Fostering Agriculture Environmental Awareness

Rui Prada, Daniel Dias
INESC-ID and IST-UTL
Av. Prof. Cavaco Silva - Taguspark
2744-016 Porto Salvo, Portugal
Email: {rui.prada,daniel.dias}@gaips.inesc-id.pt

Helmut Prendinger, Arturo Nakasone
National Institute of Informatics
2-1-2 Hitotsubashi, Chiyoda-ku
Tokyo 101-8430, Japan
Email: {helmut,arturonakasone}@nii.ac.jp

***Abstract*—Agriculture is important to any society, but its activity often has negative impact in the environment. We propose a game, implemented in the on-line virtual world platform OpenSimulator, that gives the opportunity to players to experience the potential effects of agriculture in the environment. The game was built with the purpose of promoting the awareness of agriculture issues, such as, the impact of fertilization in sources of fresh water, the problems related to deforestation and impact on the weather, and the importance of producing food with good quality. To make players care about these issues we explored the people's factor and created direct impact on a population of villagers that the player must satisfy in order to succeed in the game. A small pilot study was performed that showed signs of good acceptance by the players.**

I. Introduction

Agriculture has always been an important activity for mankind and is often regarded as the basis for human civilization to develop. In modern societies it has recently gained particular relevance for two main reasons. First, people care more about the food they eat and, second, due to the hype of the global warming and the Kyoto protocol. Agriculture is associated with deforestation, which have direct impact on the levels of concentration of $C0_2$ in the atmosphere [1]. Nevertheless, the impact of agriculture in the environment has been recognized and studied for years [2] [3] [4] and is part of any program of sustainable development.

Furthermore, agriculture has gained some attention, although in a minor scale, as an hobby for some people that live their lives in big metropolis, such as, Tokyo. In fact, agriculture has often been explored as a theme for entertainment. It has been the topic of many computer games and is even the theme of the most popular board game of the moment in the board gamers' community[1].

However, despite its relevance in society, agriculture has seldom been explored in serious games. In the few examples found the issues of the environmental impact of agriculture are not the main focus. In this paper we present a game designed with the purpose to sensibilize players to these issues. In addition, due to the popularity of agriculture in games we believe that the theme can also be used as a means to raise awareness to environmental problems in general.

Furthermore, the rapid growth of the web has promote gaming in wider audiences that were not previously targeted. For example, one of the most popular games at the moment runs on *Facebook*[2]. *Farmville*[3] was launched last June by Zynga Inc.[4] and has now nearly 60 million active players. In fact, millions of people spend their time on-line using social networks, such as, *Facebook*, to seek social contact and new ways of expression and entertainment. Social networking websites are becoming the prime collaboration and advice-giving work spaces [5] and are being explored as media to support new learning styles [6].

However, the communication in current social networking sites still lacks the immediate nature of face-to-face communication or presence. This is handled in 3D virtual world communities, such as the ones supported by *Activewords*[5], *Second Life*[6] or the *OpenSimulator*[7]. In fact, since the new generation of personal computers can bring good performance for 3D interfaces to common users at a reasonable price, 3D networked virtual worlds have been suggested as affordable collaborative platforms with great potential [7].

We targeted our game for an on-line virtual world platform to explore the potential of integrating gaming with other aspects of the virtual community making the game accessible to a wider population, as it has been explored successfully in *Facebook*.

The rest of the paper is organized as follows. In the next section we will review some games about agriculture. Then we will discuss the environmental issues of agriculture and describe the ones we have decided to include in our game. In section IV we present the design of the game, *AgriVillage*, and discuss our choices to make players care about the ideas the game should teach. Later, we describe the architecture used to implement the game and present a small study performed to assess the reaction of players to the game. We end with some conclusions and future work.

II. Agriculture Games

Agriculture is the theme for several games. First of all, several simple games for casual play have mechanics related to agriculture. For example, in games, such as, *FarmMania*[8],

[1] http://www.boardgamegeek.com/browse/boardgame

[2] http://www.facebook.com
[3] http://www.farmville.com
[4] http://www.zynga.com
[5] http://www.activeworlds.com/
[6] http://secondlife.com/
[7] http://opensimulator.org/
[8] http://www.realore.com/games/farmmania/

VitualFarm [9] or *The Farmer Game* [10] the main actions of the players are to sow, to fertilize and to water fields in order to grow vegetables. Furthermore, one of Facebook[11]'s most successful games, played by millions of people, is Zynga's Farmville[12] which is based in similar mechanics.

On the other hand, there are more complex games that simulate, more precisely, many aspects of the activities around agriculture. Two classic examples are *SimFarm*[13] and *John Deere American Farmer*[14]. These games take into account weather, seasons, natural disasters and pests and have many different types of crops and include livestock. In addition, players have to manager a team or workers and buy equipment for the farm.

Some other games, such as *SimAgri*[15] run on-line persistent worlds that involve hundreds of players. *SimAgri* has similar game mechanics as the simulation games.

Despite the fact that agriculture is a topic for several games most of these games were not developed with serious purposes. Nevertheless, there are some exceptions. For example, *NASA's BioBlast*[16] that has been used in high schools to help students understand the processes that involve the growth of plants. The goal of the player is to produce food (biomass) and oxygen to sustain a crew of six in the space for three years. Players have control of a greenhouse where they grow different vegetables. They can change the temperature, CO_2 levels, light exposure and check how this affects the plants.

Another example, is *Bet the Farm*[17] where the players start by defining polices for running a farm and then see the results of their choices in the course of a year. The choices provided are quite detailed (e.g. the player can choose to use precision farming, to give antibiotics to animals or use genetic engineered seeds) and the player gets some advice/warning after making each decision. The goal is to have the most money in the end of the year. The game promotes replayability to allow the player to explore difference approaches.

One more example is the *3rd World Farmer*[18] where players manage a small virtual farm in a developing country and, thus, experience the hardships and dilemmas faced by the poor. Apart from the agriculture this game focus on political, social and health issues. For example, the player is motivated to invest in the local development of the village and send children to school.

Although not totally related to agriculture, Design-A-Plant [8] is worth mentioning because it explores the use of animated pedagogical agents for foster knowledge-based learning in game-like scenarios. In Design-A-Plant, students learn about botanical anatomy and physiology by graphically assembling customized plants that can thrive in specified environmental conditions. The goal of the players is to find the characteristics that compose the plant that grow stronger in each different environment.

None of the above (with a few exceptions in some of the warnings in *Bet the Farm*) consider the environmental impact of agriculture. However, this impact should be not disregarded because it can be significant as we will discuss in the next section. On the other hand, there are many games related to environmental issues (some can be found here[19]), but they never focus on agriculture.

For this reason, we see a perfect opportunity to develop a game that explores environmental concerns regarding agriculture. Furthermore, we believe that due to the popularity of agriculture games, the theme of agriculture may constitute a good medium to introduce the environmental issues in general.

Finally, we would like to state that the issues regarding environmental impact of agriculture have been explored in simulation tools [9] [10], however, these simulations are meant for experts and are not explored in gaming scenarios.

III. Issues in Agriculture

Agriculture can have strong impact on the environment. For example, the fertilizers used to foster plants grow can have a negative impact in the soil [2] in particular due to high concentration as phosphorus and nitrates and the same chemicals that damage the soil often get infiltrated in water streams polluting important sources of fresh water [3].

Furthermore, associated with agriculture is usually deforestation. Many trees are chopped down to make space for agriculture fields. The problem is that such forests constitute the habitat for many species, thus, the loss of forested areas have great impact on wild life and biodiversity which is often referred as one of the main richness of our planet [11] [4]. At the same time forests have an important role in climate change. The presence of forests reduce the concentration of CO_2 in the atmosphere [12] and increase the levels of precipitation and rainfall [1]. These are two of the factors that can contribute to slow down the global warming.

Nevertheless, even with such problems agriculture is important because it constitutes one of our main sources of food. The quality of the food produced by agriculture is, in fact, one of the major concerns with modern agriculture [13]. People care about the food they eat, since there is a direct impact on what they eat and their health and wellbeing.

Agriculture have a strong impact on people's life. The game presented here was built to sensibilize people about this impact. Having in mind the issues we described above we have defined a set of ideas that our game should teach:

1) The game should show that the fertilizers used in the soil may pollute the water streams.
2) The game should show that cutting too many trees is not good for the environment.

[9] http://www.alawar.com/game/virtual-farm/
[10] http://www.lsuagcenter.com/en/4H/Kids/agriculture/games/TheFarmerGame.htm
[11] http://www.facebook.com/
[12] http://www.farmville.com
[13] http://en.wikipedia.org/wiki/SimFarm
[14] http://www.universalfarmer.com/
[15] http://www.simagri.com/
[16] http://www.cet.edu/?cat=online_learning&page=54
[17] http://www.cosi.org/visitors/on-line-activities/farm/
[18] http://www.3rdworldfarmer.com/
[19] http://www.gamesforchange.org/channels/environment

3) The game should show that the quality of the food produced is important.

IV. Designing the Game: AgriVillage

The AgriVillage game was designed having in mind the 3 ideas defined in the previous section and the fact that it should be played in an on-line virtual world platform (e.g. *OpenSimulator*). The development of the concept of the game was iterated through several steps the first ones using paper prototypes as shown in figure 1. The next sections summarize the resultant ideas.

Fig. 1. AgriVillage paper prototype.

A. Game World

The game world consists of an island with a small village and a river (see figure 2). Next to the village are small forests (one per player) that can be used for farming.

Fig. 2. The game world. In this image you can see the village on the right and one forest on the left.

The main playing area is the forest, but the player finds relevant information in the rest of the world (e.g. the player can see the pollution levels reflected on the river). The forest is a cluster of fields, organized in a grid, that represent areas that can be worked by the player. Each field has a tree in the beginning of the game. The tree can be chopped from the field and the field can be, later, fertilized and planted using seeds. In addition, each farm has a water pump that drains water from the river to the entire farm (e.g. waters all fields at the same time).

The village is populated with some autonomous characters that are the recipients of the food produced in the farm and may help the player with some hints on the game.

The environment is characterized by four variables, two regrading the weather (temperature and rain fall) and two regarding pollution (level of nitrates in the river and concentration of CO_2 in the atmosphere).

The game takes place in the course of a full year starting from January to December. It is played in 12 turns (one per month). Each turn takes one day of real time[20]. The game was designed to be a persistent world that do not require the player's presence all the time.

B. Player Challenges

The main challenge of the player is to grow vegetables to sell in the village's local market and make some profit. To do this s/he must work the fields and plant seeds that will grow into vegetables (see figure 3). The quality of a vegetable depends on the conditions of the environment and the farm during its grow and affect its value in the market. Therefore, the challenge is to match the conditions required by the vegetables that are growing in the fields. The conditions are defined in terms of range of water, temperature and fertilizer needed. The values should not be above or below the requirements for each type of vegetable.

The player must consider, each month, what to sow given the current weather (and the forecast for the next month), how much fertilizer to add in each field and how much water to apply in the farm (waters all the fields at the same time). All these have costs, so to produce good food is essential to keep a good budget. The decision regarding the fertilizer takes into account the amount of pollution that will go to the river. The player has to choose from a set of fertilizers. Some pollute more than others.

At the same time the player must decide if s/he cuts down another tree. Doing this opens one more space to grow vegetables, but it will have impact on the CO_2 levels in the atmosphere. In addition, trees give some money to the player due to carbon credits they generate.

C. Making Players Care

Given the focus on serious gaming we have created game elements specifically for making the player care for the issues discussed in section III. The most important is the fact that, in addition, to the goal of producing (good) food the player also have to keep the levels of pollution low. To emphasize this we defined one variable in the game, the population happiness.

[20]This is the initial idea, but we have not yet performed tests to assess what should be the best interval in real-world time between turns.

Fig. 3. A farm with some worked fields.

Fig. 4. Villager Ti Maria complains about the river, but is happy concerning the quality of the air.

This variable reflects how happy the population is with the state of the environment.

Population happiness decreases as the villagers see that the river is polluted or feel that the concentration of CO_2 is too high. It also decreases if the vegetables villagers get from the players are of bad quality. Vegetables are always sold independent of their quality, thus, players cannot throw them away to avoid this penalty. The villagers will also get unhappy if the farm is not producing any food (e.g. if the fields are empty). This last penalty was introduced to motivate players to always grow some vegetables and come often to check the state of their farm. So not to produce food at all is not an option.

If the villagers gets too unhappy they riot and expel the player from the farm and s/he looses the game. The challenge of the player is, therefore, to produce food to gain the most profit and keep the population as happy as possible. The final score of the game reflects the two things. Players get points for the money they have and for the level of happiness of the population.

The dimension of the population happiness was added to take advantage of the people factor [14] that fosters enjoyment in gaming experiences. Playing with other people or game characters in a social setting is one of the factors that elicits fun [14]. The villagers convey a sense of social dimension in the game that can make players care more about the impact of their choices. This sense is better if the characters are believable and able to achieve the suspension of disbelief [15]. Furthermore, the use of game characters may increase the motivation of players and improve their learning experience [8].

To improve the believability of the villagers, the player is able to speak with them and they will pro-actively complain, when they are unhappy, referring to the source of their unhappiness (e.g. shouting that they are unhappy because the river is polluted) - see figure 4. If they are happy for some reason they also make positive comments.

Apart from giving life to the villagers and making their happiness part of the *gameplay* we made some other specific design choices to stress the ideas we want to teach with the game.

Concerning the impact of the deforestation, we made the decision to define the action to chop down trees irreversible (although in some of the tests with the paper prototypes players would like to plant trees back). As the effect is irreversible players need to consider more carefully if they cut a tree or not. In addition, the villagers make some comments regarding the biodiversity and the use of forests to spend quality time (e.g. rest in the shade of a tree). They will get unhappy if the percentage of trees drops below certain levels.

Concerning the choice of fertilizers we explicitly designed the ones that pollute less more expensive, so that the motivation to choose them is not monetary.

D. Gaming Scenarios

To support the adaptation to different kinds of player's needs, the game offers some flexibility in the configuration of the scenarios that can be played. A scenario defines the flow of the environmental variables throughout the course of the game. It defines the initial values of temperature, rain fail, CO_2 in the atmosphere and nitrate levels in the river and the updates applied each turn on these values (e.g. monthly update). In addition, to enrich the context, the scenario is characterized by a place and each month update is associated with a season. These are tags that are shown to the users to help them understand better the scenario. For example, this enables the person that configures the game to express the differences in seasons from the north and south of the globe (e.g. July is summer in Europe but winter in South America). Table I shows a possible scenario.

The scenario defines the typical weather fluctuations for the locale and the pollution that is generated (by the population) in that locale. This creates the possibility to present several different situations to the players. For example, they can play in environments that they recognize and identify with (e.g.

	Initial (Jan)	Feb	Mar	Apr	...	Dec
Temp.	5°C	+3	+5	+6	...	-5
Rain	50 mm	+20	+10	-20	...	+10
CO_2	400 ppm	+200	+200	+200	...	+200
River	20 N mg/L	+0	+0	+0	...	+0

TABLE I
A POSSIBLE SCENARIO. THE TABLE SHOWS, FOR EXAMPLE, THAT THE TEMPERATURE STARTS AT 5°C IN JANUARY AND RAISES TO 8°C IN FEBRUARY AND THAT THE CO_2 LEVELS START AT 400 PPM (PARTS PER MILLION) IN JANUARY AND THAT MORE 200 PPM ARE GENERATED EVERY MONTH.

similar to place they live or where they spent their childhood) or experience completely new environments that correspond to distinct places in the globe (e.g. grow a farm in the desert). The challenges presented may also vary in difficulty. The player may face extreme weather conditions or face some situations where the control of the pollution must be tighter.

In addition, the villagers may have different sensibilities for each of the issues that influence their happiness. For example, they may worry more about the water and not so much about the air or give no importance to the quality of the food.

Furthermore, some other minor definitions, such as the cost of water and the money the player has in the beginning of the game, may influence the challenge and situation the players face.

All these definitions open the possibility to adapt the game to different audiences and/or to give emphasis to different issues.

E. Multiplayer

To further explore the people factor [14] and to foster discussion about the agriculture environmental issues, the game can be played by several different players at the same time. Each control a different farm and is competing with the others for profit. However, since they all share the same environment, they all suffer from the negative effects in the environment even if they are not responsible for those. For example, if one of the players is polluting the river the population will get unhappy and eventually riot and expel all the players. This fact induces the users to collaborate to improve the environment, otherwise, they all loose the game. This characteristic of the game may improve learning due to the discussion and argumentation it elicits [16].

V. ARCHITECTURE

The game was built to run on a *OpenSimulator* server. *OpenSimulator* is a 3D Application Server that can be used to create persistent 3D worlds. These worlds can be accessed through a variety of clients, including the *Linden Lab's Second Life* viewer.

To support the integration of the game with *OpenSimulator* we use the *OpenLibrary*[21] developed at National Institute of Informatics. It consists of a middleware that offers the capabilities to create and manipulate *OpenSimulator* entities through a socket connection.

The overall architecture of the system is shown in figure 5.

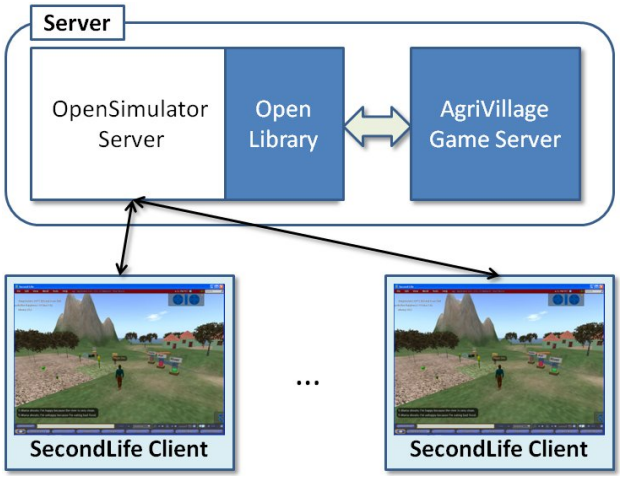

Fig. 5. System's overall architecture.

The *OpenLibrary* runs as part of *OpenSimulator* and the *AgriVillage* game server runs independently. The game server uses the connection with the *OpenLibrary* to create the game entities in the 3D world and to control their state, as well as, to receive information regarding the players' actions in the world. Players connect to the game using the standard *Second Life* viewer.

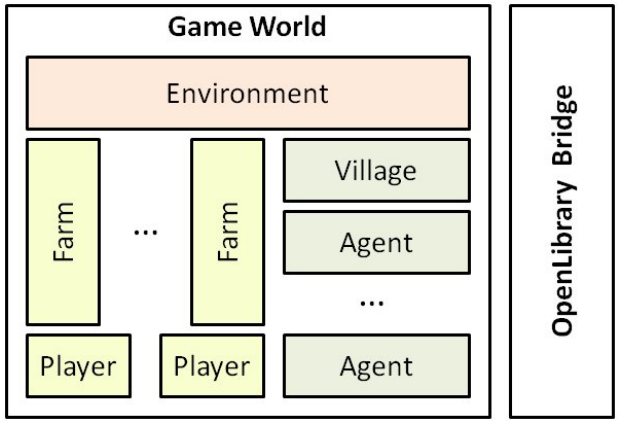

Fig. 6. The core game world components in the game server.

The game server runs a model of the game world and is responsible for all the logic of the game. The state and dynamics of the model have a corresponding representation in the 3D world. The synchronization of this representation is performed by a component (the *OpenLibrary* Bridge) that translates the game simulation into *OpenLibrary* requests. For example, when the state of the game simulation expresses that it is raining in the world the *OpenLibrary* Bridge requests the execution of a particle system that shows drops of rain in the 3D world.

[21] http://www.globallabproject.net/OpenLibrary

The main components of the model are (see figure 6):

- **Environment** - Stores the values that define the weather (rain and temperature) and the levels of pollution (concentration of CO_2 in the atmosphere and nitrates in the river). Updates the weather according to the definition in the scenario.
- **Farm** - Keeps track of the state of the fields (e.g. if they contain a tree, are fertilized or planted) and the state of the water pump. If a field is planted, the quality of the vegetable is tracked.
- **Player** - Stores the information regarding players. Keeps track of their money and their score. A player is associated with a farm.
- **Village** - Defines the impact of the village in the levels of pollution defined in the environment. Updates the values of the concentration of CO_2 and river nitrates according to the definition of the scenario.
- **Agent** - Each villager is defined as an autonomous agent that senses the environment and act according. The actions depend on the level of happiness of the agent.

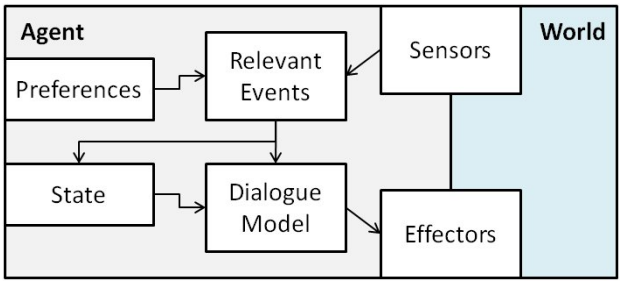

Fig. 7. Agents' architecture.

The agents' architecture is shown in figure 7. The main components are:

- **Sensors** - these constitute the means of the agent to gather information from the world. Agents have sensors to perceive if a player approaches or leaves its vicinity, to listen to players statements in the chat and to recognize events in the game (e.g. a vegetable is sold, or changes in the levels of pollution).
- **Effectors** - these constitute the means of the agent to act in the world. Agents have effectors to walk around and to speak.
- **Relevant Events** - this component analyzes the information gathered from the sensors and checks if an event that is relevant for the agent occurred. This depends on the preferences of the agent. A relevant event is, for example, the perception of high concentration of nitrates in the river. Such events may change the state of the agent and trigger a reaction that is handled by the dialogue model.
- **Preferences** - these define the sensibility of the agent to the issues regarding the environment and the agriculture activities of the players. The preferences define what are the accepted levels of CO_2 and nitrates in the river, the accepted percentage of forests and the accepted quality of the food.
- **State** - this defines the level of happiness of the agent. The identification of relevant events may induce changes in the happiness of the agent. These changes depend of the agent's preferences and may increase the happiness or decrease it. If the happiness reaches zero the agent riots and the players loose.
- **Dialogue Model** - keeps a simple model of the dialogue the agent is having with a player. Stores patterns of conversations (e.g. to give hints/instructions to the player in a tutorial format) and conversation steps to avoid repetition in the dialogue. The occurrence of events that change the agent's happiness in a given turn may make the agent to react. The reaction is in the form of a comment that refers to the event that provoked the change (e.g. state a reason why the agent is unhappy).

VI. Evaluation

We have prepared a study to check players' reactions to the *AgiVillage* game. The following sections present the design and results of this study. Note that the study is very preliminary as we did not include much diversity in the subjects.

A. Participants

The study was conducted with 5 subjects, most of them students from the Technical University of Lisbon (IST-UTL), with ages between 21 to 35 years old, two of the subjects were female and 3 male. Most subjects did not have prior experience with *Second Life* or similar communities even though they have some experience with virtual environments in general. When asked about their expertise in agriculture, they stated to have some knowledge[22] (e.g. common sense).

B. Procedure

Participants were asked to play a full year in the game (e.g. 12 turns). For practical reasons the time interval between turns was set to 90 seconds. Therefore, each game session took about 18 minutes. Before starting the game players could explore the world at will. To start the game players need to talk to one of the villagers that would instruct them on how to play the game. The village was inhabited by 3 villagers. Two of them were used to help players understand the game concepts. They are able to describe the main mechanics of the game through dialogue with players. The third villager was used to comment on the environment state. She makes comments such as: *"I'm happy because I'm eating good food."*, *"I'm very happy because of the good quality of the air."* or *"I'm unhappy because the river smell bad."*.

The participants received very few instructions regarding the game. Only a few hints on how to interact with the world using the *Second Life* viewer were given. The main idea is

[22]This was assessed by asking subjects to rate their expertise in agriculture in a 7 point Likert scale (1 representing "no knowledge at all" and 7 representing "expert knowledge"). The mean value for this was 2.8 (σ = 1.3)

that players should learn the game only with the in-game instructions given by the villagers.

After the game session subjects were asked to fill a small questionnaire.

C. Measures

To assess the quality of the game and the player's experience. We designed a questionnaire based on the Game Flow criteria for player enjoyment in games [17]. We included questions regarding the players' concentration, the level of challenge, game understanding, clarity of the goals, player's sense of control and feeling of immersion. The questionnaire is shown in table II. Each question was rated in a 7 point Likert scale as described in the table II.

Question
1. To what extent did you have a sense that the game kept you concentrated when you are playing? (1-Never ... 7-All the time)
2. How challenging was the game for you? (1-No Challenge ... 7-Too Difficult)
3. How difficult was to understand the game without any previous instructions? (1-Very Easy ... 7-Very Difficult)
4. Did you felt that you were in control of what was happening in the game? (1-Never ... 7-All the time)
5. The goal of the game was clear? (1-Never ... 7-All the time)
6. When you were playing did you felt involved by the game and less aware of what was surrounding you and less worried about everyday life or self? (1-Never ... 7-All the time)

TABLE II
QUESTIONNAIRE TO ASSESS THE FLOW EXPERIENCE.

Furthermore, we included 2 questions in the questionnaire in order to check if the game has impact on the player's perception of their knowledge about agriculture and its environmental issues. These questions are shown in table III.

Question
7. This game improved your knowledge about agriculture? (1-Not at all ... 7-Very Much)
8. This game made you more aware of the impact of agriculture in the environment? (1-Not at all ... 7-Very Much)

TABLE III
QUESTIONNAIRE TO ASSESS THE IMPROVEMENT IN THE AWARENESS AGRICULTURE ISSUES.

D. Results

The results of the questionnaire are summarized in table IV. Since we have few respondents we present the individual responses as well as the average and the standard deviation for each question.

From the table we can see that the game is not difficult to understand (Q3 = 4.8) (even though some players complained a bit in the beginning, because we did not give them many instructions), its goals are very clear (Q5 = 5.8) and it is able to maintain the players concentration (Q1 = 4.4). However, the level of challenge (Q2 = 2.4) does not seem to be enough. This may be due to the fact players always finished the game and have some positive score. In the tested scenario the villagers would rarely riot. One possibility to solve this is to give specific reference values for the score the players should achieve (e.g. it is not enough to reach the end of the year with positive money they need to have more than X money). This can also be solved by tweaking the revenue of the sales and the preferences of the villagers turning them more exigent.

Subject	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
A	3	2	5	4	5	4	1	4
B	5	3	4	3	6	3	2	4
C	4	4	6	4	7	5	1	6
D	6	2	5	4	6	3	1	5
E	4	1	4	4	5	4	2	4
Average	4.4	2.4	4.8	3.8	5.8	3.8	1.4	4.6
StdDev	1.14	1.14	0.84	0.45	0.84	0.84	0.55	0.89

TABLE IV
RESULTS OF THE QUESTIONNAIRE. Q1 - CONCENTRATION. Q2 - LEVEL OF CHALLENGE. Q3 - GAME UNDERSTANDING. Q4 - SENSE OF CONTROL. Q5 - CLARITY OF THE GOALS. Q6 - FEELING OF IMMERSION. Q7 - KNOWLEDGE OF AGRICULTURE. Q8 - IMPACT OF AGRICULTURE.

The sense of control (Q4 = 3.8) and the sense of immersion (Q6 = 3.8) were ranked close to neutral. Some sense of lack of control may be due to the nature of the game, because the player needs to wait until the vegetables grow and does not have much to do meanwhile. The sense of immersion can be broken for the same reason. We need to consider adding actions to the player while s/he waits for the vegetables to grow. We can improve the interactivity with the villagers to achieve this.

Regarding the impact on the players' knowledge and awareness it seems that the game does not teach much about agriculture (Q7 = 1.4), but most of the players stated that they have learned something regarding the impact of agriculture in the environment (Q8 = 4.6). These results might be due to the fact that people often know a bit about agriculture but not much about the impact it can have in the environment (this question should be assessed in a pre-test questionnaire in future studies). Nevertheless, this is a good sign that the game may have success as a medium to sensibilize people for the environmental impact of agriculture. However, the few number of participants involved in the study and the subjective nature of the questionnaire prevent us from taking strong conclusions.

Furthermore, we would like to refer that during the test we observed some player's remarks regarding the villagers' comments that suggest that those have impact on the players' decisions. It seems that the fact that villagers complain make the players worry more about their actions. A typical comment was: "She is complaining... Now she is mad at me!". These observations should be explored in future studies.

VII. CONCLUSIONS

Agriculture is one of the activities that can have great impact in the environment. In particular, in the sources of fresh water and climate changes. However, usually, serious games about agriculture do not focus on these issues. We believe that since agriculture has regain some relevance in modern

societies it is a good timing to sensibilize people about the impact of agriculture. To achieve this we developed a game that places the user in a virtual environment where s/he has the responsibility of running a farm that produces food for a small village. The game mechanics were designed in a way to make the player think carefully about the impact of their actions as farmers. In particular, we have enhanced the role of the villagers in the game and turn them into active elements that reinforce the good behaviours by encouraging players if the environment is in good conditions and penalize their bad decisions by complaining about actions that damage the enviroment. We explored the fact the "people" make these comments and not a faceless system to make use of the people factor to foster the impact of the game. The game was tested in a pilot study but due to the small numbers of participants we cannot take strong conclusions regarding the impact of the game. Nevertheless, the reactions of players are positive. In addition, we observed that the fact that villagers complain make the players worry more about their actions.

We will perform more studies with the game in the future. In particular, we plan to let the game server running for a few months and disseminate the game and check the reactions of random players that enter the game. For this, we will try to connect our server to a wide *OpenSimulator* community such as *OSGrid*[23].

We believe that other issues can be explored with the *AgriVillage* game, with a few simple extensions. One is the exhaustion of the soil. The game can promote crop rotation in the fields and periods of rest. Another issue is the usage of water. The game score can reflect how much water players used in their farms and can penalize players that wasted more water. Furthermore, we will involve experts from ecology and agriculture to help us integrate, revise and validate the concepts that the game teaches.

As we found some evidence that even with the limited "life-likeness" of our agents the players seem to care about them we will explore ways to improve the "human-like" abilities of the villagers to achieve higher levels of suspension of disbelief. In particular, we will try to promote empathy between villagers and the players. We believe that this should be achieved by enabling more (and deeper) interactions between the players and the villagers. This can be a challenge if we aim at having long turn intervals and without requiring the presence of players all the time.

Furthermore, we will explore better the multiplayer modes of the game, because we believe that multiplayer situations will lead to more reflection about the impact of the actions. In addition, the competition and collaboration among players can be a source of motivation for playing the game.

REFERENCES

[1] J. Shukla, C. Nobre, and P. Sellers, "Amazon deforestation and climate change," *Science*, vol. 247, no. 4948, pp. 1322–1325, 1990.

[2] A. N. Sharpley and R. G. Menzel, "The impact of soil and fertilizer phosphorus on the environment," *Advances in Agronomy*, vol. 41, pp. 297–324, 1987.

[3] J. F. Power and J. S. Schepers, "Nitrate contamination of groundwater in north america," *Agriculture, Ecosystems and Environment*, vol. 26, no. 3-4, pp. 165–187, 1989.

[4] B. W. Brook, N. S. Sodhi, and P. K. L. Ng, "Catastrophic extinctions follow deforestation in singapore," *Nature*, vol. 424, pp. 420–423, 2003.

[5] A. C. Weaver and B. B. Morrison, "Social networking," *Computer*, vol. 41, no. 2, pp. 97–100, 2008.

[6] D. E. Baird and M. Fisher, "Neomillennial user experience design strategies: Utilizing social networking media to support "always on" learning styles," *Journal of Educational Technology Systems*, vol. 34, no. 1, pp. 5–32, 2005.

[7] W. S. Bainbridge, "The scientific research potential of virtual worlds," *Science*, vol. 317, no. 4948, pp. 472–476, 2007.

[8] J. C. Lester, S. A. Converse, S. E. Kahler, S. T. Barlow, B. A. Stone, and R. S. Bhogal, "The persona effect: affective impact of animated pedagogical agents," in *CHI '97: Proceedings of the SIGCHI conference on Human factors in computing systems*. New York, NY, USA: ACM, 1997, pp. 359–366.

[9] C. O. Stöckle, M. Donatellib, and R. Nelsona, "Cropsyst, a cropping systems simulation model," *European Journal of Agronomy*, vol. 18, no. 3-4, pp. 289–307, 2003.

[10] J. B. D. Edwards-Jones and M. J. McGregor, "Simulation of ecological, social and economic factors in agricultural systems," *Agricultural Systems*, vol. 49, no. 4, pp. 337–351, 1995.

[11] E. O. Wilson, "Threats to biodiversity," *Scientific American*, vol. 261, no. 3, pp. 108–116, 1989.

[12] R. A. Houghton, "Tropical deforestation and atmospheric carbon dioxide," *Journal Climatic Change*, vol. 19, no. 1-2, pp. 99–118, 1991.

[13] H. N. J. Schifferstein and P. A. M. O. Ophuis, "Health-related determinants of organic food consumption in the netherlands," *Food Quality and Preference*, vol. 9, no. 3, pp. 119–133, 1998.

[14] XEODesign, "Diner dash and the people factor," Oakland, CA, USA, 2005. [Online]. Available: http://www.xeodesign.com/xeodesign_dinerdashcasestdy500n031405.pdf

[15] J. Bates, "The role of emotions in believable characters," *Communications of the ACM*, vol. 37, no. 7, pp. 122–125, 1994.

[16] A. L. Veerman, "Computer-supported collaborative learning through argumentation," Ph.D. dissertation, Department of Educational Sciences, Utrecht University, The Netherlands, 2000.

[17] P. Sweetser and P. Wyeth, "Gameflow: a model for evaluating player enjoyment in games," *Computers in Entertainment*, vol. 3, no. 3, 2005.

[23] http://www.osgrid.org