

EntVenture - From Binary Trees to Kenyan Forests: an Android Game Designed by Students

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Abstract: In an attempt to increase the awareness of the importance of forests and forestry to the environment, economy and everyday life, a forestry game was developed by Kenyan students at University of Eldoret and a Finnish student at the University of Eastern Finland. The game ‘EntVenture’ is a quiz game where the character Ent guides the user through various forestry related topics such as managing a tree nursery, uses of different trees and the importance of forests for sustaining life. EntVenture also consists of three mini games within the game - a word search, picture puzzle and a balancing game. EntVenture was developed during 2012 for Android phones and tablets. In this paper, we present the process of the development, lessons learned and provide suggestions on how to design educational games for viability.

Keywords: Forestry, game, Android, user-centred design, education

1. Introduction

With a population of 38 million and growing at a rate of over 1 million people a year [11], Kenya is a mega-biodiversity served by various ecosystems ranging from marine, mountains, tropical, drylands, forests, and arid lands [12]. While forests cover only 6% (i.e., 3.4 million ha) of the land area [13], these forests as well as trees outside forests and other wooded lands constitute important resources for rural communities. However, Kenya’s natural resources are dwindling and lands are fast degrading including the forests due to human population growth and ever-increasing pressure on land and renewable natural resources [14]. In addition, the country performs poorly (96 out 149 countries) in environmental health criteria as per the Environmental Performance Index [15]. Global challenges, especially reversing deforestation and forest degradation, mitigating climate change and halting desertification are increasingly important for Kenya. The crucial role of foresters in the adoption of participatory methods for the inclusion of local communities in

the management of forests, trees and other wooded lands, has become even more evident within the last years and is embedded in a new Forests Act (Forests Act 2005).

However, forestry education suffers from low investments and a decline in interest, as demonstrated by reduced enrolments in many countries. Exposure to field experiences and to the area of environmental protection has been recently identified as key motivators for studying forestry across continents [16]. While thorough reforms in forestry curricula that reinforce the competencies of foresters for their work as versatile natural resource and environmental experts and managers have occurred in developed countries (e.g. Finland, Germany, Canada), forestry education in the developing world and particularly Africa is lagging behind. These issues were recently addressed in a joint project between the University of Eastern Finland and the University of Eldoret in Kenya with funding from the Ministry for Foreign Affairs of Finland. The project aimed at the review of curricula, development of relevant learning materials and resources, and use of ICT as medium for generating and disseminating new relevant knowledge.

The development of the forestry game was seen as one of the key activities within a result area that aimed at improving the recognition of the relevance and importance of forestry by local school going children, who hardly get to know the important role of forests in sustaining life. The importance of children's perceptions over issues like forests and the environment cannot be overemphasized. Within the abundant literature in this subject, environmental education has been seen as an effective contributor to changes in behaviour that ultimately translate into environmental citizenship [17]. In this sense, this game development was also aimed at ensuring early exposure and a solid foundation on forests and the environment to school children.

Kenya has 29.7 million mobile phone subscribers and a mobile penetration of 75.4% [1]. The uses of Mobile phones are increasing together with the services used on the phones. Kenya was the pioneer when it came to introducing for instance the mobile money transferring system M-pesa in 2007, which is currently widespread throughout Africa. In Kenya alone there are 19.5 million accounts that have been registered [1]. In June 2012, there were 7.7million Internet subscriptions where the mobile data/Internet subscriptions contributed 98.9 percent of the total subscriptions [1]. Android phones currently account for approximately 25 per cent of the web enabled mobile phones on the Kenyan market but the number is rapidly growing as the phones are becoming cheaper and more affordable [10]. Android phones are the most common smartphones on the Kenyan market and worldwide. By 2015, low-end Android smartphones are expected by market researchers to seize 80% of the market in Africa, India, and China [9]

In order for the game to be effective, it must be able to persuade the player to appreciate the importance of forests [2]. A few other research projects have contributed to the goal of educating the users about the importance of the environment using a game as the method. GreenSweeper [3] is a pervasive game that promotes environmental awareness in an urban environment. In GreenSweeper, a modification of the popular Mine Sweeper game, the player navigates through a real world map while defusing mines which are represented by non-green areas. Thus, an urban environment with very little green areas is filled with mines. Environmental Detectives [4] is a multiplayer pervasive game for environment education. In the game, the player assumes the role of an environmental detective whose task is to solve a contamination problem. The game map is an overlay on a real world map, indicating (imaginary) contamination problems in real world locations. Ambient Wood [5] is context-aware educational tool which facilitates children's learning about scientific inquiry and hypothesis testing in a forest environment. The learner is equipped with a PDA and a probe device for measuring sunlight and humidity at predetermined hotspot areas in the forest. Finally, Heroes of Koskenniska [6] is a pervasive educational game in which the player solves various challenges that aim at increasing the player's environmental

awareness in a Finnish forest context. This game uses environmental sensors deployed in the forest, indicating differences in environmental conditions in hot spots.

In the following sections we present the Entventure game and its process of development. To our knowledge, Entventure is the first mobile game specializing in increasing forestry awareness in a developing country context. Moreover, it has very strong roots in the local community involving professors and students at the University of Eldoret as well as local primary school children.

2. Objectives

The main objective of the development of EntVenture was to increase the awareness and interest for forestry among school going children in Kenya. The game is to be used by University of Eldoret in outreach activities for the community, for showcasing the opportunities of new learning technologies to students and staff at the university and to make it available to a wider audience where anyone with an Android phone with an interest in Kenyan forestry can download it from the Internet and learn more about forestry in Kenya. University of Eldoret has purchased a number of Android tablets to be used for teaching and outreach activities. With the available tablets' they can use the game at primary and secondary schools close to the university. As smart phones become more available the hope is that the game will eventually also benefit schools further away from the university. The University has a tree nursery and tree arboretum for the students within the campus from where most of the content for the game was taken. The idea was that the game would also be a complementary tool for teaching some of the students curriculum in regard to raising a nursery and planting/maintaining a forest.

A Secondary objective of the Entventure development project was to give the participating students know-how which could be valuable for their future careers. This objective was encouraged by our previous experience with student-driven development of the Caravan game in Tanzania [7]. Equipping the students with the responsibility and ownership of the development starting from the concept creation phase can contribute to overall positive outcomes of the project.

3. Methodology

When the project for improving forestry education in Kenya started, the development of a mobile game was not included in the original project agenda. One of the goals of the project was collection, development and distribution of materials about forestry from the local knowledge. This goal, however, did not specify the means of distribution which could be anything from booklets to digital e-learning materials. Given this flexibility, we chose to use an Android-based mobile game as a knowledge distribution vehicle for these reasons:

1. mobile technology is familiar to many people including rural areas in Kenya
2. mobile devices are highly portable, thus allowing the game to be played in the forest
3. game features make learning fun both for children and adults
4. we had good experiences with using mobile games as educational tools in the past
5. Android is the most widely used platform both in low-end and high-end smart phones and tablets

Once we had an idea what was to be done, it was time to find skillful and motivated people to do the job. The project members from University of Eldoret identified five prominent Kenyan undergraduate students - two of information technology major and three of forestry major - who were appointed to work on the game. Later, a Finnish computer science student joined the project so as to assist the technical team with Android programming. The roles of the students were clearly set from the beginning: the forestry students were to develop content for the game, the IT students were to work on technical

implementation, and all students and their supervisors would work together as a team to develop the game concept.

The nature of the game development process was very much exploratory because none of the students, except the late-joined Finnish student, had experience with similar projects. Thus, we can say that the process followed the exploratory software development method which tackles situations where the requirements are unclear or the domain of the application (both technical or conceptual) is poorly understood [8]. The exploratory approach manifested itself in various challenges, both conceptual and technical, that the project team met. These challenges are described in section 4.

Local primary school children were invited to participate in the game concept and content development process. Specifically, we held a game prototype workshop in which the children played a paper prototype of the game. During the game play, the development team collected feedback from the children on how the game flow and the content could be further developed. This information was then used to polish the game to its final form.

4. Developments

4.1 Game Description

In its current form, EntVenture consists of 15 standard question and three picture questions where each question is followed by an information screen (Figure 1). The way the game is designed is however easy to add or modify the questions. The standard questions generally have some text information and show photos, under the photo come the question and the alternatives where the user selects an answer by checking a checkbox. If the user does not know the question there is a hint button at the bottom where the user can get a hint that might help leading the user to the correct answer. The user will have to keep answering until they have selected the correct answer. The first attempt however generates more scores than the second and for each attempt the score gets lower. The picture questions consist of the question and four pictures where the user needs to select the picture that best answers the question, also here the user will need to select the correct picture before being able to continue to the next question. The questions deal with issues of starting and managing a nursery, identifying different trees, the importance of forests and forestry services in Kenya.

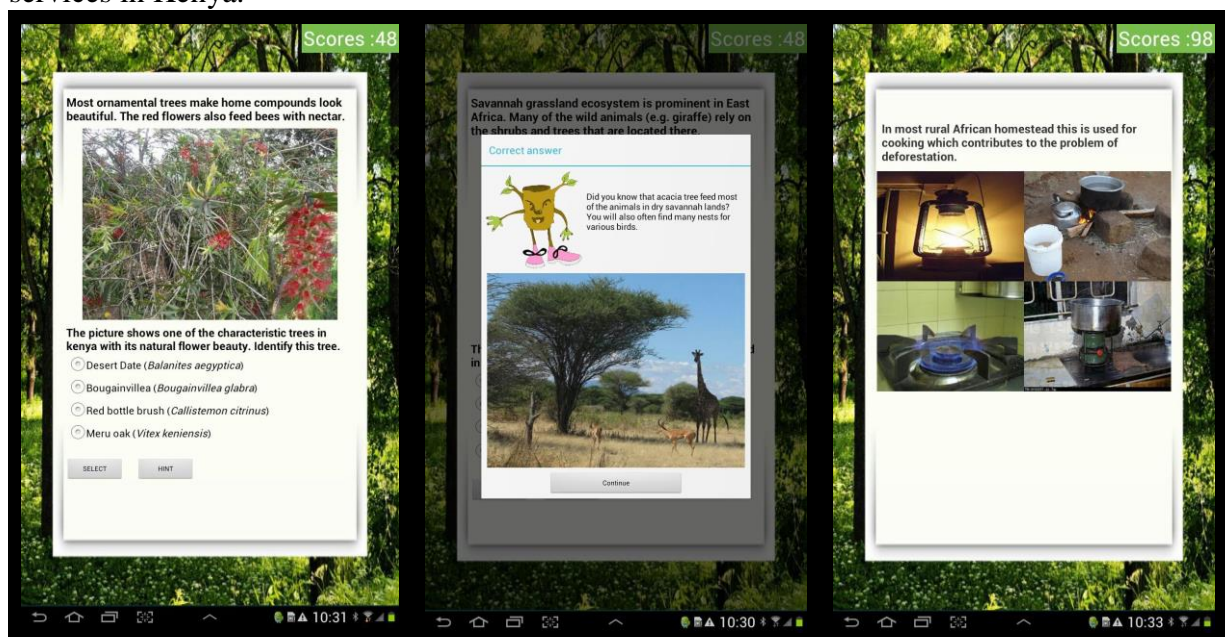


Figure 1: Sample of a Standard Question, an Info Screen and a Picture Question

Each question is followed by an information screen where the wood log looking character named Ent either provides some additional information related to the question or just provides some general information about forestry in Kenya. The information is displayed by text paired with a picture.

In order to make the game more exciting and entertaining three mini games were developed and integrated to the game (Figure 2). After answering a few questions a mini game will be introduced to the user. The first mini game that the user will be challenged with is a word search game where the user will need to find 10 words related to a tree nursery. For each word there is an explanation of the word so that the user can get an idea of what words to look for. In case the user is not able to find all 10 words there is an option to give up and gain the points for the words found. The user selects the word by dragging the finger across the letters of the word on the touch screen. This mini game however requires a larger screen and is only invoked into the tablet version of EntVenture.

The second mini game is a picture puzzle where a picture of the late famous and very popular Kenyan environmentalist Prof. Wangari Maathai has been scrambled and the user needs to restore the order of the 9 pieces of the picture. The points credited for solving the picture puzzle are related to the time it takes for the user to solve the puzzle where a faster time will generate a higher score.

The third mini game is a balancing game, consisting of blue circles symbolizing water droplets where the idea is that the user should collect as much water as possible for a nursery. One droplet is controlled by the user and how he/she tilts the screen, the size of that droplet is at the beginning rather small and only smaller droplets than the one controlled by the user can be captured. As the user captures more and more droplets the droplet being controlled by the user grows bigger. If the user catches a bigger droplet than his/her own size the game will end and points will be awarded for the droplets caught. If the user manages to capture all the droplets the game will end and maximum amount of points will be awarded.

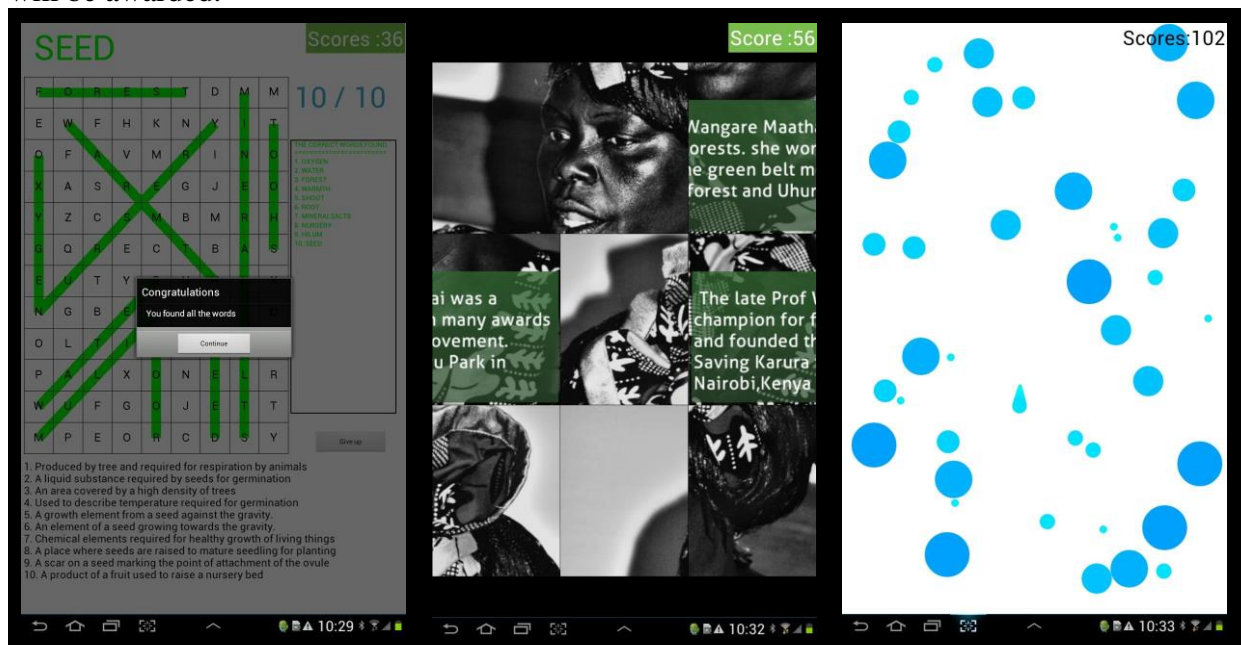


Figure 2: Three Mini Games Found in EntVenture

At the end of the game the user will be given a certificate showing the rank assigned to the user which corresponds to the amount of points collected. The different ranks are; ultimate forester, forester, forest guide, forest ranger, basic knowledge in forestry or 'You have been sleeping too much in class!'. In addition the users will be able to add their names to a scoreboard that is also available from the main menu of the game. In the main menu

apart from starting the game the user can also go to credits which will display information of who were involved in the development of the game.

4.2 Challenges During the Game Development

For the students participating in the game development this was a first experience of working in an interdisciplinary and international project. During the shorter periods when the project coordinators from Finland were on-site and working closely with the team things were working well and good progress was made. In the absence of the coordinators however the progress slowed down. Communication through email, phone and social media was used to keep a constant progress forward towards set up goals, especially technological challenges including programming challenges which slowed down the progress from time to time. The main coordinator who initiated the game idea and started up the work also left his position in the project and during the transition period as the new coordinator took over the progress in the development of the game slowed down.

Three of the students in the group were in their final year which also meant that their course work at the University ended before the end of the project. This meant that they left the University in search of work elsewhere which led to the team being more scattered and that they had less time to work closely together for the game development. The programmers shifted to Nairobi which is 320 km from Eldoret in search of jobs and apart from time availability also costs of transportation became an issue. In order to increase the motivation of the students and to cater for cost implications, the students received a token of appreciation in form of money for the hours they spent on the game development. Paying the students for the time they committed was seen as controversial but did help in keeping the students committed, especially after some had completed university course work.

The students were personally challenged, especially the programming students as there was a lot of new things that they needed to learn both conceptually and technically as Android development was new to them. Often the content developers had ideas or were ahead waiting for implementation from the programmers who needed to struggle with technicalities, programming possibilities and figuring out how to modify the platform used for designing the game. To improve the final quality of the game and to increase the Android development knowledge of the Kenyan IT students, a computer science student from Finland specializing in Android development joined the team and spent almost three weeks in Kenya to work closely with the Kenyan programmers, with great success.

During the wrap up of the project the programmers were working intensively with the Finnish programming student in Nairobi while the content developers were working intensively with the project coordinator in Eldoret. At the end of each day a new version of the game was developed and shared between the team members in order to be able to polish it and suggest improvements that could be implemented the following day.

5. Technology Description

The foundations of the Entventure game are in the Android-based Caravan game developed for a slavery museum in Bagamoyo, Tanzania, by a group of students from University of Eastern Finland and Tumaini University [7]. The Caravan game was a fairly intricate game, consisting of series of quiz-like questions, supplemented with various mini games. As it was the first touch with Android for all project members, it resulted in many rookie mistakes in programming and design. By the time the Caravan project ended, the game was working fairly well but it was held together with needlessly complicated structure.

Like the Caravan game, Entventure is also based on Android. It is primarily targeted at Android tablets but Android-based smart phones are also supported. Due to limitations of physical screen size, not all features are available on smart phones. Specifically, the Word

Search mini game is available only for tablets. To avoid the pitfalls faced in the Caravan game development process, one of the Caravan programmers joined the Entventure development group so as to bring in much needed Android expertise. With the lead of the experienced programmer, the Caravan source code was significantly modified towards greater simplicity and maintainability. The following paragraphs describe the major problems of the Caravan game and how they were solved in the Entventure game.

One of the problems with the Caravan was that it kept the game story and other content in an internal database which could not be easily modified by the content developers. The other problems in the use of databases were that they were a lot harder to manage, needlessly complex from the programming point-of-view, and the structure was hard to visualize. Thus the developers opted for a simpler solution, which was to use XML. This solved all aforementioned problems, allowing the story to be separated into one easily readable plain text document, which the content developers themselves could modify. This small document could then just be dropped into the project folder, requiring no additional effort from the programmers.

The Second major problem was in the basic structure of the application itself. In the development of the Caravan, the Android activity lifecycle (which handles the different states of an application, such as starting, pausing, resuming and ending) was too complex to understand and it did not seem that important, because the application had worked fairly well for most of the time. However, the incorrect use of the life cycle functions had very far reaching repercussions, making the application act unexpectedly and ultimately crash after longer use. The problem was that the application did not save its state correctly when it was paused, making the game to restart and/or crash when resumed. Moreover, it did not properly manage its activity stack, which basically contains a list of all the game screens which are currently active. In practice, some of the game screens did not close when they were supposed to, but only got hidden. This, in turn, meant the application would at some point run out of memory and crash. Fixing these issues was a relatively big task, but it solved a lot of other seemingly unrelated problems, thus making the effort well worthwhile.

After fixing these major faults in the Caravan code base, programmers focused on optimizing, polishing and expanding the game. They created a new mini game and improved the playability of previous ones, implemented a high score system which would keep the top high scores stored locally on the device and redid the entire user interface.

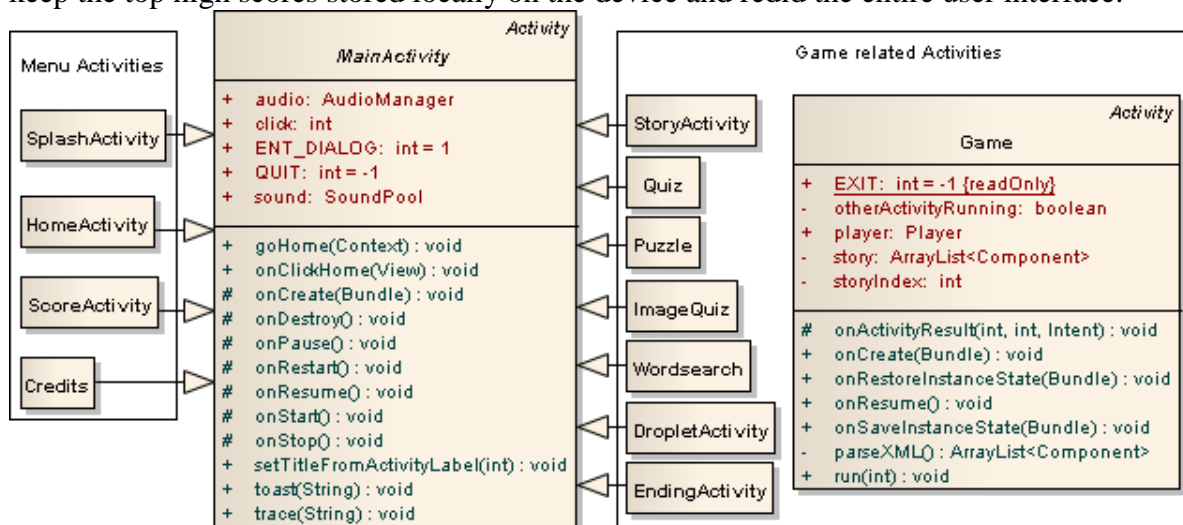


Figure 3: The Application Architecture

The activities in the final design can be divided into two categories: menu and game related activities (Figure 3). The first category contains all the activities which make up the menu system and the second all those activities which are part of the game. All the

activities with visible user interface extend the MainActivity-class, which provides the most common functions and variables, including sound support and some debugging methods. HomeActivity is the root of menu activities, containing the main menu itself. The Game-class is the root of game activities, with no visible user interface. When the game begins, the Game-class parses the story structure from the XML file into a list of activities. It then starts iterating through it launching one activity at a time, and always waiting for the previous one to end before continuing to the next one. When all the items in the list have been handled, it launches the ScoreActivity-class and finishes itself.

6. Results

During the first tests of the platform with pupils from the nearby Chepkoilel primary school, the pupils showed excitement and were generally positive towards the design of the game. They said they learnt something about forests and the game gave them more reason to conserve the forests. They also said it was fun to learn about forests through new technologies and they enjoyed the competitiveness aspects of the game. They were also excited to recognize the late Prof. Wangari Mathai in the picture puzzle game. The primary school teachers who took part in the testing were impressed it was a Kenyan application.

The pupils said that they learned;

- to differentiate different types of trees and the uses of these trees.
- how the nursery functions and technical terms like pricking out and hardening off.
- about different environmental services offered besides the tangible products from trees.
- the idea that forests can be a business
- how information technology can aid in learning.

The pupils also suggested that another mini game be added. They had an idea of a number game that would encompass part of their curriculum and would provide additional excitement. They also suggested including more information about forests in other regions of the world and that more information should have been added on emerging issues in the environmental field. They asked questions on one of the pictures in the game showing the hydrological and carbon cycles where they requested more information on them and the importance that forests played in these. A concern from the pupils during the testing was that the last mini game which required balancing a droplet was not well explained and hence not well understood which led to the students failing on that part in their first attempts. Since it was placed at the end of the game they had to go through the whole game to be able to try it again which they felt a bit demoralized about.

The content developers and programmers who designed the game said it increased their creativity which was especially elaborated through the brainstorming sessions on how to design the game, the general flow of the game and the graphical interface of the game. They indicated that the game developing experience supported interdisciplinary learning as the programmers learned more about forestry and the foresters learned more about programming and new technologies. They also indicated that the teamwork environment added value to their interpersonal skills, where they learned to work as a team, divide the labour and assign roles according to their different strengths. In addition they said they learnt to work under pressure by trying to meet the set deadlines.



Figure 4: Downloads During the First Two Weeks in Play Store

To make EntVenture accessible to everyone with an Android device, an Android developer account was created and the application was uploaded to the Android market 'Play Store'. The application can be downloaded free of charge apart from possible data charges. Without EntVenture being promoted or advertised, the download statistics (figure 4) indicate that there is considerable interest in the game in Kenya and that people have found the game and downloaded it from the Android market. Since the application was only uploaded a few weeks prior to the submission of this paper it is too early to conclude further on the penetration but it is promising.

7. Business and Community Benefits

Among the benefits of the development of this game is that it taught the students involved in the development process how to make educational Android applications. Being developed locally makes the game more contextually relevant and supports the sense of ownership for the University and the users as it is not yet another product from outside but developed within the context itself. With the experience of this development other applications can be made with the possibility to make applications that can generate an income, for instance applications targeted for tourists. An increased awareness of forestry will also help in conserving the environment and make people aware of the business opportunities that forestry can offer.

8. Conclusions

In collaboration between University of Eldoret and University of Eastern Finland the educational game EntVenture was successfully developed within the timeframe of the project. Participatory design principles were applied and the main development was made by students from University of Eldoret in Kenya. Despite the Kenyan students lack of previous knowledge of Android development a useful and fully functional application was developed with the main objective to increase knowledge and awareness amongst school going children on forestry in Kenya. The game development experience helped develop new skills amongst the student designers and served to further strengthen the collaborations between the three departments involved - School of Computing and School of Forest Sciences at University of Eastern Finland and the Department of Forestry and Wood Science at University of Eldoret.

Technical, logistical, cultural and motivational challenges had to be overcome to ensure successful completion of the game. Oayment of the students was crucial for the completion as it kept the student designers motivated but it also contributed to the logistical and cultural challenges as the payment of students was seen as controversial and there were no routines in place for paying students for this kind of projects. Preferably students should

rather be motivated and rewarded in form of academic credits but the curriculums allowed little space for that. As there were delays in the game design it was also an important intervention to bring in an experienced student on Android development from Finland at the end to work intensively with the Kenyan students to wrap up the game development.

The response from preliminary tests of EntVenture at Chepkoilel primary school was very positive. Judging from the students' engagement and excitement, they preferred the learning experience compared to how teaching is traditionally delivered at the school. They also indicated they learnt a lot about forestry from playing the game. The way the game is designed is relatively straightforward. To modify it for other topics where most changes can be made in a single XLM file is therefore possible. There are plans on developing a Finnish version of the game as well as a commercial tree identification version targeting tourists visiting Kenya. While children are more receptive to new ideas and can act as educational agents growing up as environmental conscious citizens [18], little is known on how other groups such as adults would adopt these types of games. More research is also needed on the impact of the intervention and how it can be improved to support increased awareness and knowledge on forestry among school going children in Kenya.

Acknowledgement

The development of EntVenture was funded by Ministry of Foreign Affairs of Finland and the Regional Council of North Karelia. We would also like to acknowledge the contributions from the student developers that are not co-authors of this paper, that is: Kevin Kiptoo, Tabby Mungai, Moses Wakanyi and Sammy Mwiroti. We also thank the teacher and the students of Chepkoilel Primary for their valuable input. This work was partially supported by the new faculty research fund of Ajou University.

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