitats, human activities, environmental damage, and the responsibility to communicate conservation messages to others.
The statement "So that we do not destroy the homes of animals" reflects an understanding of forests as habitats rather than simply areas covered by trees. Similarly, the statement "Forests are much more important than I thought" indicates that some students perceived the educational activities as contributing to a broader understanding of forest ecosystems.
The responses also demonstrate the emergence of a communication-oriented dimension. Students did not only describe what they personally should do; they also mentioned informing other people and encouraging them to avoid activities that damage forests.
These qualitative observations complement the quantitative results and are particularly relevant to the project's emphasis on student-produced educational materials and family engagement.

Student-produced educational outputs and continuity of the project

An important component of the intervention was the production of educational materials by the students themselves. The digital book developed through StoryJumper represented a collaborative learning product through which students transformed environmental information into a structured digital narrative.
The preparation of brochures provided another opportunity for students to organize ecological information and communicate key conservation messages. Their presentation of these brochures to family members extended the educational process beyond the school environment and created an opportunity for intergenerational communication about forest protection.
Padlet was used to share activities and results and to maintain a digital record of the project. The continued uploading of materials and activities indicates that the project was not limited to a single workshop but retained an ongoing documentation and communication component.
These products and practices are important educational outputs in their own right. However, they should be distinguished from measured learning outcomes: the creation of a digital book or brochure demonstrates participation and production, but does not independently prove the extent of knowledge acquisition. Their educational value is best interpreted alongside the questionnaire findings and qualitative student reflections.

Discussion

Environmental awareness and understanding of forest ecosystems

The initial questionnaire revealed that most students were familiar with the National Park status of Sharr Mountain (85.3%). Nevertheless, the results also identified areas in which ecological understanding could be strengthened. Although 58.8% recognized deforestation as a threat, 20.6% did not consider it a threat and a further 20.6% were uncertain. Similarly, 34.1% did not know whether forest protection contributes to addressing climate change, while 26.5% were uncertain about the relationship between deforestation and clean water resources.
These findings indicate that familiarity with a protected area does not necessarily imply a comprehensive understanding of the ecological processes that make its protection important. Students may know that a mountain is a National Park without fully understanding the

relationships among forest vegetation, biodiversity, soil stability, water resources, and climate regulation(Jashari et al. 2023).
This distinction is important for environmental education. Educational activities should therefore move beyond the simple transmission of facts about protected areas and provide opportunities to explore ecological relationships. The project addressed this need by presenting forests as interconnected ecosystems and by discussing the consequences of deforestation for organisms, habitats, soil, water, and human well-being.
The results of the initial questionnaire also suggest that students had different levels of understanding of forest functions. Although 69.7% of valid responses identified all listed functions of forests, only a small proportion selected biodiversity protection as a separate function. This may indicate that some students recognized the general importance of forests but did not necessarily distinguish the ecological processes involved.

The contribution of STEM integration to active environmental learning

One of the main contributions of this project was the integration of environmental education with STEM-oriented activities. The educational process involved scientific concepts, digital tools, design tasks, creative communication, and quantitative interpretation of questionnaire results.
The scientific component provided the ecological content. The technological component enabled students to create digital stories and share their work. The design component encouraged students to develop brochures for a specific educational purpose. The mathematical component was reflected in the organization and interpretation of questionnaire data.
This integration is important because environmental problems are multidimensional. Understanding deforestation requires more than memorizing its definition. Students need to understand ecological processes, recognize environmental consequences, evaluate information, and communicate possible solutions.
The project also incorporated creative and artistic elements through digital storytelling and visual design. These activities are consistent with a STEAM-oriented approach, in which artistic and communicative forms complement scientific and technological learning.
The educational value of this approach lies in the transition from passive reception to active production. Students were expected to organize information, make decisions about presentation, create educational outputs, and communicate their messages to an audience. This provided a practical context for applying knowledge rather than treating environmental education as an isolated theoretical topic.

Digital storytelling through StoryJumper

The creation of a digital book through StoryJumper was a central component of the intervention. By developing their own digital book, students participated in the process of selecting information, organizing ideas, constructing narratives, and combining written and visual elements.
Digital storytelling can provide an accessible way of communicating environmental issues, especially when complex ecological concepts need to be presented to younger audiences. The process also encourages learners to take responsibility for the accuracy and clarity of the information they communicate.
The relevance of this activity is supported by the study of Ergül and Demirci Güler (2026), which examined the experiences of primary school students in creating digital stories about environmental issues. Their findings describe positive experiences related to imagination, writing, collaboration, and the integration of technology into learning.

In the present project, the digital book was not simply an exercise in using an online platform. It functioned as a student-produced educational resource through which ecological information was transformed into a narrative. This distinction is important: technology becomes educationally meaningful when it supports a defined learning objective and enables students to create, communicate, or investigate knowledge.

Educational brochures and the extension of learning into the family environment

The preparation of educational brochures represented another important aspect of student participation. Unlike activities intended exclusively for classroom assessment, the brochures were designed to communicate environmental messages to an audience beyond the school.
Students took the brochures home and presented them to their family members. This created an opportunity for the knowledge developed during the intervention to be communicated within the household. It also positioned students as active contributors to environmental awareness in their families (Canva Pty Ltd., n.d.).
This aspect is particularly relevant when considered alongside the initial questionnaire. Only 23.5% of students reported having discussed forest protection with their parents before the intervention, while 76.5% reported that they had not. The presentation of brochures at home therefore provided a practical opportunity to initiate or strengthen communication about forest conservation within families.
However, the available data do not establish how many family members received the brochures, whether discussions occurred in every household, or whether family members changed their environmental practices. These outcomes would require separate data collection, such as family feedback forms, short interviews, or follow-up questionnaires.
Nevertheless, the family-oriented component represents a meaningful educational strategy because it extends environmental communication beyond the immediate classroom setting. It also corresponds with the broader understanding that effective environmental education can involve partnerships and action-oriented learning rather than information transfer alone (Ardoin et al., 2020).

Padlet and the continuity of environmental learning

Padlet provided a digital space for sharing student activities and documenting the results of the project. Its use supported the organization of educational materials and allowed the project to maintain a visible digital record beyond the initial workshop.
This aspect is important because educational interventions are often limited to a defined period, after which student engagement may decrease. The continued uploading of activities and results to Padlet offers a way to maintain communication, revisit previous work, and make students' contributions visible.
The platform also supports the idea that environmental learning can be iterative. Students can return to previously shared materials, observe the work of others, and contribute additional content. In this way, Padlet can function as a digital learning portfolio and a space for collaborative documentation (Padlet, Inc., n.d.).
The present study does not quantify how frequently students accessed Padlet or how many contributions were uploaded after the workshop. Therefore, the platform's contribution is described as an educational and organizational feature of the intervention rather than as a separately measured learning effect.

Students' reported willingness to participate in environmental protection

The post-intervention questionnaire showed that 92.9% of students reported a very high willingness to participate in environmental protection activities. Furthermore, 73.5% selected all the proposed actions when asked what they would do after the workshop, including avoiding littering, saving paper, informing others, and participating in environmental activities.

These findings are encouraging because they indicate a strong stated intention to participate in environmental protection. The qualitative responses also support this interpretation. Students referred to protecting animal habitats, avoiding littering, preventing tree cutting, and communicating environmental messages to others.

Nevertheless, willingness to act should not be interpreted as proof of actual long-term behavior. Environmental education research distinguishes between knowledge, attitudes, behavioral intentions, self-reported behavior, observed behavior, and measurable environmental action. Ardoin et al. (2020) emphasize that documenting direct conservation outcomes requires intentional planning and appropriate measurement.

For this reason, the high level of willingness reported in the present study should be understood as a positive self-reported outcome that may provide a foundation for future action-oriented activities. Follow-up observations would be needed to establish whether students subsequently participated in campaigns, reported environmental damage, reduced waste, or engaged in other measurable conservation activities.

Students' evaluation of the educational methods

The workshop was considered very interesting or interesting by 97.1% of participants. In addition, 88.2% expressed interest in participating in similar workshops in the future.

When asked which learning method was most helpful, 57.6% selected teacher presentation, 24.7% selected practical activities, 11.8% selected videos and photographs, and 5.9% selected group discussion.

The high proportion selecting teacher presentation suggests that structured explanations remained important for students' understanding. At the same time, the proportion selecting practical activities indicates that experiential learning also had a meaningful place in the educational process.

These findings suggest that digital and practical activities should not necessarily replace teacher explanation. Instead, they can complement it. A balanced approach can combine clear scientific explanations with student-centered tasks, collaborative production, and opportunities to communicate knowledge.

The educational products developed during the intervention also illustrate the importance of allowing students to demonstrate understanding through different forms of expression. Some learners may communicate more effectively through writing, others through visual design, storytelling, discussion, or practical activities.

Environmental education as a bridge between school and community

The project's most distinctive feature was the combination of classroom learning, student-created digital content, printed educational materials, family communication, and online documentation.

The creation of brochures and their presentation at home provided a direct connection between school-based learning and family environments. The digital book and Padlet extended this process into digital spaces, allowing student work to be shared and revisited.

This approach is consistent with the broader objectives of Education for Sustainable Development, which emphasizes the role of education in supporting sustainable societies, developing capacities, and encouraging local-level action. UNESCO's Education for Sustainable Development: A Roadmap identifies youth engagement and local action as important areas for implementation (UNESCO)
In the context of Sharr Mountain, this approach has particular educational relevance. Students live in communities connected to the mountain landscape and its natural resources. By developing an understanding of forest ecosystems and communicating conservation messages to their families, they can become participants in a broader culture of environmental responsibility.

Educational implications

The results and implementation of the project suggest several implications for environmental education and integrated STEM teaching.
First, environmental education should be connected to local ecosystems and protected areas. The use of Sharr Mountain National Park as the central context enabled students to relate ecological concepts to a natural area with regional significance.
Second, STEM activities should encourage students to produce educational outputs rather than merely use digital tools as passive recipients of information. The development of a digital book and educational brochures provided opportunities for research, organization, design, communication, and creativity.
Third, digital storytelling can be incorporated into science education as a method for communicating ecological knowledge. Students can create stories about habitats, biodiversity, water resources, forest ecosystems, and the consequences of human activities.
Fourth, environmental education should include opportunities for communication beyond the school environment. The presentation of brochures to family members illustrates how students can become communicators of environmental messages within their households.
Fifth, digital platforms such as Padlet can support continuity by providing a shared space for documenting activities, presenting student work, and maintaining engagement after the completion of a workshop.
Finally, future projects should include systematic follow-up activities to determine whether students' reported willingness translates into observable environmental action. Such activities may include school-based conservation campaigns, tree-planting initiatives where ecologically appropriate, litter monitoring, biodiversity observations, or student-led awareness campaigns.

Recommendations for future implementation and research

Based on the experience of the project, the following recommendations are proposed:

1. Develop a longer-term STEM environmental education programme. Activities should extend beyond a single workshop and include repeated opportunities for ecological investigation, digital production, and environmental action.
2. Include field-based learning. Where possible, students should observe forest habitats, identify plant and animal diversity, examine soil conditions, and document human impacts in appropriate and supervised locations.
3. Expand digital storytelling. Students could develop additional digital books about biodiversity, forest organisms, water resources, and the ecological importance of protected areas.
4. Develop family participation indicators. Short feedback forms could establish whether brochures were presented at home and whether they stimulated family discussions.

5. Use Padlet as a continuing learning portfolio. The platform could include student reflections, photographs of activities, digital stories, brochures, and records of school-based environmental initiatives.
6. Introduce follow-up assessment. A questionnaire several months after the intervention could explore whether students retained their knowledge and participated in practical environmental activities.
7. Strengthen quantitative evaluation. Future studies should use clearly defined pre- and post-intervention questions, consistent response options, complete response records, and participant codes that allow anonymous matching where ethically approved.
8. Measure concrete environmental actions. In addition to attitudes and intentions, future research should document participation in campaigns, waste-reduction activities, biodiversity observations, and other measurable actions.

Conclusions

This study presents an educational intervention that integrated environmental education, STEM-oriented learning, digital technologies, creative production, and family communication to promote awareness of forest conservation in Sharr Mountain National Park.

The initial questionnaire demonstrated that many students were familiar with the protected status of Sharr Mountain, but uncertainties remained regarding the ecological consequences of deforestation, particularly its relationship with climate change and water resources. The educational activities addressed these issues through scientific explanations, collaborative learning, practical tasks, and the creation of student-produced educational materials.

The post-intervention questionnaire indicated that 94.1% of students considered forest protection important or very important, 78.8% reported a better understanding of the consequences of deforestation, and 92.9% expressed a very high willingness to participate in environmental protection. Furthermore, 88.2% reported a change in their perception of Sharr Mountain forests, while the same proportion expressed interest in participating in similar workshops.

An important contribution of the project was the integration of digital technologies into the learning process. Through StoryJumper, students created their own digital book, transforming environmental information into a digital narrative. They also designed educational brochures and presented them to their family members, extending environmental communication beyond the classroom. Padlet provided a collaborative digital space for sharing activities and documenting the continuing development of the project (StoryJumper, n.d.).

These activities demonstrate the educational potential of positioning students as creators and communicators of scientific knowledge. The project brought together ecological understanding, technological skills, design, creativity, data interpretation, and environmental responsibility. It also showed how school-based learning can be connected with family communication and digital collaboration.

Although the findings are descriptive and do not establish long-term behavioral change or a causal effect of the intervention, they provide encouraging evidence of students' positive perceptions, engagement, and reported willingness to participate in environmental protection.

Overall, the project illustrates how integrated STEM and environmental education can support a more active, creative, and community-connected approach to learning about forest ecosystems. By linking scientific understanding with digital creation and communication, schools can help students develop not only knowledge about nature but also the confidence and responsibility to communicate its importance to others.

References

[1] Ademi, F., Jashari, H., Memedi, B., Aliti, R., & Ziberi, B. (2024). THE ROLE OF NETWORKING AND INTERNATIONAL EXPERIENCES IN SHAPING STEM CURRICULA. *EDUCATION Journal of Educational Research*, *6*(11-12), 170-177.

[2] Ardoin, N. M., Bowers, A. W., & Gaillard, E. (2020). Environmental education outcomes for conservation: A systematic review. Biological Conservation, 241, 108224. https://doi.org/10.1016/j.biocon.2019.108224

[3] Canva Pty Ltd. (n.d.). Canva [Graphic design platform]. https://www.canva.com/

[4] Ergül, S., & Demirci Güler, M. P. (2026). Primary school students' experiences in developing digital stories on environmental issues: An action research. Education and Information Technologies, 31, 4369–4396. https://doi.org/10.1007/s10639-026-13966-6

[5] Jashari, H., Tofilovska, S., Karadelev, M., & Rusevska, K. (2023). Diversity of larger fungi in coniferous communities of Shar Mountain National Park (Republic of North Macedonia) with new country records. *Ecologia Balkanica*, *15*(2), 83.

[6] Jashari, H., & SHEMSHIU, S. (2024). Environmental awareness through STEM education. *EDUCATION Journal of Educational Research*, *6*(11-12), 58-64.

[7] Jashari, H. (2023). Some practices from STEM education and the incorporation of some SDG goals in the educational process in the Republic of North Macedonia. *European Journal of Social Sciences Education and Research Articles*, *10*.

[8] Jashari, H., Tofilovska, S., Karadelev, M., & Rusevska, K. (2026). New data on the diversity of fungi and fungus-like organisms in the coniferous forests of Shar Planina National Park with two species registered for North Macedonia for the first time. *Comprehensive Plant Biology*, *50*(1), 1-10.

[9] Padlet, Inc. (n.d.). Padlet [Collaborative digital platform]. https://padlet.com/

[10] Public Institution National Park Shar Mountain. (2022). Management plan for Shar Mountains National Park for the period 2022–2031. https://www.sarmountain.org.mk/sites/default/files/2023-07/management-plan-np-shar-mountains_en-final-22-may.pdf

[11] StoryJumper. (n.d.). StoryJumper [Digital storytelling platform]. https://www.storyjumper.com/

[12] UNESCO. (2020). Education for sustainable development: A roadmap. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000374802