A Digital Learning Game Environment for Natural Resource Management

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Abstract. The climate change that modern society is continuously coping with convey the issues of biodiversity preservation and the long-term health of natural ecosystems. The European Commission has co-funded the NATURE project under the Erasmus Plus programme for Higher Education. The general target of the project is to construct an experiential intervention designed on a specific serious game-based methodological framework. The last is aimed at challenging students to develop awareness, sector knowledge, and skills on responsible natural resource management. The related activities are inspired by real-world environmental sustainability practices. This paper presents and discusses the preliminary results achieved for the methodological framework construction and the features of the digital learning game environment.

Research Contribution: First is the design of the experiential learning scenarios for environmental education in higher education, and second is the design of innovative digital learning games deploying the scenarios.

Keywords: serious game · environment · experiential learning · game design

1 Introduction

The continuous action of modern society on climate change in general and in a form of compensation measures for habitats destruction, in particular, is crucial in terms of biodiversity preservation and the long-term health of natural ecosystems. As an example of such an endeavor, the responsible management of natural resources, including land, water, air, minerals, and forests, should ultimately manifest itself in creating a balance between socio-economic and environmental factors. Therefore, it is not surprising that sustainable natural resource management is highly prioritized in the 21st century at different levels regional, national and international, as eloquently evidenced by its inclusion in the United Nations sustainability goals.

Undoubtedly, the young generation, therefore, is expected to adopt responsible natural resources management behavior through developing scientific and technical knowledge on the function of ecosystems and their life-supporting effects. However, as every multifaceted and complex initiative, this process requires developing critical and analytical thinking and innovative mindsets to design environmentally sound solutions and

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collaborate in multidisciplinary teams. In addition, needless to say, that the ecological situation never remains immutable, and therefore inherently requires the continuous update of the action strategies adopted. Logically, the development of educational initiatives aiming at cultivating the young generation's awareness in becoming active citizens as regards environmental sustainability remains fundamental.

In this context, the NATURE project, co-funded by the European Commission under the Erasmus Plus programme for Higher Education, intends to develop an experiential learning intervention for building students' capacity to adopt responsible behaviour in natural resources management and to design solutions for environmental sustainability in everyday and professional activities.

Thus, in the following sections, the project work performed so far is described. In particular, the presentation is built around two basic points: the current state of the design of experiential learning scenarios for environmental education and the related aspects of an innovative digital learning game.

2 Method

Due to the complex nature of the topics, environmental education requires a holistic approach, especially when it comes to attitudinal change for environmental sustainability [1]. This means that a specific teacher cannot entirely exhaust it within a single discipline thus inevitably appealing to a broader perspective [2]. Therefore, developing specific skills for teachers and educators assumes strategic relevance.

As indicated by the 2011 UNECE document "Learning for the future - Competences in Education for Sustainable Development" [3], the skills of educators in sustainable development can be classified according to the following types:

- The holistic approach that includes three interrelated components: (a) integrative thinking; (b) inclusivity; (c) dealing with complexities;
- Integration between thought and practice;
- Envisioning change which covers competencies relating to three dimensions: (a) learning from the past; (b) inspiring engagement in the present; (c) exploring alternative futures;
- Achieving transformation, which covers competencies operating at three levels: (a) transformation of what is an "educator"; (b) transformation of pedagogy, i.e., transformative approaches to teaching and learning; (c) transformation of the education system as a whole.

Therefore, the need emerges to identify and implement a training system for teachers capable of guaranteeing the same basic level of knowledge and skills of the teaching staff who will teach, in an interdisciplinary way, environmental and sustainable development issues [4].

To ensure an adequate contextualization and the future integration of the projects results into the current educational practices the survey considered the existing national practices and policies in environmental education as well as related activities, initiatives and projects.

As the starting point for the learning scenarios development the students' and educators' learning needs analysis in relation to building knowledge on natural resource management was chosen. In particular, the corresponding questionnaires (Appendix 1) submitted in Latvia, Italy, Estonia, Greece, Spain and Portugal, mainly investigated two primary dimensions: a) the educational needs of students on natural resource management; b) educator skills and gaps in the delivery of engaging environmental education activities.

The sample was composed of 163 responses, with the majority of respondents affiliated with higher education institutions (58,90%) as teachers/lecturers (57,06%) and as employees (23,31%) in public institutions (16,56%) involved in environmental issues. Following section outlines the highlights of the feedback gathered.

3 Findings and Discussion

As the most important natural resource to be included in corresponding educational materials, the respondents' opinion is distributed in the following way: water (92,64%) followed by land (61,69%), plants (61,35%), ecosystems (60,12%), animals (50,31%), fossil fuels (49,08%) and Minerals (26,38%). Provided the results, the gaming environment development will bring the correspondent distribution of the assets available to the player. While the most important knowledge and skills on natural resources management that shouldn't be missed in these educational initiatives, according to the respondents' opinions', are biodiversity conservation knowledge (57,67%), responsible environmental behaviour knowledge (56,44%), critical thinking skills (54,60%) followed by the situation assessment (49,69%), problem-solving (47,85%) and water management skills (46.63%).

In the current educational programme available on natural resources management in the countries-participants involved in the survey, the respondents underlined that knowledge and skills are lacking, even though they should have relevant room in education. They are primarily those related to "land use planning knowledge" (43,56%), "biodiversity conservation knowledge" (36,20%), "engineering design-thinking skills" (34,36%) and "water management knowledge" (32,52%).

In the teaching of natural resource management, the educators/instructors/teachers should give more attention to specific topics such as sustainable use of the natural resource (60,12%), ecosystem health knowledge (52,15%), ethical and sustainable thinking (51,53%) and more in general to environmental problems (51,53%).

Currently, the available educational materials on natural resource management, as shown in Fig. 1, are mostly textbooks (28%), problem-oriented learning scenarios (20%) and databases (18%) at disposal for students' research. Besides, e.g. in Latvia, the materials are complemented by the scientific articles or specific events organised by Nature Protection Administration.

However, 50,31% of the respondents agree that the current educational programs do not sufficiently address the resource management issues against the 17,79% who consider them sufficient, and the 31,39% who remained neutral.

Regarding the typology of the educational activities implemented with the students, the respondents consider the "analysis and discussion of real-time situations" (74,23%),

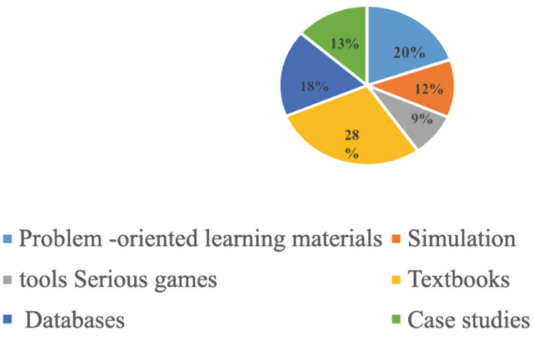


Fig. 1. The natural resource education materials currently available.

group projects (65,03%) and simulation tools (64,42%) as the most efficient natural resource training. Whereas the least efficient the textbooks (31,90%), database (29, 45%) and individual projects (20,25%) were nominated. For the textbooks and database, a quite high number of respondents also assumed a middle position and the 34,36% and 41,72%, respectively.

Only 53,99% consider the "learning games" as efficient instruments to teach natural resources management, comparatively less than simulation tools (64,42%).

Thus the results obtained basically serve as the starting point for the digital learning game environment development. Given the intention of its further adoption within the framework of regular curricular activities, possessing such detailed feedback of responsible adopters is of crucial importance. Moreover, as authors [1] specify, despite the fact that digital game-based learning (DGBL) environments offer a suitable pedagogical tool for environmental sustainability education, there is still a need for more research in the field before one can unequivocally confirm their crucial impact on the environmental friendly behavior retention.

4 The Project Current Results

Based on the results described in the previous section, a digital learning game environment and learning scenarios on natural resources management will be implemented. The choice is largely dictated by the successful implementation of such instruments, i.e. game-based learning, in general [5–8] and within environmental context as well [1, 9, 10].

As noted previously, the experiential intervention, to be developed in the future phases of the project, is based on a specific methodological serious game-based framework. Structured as a set of activities inspired by real-world environmental sustainability practices, it is aimed at challenging students to develop awareness, related knowledge, and skills on responsible natural resource management.

Through gaming activities students will be encouraged to undertake the role of stewards of natural ecosystems in a manner that would not be possible in an offline physical laboratory. They will be challenged to design solutions that maintain the balance of environment preservation, economic activity, and quality of life. In addition, game- based

Fig. 2. The digital game environment elements: a – handmade terraforming modality, b – automatic terrain generator interface, c – city builder engine interface (under construction).

approaches will foster students' internal motivation for engaging in learning through gaming elements such as clear goals, rewards, recognition and social interaction.

Through these games, students will be provided similarly rich opportunities for introducing environmentally sustainable solutions to the given challenges through terrain formatting, city building and the design of technical infrastructures.

From the instructional design process point of view the game formally will concentrate around three basic components: aim, systems and in-game editor.

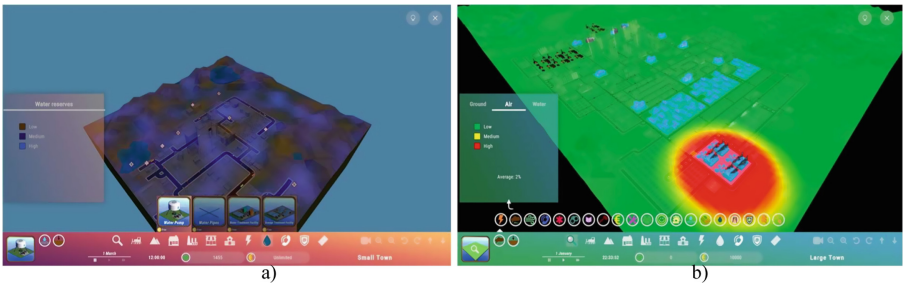
The first component, basically consisting in managing the existing eco-system and natural resources fundamentally, is related to the map of the city within the context of which the corresponding gameplay develops. Starting from the terrain generation (Fig. 2a, 2b), that includes both automatic and hand-made terraforming modalities, up to the entire city development through the use of a city builder engine (Fig. 2c).

Simultaneously the map creation enables the generation of the biomes and, consequently, natural resources. Particularly, each biome, providing its own fauna and flora, is the fruit of a set of conditions (e.g. humidity and location). Moreover, given a wide temporal span of the gameplay, the game settings include all types of climates and seasons including, for example, the related flora adaptability.

As regard to natural resources in general, the game engine provides the following classification:

- origin (biotic, abiotic);
- development, with the following types of resources: potential, actual, reserve, stock;
- recovery rate (renewable, non renewable).

The last point, for example, as one can see from the Fig. 3a, can be treated in a strict connection in determining the existing system for water source and its pumping and



a) b)

Fig. 3. Game interface examples: a – water reserves generation, b - air pollution levels tracking.

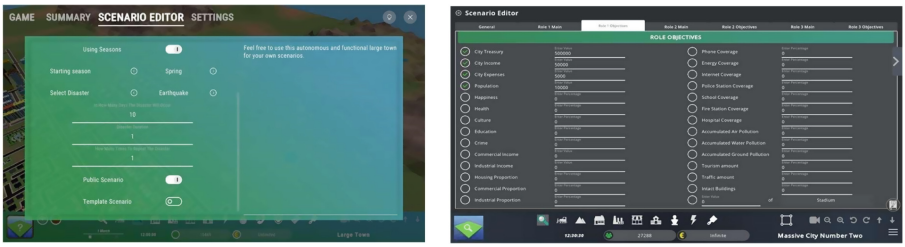


Fig. 4. The interface of in-game scenario editor.

management at the stage of the city map generation from one side, and the work with the system tracking of pollutions (air/ground/water) from the other (Fig. 3b).

The second component, systems, consists of a dynamical interplay of the following components: *layers, needs, area of effect,* and *characteristics*. *Layers* provide a live graphical update on the city evolution. Whereas *needs* fundamentally govern the existing infrastructure demands satisfaction. For example, in response to a certain building needs for services to function the player is supposed to supply those. In addition, buildings have their *area of effect*, e.g. in terms of overall damage to the ecosystem challenging the player to provide an efficient remedy. Finally, city life has a number of *characteristics* describing it as a living organism including such aspects as: energy, pollution, wind, health, crime, fire protection, education, traffic, garbage collecting, food access etc. All these, can be selected from the scenario in-game editor (Fig. 4), which enables to define specific goals posed and chosen by the teachers.

In sum, the core of experiential learning concentrates around the gameplay aiming at balancing in development of one's town and infrastructure while preserving natural resources (Fig. 5). Natural resources, or biomes, are here taken in the broad sense and closely interrelated with the infrastructure. For example, factories while bringing money cause pollution as well. The last has an inevitable impact on the trees and animals around, which, in turn, have an impact on the happiness of the citizens. Thus, the experiential learning enables one to figure out all the interactions that exist and how to use them to balance the development of the town.

As to the teachers' input, generally it consists in defining the challenges to deal with and targets to aim at during the setting up the in-game scenario editor. Moreover, to

Fig. 5. Examples of biomes and flora assets for natural resources management.

support teachers' monitoring process during and after the game, the system is planned to include a student performance analysis matrix. This instrument aims at providing a dynamic and intuitive graphical insight for the teacher to figure out eventual strong and weak points in the students' in-game accomplishments.

5 Conclusion

The main aim of the project is to enrich environmental education through digital technologies by developing an experiential learning intervention. Such an endeavour is focused on building higher education students' capacity to adopt responsible behaviour on natural resources management and to design solutions for environmental sustainability in everyday and professional activities.

First, the project team was involved in developing theoretical knowledge and practical skills that can empower students to become active citizens designing environmentally sustainable solutions. Secondly, designing a digital game environment can educate students by developing soft skills that foster innovative mindsets to help students become the problem-solvers of tomorrow towards sustainable practices in the industry and society. Finally, to evaluate the effectiveness of the teaching and learning tools designed, the project foresees the evaluation of the digital learning games by students and teachers in Latvia, Greece, Estonia, Portugal, Spain, and Italy.

In addition, the project team will train instructors by supporting the seamless integration of the proposed experiential learning design and digital learning games in existing instructional practices through reference material in diverse media.

Research Contribution: First is the design of the experiential learning scenarios for environmental education in higher education, and second is the design of innovative digital learning games deploying the scenarios.

Appendix 1

NATURE project survey for situation assessment in natural resource management

Project number: 2021-1-LV01-KA220-HED-000032033

1. **Country**

2. **Name of your institution**

3. **Institutional sector represented by your institution**

o Vocational education
o Higher education
o Adult education
o Private body (SME or another)
o Public institution
o Non-governmental institution(NGO)
o Other

4. **Your position in organization**

o Employee
o Owner
o Student
o Teacher/lecturer
o Other

5. **Which natural resource type inclusion in natural resource management educational materials are the most important? (please choose five most appropriate)**

o Water
o Air
o Land
o Minerals
o Fossil fuels
o Plants
o Animals
o Ecosystems
o Other

6. **Which knowledge and skills related to nature resources management are the most important, in your opinion? (please choose five most appropriate)**

o Analytical skills
o Situation assessment skills
o Responsible environmental behaviour knowledge
o People-natural landscapes interaction knowledge
o Land use planning skills
o Water management skills
o Biodiversity conservation knowledge

- o Problem-thinking skills
- o Creativity skills
- o Critical thinking skills
- o Collaboration skills
- o Engineering-Design thinking skills
- o Other

7. **Which of the natural resource management knowledge and skills are most lacking in your professional activities:**

- o Analytical skills
- o Situation assessment skills
- o Responsible environmental behaviour knowledge
- o People-natural landscapes interaction knowledge
- o Land use planning knowledge
- o Water management knowledge
- o Biodiversity conservation knowledge
- o Problem-thinking skills
- o Creativity skills
- o Critical thinking skills
- o Collaboration (interpersonal) competencies
- o Engineering-Design thinking skills
- o Strategic thinking competence
- o Systems thinking competence
- o Futures thinking competence
- o Values thinking competence
- o Other

8. **Which topics need more attention when teaching natural resource management?**

- o Basic science concepts related to resource use and management
- o Environmental problems
- o Ecosystem health knowledge
- o Sustainable use of natural resources
- o Creative thinking
- o Vision development
- o Ethical and sustainable thinking
- o Mobilising of material resources
- o Financial and economic literacy
- o Mobilising of human resources
- o Taking the initiative
- o Planning and management
- o Coping with ambiguity, uncertainty and risk
- o Working with others

o Learning through experience
o Other

9. **Which natural resource education materials are/have been available for your current use?**

o Problem -oriented learning materials
o Simulation tools
o Serious games
o Textbooks Databases
o Case studies
o Other

10. **Do you find that resource management issues are sufficiently addressed in current educational programs you're familiar with?**

	1	2	3	4	5	
Strongly agree	O	O	O	O	O	Strongly disagree

11. **Which of the activities are the most efficient in natural resource education training? Please rate from 1 (least efficient) till 5 (most efficient).**

	1	2	3	4	5
Problem oriented learning materials					
Simulation tools					
Learning games					
Textbooks					
Database					
Case Studies					
Individual projects					
Group projects					
Analysis and discuss of real time situations					
Scientific visits					

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