USE SERIOUS GAME DESIGNS TO IMPROVE EDUCATION EFFECTIVITY OF COMPLEX ENVIRONMENTAL ISSUES: FLOOD CONTROL AND ECOSYSTEM SERVICES

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Abstract

The issues of ecosystem services, flood control and its social and economic impacts rank among the most complex and difficult disciplines in environmental education. For an effective interpretation and education it is necessary to choose an appropriate teaching methods. This paper presents the game design and game use experience of a two interactive serious games based on the principles of constructivist pedagogy and heuristic education.

Both games are inspired by actual Central European environmental issues and both are based on similar education methods, but there are thematic and functional differences between them. The game called "Beware of the flood!" is focused on the flood-control systems in the landscape and are the main target group are primary school pupils. The second game called "ESLAND" (Ecosystem Services LANDscape) deals with ecosystem services, sustainable landscape management and stability. It utilizes our experience gained using the game „Beware of the flood!", but it widens its aim to the secondary school students, landowners and general public. It enriches the ways of game evaluation and game flexibility as well.

Both games are focused not only on increasing environmental awareness in fun and interactive way, but also want to improve evaluation methods of multimedia learning and to contribute to intergenerational and interdisciplinary learning.

Keywords: ecosystem services, flood control, serious games, multimedia learning, pedagogical constructivism

Introduction

The "Simulation-Gaming" expression (Duke's, 1974) and the oxymoron "Serious Games" (Clark Abt, 1970), both abbreviated as SG, represent with no doubt modern education tools efficiently used, especially for understanding complex and difficult topics. Environmental issues such as Flood control and protection of Ecosystem Services are characterised by a huge range of complexity and integrate a wide range of natural, social and economic aspects. Comprehension of interconnections is essential in the current economic-based world where economic considerations play the main role in a decision making and landscape planning. Concept of Ecosystem services shows both positive and negative influences of nature on human society and the economy. Provisioning Services (e.g. food, freshwater and fuelwood production), Regulating Services (e.g. climate, disease, water regulation) and Cultural Services (e.g. aesthetic, cultural or educational values) (Fisher, 2009) provide financial and non-financial benefits to society. On the other hand ecosystem malfunction, represented by floods, droughts, illnesses or soil dysfunction, can cause big losses not only directly decreasing money income but also endangering welfare and even lives.

A pair of interactive SGs has been developed with the purpose to improve social impacts of environmental education and to enhance the evaluation methods of multimedia learning.

Methodology

Our SG games are designed as a simulation of a realistic landscape representing the examples of a land management. A player is placed into the role of land manager and on the base of his/her decisions the landscape stability is influenced. Economic aspects are considered as an important game indicator, however the landscape stability and its consequences plays a crucial part affecting game results.

The first game is called “Beware of the flood!”, and it has been used over the last 2 years for education with high success. The second game called “ESLAND” (abbreviation of Ecosystem Services LANDscape) has recently been developed using approved methods from for more complex topic. Comparison of both games is drawn in Table 1.

Table 1: Comparison of developed games

	Beware of the flood!	**ESLAND**
Topic	Flood control	Ecosystem Services (including flood control and others)
Context	Interaction with the software (with or without tutor)	Interaction with the software (with or without tutor)
Learner specification	Primary school students working singly or in groups	Secondary school students / landowners working singly or in groups
Pedagogic considerations	Constructivist Teaching and Kolb’s Experiential Theory	Constructivist Teaching and Kolb’s Experiential Theory
Mode of representation	High level of interactivity represented by playing as a multiplayer role playing game with discussion	High level of interactivity represented by playing as a multiplayer role playing game with discussion, enables Content management and sophisticated evaluation

Didactic approach

The didactic basis of our serious games is based on Constructivist Teaching Theory (Richardson 2005, Cooperstein, Kocevar-Weidinger 2004, Bílek 2008) and Kolb’s Experiential Theory (Kolb 1984) where learners learn through conceptualisation and application into practice learning. It uses the term of “naive preconcept” – the learner has to remake his own ideas on the basis of his experience gained through the game playing. To be successful he/she can´t simply accept new information, but to understand it. Constructivist Teaching requires a different role of the teacher – instead of a tutor he´s becoming an advising mentor and instructor. A practical example of such use is a method of “Blended learning” (Macdonald 2006) using the combination of e-learning and lectured face-to-face education for multiple players (e.g. classroom).

Games description

Beware of the flood!

The SG “Beware of the flood!” is turn-based Adobe Flash game focused on the relation between landscape management and flood control. It has been created as a didactic activity of the Museum of Moravian-Wallachia region, but it exceeded museum´s province (Husák 2013) through the cooperation with universities (Palacky University Olomouc, University of Edinburgh) and other institutions (Ministry of Environment in the Czech Republic, River Morava basin). The

main target group are primary school pupils, but it can be used for general public, secondary school and university students as well. Its theoretical background was derived on the basis of literature (Hladný 2004, Langhammer 2007, Brázdil 2011) and consultations with experts. Graphical base and game principles are derived from natural and cultural features of the Moravian-Wallachia landscape.

The goal of the game is to protect a town in the valley against flood. Players are placed into the role of a municipal council and on the base of their decisions the flood resistance of the landscape is changed. Each turn they can invest money into one of 6 options (flood control systems), which are randomly chosen from 6 flood control options (Table 2). Each option is explained and after purchasing it influences the flood resistance of the landscape (Table 3). After several turns (the player doesn´t know exactly when) comes a flood testing the efficiency of current flood control. The amount of financial losses and casualties is proportional to the level of flood resistance.

Table 2: Flood control options

A (excellent)	B (good)	C (suitable)	D (not-suitable)	E (profitable)
Wetlands revitalisation	Flooding polder	Small reservoirs	River regulation	Clear-cut felling
Grove revitalisation	Levee construction	River shore vegetation planting	Draining canals	Selective-cut felling
Infiltration belts	Stream bank revitalisation	Little weirs construction	Spruce monoculture planting	Supermarket building
Contour lines ploughing	Bridge renovation	Dam construction	Converting meadows to potato fields	Housing development
		Mixed forest planting	Wood roads asphalting	Bottomland forest felling
		River grit mining		

Table 3: Options description and rating example

Package	Option	Flood resistance	Finances	Description	Explanation
A	Grove revitalisation	+15	-3	Let's plant green vegetation in the landscape, especially in the slopes. Planting cost is 3 mil. £.	Excellent! Groves can lower the erosion rate and slow down torrential rains outflow..
D	Draining canals	-10	-10	Agricultural adjustment enables to drain the water from fields and meadows. Acquisition cost is 10 mil. £.	Unfortunately, draining canals enable to fasten the water outflow.

SG "Beware of the flood!" is available in Czech and English language versions and both versions are available on the Internet (http://www.ursus.cz/soubory/povodne/beware_flood.html, http://www.ursus.cz/soubory/povodne/pozor_povoden.html).

ESLAND

"ESLAND" is a game designed as a web-based SG game with content management and evaluation system. The name is an abbreviation of "Ecosystem Services LANDscape" thus it is focused on Ecosystem Services and sustainable landscape management.

The Player takes the role of land manager – who has to take care of estate for the next 20 years maintaining economic prosperity and ecological functioning. Each year he/she can choose

between 4 different activities; the activities are based on different land use choices (farming, grazing, forestry and built development). There are different kinds of resources: crop, livestock and wood production generating money each year (Provisioning Ecosystem Services). Each activity will usually consume some money, but it will also generate some annual income. Activities can affect the landscape stability (Regulating Ecosystem Services) – soil fertility, pollution resistance, water retention and biodiversity. Each year some natural or social phenomena can occur depending on the landscape stability. There can be negative phenomena such a natural disasters (flooding, drought, forest fire), pollution problems, environmental penalties and other hazards; there can also be positive events such an organic farming or ecotourism income. These events can significantly influence the money budget and the player can understand positive or negative feedback of his deeds. Game over occurs after 20 turns or in the case of bankrupcy.

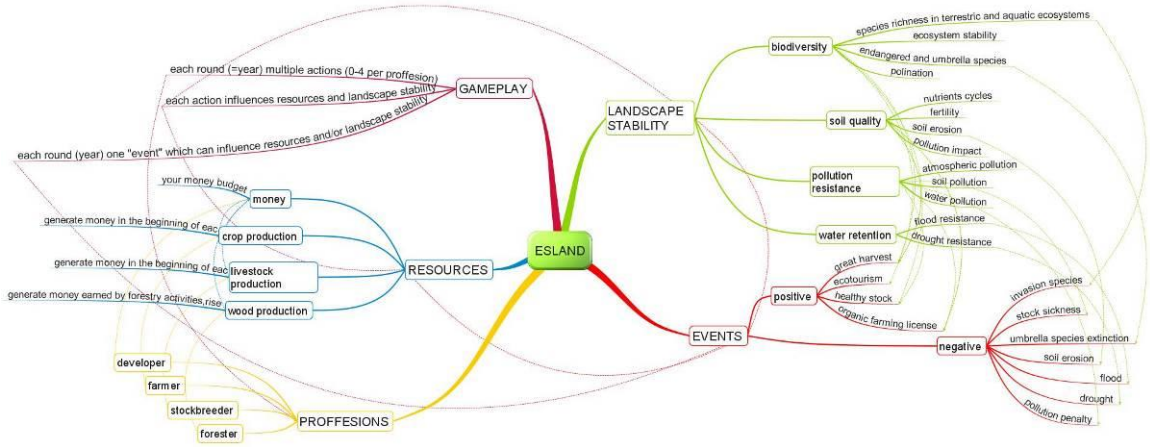

Fig. 1: Mind map showing the principles of ESLAND game

The game development is in progress; we are also creating a card version of ESLAND game. The content management system is being created. This will enable us to create various game combinations and the evaluation system capable of recording important information about game playing and users.

Results

The game “Beware of the flood!” can generate different outputs depending on 3 main methods of use:

a) solo single player (exhibitions, Internet),
b) lectured single-player,
c) lectured multi-player.

The game finds its use as an interactive tool in the environment-focused exhibitions in the Museum of the Moravian-Wallachia region and due to the availability on the Internet it can be used by the general public. We have limited options in getting an output from solo single-player games due to the absence of a sophisticated evaluation system. A concrete result is the number of visits in the website http://portal.muzeumvalassko.cz/povoden/, where the game is placed for the use of museum exhibitions. Since August 2013 until now there are 2 746 visits with an average time spend on the page 3:13 min. We can interpret visitors are trying to play at least one game on average per visit.

On the other hand we have an extensive experience with the lectured single-player and multi-player version – since August 2013 the game has been used for more than 60 education activities such as lectures, shows, competitions and conferences.

Pupils of primary schools prevail as the main target group, but we have very good experience using the game at secondary schools and at the universities. Surprisingly, the lectured game version is also comprehensible for very young pupils, around the age of 8.
Blended learning has been proved as a very effective education method. Blended learning is a combination between e-learning and lectured face-to-face education for multiple players (e.g. classroom). The instructor can choose a few players a special roles (mayor, engineer, developer, environmentalist, etc.), the rest of players are becoming members of a municipal council (the role-playing game principles). They have a collective game quest – to prevent flooding of a town. According to their roles they have to discuss about the options and finally they vote and purchase "flood control system". The Instructor explains the consequences, he serves just as a facilitator and a game guide. Players acquire knowledge on the basis of their decisions and mutual discussion.
Quite remarkable is frequent player behaviour – during the first game they try to have as good anti-flood result as possible. But the next game they do the opposite, usually they enthusiastically choose the worst options to find out the catastrophic game scenario. We consider it as an efficient learning from good and also bad examples with a high level of enjoyment.
Observation of change of player behaviour and additional questions enable us to verify gained knowledge and attitude. A feedback from professionals and university students is enriched by discussion.
In the case of ESLAND game we are designing the Evaluation system capable of getting important information about the player and his answers. Such results will improve our understanding of the education impact significantly. If this evaluation proves effective, we will implement it to the SG "Beware of the flood!" as well. Unfortunately we can´t evaluate the educational impact of the ESLAND game yet, because it hasn´t been used up to the present.

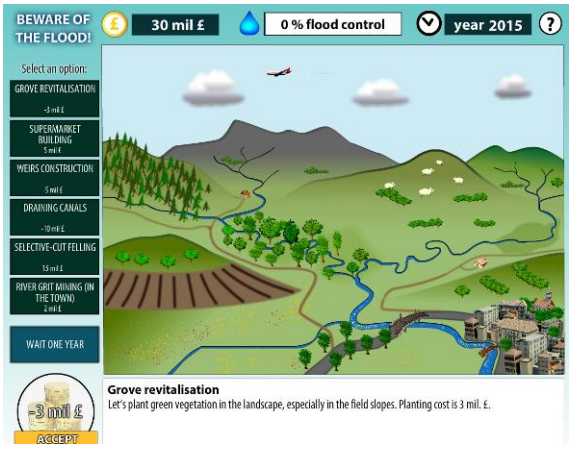

Fig. 2: Beware of the flood game interface

Fig. 3: Schoolchildren playing non-lectured version of the SG "Beware of the flood!"

Discussion and conclusions

With no doubt current environmental issues pose a big challenge for an environmental education. In recent years some efforts using SGs have been made in this field (ISDR: Stop disasters!, CGIAR: Ecosystem Services game, Facebook: Farmville, Cenia: Vítejte na Zemi), but still there is a lack explanation of the of interconnection of issues in practical examples and lack of methods for evaluation.
Our games don´t try to build exact models of a real landscape. They try to simplify complexity, to capture the fundamental mechanisms, to show practical examples and to raise environmental

awareness. We put the accent on quality of enjoyment – players are identifying with the game goal after obtaining special roles, they also appreciate when they can see the change in the landscape. The last but not least – game design can attract and maintain the player´s attention.
After two years of using the game "Beware of the flood!" we can say that the education effect is much more comprehensible and entertaining compared to classical school methods as verbal, text or illustrated explanation, especially when using Blended learning method.
On the other hand there are still imperfections (availability, evaluation) and many challenges for improvement, concerning content (different regions, landscape types, periods of time) and graphical design. After starting up the Evaluation system in the ESLAND game we will be able to collect quantitative data of knowledge and attitude change of players. We want to make our games accessible not only for teachers and other facilitators of learning, but for nature conservation professionals, policy makers and land managers.

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