Challenges in Geogame Design for Biodiversity Education

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Abstract

Using Geogames in educational scenarios is an entertaining way to foster experiential outdoor learning. Especially in environmental sciences they provide new potentials by connecting the learners with the local surroundings. This paper discusses technological challenges relevant to Geogame design for environmental education. A Geogame app with the purpose to enhance the player's sensibility to biodiversity issues is presented that can be played without server connection since network connectivity often lacks in rural regions. To provide the possibility for creating customized game variants for diverse locations, a Geogame editor is introduced that assists the game stager in relocating existing games and adjusting the game narrative to a given situation.

Keywords: Geogames, Location-based Games, Educational Games, Biodiversity, Geogame Editor, Offline Gaming

1 Introduction

The usage of mobile technologies facilitates contextual and location-based learning in general [1] and is especially of interest in environmental education [3, 7, 10]. Thus, serious location-based games are replacing the classical field trip by providing novel potentials to explore the surrounding environment on the one hand and increasing enjoyment on the other [5]. In addition, they adapt to new learning habits of the Digital Natives that nowadays are organizing almost everything with their mobile devices [4].

This work is part of the BioDiv2Go[1] project that started in December 2013 as a cooperation of the Department of Biology and Biological Education at the University of Education in Ludwigsburg, the Chair of Computing in the Cultural Sciences at the University of Bamberg and the German Youth Hostel Association (DJH). The goal of the project is to create entertaining experiences for school children discovering biodiversity by playing mobile games in the natural environment [8]. While the pedagogues from Ludwigsburg are mainly focused on designing appropriate Geogames for different scenarios based on a theoretical framework for biodiversity education, the technological part of the Geogame development is done by the computer scientists at the University of Bamberg. The DJH's role in this project is the dissemination of the Geogames to the target group.

In this short paper we first discuss different types of Geogames in environmental education. We identify technological design challenges based on different application scenarios and provide solutions for (1) being able to play without server connection and (2) creating site-specific games based on the local environment. We present a game app that was developed within the BioDiv2Go project to demonstrate the applicability of the proposed methods.

The remainder of this paper is organized as follows: Section 2 gives an overview about related work in the field of Geogames for environmental education. Section 3 identifies design challenges and describes Finde Vielfalt Simulation – a game app for biodiversity education – as well as a Geogame editor used for creating customized games and analyzing game results. Section 4 concludes this paper with a discussion and outlook.

2 Geogames in Environmental Education

Location-based mobile learning (LBML) in combination with gamification techniques offer new possibilities that go beyond classical field trips. Especially for environmental education game-based mobile learning can enhance sustainable learning experiences on-site [5, 10].

Benford et al. [2] present an experimental location-based game called Savannah which aims to encourage the players in understanding the behavior of lions trough personal experience. Different frame conditions (hazards, hunters and other lions) have to be taken into account in order to make decisions about territory, shelter, food, water and reproduction. The game is staged on an empty school playing field by five students at a

[1] www.biodiv2go.de

time each having the role of a lion. The authors report on a positive effect in enjoying the experience and learning about lion behavior.

Squire and Klopfer [10] are facing the question how handheld technologies and game play can be used to enrich enquiry and provide a new pedagogical paradigm for environmental science education. They present a game named Environmental Detectives – an augmented reality simulation of a carcinogenic toxin (TCE) flowing through an urban watershed. The game provides virtual (information about toxicology, hydrology and similar cases) and real-word (data about the location and severity of the TCE spill) components to students whose goal it is to locate the cause of a TCE spill. They argue that augmented reality simulations can create a compelling context for environmental investigations.

Huzienga et al. [6] present a game for secondary education pupils to engage them in historical knowledge about medieval Amsterdam. In a quasi-experiment, they could show that pupils playing the game gained significantly more knowledge than the control group that received regular project-based instructions.

Feulner [5] is researching the impact of Geogames on the student's learning experience by experimenting with different Geogames like Neocartographer [5, 9]. Both are multi-player games containing game points (caches) that must be captured by solving some place-related tasks. Besides, the Neocartographer game is said to foster spatial sense and cognitive mapping skills by assigning the Voronoi cell associated with a cache instead of the point itself to the capturing player [9].

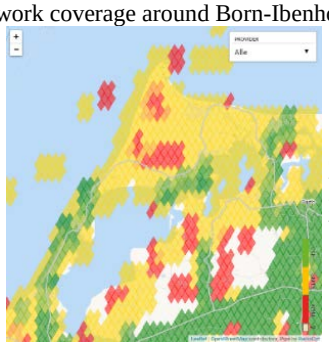
3 Geogame Design for Biodiversity Education

Previous section discussed different approaches to location-based games in the context of environmental education. Different learning environments and goals require varying prerequisites for the technological development of a Geogame. We categorize the games depending on the following two dimensions to provide a basis for decisions in the design process:

1. Single-player vs. multi-player Geogames
2. Geogames with vs. without spatial and/or temporal restrictions

Multi-player games need a constant network connection since every change in the game state needs to be communicated to the opponents. While the general network coverage in Germany is almost nation-wide, rural regions often lack sufficient connectivity.

Figure 1: Network coverage around Born-Ibenhorst, Germany



Green: LTE
Yellow: UMTS
Red: GSM
White: unknown

Source: http://www.computerbild.de/specials/netzabdeckungskarte/

Figure 1 shows a network coverage map for Born-Ibenhorst in North-Eastern Germany where one of the youth hostels involved in the BioDiv2Go project is situated at the edge of a national park. Since national parks are mostly unviolated pieces of wilderness they are of special interest in biodiversity research and education.

Figure 2: Network connectivity in Bad Urach, Germany

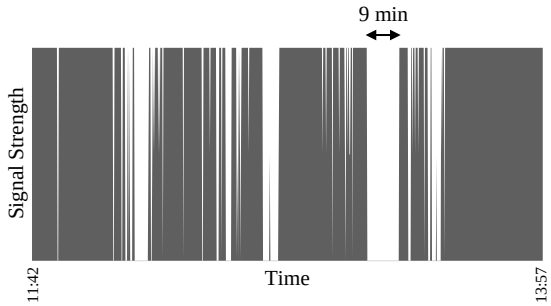


Figure 2 demonstrates the results of a connectivity test performed by a researcher on May 27th, 2014 within a region of interest near another youth hostel situated in Bad Urach in Southern Germany. Although the testing person was not moving in space, the signal strength was unsteady with signal losses up to 9 minutes.

These circumstances imply that the general gameplay of an environmental Geogame should not rely on a constant client-server connection, i.e. on direct interaction between players.

However, this restriction does only apply for Geogames that are spatially limited to a specific location which does not provide sufficient connectivity. In our categorization, we differentiate between types of games based on their spatial and temporal restrictions. Games without any spatio-temporal limits can be played everywhere at any given time while spatio-temporally limited games are scheduled on a specific date and location. Geogames played in class are usually staged and spatio-temporally limited since all players take part in the same Geogame event. Games developed in the BioDiv2Go project usually don't have temporal limits but are bound to a specific location and include customized game content about the surrounding region.

That brings us to another challenge in the development of Geogames, namely the relocation of game contents [9]. In environmental education, Geogames are often intended to provide a learning experience about a specific location. Thus, the game cannot easily be transferred to another place and methods need to be provided that can automatically relocate a game field to another location or at least support the stager of a game in relocating a game field manually.

3.1 The Finde Vielfalt Simulation Game

The Finde Vielfalt Simulation (FVS) game is one of the Geogames developed within the BioDiv2Go project. Its target group are adolescent visitors of German youth hostels. Each of the participating youth hostels provides different variants of the game, tailored to the ecological focus of the local surrounddings. Thus, it belongs to the class of spatially limited single-

player games that are bound to a specific location. The goal of the game is to discover the natural environment and to learn about the impacts produced by interventions in the same [8].

A game editor (see section 3.2) can be used to adjust the narrative story line to a given situation. The exemplary game variant described in this section was built for the youth hostel Bad Urach which is situated in a beautiful mixed orchard environment. It lets the player slip into the role of Adam who must keep on the traditions of his ancestors' heritage. His goal is to balance biodiversity and economic success by collecting diversity points (VT) on the one hand and coins (G) on the other. Figure 3 shows the result of a game which can have four different outcomes summarized in table 1.

Figure 3: Result screen of the FVS game

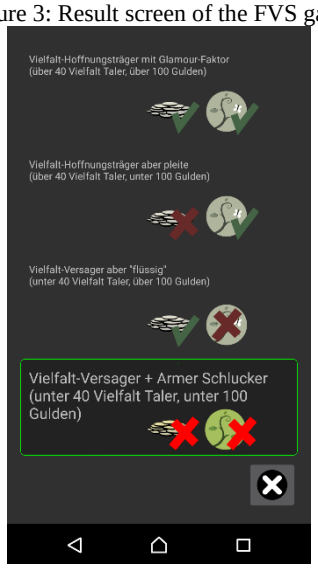


Table 1: Possible outcomes of the VFS game

		diversity points (VT) ≥ 40	diversity points (VT) < 40
coins (G)	≥ 100	wealthy diversity white hope	wealthy diversity loser
	< 100	bankrupt diversity white hope	bankrupt diversity loser

The game is usually played in groups with one device such that the players have the possibility to discuss their decisions. After a start sequence the game continues with several game sequences which are triggered when entering a cache. Each sequence consists of several screens. The following screen types are part of the game:

- Information and story screens introduce the game narrative to the players and provide them with background information using text, images, audio and video.
- Task screens provide different questions and other tasks to be executed by the players. The tasks demand the players to explore the surroundings or rely on information given in previous screens. Here players can earn coins.
- Simulation screens require the players to make decisions which change the environment. The result of the decisions is presented to the players and affects the players' coins and diversity points.

Thus, the simulation is the exciting part when trying to achieve the goal. There is only one overall simulation in a game which means that each simulation round starts with the result of the preceding one. Thus, the player has several attempts that allow him to gather insights about the dependencies and impacts of his actions and finally to maximize his outcome. He is also allowed to execute an arbitrary number of test rounds to learn about the outcome of the simulation.

Figure 4: Simulation screen of the FVS game

Figure 4 shows an exemplary screen of a traditional orchard simulation with the possibility to plant or remove apple, cherry and pear trees.

3.1.1 Offline Capabilities

Due to insufficient cell coverage Geogames in environmental education have to rely on the following offline capabilities:

1. In-game elements on a location-specific game field as well as the map itself need to be available throughout the game.
2. Data collected while playing the game needs to be stored as it can be relevant as a data source itself and for post-game analysis.

Developing a location-based game without network connection implies that only GPS is available and server communication is not possible. For being able to display the player's position as well as the positions of caches on the game field and to provide additional information associated with location-based in-game elements, all parts of the game – including the play engine, game elements and the map – must be available in the client on the mobile device. The FVS Android app has a client side map module which locates the GPS position of the user on a local map based on bitmap map tiles downloaded from

OpenStreetMap[2] in three different zoom levels and compiled into the app together with all other in-game elements. The usage of bitmap instead of vector maps reduces hardware requirements and improves battery life.

Figure 5: Map screen of the FVS game

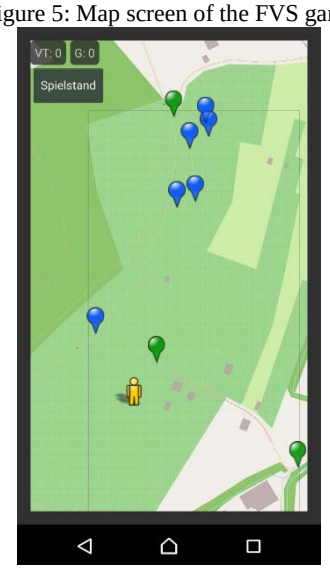


Figure 5 shows a map screen with a region of interest containing six action caches (blue) and three navigation hints (green). Entering an action cache triggers a game sequence while navigation hints support path finding. The screen is loaded independent from an existing internet connection since the map tiles as well as the game data is included in the local game storage on the mobile device.

For the game analysis in the debriefing phase as well as a scientific evaluation of the game, the player's GPS tracks, answers, photos, audio recordings are stored in the client and uploaded to the server after the game, when the smartphones are connected to the local WiFi of the youth hostel.

3.2 The Finde Vielfalt Game Editor

Technically speaking, FVS is not a single game but a game model kit which allows for the creation of customized games for desired locations by providing the possibility of including different types of biodiversity-related simulations, adjusting the story line, inserting different tasks, questions and media and finally relocating the game by manually defining the locations of caches.

Since most of the game stagers (youth hostel staff, teachers) have no programming skills, there was a need for a simple user interface that assists the stager in the game creation process and automatically compiles a customized game file. For this reason, a web-based Finde Vielfalt Geogame Editor (FVGE) was developed while the FVS Android app only contains some basic game mechanics as well as the possibility to load different games produced with the editor.

After creating an account and logging on to the system, there are two possibilities to create a new game instance: Either an empty game field is loaded or an already existing game is copied. The first option is suitable for creating completely new game instances with new locations and game content. The second option is for reusing relevant game objects such as locations and game elements. Thus, it is possible to relocate an existing story to a new environment by simply repositioning the already existing game elements on the map.

Basically, the FVGE consists of two main parts – the location and the sequence editor. Figure 6 shows a screenshot of the FVGE location editor with the possibility to place, delete and name game caches on a map (A) as well as to assign sequences of actions to the game caches (B).

Figure 6: Defining caches with the Geogame editor

The story of the game is created by manipulating the sequences that are associated with every cache on the game field. Every sequence as well as the corresponding screens and media files can either be defined from scratch or copied from other already existing games.

After finishing the game creation process, the customized game is compiled and a configuration containing the game as well as all media and map elements is automatically generated. This configuration can afterwards be loaded into the generic FVS Android app.

The editor also provides for some post-game analysis by storing data collected during the game play on the server as soon a network connection is available. The data is integrated in the FVGE user interface and offers some simple evaluation options. It contains answers that were given to the questions, recorded media as well as the conducted simulation rounds. The recorded player tracks will be included in the evaluation in the next version of the analysis component. Due to privacy reasons the access is restricted to the stager/teacher and the researchers.

4 Conclusion

In this paper, we discussed several design issues for Geogames in environmental education. While most of the reviewed games rely on an existing internet connection, we could show that it is often insufficient in biodiversity hot spots. Thus, Geogames

[2] https://www.openstreetmap.org

with offline capabilities are needed for environmental sciences whenever the region of interest is not covered by local network providers. We pointed out that there is a need for software solutions that help users without programming skills to develop new Geogames. Finally, we demonstrated a Geogame that can be played offline and a Geogame editor that is used to assist a game stager in the creation process of customized game variants that are adapted to the local environment.

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