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THE BIG GAME: Immersive and Multidisciplinary STEM Learning through A Cooperative Story-Driven Digital Game

Code 2021-1-FI01-KA220-SCH-000024098

R2 Handbook and Toolkit on Digital Storytelling approach in STEM

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Activity related	***R2 Handbook and Toolkit on Digital Storytelling approach in STEM***
Deliverable N° and title	**R2/A4.** Development of a set of learning scenarios. **R2/A5.** Development of the handbook and the toolkit to be delivered to the target groups to be used to submit the suggested solutions to solve the environmental missions/problems arisen in the digital game-based learning environment or as lesson plans to exploit in the face-to-face activities in the classrooms.

Contents

Introduction

Nowadays, digital transformation and recognising digital skills are crucial for citizens of current and future society. Therefore, everyone should gain sufficient base skills in basic education to master various ICT tools and working methods. However, based on OECD PIAAC (Programme for the International Assessment of Adult Competencies) surveys, gaps in the digital skills of European teachers have been identified, as they often do not have the time or the opportunities offered by the work environment to adopt new technology-based ways and methods of learning.

In addition, the students' interest in STEM (Science, Technology, Engineering and Mathematics) subjects has declined across Europe, according to the current research findings. The latter manifests in the students' difficulty approaching scientific topics and dealing with the problems and phenomena studied from a multidisciplinary perspective.

In this context, the BIG_GAME project, co-funded by the European Commission through the Finnish National Agency in Erasmus Plus Programme – School Education (Code 2021-1-FI01-KA220-SCH-000024098) aims to promote interest and excellence in the STEM approach to education through multidisciplinary learning and problem-solving related to the environmental context in the form of a serious learning game. This will support digital transformation in schools by providing an online and hybrid learning model and a digital storytelling approach based on methodology and tools in learning and cooperation in digital environments.

Moreover, it will show its benefit in raising awareness of environmental and climate change issues and engaging in the fight against climate change through impressive and attitude-shaping immersive learning experiences.

In this context, this outcome results from an exhaustive analysis realised in the partners' countries (Finland, Italy, Romania, and Estonia) implemented in the report "R2.1 Digital Storytelling and STEM: good practices and experiences implemented". This report, available on the project website (https://big-game.eu-track.eu/) aims to explain and describe the digital storytelling methodology, its use in STEM education and the game design and to collect the existing good practices and experiences of using Digital Storytelling in STEM education. In addition, it showed some practical examples related to the modality implemented in the partners' countries to assess and evaluate the learning

scenario constructed by the students. Following this first result, this second section of the *R2 Handbook and Toolkit on Digital Storytelling approach in STEM, related to R2/A4 and R2/A5, provides* the targets groups, teachers and students with the instructions and the learning scenario template to support them in constructing an experience, based on a game world on the verge of an environmental catastrophe. The students will be able to structure a set of scenarios or missions in the form of environmental problems arising in the game's fictional world that should be solved.

1. Digital storytelling and games

Digital resources can constitute valid support for the innovation of the teaching of any discipline, as they offer didactic mediation in the use and selection of the contents to be taught through the transformation of these contents into skills to be developed by meeting the needs of the learners. Research and experimentation with new languages and methods stimulate the students by encouraging their involvement: the combination of storytelling with gameplay practices and the media responds to this purpose.

Usually, digital storytelling can facilitate teachers in introducing complex topics in a captivating way. It is based on a playful-narrative approach to "mediated" learning with digital technologies. With storytelling, students can use sequences of pre-established events with interactive stories and construction of scenarios, also called story world. The design of the latter, i.e., interactive stories like role-playing games and videogames, involves reflecting on the narrative structure and on the constraints of internal coherence, which is essential to make stories and narratives interesting and meaningful to use expressive and communicative skills. The game takes the form of the "manipulation" of historical knowledge and editing of digital resources (sounds, images, and videos) selected from web archives based on a shared digital storyboard.

The digital storytelling game is configured as a game and learning context aimed towards producing digital narratives. Playing with disciplinary knowledge is an effective way to learn by exploring new technologies' creative and playful potential: relationships are established between facts that become digital narratives through responsible use of the sources utilised. The digital storytelling methodology favours the learning and development of grammatical, compositional, expressive, technological, and critical skills through the manipulation of multiple codes and formats of oral, written and visual narration. Consequently, the educational potential of storytelling is closely related to narration, understood as an interpretative and cognitive device, precisely because stories are categories of knowledge that allow students to understand and order information and knowledge by acquiring competences based on knowing how to set one's skills and knowledge in motion to identify solutions and solve new and complex problems as state by Le Boterf (1994) [1].

1.1 The use of digital storytelling in the educational context

The disciplinary content presented through a story, an anecdote is easier to understand and remember than a simple explanation: the events are linked chronologically, and a common theme also links them, and this facilitates the learning process. The narrator selects the events and determines the story's significance through the order in which he orders these events in sequence. The narratives are structured on two temporal levels: the sequence of plot events and the sequence in which they are connected: story setting, confrontation and resolution, with passages from one act to another through key points and a central point in the middle of the second act. It is an educational format that empowers the student to conceptualise the story in a narrative sequence, the "educational events", and involves the relationship between the organisation, selection and integration of information. The creation of digital narratives is aimed at actively enhancing the students' learning experiences. Storytelling is an authentic task. The key factor is to make sense of things to organise them within narrative structures according to the logic of cause and effect. In this way, the narration, creation and use of stories become a system of organisation and interpretation of our experience.

A story can be defined as a unique series of events or mental states that do not have an autonomous life or meaning but acquire one only within the sequence in which they are arranged in the plot. (Bruner, 1992). [2]

Storytelling is a useful teaching strategy for:

- Integrating active learning scenarios, planning resources, spatial skills, and immersion, and observing interactions and results in the environment; all this can help students in the development of high-value skills such as managerial resources or decision-making.
- Communicating ideas, telling stories, encouraging exploration and the exchange of ideas, and team play.
- Creating interdisciplinary links.
- Facilitating the learning of disciplinary contents and concepts engagingly by encouraging problem-solving and the identification of links between different concepts.
- Memorising information and concepts.

Storytelling and, therefore, the educational function of narration can support educational activities in many disciplines, including STEM (Science, Technology, Engineering and Mathematics). One of the reasons is that interactivity facilitates the learning experience by participating in the construction of a narrative, as in:

- The drafting of an interactive non-fiction text on a study area or the creation of an invented story.
- The drafting of an experience report gained in the field, the personal re-elaboration of concepts and contents related to the subject of study with a view to skill-based teaching.

1.1.1 The educational function of storytelling

Storytelling is one of the functional educational approaches to developing cognitive skills because, through guided and engaging strategies, it supports giving meaning to concepts and asking students to engage in complex activities. With the experience of the game, students follow a path to build a specific narrative, interact in a new learning environment, manipulate resources and activate the game's dynamics. It is functional to contextualise the playful situation in which the interactive and game dynamics occur.
Some key digital storytelling concepts are writing speed, commenting speed, source verification and writing speed.
Digital storytelling can expand learning scenarios, allowing students to use their experience and creativity to develop multimedia products within the study curriculum.
Storytelling uses a structure of discourse: telling a story involves the identification of a protagonist (real or fictional) and follows his/her events and emotions, intertwining with other elements (e.g. characters, phenomena), identifying the characteristics of the potential user of the product, preparing the ability to assess whether what is said/written is effective with respect to the communication objective that has been set, the choice of the possible form of the story (e.g. written, video, comics, theatre, public speaking).
Storytelling is also used in scientific dissemination, which takes place on the web. Therefore, this approach is transversal and acts as a bridge for an interdisciplinary view by guaranteeing the development of those soft skills necessary for the world of work.

1.1.2 Digital storytelling in the classroom

Digital storytelling activities in the classroom are part of the logic of student-centred learning paths since the student is active in their own learning process, mobilising internal resources (knowledge, skills, and creativity) and external resources (media, equipment), in order to create original products such as videos, multimedia presentations, digital books and stories, comics and posters, etc. These artefacts are the results of one's own learning. Digital storytelling activates transversal skills through learning by doing, cooperative learning, critical thinking and problem-solving. It takes time to develop an educational game, a story, or an experiment and translate it into a media resource.

Personalised games, i.e., developed within the class/school context, are integrated with the curriculum; therefore, they are closely related to the objectives set for formal learning. In addition, they respond to student profiles. Reaching the goal focuses students' attention and continuously guides their participation in the game. The rules impose constraints in achieving the goal, but the teacher limits the obvious ways to achieve the goal; for this reason, the rules push students to explore spaces of possibility, freeing creativity and encouraging strategic thinking.

Work is performed in laboratory mode on the fundamental elements of storytelling, on the use of software and apps suitable for the purpose, on didactic planning and on the concrete realisation of storytelling. The design of a learning situation opens to multiple solutions in which subjects' experiment, in the form of a game, strategies for solving one or more problems contributes to making learning meaningful and contributes to the development of students' affective, cognitive, psychomotor and social skills. Adopting the game in educational paths means not simply using an artefact already prepared by companies (which perhaps does not fully meet the training objectives) but designing a playful learning situation that "brings into play" open problems and players, solution strategies and interactive dynamics. The discussion and interactions generated between the students favour the processes of reflection and sharing.[1][3] If learning is also a social

[1] For Vygotsky social interactions between students and with teachers influence their cognitive development. The zone of proximal development is the social space between the actual level of development of a learner (determined by autonomous problem solving) and the level of potential development (determined through problem solving under the guidance of adults or in collaboration with more capable peers).

process, the digital storytelling technique presupposes the promotion of social activities for:

- the production of ideas, the construction of digital narratives and the storyboard.
- the creation of shared meanings through the connection of events, materials, work practices, the manipulation or combination of various media.
- the promotion of discussions and moments of confrontation between peers.
- the promotion of the process of reflection on one's own media and narrative skills.

A digital narrative's pre-production, production and post-production phases take place in subgroups. During these processes, the construction, de-construction, and re-construction of the digital narrative take place, as well as the negotiation of acceptable social behaviours prompted by the continuous feedback received from the peer group and the teaching staff.

2. A story model for learning

As for the planning of any educational intervention, the teachers ask themselves the following questions: what the objectives of the educational intervention are (in this case, it is an intervention based on digital storytelling); what are the criteria on which to base the measurement and evaluation of objectives, and which strategies and tools to adopt.
To facilitate the learning process, a photo, an audio track, and some documentation can be presented to the class to start the discussion and make the contents less abstract and more understandable.
The Learning Story model for scenarios proposed by the European Schoolnet *Creative Classrooms Lab project* (CCL)[2] suggests the following work phases:

1. *Dream:* students can brainstorm, think freely and share ideas.
2. *Explore:* students collect information on a specific topic.
3. *Map:* students structure their thoughts and ideas and seek to understand how they are related.
4. *Make:* students develop or create a product or practice an activity.
5. *Ask:* students can interview experts and stakeholders.
6. *Remake:* students replan or revisit their product based on the feedback or further information they have received.
7. *Show:* students publish and present the results of their work.

Based on this model, digital storytelling is part of the "MAKE" phase.
In order to support editing and playing, the teacher identifies a format, a defined model: an authoring tool that allows students to create (based on a flexible and customisable template with respect to sequences of events and rules of adaptation) different cognitive paths by integrating various types of multimedia content. The authoring tool is presented as a desktop application, and the digital stories created can be used both from a PC or a mobile device such as a tablet or smartphone.
Here are some hints and ideas to implement digital storytelling in the classroom [3]:

[2] http://creative.eun.org/
[3] Some ideas are taken from: https://insegnantiduepuntozero.wordpress.com/2018/04/01/percorsi-di-digital-storytelling-dalla-teoria-alla-pratica/

- Identify the learning objectives in order to facilitate the understanding of the topic.
- Identify an educational resource or a situation as an example to raise students' awareness of the subject and recognise its elements of complexity.
- Transform a story or part of it into a dialogue, an interview or a telephone conversation.
- Transform a story into a comic or a video animation.
- Narrate a complex dream set in the past or in the future.
- Show the image of a person about to perform an action and ask students to imagine what will happen next.
- Present a video of a news report or an article and ask the students to tell the story from the point of view of the different characters involved.
- Create imaginary interviews or a video reportage.
- Create a fake radio broadcast or a talk show in which young people are spokespersons of opposing ideas and simulate the intervention of experts.
- Recount historical events from the point of view of a fictional character (e.g., the story of a soldier on the front line, the official speech of a historical figure, or the farewell for the funeral of a famous person, etc.);
- Create a fictitious newspaper article that tells of a historical or biographical event.
- Reconstruct a sequence of events, a historical event or a biography through a timeline or the itinerary travelled by the protagonist of a novel, a scientist or an explorer, through an interactive map.
- Create an advertising campaign for the dissemination of shared messages and values.
- Create a video trailer or an invitation flyer to read a book, visit an exhibition or watch a film/show.
- Create fake Tweets, or Facebook comments to recreate the dialogue between the characters of a story.
- Express the inner monologue of a character at a particular moment in the story.
- Propose a short video and ask students to continue the dialogue between the characters, identifying with one of the characters and writing their diary, imagining possible endings.

To produce shared digital stories, students use multimedia linguistic stimuli, adopting a multimodal and interactive approach to use/produce content, "manipulating" digital resources (images, videos, texts), technological tools (mobile devices, computers, iPads, digital cameras), software, social networks and platforms for the production, publication and sharing (YouTube, Facebook, Twitter) of digital narratives. The tools that can be used in educational contexts are smartphones, tablets, and computers to use applications to create video animations in various resolutions, online graphics applications to create interactive images, and online platforms for creating and sharing eBooks.
Some of these resources are:

- text generators (such as https://cooltext.com/, https://glowtext.com/),
- image generators (such as https://pixabay.com/, https://storyset.com/),
- backgrounds, templates for presentations (such as https://slidescarnival.com/, https://slidesgo.com/),
- voice recorders (such as https://vocaroo.com/),
- music (such as http://dig.ccmixter.org/film, https://freemusicarchive.org).

An example of the effective use of this approach in the class is to foster scientific culture. Actually, the teacher can deliver to the students a real case because it can lead them to problematisation, analyse complex situations, and reflect on possible solutions. Before starting these activities, they should first understand the phenomenon, analyse the problem, and analyse both the context and all the variables involved.
A similarity between the case study submission and the use of the digital storytelling approach in the classes in coping with the phenomena to be studied is represented by the following example:

Table 1 - Similarities between "case study" and the use of "digital storytelling"

Case study [4]	Digital storytelling
Define the topic and the problem.	Define the topic of the story, its purpose, and potential audience, and create a map of your story.

[4]Adapted from https://it.pearson.com/aree-disciplinari/italiano/didattica-digitale/storytelling-digital-storytelling.html

Define data collection and analysis techniques.	Receive feedback from others on your story and look for relevant documentation to deepen the context/case/character.
Prepare for data collection.	Write the script and draw up the media needed to make the product.
Collect the data.	Prepare audio/video/sounds/images/drawings.
Analyse and evaluate the data.	Listen, select, and edit footage/materials. Evaluate the product and reflect on a possible revision.
Disseminate the data.	Disseminate the product.

2.1 Designing interactive stories

The creation of digital storytelling requires **detailed planning of the operations** to be carried out. It places students in the situation of using different technological tools and solving the problems that emerge during their use, both regarding technical mastery and the social and behavioural dynamics related to them. In practice, eight steps can be identified for the creation of digital storytelling [4]:

1. start with an idea - define the initial idea through a brief description, a diagram, or a question.
2. research/explore/learn - research, collect, and study information from which the story will be created.
3. write/script - write the story by defining the style of the narrative.
4. storyboard/plan - translate the story into a script/screenplay/storyboard.
5. gather and create images, audio and video.
6. put it all together - edit and reassemble the material.
7. share - distribute the product.
8. reflection and feedback - collect and analyse feedback.

As indicated in point 1, the **game action** must be defined: the game action is to design the story and the narrative junctions. The **first game action** is the drafting phase of story planning. [5] Different activities are foreseen to approach the story's writing: textual, graphic, and scenarios. The teacher's decision is essential to proceed with the design of the writing experience to be proposed to students. This decision involves the use of

different expressive languages. The approaches are based on the presentation of a stimulus, such as, for example, plotlines that the students have to develop using search engines and sites of interest that are useful for drafting the continuation of the story. The textual approach involves activating an information search process intending to draw a text. The visual approach involves searching for images and news to produce a media product. The scenario approach provides that students build game scenarios through the applications after selecting a series of information and images about the event.

The **second game action** is the construction phase of the story, i.e., the actual writing of the story, the schematisation of the events in which the story unfolds and the reflection on the drafting of a list of materials necessary to create a digital story. Ohler [5] proposes three instruments:

- **Story Core**: This tool indicates the presence of key elements of the narrative, such as the central problem, the transformation of the protagonist and the solution to the problem.
- **Story Map**: This page contains the plot and key elements of the story to show it graphically in summary.
- **Storyboard**: This is a tool for organising the time and space of the story through scenes to represent their graphic visualisation. For each scene to be shot, photographed, or inserted, the students indicate the corresponding textual part, the effects or transitions, and the music or sounds they intend to insert.

The storyboard facilitates the overall vision of the story and the generation of an action plan for its production. This is functional to any discussion and divergence of ideas and the activation of problem-solving and reflection strategies in the construction process.

The **third game action** is the story production phase. After writing it, it is necessary to draw up a list of the media (starting from the indications included in the storyboard) to create a digital story (music, images, videos, drawings) necessary for its production. Subsequently, it is necessary to reflect on editing, or rather on the choice of the manipulation of the "media", as the digital game storytelling workshops can also be exploited outside the school (excursions, historical museums, libraries, associations) and adopting simulation methodologies (such as role-playing, imaginative play).

In active teaching, the focus is on the skills that students should acquire; in this context, technology offers the possibility to express one's creativity. This implies that they must

understand the tasks well, allowing them to present their final work to the class or a wider audience. To give significance to the activity, it is essential to carry out the presentation of the product outside the classroom context, to carry out the debriefing or the metacognitive reflection on both individual and group learning processes, as well as the progress achieved. The presentation to others can also take place in original ways, such as through videos or blogs. The latter can be enriched with in-depth courses.

2.2 The learning evaluation

It would be desirable to further document educational practices in the use of digital games in the classrooms to evaluate the actual impact on students and understand how the teachers can evaluate the students' learning. Usually, when the games are used in the classroom, the main goals are the following:

- To develop the acquisition of specific technological skills, video editing, creative writing, the organisation of a storyboard.
- To use techniques and strategies to facilitate creativity (brainstorming, creative writing techniques, etc ...).
- To study the strategies used by the working group to write and share digital stories collaboratively.
- To promote reflection on one's own actions and relational dynamics implemented during the various phases of the game and in any conflicts with other students.

Considering that this is an educational intervention based on the development of skills through *learning by doing* and *cooperative learning*, it is not functional to evaluate skills by simply using quizzes or multiple-choice questions, as it is necessary to evaluate the educational experience and the interaction models. In this context, three main types of evaluation have been identified [6]:

1. **Completion assessment** measures whether the result has been obtained. Therefore, it is carried out at the end of the learning process (equivalent to the summative assessment).

2. **In-process assessment** measures how, when, and why the player has made choices. Therefore, it is carried out during the learning process (equivalent to formative assessment) and is the most difficult to carry out.
3. **Teacher assessment**: observations and judgments of the teacher in action, difficult to obtain by technology.

The following tools are used with the **Completion assessment**:

a) Pre-tests and post-tests to measure the level of development of ability and competence, as well as to verify the effect of a new teaching method, but there is a limit given by the difficulty of controlling the effects of external variables. One can check usage times, access to the resource, and the usability level of the interaction interface of the environments and educational software. An element of evaluation is to verify whether the teaching resource was able to guide the student in the acquisition and maturation of certain concepts using real scenarios. An element of evaluation is the presence of alternative resources for further study, which means that the guided structure affects the impact they have had. For example, in an imaginary situation, students can use a quantitative reading of the laws and their applications. This reading accompanies understanding and reflection on the phenomena presented within the interactive narrative. Is there a direct correspondence between access to resources and learning levels achieved? Are the levels of knowledge achieved correlated with these alternative resources? Is the guided structure able to allow students to build solid conceptual links?

b) A final questionnaire to detect the player's self-assessment, but the limit is given here because it is based on the opinion and perception of the individual and not on what happened in the game. To support self-assessment by the students, the first criterion is to follow the principle of the synthesis and effectiveness of communication, i.e., to use only the necessary and sufficient content to tell the story, such as, for example, a 30-second video or a page of text. The didactic value lies in the significant reworking of the contents according to the product recipient. In recent years, the language of adolescents is based on the few characters of tweets and on emoticons, for which there is a general lack of attention and availability of time.

Regarding the second type of **In-process assessment**, it is necessary to reflect on the indirect measurements of data collection since they are aimed at recording the level of commitment and motivation on behalf of the student, participation in the use of audio-visual technologies, and in debriefing activities with the teacher, as they offer the possibility to collect a lot of information, both explicit and implicit. To make the learning experience definable and measurable, it would be desirable to insert an evaluation system within the game and measure the performance of the players in progress, allowing a personalisation of the activities carried out. For example, a conflict situation is inserted into the game to measure the ability to negotiate and manage a conflict (where soft skills are important) [5]. The player chooses from a range of options, and the character representing them modifies their facial expressions and makes moves, some questions represent control items which are followed by the player's choice or other data to be detected and analysed. At the end of the scenario, following the data collected, the player analyses the feedback and the debriefing form with suggestions to improve their performance.

An element to be evaluated is the use of the resource, also by resorting to multiple accesses, thanks to the possibility of keeping students' profiles updated and therefore being able to suspend and re-enter the story autonomously, which respects individuals' needs and learning times. It would be appropriate to note the number of times that students have left the narrative session to re-enter later, starting from the point at which they left the story with the level of learning achieved.

An element subject to evaluation is attractiveness, which can be confirmed by the tracking data that shows an increase in the number of accesses directly proportional to the browsing time spent for each experimental class. Students explore the various levels of communication of the narrative experience and navigate the complex resource for an average time deemed sufficient to complete all the educational events and support the various assessments that the situations present. Students need to pay more attention; therefore, the usage times increase because they need to return to the concepts several

[5] Another example is ENACT (Enhancing Negotiation skills through on-line Assessment of Competencies and interactive mobile Training) a serious game in 3D, single-player; it is an asynchronous system that does not require the simultaneous participation of multiple users, aimed at training and assessment of negotiation and communication skills in realistic scenarios www.enactskills.eu

times and reflect on those to be used in the situations in which they are called to choose and act.

An element to be evaluated are the comments entered (memos and tags) by the students to the various scenes of the narration. Comparing them makes it possible to obtain a measure of the level of involvement with respect to the issues addressed. For example, students made a comment every 10 minutes of browsing. This value increases for situations requiring more activity from students, greater reflection on the laws and concepts to be learned, and greater responsibility for their problem-solving and decision-making.

The **Teacher assessment** is based on the observation that the educator is also a "reflective professional" because he/she reflects on the action as it takes place. Observation and documentation of professional practice are founding cornerstones of the professionalism of those who work in the educational field. The logbook is a document that accompanies the professional experience of an educator in the specific context in which he/she operates. In the logbook, the subject describes all the information deemed relevant for understanding the event to be treated. It must outline what happened during the observation period. It must contain all the useful elements to be able to reconstruct the time sequences useful for *a posteriori* reflection on the experience and understanding of aspects of the reality studied.

- ✓ a tool for observation (it records observed behaviours);
- ✓ a tool for documentation (a detailed analysis of observation, clarification of cognitive processes and emotional experiences);
- ✓ a tool for reflection during the action and the results of the action (a critical reading of the experience, a source for subsequent re-elaborations).

For example, to measure and evaluate the educational impact during the implementation of the various phases of work, the teacher monitors the relational dynamics within the group, the level of involvement and participation, if the development of the work is relevant to the educational objectives and the process of sharing deliveries. Involvement indicates the attraction that the subject feels for the aesthetic impact, the sensations, and the design created to produce emotions.

After creating the product, the teacher collects the evaluation reports drawn up from the game, carries out the debriefing in class, and peer evaluation, receives feedback from students, analyses the results, and explains any mistakes that have been made.

3. The learning scenario in THE BIG_GAME project

In THE BIG_GAME project, the partnership has developed its own template based on the project aims and the survey's results achieved and described in the *R1.1 Game world and environmental issues,* which is a part of *R1 The BIG GAME Learning Concept Model*

The learning scenarios will be focused on the STEM subjects, particularly the environmental issues analysed on multidisciplinarity and interdisciplinarity ways to support students' transversal/soft skills development.

In addition, they will be constructed following the digital storytelling approach as story-driven learning scenarios on environmental issues where students suggest solutions to solve problems regarding the environment.

All the learning scenarios should be activities to be realised in face-to-face modality in the classroom. However, some of the learning scenarios submitted will be transformed in missions in the game-based learning setting developed during the project timeline through the use of a template realised in google form (https://forms.gle/pzSEFEQMf4oRyozb9 - *Annex 1 - THE BIG_GAME Learning Scenario*).

The scenario setting is 2030 – but Earth continues to face the same climate challenges as people are already dealing with it, but the situation has gotten even worse. In this context, the United Nations has formed the UN Anti-Apocalypse Force (UNAAF), which the student teams play part of, to quickly respond to various environmental emergencies around the globe.

Regarding the face-to-face activities to carry out in the classroom, the teachers will:

- Provide students with information on environmental issues.
- Provide students with information regarding the learning scenario setting.
- Prepare, if they wish, the topic to be studied by their students. *Annex 2 - Operation "Black Ice"* is an example describing how teachers can deliver a specific topic to their students.

The suggestion is to let the 11-16 years-old students work in small groups with no more than 3-4 members. However, teachers can choose the best way to manage their classes.

The students' task starts with the research on the environmental issue selected. However, it would be better if they could focus on local and specific problems connected to a

particular place. For example, one of the main problems in Finland is our endangered species, the" ringed seal" or "arctic fox", which will not survive without snow.
In particular, they will:

- Come up with the scenario idea (e.g., problem to be solved, setting);
- Search the information about the environmental problem to be solved.
- Provide a possible solution to the problem selected.
- Prepare their scenario analysing the problem. They can use the following model for students' research (Figure 1):

Team name_____

Proposed solutions *What are the steps to be taken?*	**Requirements/Resources** *What equipment and resources are required?*	**Expected outcome** *What will the solution achieve?*
Risks and limitations *What can the solution help with and what it may not?* *What could go wrong?*	**Priorities** *What are the priorities?*	

Fig.1 - Model for students' research

After the research, students will present their findings on the studied topic to the class. The suggestion is to include all they consider important to describe their work, such as pictures, videos, articles, etc. However, control of the copyright of the references (videos, pictures, etc.) inserted should be done before submitting their learning scenario to the project team.
The research work can be delivered in their national language or directly in English if students wish.

During the students' work, teachers:

- Observe, help and encourage students to work on their scenario.

- Help students find suitable references for their scenarios.
- Manage the groups in the class.

3.1 The assessment procedures in THE BIG_GAME

The first step of the assessment process will take place in the class or the school. Students make it through a *peer review* and by the teacher or a group of teachers who have worked with the students.
The students will be guided by three/four questions asked by their teachers. In the peer review and the teachers' assessment, the criteria for the learning scenarios evaluation are the following:

- *open - endedness*
- *realism*
- *importance*
- *specificity/focus*

Afterwards, the teachers will submit the best learning scenario prepared by their students to the Game Design Team by synthesising it in English using the template available in the Google Form, as specified in *Annex 1*.
The aim is to collect ideas from the students for the games and to build the missions. Every school can submit max 5 learning scenarios.
The second step is related to the Project Game Design Team who will decide if the scenario submitted through the template is suitable for the Game-based Learning Environment developed for the BIG_GAME project based on the same criteria specified above and the Game-based Learning Environment technical features.
If the scenario is suitable, it will upload, adapt, and transform into “missions” in the Game-based Learning Environment.
Afterwards, the students can be challenged in the Game-based Learning Environment to overcome the missions they ideated by launching European contests among schools.

4. Examples: the learning scenario developed by the school partners

4.1 THE BIG_GAME Learning Scenarios in Finland

4.1.1 First learning scenario

School Name	Lyseo secondary school Joensuu
Scenario description	The Saimaa ringed seal population is about to collapse. There were around 400 seals in 2020 because of different conservation methods. Now there aren't any offspring born in 2030, mainly due to the total absence of a snow layer on lake Saimaa.
Location and conditions	Lake Saimaa is the largest lake in eastern Finland and Europe's fourth largest lake. The shores of the lakes are rugged and rocky, made up of many interconnected areas of open water, channels and bays, and there are many islands and islets and places to hide for this relatively big and hermitting seal. The animal is an excellent swimmer but a poor mover on land, and it often waddles around on a low rock in the water. The seal digs a nest in February on the icecover under a thick layer of snow (needs about one metre of snow), where its pups are safe from the cold and harsh weather and predators. In the former years, there was about 30 -40 cm of ice in February, and the snow cover varied from 0 – 75 cm. Now the ice cover is thinner or even missing in some parts of the lake.
Reactive or proactive	Prevention
Type of problem	Climate change
Specific problem	The ice cover is thinning in lake Saimaa, and there is a total absence of snow cover. The Saimaa ringed seal has failed to breed due to missing snow cover.
Possible solutions	One solution is that voluntary people piles up snow into snowbanks that can act as nesting sites for the seals, and the seal pups are born in nests built in human-made snowdrifts.
References	https://www.elomatic.com/en/elomatic/expert-articles/innovation-and-engineering-saving-the-day-case-saimaa-ringed-seal.html (man-made nests) https://finland.fi/life-society/warm-winter-makes-rescuing-finlands-saimaa-seal-many-degrees-more-difficult/ https://finland.fi/life-society/endangered-finnish-seals-get-winter-help-from-locals/ https://wwf.fi/en/saimaa-ringed-seal/ (basic information end conservation)

	https://www.sttinfo.fi/data/attachments/00147/6b513d91-8938-4205-a5e0-68bb8a0bfb55.pdf (latest data of ice cover in lake Saimaa) https://yle.fi/news/3-12661185 (YLE news: Highly-endangered ringed seal drowns in a fishing net in eastern Finland
Other notes (optional)	There might be lakes similar to lake Saimaa in northern parts of Finland, but these seals are timid and not easy to catch. There are closely related species nearby that are abundant (Laatokka ringed seal and Baltic sea ringed seals), but since the Saimaa ringed seal population has lived isolated in Lake Saimaa since the latest Ice Age, they might no longer interbreed. Moving these animals to new areas is not an option.

4.1.2 Second learning scenario

School Name	**Joensuun Lyseon peruskoulu**
Scenario description	On October 15th 2030, at 5: 00 am, the cooling system of the Loviisa nuclear plant stopped. There have been seven days of storms, heavy rainfall and flooding in southern Finland. The storm has been exceptionally strong. In Loviisa (a Town of 15 000 inhabitants in Southern Finland) nuclear power plant is under the water. Cooling systems of the nuclear power plant have stopped. There is a big risk for overheating and melting of nuclear reactor cores. Actions of The UNAAF are needed immediately.
Location and conditions	Two of Finland´s nuclear reactors are situated in Loviisa nuclear power plant. The reactors at Loviisa went into operation in 1977. Loviisa is a town of 15 000 inhabitants in Southern Finland. It is situated on the coastline. There are approximately 90 kilometres from Loviisa to Helsinki
Reactive or proactive	Emergency
Type of problem	Climate change, Pollution and waste, Loss of biodiversity
Specific problem	Floods, storms, heavy rain, and radioactive material can release --> land, air, and sea can be polluted.
Possible solutions	1. People within the surrounding 20–30 km zone stay indoors, 2. restarting cooling system 3. adding more water for the cooling reactor, 4. people should eat iodine pills 5. If radioactive waste releases: evacuation of people, people should eat iodine pills, and moving some marine animals.
References	**In English:** https://www.climatechangepost.com/finland/storms/

	https://yle.fi/news/3-12111938 https://thl.fi/en/web/environmental-health/climate-and-weather/climate-change (varsinkin veden laatu) https://en.wikipedia.org/wiki/Loviisa_sub-region **In Finnish:** https://www.is.fi/taloussanomat/art-2000001706158.html https://lutpub.lut.fi/bitstream/handle/10024/104493/Maailman%20ydinvoimaloiden%20alttius%20tulville.pdf?sequence=2&isAllowed=y
Other notes (optional)	--

4.2 THE BIG_GAME Learning Scenarios in Estonia

4.2.1 First learning scenario

School Name	**Tartu International School**
Scenario description	The Republic of Maldives, home to 500,000 people and a tourist destination for more than 1.7 million people yearly, is sinking. More than 80% of the state's territory is located above the average sea level. Due to global warming, the glaciers melt, and the sea level rises yearly. The ocean tides are getting stronger, and more sand is washed away daily into the Indian Ocean. The Maldives has lost over 20 islands in the last two decades, and around 30 islands are identified as severely eroded. The country suffers from constant flooding, and a tsunami can be devastating. With the rising sea temperatures, corals are either getting bleached or have died completely. If the world does not address the challenge, the Maldives will become the first country in history to cease to exist because of a natural disaster.
Location and conditions	The Republic of Maldives. More than 80% of the state's territory is located above the average sea level. Due to global warming, the glaciers melt, and the sea level rises every year. The ocean tides are getting stronger, and more sand is washed away every day into the Indian Ocean. In the last two decades, Maldives has lost over 20 islands and around 30 islands are identified as severely eroded.
Reactive or proactive	Prevention
Type of problem	Climate change, Loss of biodiversity, Demographic and agricultural (e.g., clean water, farming, overpopulation, etc.)
Specific problem	The country is disappearing meter by a meter every year.

Possible solutions	• Submersible sand pumps suck the sand from the sea to bring it back to cover the island area (it postpones the disaster but does not solve the problem). • Stop the rise in average temperature and thus sea level. • Construction of artificial islands. • "We do not want to leave the Maldives, but we also do not want to be climate refugees living in tents for decades," said President Nasheed. Buying more land from other countries (Sri Lanka and India were targeted because of similar culture. Australia was also being considered because of the amount of unoccupied land available.
References	• NASA earth observatory "Preparing for Rising Seas in the Maldives": https://earthobservatory.nasa.gov/images/148158/preparing-for-rising-seas-in-the-maldives • New Eastern Outlook "The Maldives are Sinking, What Can be Done About It?": https://journal-neo.org/2021/06/11/the-maldives-are-sinking-what-can-be-done-about-it/ • The Guardian "Paradise almost lost: Maldives seek to buy a new homeland": https://www.theguardian.com/environment/2008/nov/10/maldives-climate-change
Other notes (optional)	Requirements: The mission will be successfully completed if students find a way to ensure that the surface area of the Maldives does not sink further or how to protect the existing surface area as sea levels continue to rise.

4.2.2 Second learning scenario

School Name	**Tartu International School**
Scenario description	Due to the war in Ukraine, it has been estimated that 47 million people are facing acute hunger [1]. The failure to agree on terms for grain export from Ukraine further worsens the situation. In response, the European Parliament seeks measures to mitigate the problem of food shortages and security and foresees exceptional adjustment aid to European agricultural producers [2]. European citizens are worried about food security, especially due to increased prices and very adverse weather conditions throughout Europe (drought) [3]. In light of this, the farmers, especially in the Northern European countries (which have faced less severe draughts), are facing an increased demand for growing grain also on lands that could otherwise be used in other ways (not only fallows but possibly also species-rich meadows [4]). In addition, the possible measures foreseen in [2] - namely, the subsidies that allow farmers to use more fertilisers to intensify their farming practices - contribute to a cascade of negative consequences on the birds [5], and on the Baltic Sea [6].

Location and conditions	Estonia (Finland, Latvia or other Nordic countries)
Reactive or proactive	Prevention
Type of problem	Loss of biodiversity, food security & shortage, eutrophication, impoverished soils, intensification of agriculture
Specific problem	1) Food shortage due to stopped export 2) Possible agricultural intensification due to an increased demand for cereal supply from the Nordic countries. To fight the first problem, aid funds are allocated to compensate for farmers' increased workload + demand for supply. In many cases, the subsidies are used to buy more fertilisers to increase yields. In the long term, this impoverishes the soils, negatively affects the biodiversity connected to agricultural and nearby landscapes (pollinators, birds), and threatens the running waters, the Baltic Sea, and possibly also local groundwater by excess nutrients and hence eutrophication.
Possible solutions	1) To opt for financial aid to cater for missing food. In the long run, this might prove not sustainable due to the above reasons, but it fights the acute hunger problem. 2) Cha organic farming, which might result in lower immediate yields but preserves the health of soils, connects biota (from soil dwellers to insects and birds) and environment (landscape, running and groundwater, the Baltic Sea).
References	[1] Picheta, R., Karadsheh, J., Gigova, R. and Lister, T. 2022. Kyiv and Moscow agree deal to resume Ukraine grain exports from Black Sea ports. CNN, Sat July 23rd, 2022 https://edition.cnn.com/2022/07/22/europe/ukraine-russia-grain-deal-turkey-intl/index.html [2] Answer given by Mr Wojciechowski on behalf of the European Commission 4.5.2022 https://www.europarl.europa.eu/doceo/document/E-9-2022-000969-ASW_EN.html [3] Cereal supplies in the context of Russia's invasion of Ukraine. Parliamentary question - E-000969/2022. 10.3.2022 https://www.europarl.europa.eu/doceo/document/E-9-2022-000969_EN.html [4] Semi-natural Grasslands. Metsähallitus. (Accessed 04.10.2022) https://www.metsa.fi/en/nature-and-heritage/habitats/semi-natural-grasslands/ [5] State of the World Birds. Birdlife International 2022. https://www.birdlife.org/wp-content/uploads/2022/09/SOWB2022_EN_compressed.pdf

	[6] State of the Baltic Sea. Holistic Assessment. Helcom. (Accessed 04.10.2022) http://stateofthebalticsea.helcom.fi/pressures-and-their-status/eutrophication/
Other notes (optional)	Requirements: The mission is successfully completed if students find ways to best mitigate the problems of food shortage/security but also do not do so on account of the environment.

4.3 THE BIG_GAME Learning Scenarios in Italy

4.3.1 First learning scenario

School Name	**IC Maria Montessori**
Scenario description	In 2030, in the countryside near Terracina, the canals and rivers are infested by the Procambarus clarkii, a crayfish from Louisiana (USA). It was intentionally introduced into Tuscany (Italy) some years before for food value. Still, some of them escaped into fresh water bodies and spread across the country. The red swamp crayfish is able to grow quickly and tolerate slightly saline and polluted water, which is unusual for a crayfish. Due to its salinity tolerance, it has invaded not only freshwaters (rivers/streams, lakes, ponds, irrigation channels, reservoirs) but also estuaries. It has damaged the water courses and altered the ecosystems since it has devoured indigenous flora and fauna, including amphibians, local crayfish and fish. Moreover, it digs holes to lay its eggs along the water course banks, causing their erosion. The red swamp crayfish can be considered an ecosystem engineer, completely transforming the habitats it invades. The use of burrows allows this species to withstand environmental extremes (e.g., high temperatures and dehydration) and protects the crayfish from predators.
Location and conditions	This scenario is taking place in the “Agro Pontino", a territory rich in water courses and rivers, where the climate has created a habitat suitable for a lot of water plants (such as the floating marsh pennywort and the marsh fern) and for animals (such as the green toad, the pond turtle, the common wall gecko, the sparrow, the little grebe, the common hedgehog, the wild boar, the Italian tree frog, the European brook lamprey and the squalius cephalus, trouts, pikes and carps). These environmental conditions are in danger because of the introduction of the alien species of Procambarus clarkii, included in the Invasive Alien Species of Union concern.
Reactive or proactive	Emergency
Type of problem	Loss of biodiversity

Specific problem	Introduction and proliferation of an alien species, which modifies the environment, destroying biodiversity.
Possible solutions	1- Biocontrol: a. Introducing animals which can eat them such as herons, little egrets, otters, foxes and wild boars. b. Sterilising male crayfish 2- Mechanical removal: a. Using traps b. Construction of physical barriers
References	https://www.kodami.it/come-luomo-rende-un-gambero-killer-della-biodiversita/ https://www.nytimes.com/2003/05/19/world/massaciuccoli-journal-the-killer-from-louisiana-on-the-loose-in-italy.html https://www.sciencedirect.com/science/article/pii/S0075951116300020 https://www.frontiersin.org/articles/10.3389/fenvs.2020.609129/full The capture of the killer crayfish in Frasso by 2C students
Other notes (optional)	- The Procambarus clarkii can cut one of its own claws in case of danger and regenerate it later. - A constraint may be represented by global warming since the invasive species are advantaged by the increasing water temperature, meaning they can spread faster and colonise previously inappropriate habitats. - Water quality, in particular dissolved oxygen and turbidity can be heavily affected by the burrowing activity of P. clarkii. - P. clarkii feeds on the diverse items present in each invaded habitat in proportion to their availability so that its diet can change with habitats. - The time of burrow occupation is short, and crayfish are not faithful to the same burrow.

4.3.2 Second learning scenario

School Name	**IC Maria Montessori**
Scenario description	In September 2030, a five day rain storm flooded the area around a nuclear plant in Borgo Sabotino (Latina province), 40 kilometres from Terracina, causing a radioactive waste spill from its concrete sarcophagus, which polluted the coast in front of the plant, arriving at Naples in the south and front of the coast of Livorno in Tuscany in the north. The immediate intervention was necessary. Action from UNAAF (the special anti-apocalypse unit of the UN) was urgent, and paramount was the call to the best chemists, engineers, technicians, and scientists available and of which the students of the 2F of the Maria Montessori Institute of Terracina are

	part of. All were in a rush to scramble for a solution to the environmental catastrophe that had occurred.
Location and conditions	Borgo Sabotino (Latina province) near Terracina along the cost. Here, in 1963, a nuclear power plant was built and entered service, producing energy from the date of its construction until 1987, the year in which a referendum on the maintenance of nuclear power plants in Italy decided to dismantle them, following the emotionality and the fear that the Chernobyl disaster (Ukraine) caused in the Italian population. Although the power plant was made safe immediately after its shutdown and the sarcophagus containing the fuel and radioactive waste sealed to protect the environment and the surrounding population, there always had been air fear among people about their own safety because of their vicinity of the nuclear site.
Reactive or proactive	Emergency
Type of problem	Climate change, pollution, and waste
Specific problem	Radioactive pollution due to an unprecedented and extraordinary amount of rain has fallen in that area.
Possible solutions	Mourou's lasers fight the radioactivity. Genetically modified bacteria eat nuclear waste, and an automated robot cleans the area.

References	https://www.youtube.com/watch?v=Il-RHT9Yh1Y;
	https://www.youtube.com/watch?v=WW1GDfvKmHA;
	https://www.sogin.it/it/chiusuradelciclonucleare/sitinucleariitaliani/centraledilatina/Pagine/default.aspx
	Folder containing links and photos used for both Montessori Scenarios:
	https://drive.google.com/drive/folders/1WfvfvcFc-hyrQPNsfus2KoUyxvD0CxcD

Other notes (optional)	Fission nuclear plants are very dangerous because climate change could produce unpredictable effects on the structures.

4.4 THE BIG_GAME Learning Scenarios in Romania

4.4.1 First learning scenario

School Name	**Școala Gimnazială EuroEd (EuroEd Secondary School), Iasi, Romania**
Scenario description	People increasingly want a green economy in the city of Iași, Romania. For this, the main problem is the way of producing electricity. Solutions like solar panels, wind turbines and nuclear power plants are being sought. The entire population of the city protests against the authorities, who support this type of economy too little. People team up with the city's wealthy people to build a green economy. Gradually, the city authorities are ignored, the wealthy

	become informal authorities, and the city will support itself on electricity from the new sources built on the hills around the city.
Location and conditions	Iasi - Romania, conditions of overcrowding with people and cars. Increasing noise and air pollution.
Reactive or proactive	Emergency
Type of problem	Pollution and waste
Specific problem	Air pollution
Possible solutions	Residents revolt against the authorities. Residents prefer to get along with the city's wealthy and rich representatives.
References	https://www.iqair.com/romania/iasi https://www.ziaruldeiasi.ro/stiri/iasi-in-topul-oraselor-poluate-din-romania-iarna-este-cel-mai-ridicat-nivel--297528.html
Other notes (optional)	Players follow a single scenario. They must identify on the city map certain streets where people can gather for the riot. It also identifies suitable places around the city where solar panels and wind turbines can be placed.

4.4.2 Second learning scenario

School Name	**Școala Gimnazială ,,Alexandru Ioan Cuza" Fălticeni**
Scenario description	The UN Anti-Apocalypse Force sends the GRAY SKY team to save a species of flying bird thought to be extinct, the bustard. Europe's largest flying bird has experienced a sharp decline following the fragmentation of its former habitats.
Location and conditions	România- Salonta, jud. Bihor
Reactive or proactive	Prevention
Type of problem	Loss of biodiversity
Specific problem	The Great Bustard (Otis tarda) is the heaviest flying bird in Europe. Classified by the IUCN as vulnerable, the species had disappeared from most parts of Europe by the 1950s, as its once extensive habitats (the Eurasian steppe) had become fragmented. This happened in Romania also, where after the nationalisation of the communist era, the grasslands (its natural habitats) were tilled and converted into farmland. Mechanised agriculture, hunting and poaching also contributed to their decline. In the 19th century, there were stable populations in Banat, Crișana, the Transylvanian Plateau, the Wallachian Plain, Dobruja and a few other places in Moldavia. However,

	according to the official records from 1988, there were only 48 bustards left in Romania. After 1990, the Great Bustard was considered extinct in Romania. After many decades of uncertainty, there is proof that the Great Bustard is breeding in Romania. It took the association 13 years of fieldwork and, perhaps, a stroke of luck to get this confirmation. Now, it appears that the bird maintained the last stronghold in Romania, in Salonta (Bihor County). According to the field observations of the Milvus Group from the last 13 years, there is a small cross-border population of around 40 individuals, whose habitat extends across the border from Romania to the Hungarian area of Salonta-Mezőgyán as well. Additionally, in accordance with the normal behaviour of the species, they tend to use their traditional display (the courtship ritual of the males) and nesting sites.
Possible solutions	1. Prohibition of hunting this species. 2. Bringing eggs from Hungary in a warm season for repopulation. 3. Renting suitable land for raising and breeding birds in our country.
References	https://transylvanianow.com/after-decades-of-being-extinct-great-bustard-nest-is-found-in-romania/ https://www.dropia.eu/gb/events/timeline https://milvus.ro/en/exclusive-great-bustard-nest-found-in-romania/ https://climategame.eu/news-article/exclusive-great-bustard-nest-found-in-romania
Other notes (optional)	Requirements: The mission is successfully completed if students find ways to mitigate the problem best and find the best solution to prevent the disappearance.

4.4.3 Third learning scenario

School Name	**Școala Gimnazială EuroEd (EuroEd Secondary School), Iasi, Romania**
Scenario description	The numerous wastes and pollution that make people's lives a nightmare are being eradicated by the heroes of 2030 in different environments. In anthropised ecosystems, robots are the ones who take care of waste and compliance with the rules of their management by humans. In the forests, we have other heroes, specialists in environmental issues, each with their own field: the Mother of the Forest takes care of the plants, the Panda is the saviour of the waters, the Duchess of the Sun warms the forest's life, the Koala greens the atmosphere.
Location and conditions	The city of Iasi and the forests on its hills.

Reactive or proactive	Emergency
Type of problem	Pollution and waste
Specific problem	Our scenario refers to the pollution of the atmosphere but also of cities and forests with waste from domestic or industrial activities from the daily activities of the inhabitants of this city.
Possible solutions	- People to be actively involved in the correct recycling of waste - There should be robots that selectively collect waste and ensure that this process is carried out properly and correctly - Polluting factories must have all filters - Reducing the number of cars in traffic and using public transport - The large-scale use of electric means of transport - Ecological education in schools - Harsh punishment of those who do not respect the environment - Waste to be used for energy production - Giving responsibility to some "heroes" who will take care of all-natural or man-made ecosystems, terrestrial or aquatic.
References	--
Other notes (optional)	--

4.4.4 Fourth learning scenario

School Name	**Colegiul Național "Mihai Eminescu" Iași**
Scenario description	It is the year 2030, and in Romania, 50% of the forests have been cut. The replanting of trees, which was carried out on much smaller surfaces than the deforested ones, fails to compensate for the devastating effects of the lack of forest.
Location and conditions	The scenario takes place in Europe, and Romania, where, due to deforestation, carbon dioxide emissions have increased exponentially, animal and plant species are in danger of extinction because they have lost their habitat. At the same time, the phenomenon of desertification is taking place.
Reactive or proactive	Emergency
Type of problem	Climate change
Specific problem	Deforestation and desertification

Possible solutions	1. Replanting some fast-growing tree species on large areas, in combination with tree species that require more time for development 2. Reducing CO2 emissions by replacing classic cars with electric ones on a large scale 3. The total prohibition of cutting down forests for a period of time so that the forest can begin to regenerate 4. Paper recycling and reducing paper consumption by replacing printed documents with electronic ones
References	https://youtu.be/M4jhjt1_eyM https://thehumaneleague.org/article/effects-of-deforestation https://education.nationalgeographic.org/resource/deforestation https://www.wwf.org.uk/learn/effects-of/deforestation
Other notes (optional)	--

4.4.5 Fifth learning scenario

School Name	**Colegiul Național "Mihai Eminescu" Iași**
Scenario description	The disappearance of the grey egret and the osprey
Location and conditions	The Okavango River Delta in Botswana, Africa
Reactive or proactive	Prevention
Type of problem	Climate change
Specific problem	The Okavango River has evaporated considerably in the last 10 years due to climate change. The vegetative forms disappear slowly and surely, as well as the faunal and fish elements. The entire food chain is under threat. In addition, poaching and electric fences are toxic factors.
Possible solutions	Botswana is taking steps to address the issues: - Law against poaching - Removal of electric fences to allow free movement and survival of animals - The construction of a canal to allow bringing water from the Atlantic Ocean (for irrigation and keeping the river alive, thus ensuring the survival of the fauna
References	https://images.app.goo.gl/UQA1Ubmp2MUsqivn9 https://images.app.goo.gl/tXkL9w758yAJZiDD8

Other notes (optional)	--

4.4.6 Sixth learning scenario

School Name	**Colegiul Național "Mihai Eminescu" Iași**
Scenario description	Deterioration of air quality due to a huge hole in the ozone layer.
Location and conditions	Eastern Europe. The air temperature has risen, and people are suffering from hyperthermia. The environment has become noxious, and people are wearing gas masks.
Reactive or proactive	Emergency
Type of problem	Climate change
Specific problem	The problem is related to both chemical and physical air pollution because the ozone layer has been compromised over time.
Possible solutions	One solution would be to reduce physical and chemical pollution by enforcing drastic laws. Another solution would be - building greenhouses or gardens with intensely photosynthesising trees. Another solution would be - to ban all freon devices.
References	--
Other notes (optional)	--

4.4.7 Seventh learning scenario

School Name	**Colegiul Național "Mihai Eminescu" Iași**
Scenario description	Due to pollution and excessive use of pesticides, which are supposed to support production in agriculture, by 2030, bees will disappear, and man will face a real food crisis. This crisis will also affect other living things on Earth.
Location and conditions	This disappearance of bees may affect Asia and Europe. Urbanisation, industrialisation, and population growth mean that producers need more and more pesticides to support the production of raw materials for food in large quantities and in the shortest possible time.

	The disappearance of bees is a real fact already existing, which is starting to worsen much faster than it has happened in the last 50 years.
Reactive or proactive	Emergency
Type of problem	Loss of biodiversity
Specific problem	Human life on Earth would not be possible without bees, as they are the ones who pollinate plants and help everything that means vegetation reach maturity.
Possible solutions	People should buy food as much as they consume, thus avoiding waste. People should avoid chain stores as much as possible to do their shopping, choosing local producers instead, where the price differences are small. Restaurants should have food portions with smaller weights to prevent food waste, not be guided by the principle: Large portions at the lowest possible price
References	https://www.academia.edu/59793265/Maja_Lunde_%C3%AEntre_apocalips_%C8%99i_speran%C8%9B%C4%83 https://youtu.be/vRBDEyIgsRk
Other notes (optional)	--

4.4.8 Eighth learning scenario

School Name	**Școala Gimnazială ,,Alexandru Ioan Cuza" Fălticeni**
Scenario description	Snowflake. July 21st, 2030, temperatures rise, and polar bears are forced to forage on land. Global warming is melting the bears' habitat. By 2032, the Arctic Circle, where the bear lives, will no longer exist. There will be a stretch of water, and the temperatures will be on the plus side. In June, my friends and I went on a trip around the continent of Antarctica. We searched for Polar Bears, and the surprise was that they were dying from lack of food. The solution is to take the last specimens and we take them to a space set up for mating.
Location and conditions	Arctic Circle, inexplicably high temperatures
Reactive or proactive	Emergency
Type of problem	Climate change

Specific problem	Global warming is melting the polar bears' habitat.
Possible solutions	The first step is to look for polar bears to save them. Pairing the remaining ones.
References	https://www.digi24.ro/stiri/externe/mapamond/ursii-polari-vor-intra-in-pericol-de-disparitie-fenomenul-alarmant-din-zona-oceanului-arctic-1037317 http://www.zooland.ro/ursul-polar-o-specie-pe-cale-de-disparitie-3727 https://ro.wikipedia.org/wiki/Urs_polar
Other notes (optional)	--

4.4.9 Ninth learning scenario

School Name	**Școala Gimnazială ,,Alexandru Ioan Cuza" Fălticeni**
Scenario description	The bacterium Vesper bac., a parasitic bacterium that can cause several diseases by destroying the host cell or releasing toxins, infected the animals in a large area located in the vicinity of the Bat Cave in the Rarău Massif. The bacterium was transmitted from the pond bat that came into contact with several animals. The disease manifests itself through paralysis and blood coagulation and is also transmissible to humans.
Location and conditions	The disease appeared on an extensive area of the Rarău Massif. Climatic conditions are favourable for the transmission of the disease; humid climate, winters with abundant snow and low temperatures, and an environment conducive to the spread of the bacterium.
Reactive or proactive	Prevention
Type of problem	Loss of biodiversity
Specific problem	The disappearance of several species of mammals that can be infected with the bacterium Vesper bac.
Possible solutions	We isolate all infected aminals to be able to analyse the genotype of the bacteria. We analyse the body structure of the pond bat, which seems resistant to this bacterium.
References	https://en.wikipedia.org/wiki/Vespertilionidae
Other notes (optional)	--

4.4.10 Tenth learning scenario

School Name	Școala Gimnazială ,,Alexandru Ioan Cuza" Fălticeni
Scenario description	On March 23rd, 2030, in the Neamț Hunting Park area, Romania, 15 bodies of bison were discovered near a pond, whose death probably occurred from the dumping of canned fish and other waste on the lake surface by an economic agent, observing wheel tracks. The situation is critical because the pond of a main water supply bank for this animal within the radius of the park, which, if not prevented, could lead to the disappearance of the bison, where 16 specimens remain.
Location and conditions	Vânători Neamț Park is located in the north-east of Romania, near the city of Târgu Neamț, in an area of hills (Moldavian Subcarpathians) and even mountains (Stânișoara Mountains), with deciduous and coniferous forests, where bison are spread over several hundred hectares.
Reactive or proactive	Emergency
Type of problem	Pollution and waste
Specific problem	Pollution of natural water surfaces with hazardous waste
Possible solutions	• Pond waste cleaning and water treatment by a specialised company • Repopulation of bison in the area • Monitoring the bison population using transmitters • Much tougher laws to protect animals
References	https://wwf.ro/ce-facem/specii/zimbrul/ https://ro.tristarhistory.org/wildlife-conservation https://www.viziteazaneamt.ro/2009/09/24/parcul-natural-vanatori-neamt/ https://life-bison.com/life-bison-stiri/wild-european-bison-roam-romanias-poiana-rusca-mountains-for-the-first-time-in-200-years/?lang=ro
Other notes (optional)	Bison repopulation comes with various benefits that go beyond its own survival. Bison's feeding habits maintain or create open, "mosaic" landscapes with patches of vegetation where other species can then forage (e.g. insects and birds); re-whole food chain with the return of bison, supports the Cycle of Life, including top predator species such as wolves. In the area, the return of an emblem species, protected at the European level, also brings opportunities for coagulation and development of local communities and micro-economies. For example, young people can be trained and employed as bison rangers or specialised guides, active youth clubs have been opened in several schools in the region and familiarised with knowledge and skills related to nature conservation, and the whole area has regained an identity and a public profile that differentiates it as a special visiting destination, where you

	can do hikes and sessions to observe and understand the landscape and wild nature.

4.4.11 Eleventh learning scenario

School Name	Școala Gimnazială ,,Alexandru Ioan Cuza" Fălticeni
Scenario description	Today, May 6th, 2030, at 10:45 am, researchers discovered that 50% of Earth's forests have disappeared due to excessive deforestation. They have been debating this issue for more than a year. They concluded that the Planet would suffer a lot if this continues. The situation in Romania is even more sensitive. Due to the exploitation of trees in a mountain area near the village of Fundata in Brasov, serious problems arose. The problem is that in 2024 18 million cubic meters were cut, and this year, 2030, approximately 420 million cubic meters, which means that in a few years, there will be no more forests. The fact that we are losing forests is a disadvantage for our country because the habitat of wild animals on the way to extinction is also affected: the bear, the wolf, the fox, and the owl.
Location and conditions	This scenario takes place in Europe and Romania.
Reactive or proactive	Prevention
Type of problem	Loss of biodiversity
Specific problem	The problem of excessive deforestation is one of the causes of global warming because the forest absorbs huge amounts of carbon dioxide, and at the time of deforestation, all the absorbed amount returns to the atmosphere, thus increasing the number of greenhouse gases.
Possible solutions	Two solutions by which we could save the forests are gathering as many people as possible to help us plant trees and building as many natural reserves as possible. Another solution would be to turn to the mass media to create a video to announce the young and the old to contribute to replanting forests in Romania. We could exploit this approach in the direction of extracurricular activities.
References	https://www.greenpeace.org/static/planet4-romania-stateless/2019/07/a3f66be5-a3f66be5-taierile-ilegale-de-arbori-in-padurile-din-romania-2009-2011.pdf https://stratos.ro/defrisarea-padurilor-si-felul-in-care-poate-impacta-mediul-inconjurator/
Other notes (optional)	--

4.4.12 Twelfth learning scenario

School Name	Școala Gimnazială Internațională Spectrum Iași
Scenario description	As of April 13th, 2030, the population of spotted frogs in Yellowstone National Park was found to have declined by 50% due to dwindling water supplies and the spread of a fungus that endangers amphibians of this species and more. These species are at risk from climate change due to global warming. The UN Anti-Apocalypse Force (UNAAF) has been activated to deal with this threat. You can reach the scene by the next day. What is your plan of action to stop or at least lessen this species' extinction?
Location and conditions	Columbia, Yellowstone National Park, presents hot springs and lakes, but also mountainous regions, relatively high temperatures, low precipitation
Reactive or proactive	Prevention
Type of problem	Climate change
Specific problem	Biodiversity loss due to global warming
Possible solutions	Bringing natural parasites to the fungus that threatens the spotted frog population Water irrigation and the creation of frog marshes
References	https://ro.thpanorama.com/blog/cultura-general/10-animales-en-peligro-de-extincin-en-colombia.html
Other notes (optional)	--

4.4.13 Thirteenth learning scenario

School Name	Școala Gimnazială Internațională Spectrum Iași
Scenario description	Operation Stop the Pungent Smell On May 4th, 2030, at 4:00 pm, the locals of Tașca Commune, Neamț County, Romania, were immediately alarmed when they felt a strong smell of ammonia from the Bicaz River. Those who work at two trout farms downstream from a cement factory also panicked because the fish were threatened. Inspectors from the Environmental Guard discovered that the ammonia pollution comes from the cement factory in Tașca: wastewater and ammonia substances were discharged directly into the Bicaz river. At 16:20 local time, the UN Anti-Apocalypse Force (UNAAF) was activated to save the fish from the two trout farms, but also part of the species from this river, having time to

	reach there until 16:50 local time. What is the plan of action to save this situation?
Location and conditions	The commune of Tașca is located in the western part of Neamț County, on the banks of the Bicaz river at a distance of 6 km from the city of Bicaz and 32 km from the Municipality of Piatra Neamț. It is crossed by the road national DN 12C and the usual railway for a distance of 9.5 km.
Reactive or proactive	Emergency
Type of problem	Pollution and waste
Specific problem	Ammonia pollution endangers the fish population both in the Bicaz River and in the two nearby trout farms and the health of people and farm animals.
Possible solutions	Coming with a supplement of clean water through the Bicaz dam to decrease the concentration of ammonia.
References	http://stiri.tvr.ro/poluare-cu-amoniac-pe-raul-bicaz--de-la-o-fabrica-de-ciment--locuitorii-din-mai-multe-comune--informa--i-de-pericol_884565.html#view https://www.youtube.com/watch?v=hYejRJkUYlc http://stiripiatraneamt.ro/2021/05/poluare-masiva-cu-amoniac-pe-raul-bicaz-mii-de-pastravi-morti-foto-video/
Other notes (optional)	To begin with, the population should be informed about the existing danger.

4.4.14 Fourteenth learning scenario

School Name	**Școala Gimnazială Internațională Spectrum Iași**
Scenario description	Operation ICEFALL At the beginning of August 2030, it was found that Greenland's situation is very serious, considering that about 70% of the ice sheet's surface has been affected by melting. Data shows that the level of the Planetary Ocean will rise on average by one millimeter per year, and by the end of this century it will rise by about one meter and flood low-lying cities, destroy beaches and property. The continued growth of this process will cause sea and ocean levels to rise to a critical point for the Planet. At the beginning of August 2030, the UN Anti-Apocalypse Force was activated and participated in a meeting with the countries that pollute the most to build an action plan to diminish this process of melting the Greenland glaciers.
Location and conditions	Greenland

	Island territory, in the north of the Atlantic Ocean. The relief consists of the plateau and mountain forms (most of which are covered by thick layers of ice). The climate is arctic, and the vegetation is poor.
Reactive or proactive	Prevention
Type of problem	Climate change
Specific problem	Melting ice caps with negative effects on the Planet.
Possible solutions	Manufacturing electric cars Reducing deforestation Dismantling factories that release toxic gases into the atmosphere
References	https://www.digi24.ro/planeta-esti-tu/de-ce-este-periculoasa-si-cat-de-mult-ne-afecteaza-topirea-ghetarilor-1419225 https://www.rfi.ro/mediu-147821-ghetarii-lumii-se-topesc-intr-un-ritm-accelerat-avand-consecinte-vizibile-analiza
Other notes (optional)	--

4.4.15 Fifteenth learning scenario

School Name	**Școala Gimnazială Internațională Spectrum Iași**
Scenario description	The Black Sea is facing massive pollution. The first signs of the deterioration of the Black Sea ecosystem appeared in the 60s. In the following years, the ecological situation in the region worsened. In a recent estimate, scientists have shown that 60 million tons of living marine organisms have died due to a lack of oxygen in the last five years. Human-generated pollution is the main threat to the Black Sea region and represents the most serious environmental problem. The main causes of the pollution of the Black Sea are: waste from land, atmospheric pollutants, waste discharged from ships intentionally or accidentally, and pollutants brought into the sea by rivers. The UN Anti-Apocalypse Force (UNAAF) has been activated to stop these threats and pollution. During a meeting, she is informed that the Black Sea is polluted with agricultural waste (different types of fertilisers) of animal, domestic and industrial origin, as well as with organic and inorganic nutrients from different sources. Most nutrients are brought to the sea by rivers. An increase in nutrient concentration leads to the excessive development of the phytoplankton population, a phenomenon called "eutrophy". Because of the nutrients, the life cycle of single-celled algae becomes very short, developing very quickly and then dying just as quickly. The decomposition of dead organic matter decreases

	the amount of oxygen in the marine environment. In ecosystems where the phenomenon of eutrophication is observed, the water becomes dark in colour as a result of the excessive growth of phytoplankton, and living organisms die en masse due to a lack of oxygen. This phenomenon leads to a decrease in biodiversity. The UN Anti-Apocalypse Force (UNAAF) is asking for an action plan to diminish and halt this alarming decline in biodiversity.
Location and conditions	Black Sea Region, Romania The land side of the Romanian coastline (the shore) stretches for a length of 245 km. and consists of three geomorphological sectors: ● To the north, the Danube Delta; ● In the middle, the Razim-Sinoe complex with the beams that separate it from the sea; ● To the south, the Dobrogean coast consists of an alternation of cliffs, beaches and harbours between the south of the Chituc ridge and the Bulgarian border. The total length of the Delta shore and the Razim-Sinoe complex (both included in the UNESCO World Heritage Biosphere Reserve) is 163 km; the rest of the coast stretches for 82 km. Every year, an increasing number of tourists visit the Romanian coast, on which constructions and improvements are multiplying, especially in the southern part (the 82 km located outside the Reserve), gradually reducing the still natural areas. A problem related to the first is pollution, both visible (trash) and invisible (unfiltered sewage, industrial or agricultural effluents).
Reactive or proactive	Prevention
Type of problem	Pollution and waste
Specific problem	Biodiversity loss due to massive waste pollution in the Black Sea
Possible solutions	● Building trash cans and placing them on the beach. ● Frequent beach cleaning. ● Building factories on the outskirts of cities and not near the sea. ● Strict laws, fining people who do not throw garbage in specially arranged places.
References	http://d2ouvy59p0dg6k.cloudfront.net/downloads/partea_4.pdf https://newsweek.ro/sanatate/de-ce-este-marea-neagra-cea-mai-poluata-din-europa
Other notes (optional)	--

4.4.16 Sixteenth learning scenario

School Name	Școala Gimnazială EuroEd (EuroEd Secondary School), Iasi, Romania
Scenario description	VIII grade students had the role of environmental saviours as follows: air saviours, water saviours, and soil saviours. Identifying the polluting factors on the three planes: air-water-soil, we started from the premise that each resource is vital and the management of these resources is the basic priority; the rescuers proposed solutions, for each level, in case of accidental pollution and a method of mobilisation and immediate notification of the pollution.
Location and conditions	The scenario takes place in the city of Iasi, Romania. The city is on seven hills partially covered with forests, the Bahlui river crosses the city from north to south, and agricultural lands are outside the city. The city is in continuous development, but the road and railway infrastructure exceed the current demand of the inhabitants.
Reactive or proactive	Prevention
Type of problem	Pollution and waste
Specific problem	The environmental problem: the congestion of the roads with cars in the morning and the evening after finishing the work makes the air unbreathable in the areas that connect the neighbourhoods of houses with the city centre.
Possible solutions	The development of an application that sends messages to the driver's phone regarding the optimal departure time from home to avoid congested traffic, the route to be taken and the state of traffic on the proposed route. The system sends a message to the driver's phone a few minutes before departure: you must leave in x minutes to reach your destination in y minutes.
References	http://www.anpm.ro/web/apm-iasi/calitatea-aerului-inconjurator http://www.primaria-iasi.ro/portal-primaria-municipiului-iasi/planuri-de-calitate-a-aerului/10468/acte-de-interes-public
Other notes (optional)	The surveillance system has incorporated sensors for monitoring the air quality in the city and video cameras to monitor the movement of cars on all city streets. When one of the quality parameters.

4.4.17 Seventeenth learning scenario

School Name	Școala Gimnazială EuroEd (EuroEd Secondary School), Iasi, Romania
Scenario description	In the scenario of an ecological catastrophe, any resource is vital, and it is taken into account that the life of every human being is important. Therefore, the water resource is managed intelligently and consciously to meet daily needs strictly. Every individual knows that any resource belongs to everyone,

	and the amount consumed is monitored. Water consumption monitoring is done with the help of an intelligent system, a battery with an active screen with a speaker that transmits and displays in real-time the amount of water available to the user and changes its colour depending on the consumption. The battery with an intelligent screen displays the blue colour with the water volume corresponding to the normal consumption, the orange color for the situation when you are approaching the upper limit of the optimal amount and the red color when you have reached the upper limit when the water consumption is closed instantly.
Location and conditions	Iasi, Romania
Reactive or proactive	Prevention
Type of problem	Pollution and waste
Specific problem	Water is a resource without which the human body can last up to three days - that's why it must be used consciously, and water consumption for drinking and hygiene must be monitored daily.
Possible solutions	The water consumption of domestic users is monitored with the help of a smart battery that is interconnected with the water distributor (the volume of water consumed is monitored in real-time). The battery emits light and sound signals for careful monitoring of consumption, is connected to the water dispenser, and will automatically disarm the user if it reaches the maximum allowed. The intelligent battery has an active screen that transmits information to the consumer: the volume of water allowed for use/day (the screen turns blue), during consumption, the volume of water left for use is constantly displayed (orange) and a warning about reaching the average and maximum level of daily water consumption (red color appears).
References	http://www.primaria-iasi.ro/portal-primaria-municipiului-iasi/planuri-de-calitate-a-aerului/10468/acte-de-interes-public http://www.anpm.ro/web/apm-iasi/detergenti
Other notes (optional)	Every resource is important and belongs to everyone. Each individual's consumption must be conscious. Consumption above the established level is paid with Nunca hours for the community's benefit. There is no money! Work for the community's benefit is the only payment method and is carried out outside working hours.

ANNEX 1 - THE BIG_GAME Learning Scenario for the final submission

Please use this form to submit a learning scenario for the BIG_GAME project. User-submitted scenarios will serve as a basis for the open-ended missions that student teams will present within the game and to which they will have to submit possible solutions.

The scenarios are set in 2030 on a version of Earth that continues to face the same climate challenges we are already dealing with, but the situation has worsened. The United Nations has formed the UN Anti-Apocalypse Force (UNAAF), which the student teams play a part in, to quickly respond to various environmental emergencies taking place around the globe.

Thank you!

BIG_GAME Project Team

Project no. 2021-1-FI01-KA220-SCH-000024098

1. Name *

_____

2. Email *

_____

3. Country *

- ◯ Finland
- ◯ Italy
- ◯ Estonia
- ◯ Romania
- ◯ Other

4. School name *

_____

5. Scenario description *

Describe your scenario in a few sentences. The scenario must be fictional (taking place in 2030) but rooted in existing, real-life environmental issues. Make sure you are outlining a clear, specific problem set in a specific place.

_____

_____

_____

6. Location and conditions *

Where in the world is this scenario taking place? What are the environmental conditions there?

_____

_____

_____

7. Reactive or proactive *

Does the scenario describe an emergency that requires an immediate response (e.g., an old nuclear dome about to collapse) or a slowly developing situation that needs more prolonged, long-term intervention to prevent the problem from worsening (e.g., a species on the brink of going extinct)?

- ◯ Emergency
- ◯ Prevention

8. Type of problem *

Select all the options applicable.

- ☐ Climate change
- ☐ Pollution and waste
- ☐ Loss of biodiversity
- ☐ Demographic and agricultural (e.g., clean water, farming, overpopulation, etc.)
- ☐ Other

9. Specific problem *

Describe the more specific environmental problem your scenario speaks to in a single phrase. E.g., what kind of pollution (air, water, light, noise, radioactive) or what aspect of climate change (e.g., ice peaks melting, desertification, etc.)?

_____

_____

_____

10. Possible solutions *

Briefly list two or three different approaches to solving the scenario (one sentence per approach). This is needed to make sure there is more than one possible "solution," as the game would be boring if every team followed the same obvious approach. Note that solutions should not rely on futuristic technology that is far from what we currently have available.

_____

_____

_____

11. References *

Provide links to 2-3 articles, videos, podcasts, etc., from reputable sources to which we can refer the players for more information on the issue the scenario explores.

Please, always check the copyright rules for the references indicated.

_____

_____

_____

12. Other notes (optional) *

E.g., what kind of considerations are important to emphasise? What kind of additional constraints should be placed on the players? Any other suggestions for the BIG_Game design team?

_____

_____

_____

ANNEX 2 - An example: Operation “Black Ice”

Mission statement

On March 3rd 2030 (Sun) at 3:30 am, a research vessel (The Vassa flying a Swedish flag) and an oil tanker (The MT Dolviken, flying a Norwegian flag) collided near the Norwegian island of Andøya in the Arctic circle. Due to the impact, the oil tanker's hull was pierced, resulting in an oil spill into the sea. By following the Shipboard Oil Pollution Emergency Plan, MT Dolviken crew were able to locate the damaged tank and stop the spill within an hour; however, by that point, a significant quantity of oil was spilt into the sea. Both of the ships’ crews were then evacuated by air rescue.

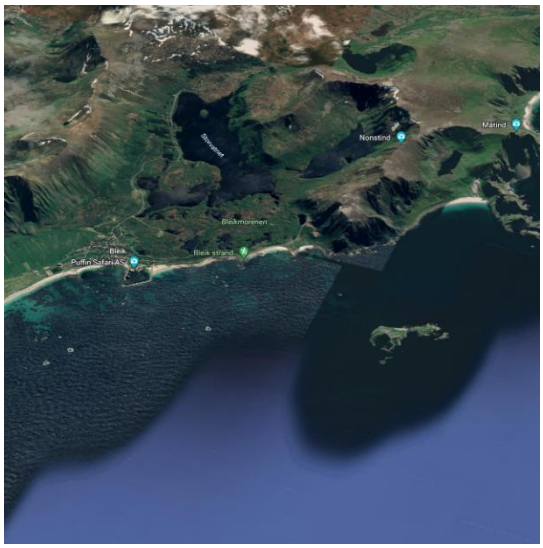
The situation is time sensitive due to the oil leak happening in a natural reserve less than 4 km away from the Bleiksøya cliff, home to one of the largest surviving sea puffin colonies. The fishing village of Bleik, a popular bird-watching destination, is also nearby.

The UN Anti-Apocalypse Force (UNAAF) has been activated to address this threat. You can be on site by 6 am local time. What is your course of action?

Location and environmental conditions

5 km off the coast of Andøya island in the Arctic circle, part of Norway’s Skogvoll natural Reserve. The closest settlement is the fishing village of Bleik (population 500), and the sea puffin colony on the Bleiksøya cliff is 4 km away. It is possible to airlift to the site from Harstad in 20 minutes.

Due to the icy waters, navigation is difficult, and since the ice is breaking, the spill can spread fast and reach both the cliff and the nearby village of Bleik, affecting local fisheries and tourists.



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