Open-Ended Virtual Experiments Towards Early Environmental Skill Development

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Abstract

Achieving long-term sustainable development requires international initiatives for the preservation of the environment as well as an environmentally-aware next generation. The development of active future citizens taking a responsible stance on natural resources management at the personal as well as civic level calls for environmental skill building starting early, at the primary school level. Recognizing the importance of environmental education, most European national level curricula include high level objectives on the development of related skills. However, teachers in the field point to lack of supporting educational material and guidelines for classroom deployment, including fully developed learning activities as well as tools, especially in digital form. As a result, environmental education in primary schools currently mostly involves off-line activities such as recycling at the school

grounds, site visits, and story-telling projects presented to classmates. The EnvKids project develops open-ended, explorative and collaborative learning methodologies that take advantage of virtual experimentation aiming at enhancing primary environmental education. End-to-end learning activities and teaching guidelines are developed on proof-of-concept virtual learning tools that cover a wide range of environmental subjects ranging from responsible residential behavior to the advantages of renewable energy resources at the civic level and responsible natural resources management, including forests, biodiversity, and water. Children are called to introduce innovative solutions in a game-based, sandbox environment where not only single solution exists, fostering creativity and an entrepreneurial spirit. Graphical interfaces and real-time feedback introduce a focus on concepts and impact of actions hiding computational details. The outcomes are being validated in Greece, the Czech Republic, France, and Sweden in real-life learning experiments taking place in primary schools with very positive reaction from learners and teachers on motivation, long-term engagement with the learning process, usability, and content design. This work is partly funded by the Life Long Learning Programme of the European Commission.

1. Introduction

The international community is aware of the urgent need to raise the awareness of young students towards environmentally friendly behavior. However, this need is not well represented in formal national curricula at the primary school level, which mainly include general, high level guidelines on environmental education, such as respecting the living world. Teachers struggle to develop in-class activities for achieving the objectives of environmental education without being supported through adequate and appropriate educational material. As a result, teachers highlight the urgent need for the development of teaching and learning content, especially in digital format.

This work aims to enhance environmental education school activities through the design and development of the EnvKids digital learning tool suite. The tools are developed in the context of an innovative didactical framework that draws upon collaborative and explorative learning approaches and targets primary school students. The EnvKids project takes into consideration current explorative and collaborative instructional practices in European schools. Explorative and collaborative learning frameworks are enriched with open-ended, game-based approaches to learning, project based learning methods, and digital story telling practices [4][5]. Game-based approaches integrate emerging half-baked methods [3], in other words ‘semi-finished environments, targeting at engaging

students with changing their rules' [1]. In addition, sandbox gaming where not one single conclusion exists is used in learning activity design. The combination of the above methodological approaches was considered of great importance in the context of teaching environmental concepts in a manner that captures children's creativity and imagination.

2. The EnvKids tool suite

The EnvKids tool suite on developing early environmental sustainability skills through exploration and collaboration deploys game-based approaches, projects, and storytelling. The suite consists of three online pilot applications, end-to-end supporting learning activities, and good practice scenarios for the deployment of the proposed methodologies in the classroom. Under the umbrella title '**my home, my town, my planet**', the EnvKids tool suite covers environmental issues that starts from concepts close to home and expands to issues concerning the planet [6]. More specifically, the suite includes the following virtual learning tools:

My home: environmentally responsible practices in everyday life: This pilot application invites students to design a green house and to manage it in an environmentally friendly way. During the design process students are exposed to significant environmental concepts concerning energy consumption from residential activities. The pilot uses virtual experimentation and game-based learning approaches based on pre-defined alternatives to help children discover mitigation solutions that can be applied in everyday life towards environmentally responsible behaviour [6].

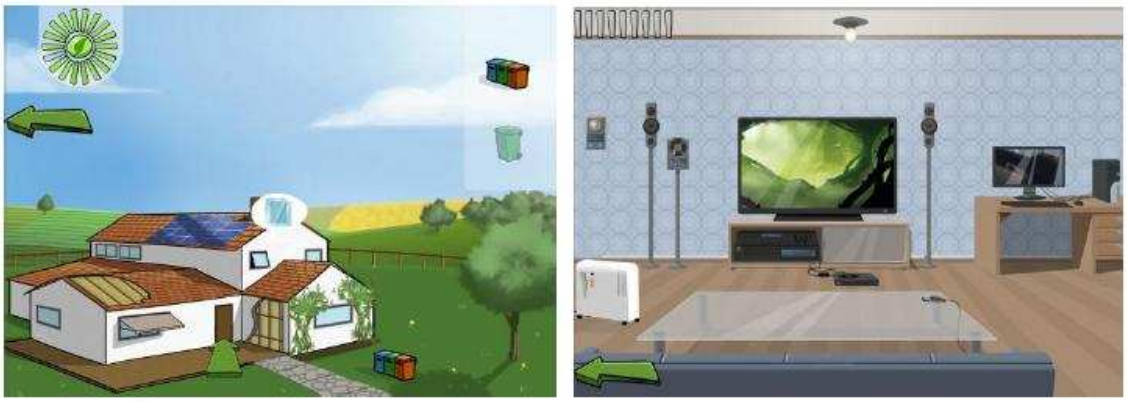

Figure 1 Good practices in everyday life pilot

My town: the benefits of renewable energy resources and wider policies for greener cities: This pilot application invites students to design a green town that promotes quality of life for its inhabitants by making energy production and urban design choices that both cover energy requirements and enhance everyday living. A sandbox educational approach is used in this pilot [3][6]. Outcomes are open with not one single correct solution. This approach exposes children the wide possibilities and is heavily game-based. This pilot application is further described in the next section.

Figure 2 Energy production through renewable resources demonstrator with real-time feedback on energy production, energy consumption, and quality of life.

My planet: responsible natural resources management: This application uses a graphical, map-based interface to demonstrate historical, current, and projected depletion trends and consequences on climate change, quality of life, animal habitat, and the welfare of endangered species [5]. Aiming at raising students' awareness on sensible management of natural resources including forests, biodiversity, and water supplies, the pilot application invites learners to interact with this interface in two ways: as information interpreters through the review of scientific data; and as narrative constructors through the development of educational content that is published through the application [5]. The published educational narratives results in a 'commonly-owned by all participating schools public outcome' [6]

Figure 3 The map-based interface of the Natural Resources demonstrator, depicting graphically scientific data.

3. A focus on the 'my town' demonstrator

This section focuses on the 'my town' pilot application and aims at describing the idea underpinning the demonstrator and the basic features dominating its design. The 'my town' pilot aims to raise awareness on the variety of energy production resources, including both traditional methods that are based, for example, on coal, and emerging solutions, including solar panels and windmills. The objective of the learning application is to cover the energy needs of the town while maintaining pollution at acceptable levels and promoting an urban plan that is inhabitant-friendly. After having mastered exploration based on pre-defined alternatives through introductory learning activities,

children are exposed to sandbox gaming approaches, in which “anything goes”. In other words, learners have the opportunity to develop from scratch their own virtual world and then introduce environmentally friendly improvements to it.

A question that is raised is how the pilot manages to inform users on the results of their design actions. For this purpose, real-time feedback indicators have been integrated into the demonstrator. The indicators provide children with graphical information on the impact, positive or negative, of their selections. Three indicators are used:

- **Energy produced indicator**: This indicator aims to raise awareness on options and effectiveness of energy production methods (see figure 4 (a)). In a way, this indicator shows how much energy the designed city produces and how much it consumes. Energy needs are raised as houses, businesses, and factories are built.
- **Pollution indicator.** Since energy production may be polluting, a second related indicator is introduced. This indicator shows how green energy production is. For example, coal-based energy production is highly polluting while solar energy is cleaner. The children can contrast the benefits of energy production levels against pollution for each production method (see figure 4 (b)). For example, wind-based energy is clean but on its own may not cover the entire energy needs of the town and may need to be combined with other production methods.
- **Quality of life indicator.** The ultimate goal is happy town inhabitants. This indicator reflects the mood of the citizens. This indicator increases as pollution is reduced and the town becomes a friendlier place to live in, for example through waste reduction, recreational parks, and other urban planning solutions (see figure 4 (c)).

Learners first have the opportunity to develop a basic building grid, to select energy production methods, to choose transportation methods, and finally to place parks and upgrade buildings in terms of energy efficiency. Learners have complete freedom in this learning activity given the sandbox explorative model underpinning this application. The functionality of the pilot can be divided over two main activities: (i) the design of the basic town layout (ii) town management in terms of energy production, pollution containment, and quality of life management.

A wide variety of assets is available for students to use in the process of designing the city. The following types of buildings are supported: residential buildings, office buildings, and commercial buildings. Structures for roads and bridges are also supported. The application supports features for the production of energy through: coal plants, gas power plants, nuclear power plants, hydroelectric power plants, solar power plants, and windmills. Taking into account that recycling plants are part of the options for improving the city two types of plants are supported: basic recycling plants and waste incinerators processing waste for energy production purposes. Parks can be also introduced as a means for improving quality of life in the town and reducing inhabitant concentration in urban centers.

In addition, the pilot application aims to bring into focus the fact that an efficient public transport system can impact positively on energy savings and pollution control. Thus, the following features have been designed for students to use: bicycle routes as an encouragement for a healthier lifestyle, subway, bus stations, and an efficient rail system (including rail way stations). Lastly, the pilot application aims at establishing a link with the ‘my home’ application pilot (see section 2), supporting improvements on the available residential and business buildings. The students can modify buildings into green ones by marking them with a green cross. Such an action will result in a positive feedback, which will be obvious through the three indicators (see figure 4).

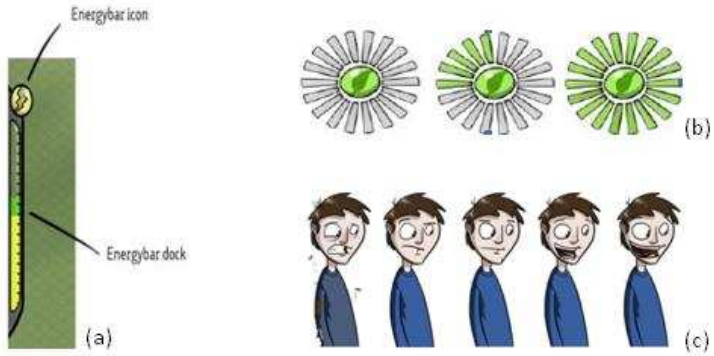

Figure 4 The three indicators

4. Instead of conclusion

Validation activities started during the 2009-2010 school year and are on-going. They will be completed in November 2011. Activities take place in primary schools in four countries: France, Greece, Sweden, and the Czech Republic. Activities cover all three pilot applications with positive feedback from learners and teachers on the educational focus, content, and game-play options. As a result of the validation activities the functionality of the pilots was improved through the addition of new features, such as the impact of house orientation on energy consumption related to heating or cooling. Teachers and learners alike reacted positively to the application interfaces, commenting that they are in-line with what children are accustomed to see in educational or recreational software. The children were particularly enthusiastic about the sandbox game-based experimentation introduced in the 'my town' pilot. The adopted serious gaming approach that allows freedom of expression through open-ended exploration encouraged the children to be engaged with the learning tool for longer periods of time thus promoting the learning process and enhancing the learning experience. The approach was very well received by additional groups; in fact, children with special needs showed elevated interest in the applications and were able to participate to learning activities successfully through the support of their teachers. These results are encouraging for additional avenues for value-adding applications of the EnvKids activities and tools.

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