

ECO CHAMPION: A Transcultural Educational eco Game for Children

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Abstract: Environmental protection and sustainability are a challenge that bundle ecologic, social and economic factors. Furthermore, in a global world all kinds of ecological challenges are interwoven. Environmental problems are often caused not only by local conditions but influenced by pollution and inconsiderate behavior elsewhere, e.g. a notable amount of the plastic waste found on west African strands can be traced back to passing ship. Despite this complexity kids commit themselves without resignation and recognition of constraints for an environment worth living in. With a serious game for school kids we try to address the shortcomings of the common perception of ecological challenges as local incidents and as a matter of personal struggle against dedicated culprit. Hence in our game, a coherent serious of mini games, the player has to fight environmental problems based on actual cases and with the need of cooperation. To address cultural differences, we used a modular design and implemented a multilingual approach. We gave our partners and the local school kids (elementary school) the ability to submit dialog parts and pictorial game assets without bothering them with the technical complexity of the engine (Unreal Engine). The game development team created a set of hero like player characters. The player takes on the role of the different champions to solve special missions. By relying on scenarios of international acting NGOs and by cooperating with schools in Rabat (Morocco), Buenos Aires (Argentina) and Gessertshausen (Germany) we created Eco Champion and it's first mini-game prototype „Garbage Patrol“. In our cooperation we utilized suggestions and visualizations from the partnering schools. With our game we aim at enhancing improvement of children's knowledge, skills and attitudes towards environmental and global issues through friendly online activities and games with a play and learn approach.

Keywords: game design, eco games, game analytics, culture

1. Motivation

In 2002, the United Nations General Assembly proclaimed a World Decade "Education for Sustainable Development (ESD)" for the years 2005 to 2014 with the goal to anchor principles of sustainable development in national education systems throughout the world. This has brought about a variety of teaching materials to be used in the classroom including working sheets, textbooks, and also educational games, some of them are in old-school, analogue format, such as card-board games, and a few of them are educational, interactive computer games. However, pollution, over-consumption and scarce, unevenly distributed resources are still among the key issues that influence our everyday lives today. To provide a livable world for our children and future generations the need to promote a sustainable lifestyle remains a big and urgent challenge. Moreover, in an increasingly globalised world ecological challenges appear to be tightly interwoven. Examples include plastic garbage washed up on West African beaches which is not only caused by residents but ocean currents and even passing ships, as well as shipments of hazardous waste from industrialised countries to third World countries.

Facing environmental issues is a human challenge that touches every aspect of society. Sustainability is commonly described as a bundle of ecological, economic and social factors. Moreover, the protection of the environment is driven by a variety of motivation and the challenges appear very different through the possible contradictory perspectives of different stakeholders. As a „wicked problem“ (Rittel and Webber, 1973; Levin et al., 2012) by the global state of adding value and hard to investigate material cycles it is demanding to explain this topic to children without oversimplification. But children are particularly aware of environmental pollution as they are using their environment not only as playground but as a strong reference for their identity. Also, they are not used to an adult indifference or resignation through the excessive demands of its complexity. To strengthen the courage of children in asking for change and backing them up with a profound knowledge of environmental contexts, approaches and methods we look for a format that proves clearness while maintaining complexity. We think that the game format and especially game development is an reasonable attempt because of its openness to create and bring to life coherent world models.

This paper introduces “Eco Champion”, an educational computer game which aims to stimulate and foster environmental awareness among elementary school students (age group 6-10). A central assumption of the underlying concept is that ecological challenges should be perceived as local incidents within global contexts, and as social conflicts of often legitimate but conflicting interests. In the sequel we first clarify our understanding of environmental awareness from which we derived basic requirements for eco games in general, and we provide a brief overview of the field. For our own game, Eco Champion, which is based on a starting concept of one of us (Jens Müller) and the experiences of one of our project partners, the NGO Ecofund, we first drafted a script (game story). To be able to localize the game for children from different geographical regions with different cultural backgrounds, an attempt was made to elicit design-relevant input from children living in different countries (Section 3). Thereafter, we sketched a first game prototype featuring different skins to accommodate for cultural differences among target players. The last sections summarize the state of the project and gives an outlook on next steps.

Our project is a cooperation between the University of Applied Sciences Augsburg and the NGOs Ecofund (www.ecofund.org) and Manos Verdes (<http://www.manos-verdes.org>). Furthermore, three elementary schools in three continents are involved. Our shared ambition is to sensitize and engage for environmental issues. We believe, that this can be done best by cooperation, thus we built up a communication network to value, use and implement experiences of all participants.

The objectives of the team project at the University of Applied Sciences Augsburg are to develop innovative media formats. Our study program interactive media brings together knowledge, methods and attitudes from applied art and information science. We believe that interactivity should expand to participation approach. Especially serious games are an appropriate format for that attempt due to its conceptual openness and wide range of genres. The demanding development and maintaining process could only be mastered by interdisciplinary teams and it could be opened to a shared experience of developers and users. Objectives in our teamproject are:

- creating applications by bringing together art, design and programming
- managing complex formats by teamwork
- cooperate with different clients and participants

The objectives of Manos Verdes are to promote the exchange of knowledge and technologies for the protection of the environment between Europe, Latin America and other continents to create awareness for the responsible and sustainable use of our natural resources. Activities of Manos Verdes are

- environmental education, especially for children,
- environmental communication,
- establishing networks between schools, universities, businesses and municipalities,
- publish training materials and organize events,
- coordinate student and corporate volunteer programs.

At Ecofund we believe climate change conferences and government laws are important, but we need more local champions and they need our help to preserve our ecosystem. We believe that everyone can be a champion, that small efforts can produce broader positive effects on our ecosystem. We believe it is more efficient and sustainable to preserve our ecosystem through small locally motivated actions than, once the ecosystem is damaged, to restore it through expensive taxpayers funded programs. Preserving our planet is not an impossible task but a challenge within everyone's reach. It is this very spirit of positive action that we are trying to spread with Ecofund and the unique platform it provides.

- Information: Our Ecoblog takes you on a journey to the most remote locations, e.g. protecting migratory birds in “Banc d’Arguin” in Mauritania ensures that after a cold and grey winter, we in Europe can still hear the songs of birds in the spring.
- Dialogue: Thanks to integration of social media within our web platform, global citizens can exchange stories and ideas on how to protect our biodiversity.
- Action: We identify, highlight and boost positive actions by connecting supporters with Champions and their concrete projects. Our Champions do extraordinary things every day to preserve our biodiversity.

The school classes in Rabat/Morocco, Villa Ballester/Argentina and Gessertshausen/Germany apply to the project as a hub for interdisciplinary questions and to foster media competence. Objectives are:

- strengthen awareness of the immediate environment
- talk about the environment and living conditions
- Identify possible courses of environment friendly action
- harnessing the enthusiasm for games in the classroom

2. Environmental awareness

Environmental awareness has different meanings in different usage contexts. We adopt the view of environmental psychologists Spada (1990), Hellbrück and Kals (2012) and consider environmental awareness as a multi-dimensional construct that encompasses the following components:

- knowledge about the environment and its protection,
- consternation, i.e., the degree of feeling personally affected by environmental challenges. Consternation is closely linked to a person's perception of environmental issues,
- value orientation concerning sustainable preservation of the environment and natural resources,
- intention to behave and manifest environmental-friendly behaviour and to engage in pro-environmental activities,
- actual behaviour.

While all components affect each other in one or the other way, there is no automatism in the sense that more knowledge about the environment and its protection results in a sustainable environment-friendly lifestyle.

In a study with children at the kindergarten/elementary school level, Wiesenthal and colleagues (1996) examined the children's level of knowledge about environmental protection, as well as the relation between knowledge and real protective activities. They conclude that environmental education must start at concrete experiences of the children. They consider such individual experiences as a requirement for sound expertise concerning ecological contexts.

Reviewing some studies on environmental awareness among adults and children, Schock (2014) concludes that students seem the most suitable target group for educational efforts on promoting environmental awareness. According to her, young people are more likely to have positive environmental attitudes and willingness to behave environmentally conscious. Educational interventions should show behavioural alternatives and learners should be able to test behavioural possibilities for a variety of motives.

Educational computer games bear the potential to transport subject matter knowledge, to increase perception of environmental issues, and to provide a sandbox for testing alternative options for action in a playful manner. In the next section we discuss a number of educational games that can be related to dimensions of environmental awareness.

3. Eco games – A brief overview

Given the plethora of online references to educational eco games, the provision of a comprehensive survey is far beyond the scope of this article. Rather, we restrict ourselves to provide the reader with a number of entry points for a web search, and we give reference to a number of eco games that we considered relevant for our work on the Eco Champion game.

3.1 Where to find eco games?

Good starting points for a search on educational eco games are collections of educational resources maintained by federal agencies, institutions, associations, NGOs, schools, and engaged private people. The United States Environmental Protection Agency (EPA) maintains the webpage "Games and Quizzes about the environment" (EPA, 2018). The page lists around 10 eco games, each issuing a certain environmental challenge. Also it provides several links to other collections, such as the Games collection maintained by the US National Institutes of Health (NIEHS, 2018). In Europe, various eco games have been developed within projects funded by European research programs (notably from FP5 to the current H2020 program). Outcomes resulting from these projects include

games to strengthen awareness for sustainable use of energy, e.g. BeAware (Jaccuci et al., 2009), EnerCities (2010), and water, or protecting the environment, such as flood prevention, e.g. 2020energy (2012): However, more often than not, games developed as part of research projects are no longer accessible or technically maintained soon after project termination. Some countries like Germany support schools and teachers by means of online catalogs of educational resources. An example is “Deutscher Bildungsserver” (DIPF, 2018). However, in this catalog only four eco games are listed. There are also special interest groups and NGOs who maintain catalogs to educational resources. An example is the “Games for Sustainability” platform (Centre for System Solutions, 201).

A few eco games can also be found on commercial web-based platforms for the gaming community. For instance, the steam platform lists a simulation game named “Eco” (StrangeLoopGames, 2016) in which players must build up a civilization in a virtual ecosystem. Also, literature on serious games research provides further references to concrete eco games. Katsaliaki and Mustafee (2012) conducted a survey on 35 serious games related to sustainability including SimEarth (Maxis Software, 1990) from as early as 1990 to “EnergyLife” (Gamberini et al. 2011) published in 2011. A survey focusing at survey on game applications addressing water conservation and management is provided by Savic and colleagues (2016).

Finally, a word of caution concerning accessibility and playability of referenced games is in order. Digital media and especially computer games strongly depend on the underlying technical implementation platform. The older the games, the less are the chances that they are still operational. For instance, in the last decade Java Applets and Adobe’s Shockwave browser plugin have been the techniques of choice for many game implementations but they are becoming more and more outdated and unsupported and thus some of valuable but older games will disappear, too.

3.2 Typical genres for eco games

A number of web pages designed encompass quizzes related to environmental education. Examples include simple query-answer patterns like the “Environmental Awareness Quiz” (Petty, 2014) or combinations of quizzes and impact calculators, such as the e-learning tool “From cutlet to rainforest” visualizing the ecological footprint (WWF Austria, 2011).

The more complex eco games we have visited during the search belong to the category “simulation game”. Simulation games like Enercities (2010), Eco (StrangeLoopGames, 2016), Sustainable Shaun (Sustainable Learning, 2015) or “Recycle City/Dumptown” (EPA, 2011) make the player a key stakeholder in a simulation of the ecosystem which may foster learning and understanding of complex interactions among decisions and their outcomes. For instance, “Recycle City/Dumptown” published by the United States Environmental Protection Agency (EPA) aims to help students understand the impact of applying specific measures for managing a town’s waste stream. The player takes on the role of a city manager. She can launch certain waste management programs (e.g. home composting, drop-off recycle center, pay-as-you-throw, etc.) and watch the impact of such environmental programs on a number of charts. The underlying game mechanics is a simulator/calculator for waste management based on statistical data of US households.

There are also games that fall into the action or adventure genre. For example, EarthGirl (EOS, 2013) is a typical “platformer” where running and jumping to avoiding obstacles and enemies are the primary gameplay elements. The game is localized for five different languages (English, French, Chinese, Japanese and Indonesian), however, localization concerns textual elements only, e.g. labels on user interface buttons and introductory text passages. The adventure e-transform (2017) let the player explore a housing complex and become acquainted with conflicting perspectives on energy related questions. The player depends on the cooperation of the NPCs to solve the tasks.

3.3 Are eco games effective?

Most of the visited online accessible eco games lack information on to what extent they have been evaluated with regard to bring about desired learning outcomes, such as an increase in the students’ environmental knowledge or the actual impacts on changes towards environment-friendly values, intentions and behaviors. One reason might be that the conduction of sound empirical evaluations is costly and time consuming and requires expertise beyond mere game development. A notable exception is the work by Gustafsson and colleagues (2009). They designed a mobile game with the aim to encourage teenagers and their families to

reduce energy consumption in the home. They conducted a small-scale field test in which they compared recorded energy-consumption data before, during, and after a ten days long game trial. They found that their game concept was highly efficient in motivating and engaging the players and their families to change their daily energy-consumption patterns during the game trial. However, due to the very small sample size of only six teenagers and their families who took part in this case study, *the findings are not conclusive as it remains unknown whether game play can engender behavioral change in the participants beyond the duration of the trial.* There are also several meta-analysis on case studies in which effectiveness of serious games was evaluated. A meta-review carried out by Wouters and colleagues (2013) included 29 serious game evaluations with games in different formats (e.g. simulation, narrative, pedagogical agent, etc.) from across diverse instructional domains such as mathematics, economy, science, and biology but not eco games in particular. A main finding of their meta-review is that the use of instructional support in game-based learning can improve learning.

3.4 Do we need more eco games?

Having revisited a number of existing eco games we see at least the following arguments as drivers to think up and develop further eco games:

- Strengthening environmental awareness and sustainable development remain important educational tasks to be tackled, and if game-based learning can make learning more effective, it is worth to invest further into this medium.
- Improvements to existing eco games are always possible. As pointed out in Section 2, *we believe that players should be able to capitalize on individual experiences made in their specific living environments. This calls for a much rigorous localization of eco games far beyond mere language localization.*
- As each generation grows in the context of contemporary media and technologies there is also the need to “upgrade” and modernize learning materials and tools accordingly.

4. Conception of the Eco Champion game

For the Eco Champion educational game, we first formulate several working hypotheses from which we derive requirements the game should meet.

4.1 Working hypotheses and requirements

The following working hypothesis address the core mechanics and main goals of our game:

WH1: Perception and consternation in children can be increased if they can recognise a link to their own experiences while playing the game.

WH2: Providing different authentic local environments makes evident that while the problems look similar the particular conditions may inherit its own options for troubleshooting.

WH3: Giving the players alternative options to cope with environmental issues will help to better understand causal relationships between behaviour and effects on the environment.

WH4: While interacting with different NPCs the player realises that environmental issues can best be addressed by mediating interests.

WH5: Organising the game development as an open process with participation of school children transforms the game into a communication tool for the concern on the environment.

WH1 suggests that the game should provide a collection of problem cases to increase the likelihood that one of those matches with a player’s own experience. Furthermore, as the game should attract players from different countries, localisation will be required. However, in this case it’s not just a matter of language localisation. Rather, playground, inventory, and characters should be chosen and rendered in a way that match the player’s experience and expectations when thinking of the environment.

WH2 goes beyond the previous scope of linking gameplay to familiar experience by availing awareness of local conditions. Observation of concrete conditions helps against feeling lost in the complexity and factuality of given circumstances. Problems become relativised by being compared with other local occurrences. Reality can be realised as a human made construction, which can be altered by involvement.

WH3 relates to the game mechanics to be provided. There should be both, actions with environment-friendly outcomes as well as actions that are not suitable for solving environmental. Game mechanics may stimulate teaming up with others to solve environmental problems. In any case the game must ensure that outcomes of actions are clearly recognisable.

WH4 refers to the human ability to cooperate. Complexity is faced best by looking for helping hands. We utilise typical game mechanics like power-ups and a dialog system to implement a cooperative gameplay.

WH5 acknowledges that games as interactive media not only rely on instant feedback. Adventure or action games may invite to explore exciting worlds and narratives and connect to virtual characters and other players. While implementing AI, chats and multiplayer mechanics is beyond the scope of this project, we provide e.g. a simple dialog system. beyond a technical level interaction is social action. We achieve this by organizing an open development process.

And last but not least, Eco Champion should be perceived as a game that is fun to play. While there are controversy opinions on the existence of a universal player typology / player satisfaction model (for a survey see Nacke et.al 2014), it is observable that players have individual preferences for specific game genres, although preferences may change over time.

4.2 Game outline

With regard to WH1 and WH3 the Eco Champion game has been conceived as an extendable suite of dedicated mini games, each addressing a specific environmental challenge. Also, each mini game must offer action choices so that players can learn about action consequences on the environment, whether they are good or bad. At the current state the following mini games, based on experiences and real projects by Ecofund are under development:

- **Garbage Patrol:** There's garbage all over an urban place. Get the garbage out of your neighbourhood. Disrupt bad habits of disposing waste by convincing NPCs to alter their habits. Separate waste and acculturate the concept of up-cycling.
- **Harbour Master:** A fishing vessel collided with a rock. Prevent an oil slick. Use a boat to catch the oil. Organise people to build a pipe system to pump off oil.
- **River Manager:** A recently commissioned industrial textile dyeing plant discharges its toxic waste water unthreatened into the nearby river. The river is not only an important source of water for the surrounding villages, but also an important source of food. Clean the river. Mediate between the interests of textile workers and fishermen.
- **City Mayor:** More and more cars and mopeds are being registered in the city. There's a thick smog cloud over the city. Fight the Smog. Motivate People to change to public transport or bicycles. Make intelligent investments into the infrastructure
- **Park Ranger:** The hot sun desiccated the earth. To clean their fields, farmers have set the grass on fire. Unfortunately, the small fires begin spreading uncontrollably, large areas of forest and pasture are in danger. Cut a path to prevent the fire to spread further. Get help from lumberman and fire fighters. Get access to the extinguishing aircraft.
- **Saviour of the Seas:** Drifting nylon nets degrade the marine ecosystem. Once lost by the fishermen, nylon nets take about 400 years to completely disintegrate. Entangled fish die a senseless death and attract predatory fish, which also get caught in the nets. Get nets out of the sea. Convince fisherman not to throw old nets into the sea and better use cotton nets.

All the mini-games are bound together by a framing story. In a central control room missions are handed out to the player, who adopt the role of a local champion. An Eco Champion – which is also the name of the entire game – is a local hero who solves problems through direct action but also by cooperation with different actors (NPCs) or by mediating between contradictory perspectives and interests. This game concept is based on the seven years of experience by Ecofund. Thus, we are able to make sure that the game script is linked to real world scenarios. The profound experience of the NGOs and their creative and constructive approaches in problem solving are a core resource for creating our game play and the design of the player's missions.

As stated in WH5 our attempt is to involve children as co-designers during game development. While participative approaches to game design involving children have been exercised by others, too – for an overview see Langridge et al. (2017) – we hope that this will help us to accommodate for cultural differences and regional characteristics of environmental problems. Furthermore, it should foster the commitment to the given missions and put the students into the role of co-developers, using the game format for a more communicative and cooperative exchange and knowledge transfer. This takes into account that the school children have substantiate implicit knowledge in the coherence of their local surroundings. This approach is described in the next section.

5. Getting input from children

Perception and consternation in children can be increased if they can recognise role models and best practice examples. That may give them orientation and encourage them. The involvement of children as co-designers should accommodate for cultural differences and regional characteristics of environmental problems.

5.1 Preparation

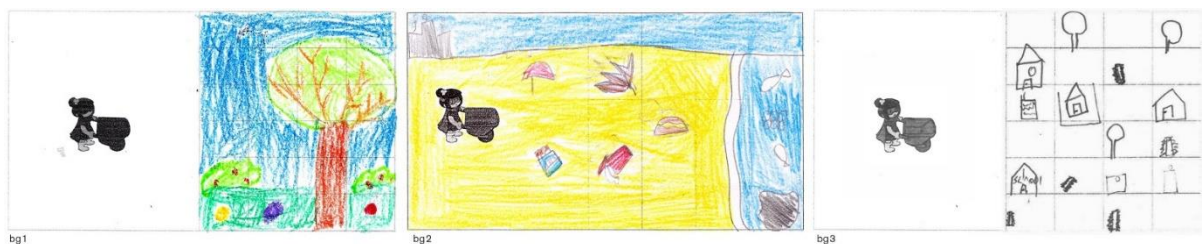
As a starting point, we produced three versions of the Garbage Patrol, one localised for German children, a second version for Moroccan, and a third one for Argentine children, based on the infrastructure of the participating NGOs. We explained the participating schools our objectives and worked out a questionnaire and worksheets to elicit input for game design from the children.

The questionnaire asks for gender and age. We show the dev teams drafts and ask the children for comparison with local conditions. The worksheets comprises room for sketching individual places and items of waste. A second worksheet shows different kinds of player characters (as heroes). The children are asked to rate the characters. Furthermore, the pupils are asked to draw their own character.

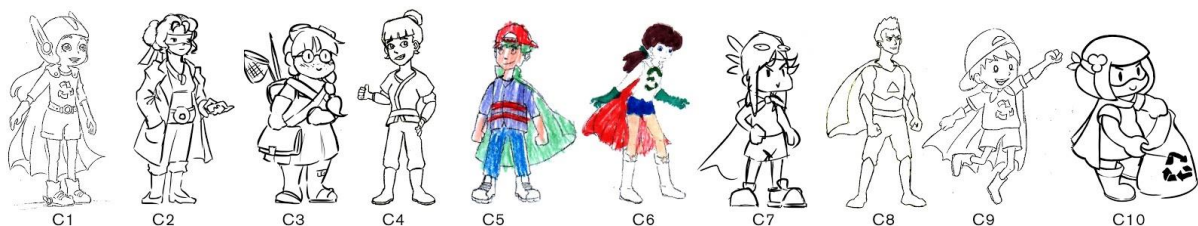
Determining the characters the school children identify most with should help to set up the localised versions with an authentic and understandable game world. To achieve a consistent and professional graphic style we transfer the childrens drawing to our style. The submitted images of garbage takes us a step further. Here we have to adopt the game story to apply to the special conditions at different locations.

5.2 Input for game assets by children of different countries and evaluation

In our first survey we received answers from 53 children from Rabat/Morocco, Villa Ballester/Argentina and Gessertshauen/Germany (see section acknowledgements). All the submissions show a good understanding of our questions. In rating they stressed the whole scale giving clear statements. The possibility to draw own pictures had been embraced very well.



Background examples submitted by the children from Germany (bg1), Argentine (bg2) and Morocco (bg3).



Characters c5 and c6 had been the favorites of the Moroccan and the German students. In this compilation the favorites are substituted by colored submission of Moroccan pupils.

While the Argentin children submitted their own characters and landscapes, the Moroccan and German school children in addition evaluated the given characters.

The majority of the Moroccan school children preferred the character c5 (10 of 22), most female children voted for character c6 (5 of 11), most male pupils for character c5 (7 of 11). Likewise, the majority of German children voted for c5 (6 of 19) and c6 (6 of 19), most female children voted for character c6 (6 of 12), most male pupils for character c5 (6 of 7).

The response to kinds of garbage shows major differences between the countries. While the German Pupils mostly depict food scraps, cans, bottles and even leaves, the Argentine pupils often refer to pollution by ships, industry and discarded bottles. Moroccan children respond with drawings of e.g. soda bottles and food packages. How much the submission is influenced by previous lessons of environment-oriented teaching and later by playing the prototype will be examined in a later stage of our project.

6. Prototype of Eco Champion and the Garbage Patrol mini game

The Game starts in a control hub. Blinking red lights point to environmental issues around the world. In a chat like dialogue the player gets a description of a given challenge. For every mission she/he is able to activate a local champion. This starts a minigame and the player slips into the role of the local hero. After successfully finishing the mini game the red light turns into green and the player achieves time credits.



Screenshots of the localized version for Germany, Morocco and Argentina.

For illustration, we concentrate on the mini game Garbage Patrol. The player character is equipped with a barrow and moves through an obstacle course. The mission is to collect garbage. The wheelbarrow has a limited capacity and must be emptied regularly. Colliding with obstacles causes garbage to fall off the barrow. At the right side of the parcour the player can deliver the garbage to a recycling depot. Delivering garbage separated by type the player achieves objects of value, which can be brought back to the parcours and deployed for powerups like a second barrow or for winning NPC to help collect garbage or avoid dumping.

Variants of the mini game resemble the different experiences of the participating school children in Rabat/Morocco, Villa Ballester/Argentina and Gessertshausen/Germany. The garbage lying around looks different, helpers are individually motivated, power ups are unique for every skin of the game. The localised Garbage Patrol mini games share the same game mechanics while the graphics, dialogs and NPCs and power ups are based on the experience of the local students. Therefore, we organized classroom workshops in the participating schools.

The game development is done by the student team in the interactive media study program at the University of Applied Sciences Augsburg. The team worked in distributed roles e.g. as game artists, level designers and programmers. Using Photoshop, Unreal Engine and other tools, prototypes are built for evaluation at the participating schools.

7. Next steps

7.1 Development of further mini games

Meanwhile some members of the development team create the next minigame, Park Ranger. We follow the same workflow. First, we do a rebriefing of Ecofund's game proposal and discuss different concepts for technical implementation. Then we create a logical consistent and playable prototype with our own graphics. In a next step we will involve school children for localizing and alternative gameplay.

At the current stage we focus on a basic gameplay and a simple story in one screen, hence mini games. In a further iteration the game mechanics should be evolved further to better incorporate and visualize the social complexity of environmental issues and to enhance the achievement system. We now provide the player with power ups that refer to the stakeholder approach. By now the player is only able to activate NPC-helpers that do the same tasks than the player. Beyond that we work on a concept in which the player has to contact various NPCs representing different perspectives and dedicated abilities on the subject and animate them to help accomplish the given mission. This will require an informed discussion with the school children. As soon as the cooperation with partner schools has been deepened the school children could be involved in an earlier state, enabling the pupils to contribute their own experiences of environmental problems and suggest suitable solution strategies.

7.2 Game evaluation

Much work remains to be done regarding evaluation work. Firstly, game play evaluation will be conducted to adjust game mechanics to a level of difficulty which is appropriate and fun to play for the children. In addition, we plan to evaluate the effectiveness of Eco Champion mini games in terms of measurable learning outputs. This will include gaming sessions with children surrounded by pre- and post-gaming interviews to examine if the children acquired new environmental knowledge and to what extent the game can contribute to a child's value orientation towards sustainable preservation of the environment.

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