3D environments as Social Learning Tools. The VIRTU@LIS experience

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Abstract
New forms of dialogue and new mechanisms for introducing scientific issues to non-scientific audiences call for radical design of interfaces between the scientific processes and products and the audiences. In VIRTU@LIS we have explored further the use of "convivial interfaces" through the concept of games. These tools stimulate self-reflection, discussion and possibly negotiation to enhance the relations with the rest of the community, trying to promote awareness and responsibility among citizens and grounds for personal decisional power and social learning. V GAS and FISHU@LIS are presented as examples of such tools. They may be used individually or in a context of debate about empowerment and lifestyles strategies, and in educational contexts, as an instrument to raise issues and deploy discussions. The first one relates lifestyles with Climate Change, while the second relates personal consumptions with sustainable fisheries.

Keywords: Convivial Social Learning tools, climate change, fisheries, ICT, game, 3D

1. Introduction
New forms of dialogue and new mechanisms for introducing scientific issues to non-scientific audiences call for radical design of interfaces between the scientific processes and products and the audiences, which should be quality-assured, transparent, socially robust, tangible and reliable.
The information society has much untapped potential to improve quality of life. This potential is growing due to technological developments that are opening up significant social opportunities [CEC 2002] providing citizens with more tangible access to information and communication tools. Information technologies for the Information Society enable new mechanisms[Ъ] for the participation of the civil society in debates that were difficult to engage with in the past [Guimarães Pereira 2001a]. Information and Communication Technology (ICT) tools hold a great potential to help individuals to construct knowledge through their own learning processes [1].
In VIRTU@LIS[Ж] we have explored further the use of "convivial interfaces" deploying ICT to pursue the building of a convivial society [Guimarães Pereira and O'Connor 1999]. By accessing information, in a tangible way, the several actors are better informed about the issue of concern, enabling them to explore policy options through "what-if" explorer scenarios. This empowerment is often a key element in social reform [Nauen 1999]. Individuals become agents of change, participating in a democratic transformation of society [Diduck 1999], in this case in order to achieve a sustainable future. To advance in the direction of sustainability it is expected that science support and become involved in processes of Social Learning [Siebenhüner 2004]. There are several concepts of Social Learning [Liberatore 1999]. Woodhill and Roling [2000] described Social learning as an "*approach and a philosophy which focuses on participatory processes of social change. It encompasses a positive belief in the potential for social transformation based on:*

- *Critical self reflection*
- *The development of participatory multi layered democratic processes*
- *The reflexive capabilities of human individuals and societies and*
- *The capacity for social movements to change political and economic frameworks for the better."*

With the type of tools developed we have explored specifically a new concept for information tools aimed at mediating the relevant knowledge in processes of social learning and debate strongly based on games, fiction and metaphors. We have called those, CSLoTs – **C**onvivial **S**ocial **L**earning **T**ools. [Guimarães Pereira & de Sousa Pedrosa 2004].
These types of tools are about social learning but they can help with the purposes of educators. Thus the aim is to allow personal visualisation of the issues and potential impacts of chosen pathways. The tools' design and implementation are as important as the kinds of processes emerged from their implementation, especially the idea of creating "virtual worlds", metaphors of our lifestyles, tangible and intangible enough so that self-reflection, learning and thoughts are not bounded by the interfaces themselves. This was specifically aided by the type of technology chosen, 3D virtual reality and learning context based on single and multi-player computer games. CSLoTs are designed to be used in participatory processes and so, agents' requirements and properties will not be inbuilt but taken from the use of the tool in those processes.
The concept of games helped with functionalities' designing; it should ease discovering of information, making relations, challenge, questioning and eventually help with individual and social learning. This interactivity is seen as means of sharing experiences and questions, maintaining the ludic, literary and media aspects of the game.

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[Ж] VIRTU@LIS project (contract no. IST-2000-28121) funded by DG INFSO, during FP 5. http://www.virtualis-eu.com/
[Ъ] Quest [2] and FloodRange [3] are examples of games engaging in environment and social learning processes.

We distinguish two main components of the learning opportunity. First, the user can gauge how their personal way of living impacts on the environmental feature or resource in question. Second, the user can explore alternative possibilities for social and economic changes towards sustainability.
The tools presented here have the same basic structure (figure 1). They are constituted by four main modules: a Personal Barometer, a Scenario Generator, a multiplayer game and a Virtual visit. From these modules, through a 3D interface the users can gauge their impacts, and explore different options of choice.

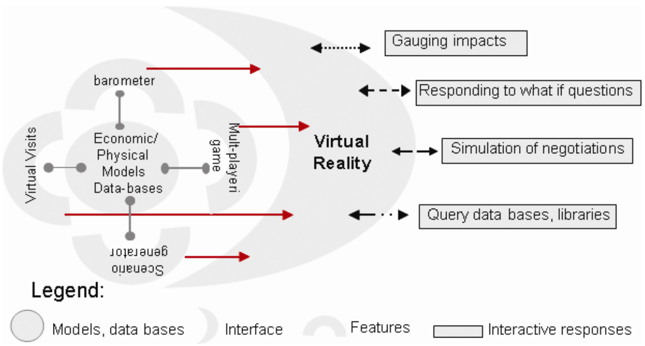

Figure 1: Global architecture of VIRTU@LIS tools.

V GAS and FISHU@LIS are presented as examples of such tools. Each tool is reviewed with focus on the modelling, interface and implementation aspects. VGAS Quality Assurance process is also reviewed.

2. V GAS

V GAS sets a context for debate, self-reflection and, more importantly, for developing empowerment both for individual decisions and for enhancing relations with the rest of the community. For instance, the user may explore what the impact of using public transportation is compared with that of using private transport in terms of CO_2 emissions. Furthermore, V GAS shall help the user to explore routes to sustainability by playing with alternative lifestyles, exploring trade-offs of new choices, e.g. “what are the trade-offs if I change from private to public transport?”. These kinds of choices can be motivated by events generated in the game module of V GAS, e.g. “car restrictions due to high levels of O_3” or “a wave of cold during winter”. To cope with these events the user must consider not only the emissions and environmental impacts but also the home economy, functionality and comfort. If the user plays at a multi-player level must consider the equity with the rest of the group, engaging in a discussion of strategies and possible negotiation to cope with the situations presented. With these types of indicators, a wider view of the *problematique* is brought to the users, connecting environmental and social impacts of lifestyles.
The audience intended to V GAS is an individual, any citizen or a group of individuals. It may be used individually or in a context of debate about empowerment and lifestyles strategies to cope with policies on climate change, energy, etc. In the end it is at micro level in family, community and citizen context that individual decide how to respond to the several policy options [Rayner and Malone 1998]. It may also be used in educational contexts, as an instrument to raise issues and deploy discussions. Being a game, it present complex issues in a playful way, contributing to a positive attitude towards learning [Papa et al. 1998; Given 2002]. It may be used by children and young people. Children and young people have the ability to contribute to a stronger environmental awareness and thus to a sustainable development. As a consequence adults can be influenced positively.
Since, V GAS gives an illustration of environmental and social issues, demonstrating different dimensions, scales and perspectives of the *problematique*, it stimulates self-reflection, discussion and possible negotiation to enhance the relations with the rest of the community, trying to promote awareness and responsibility among citizens and grounds for personal decisional power and social learning.

Figure 2: Living room 3D model.

2.1. VGAS MODELLING

V GAS consists of a set of models that relate lifestyles to emissions of three greenhouse gases, carbon dioxide, methane and nitrous oxide developed elsewhere (see Guimarães Pereira 2001a; Guimarães Pereira 2001b).
The V GAS engine consists of three main modules:

- a greenhouse gases calculator for a year basis
- a generator of events, also for a year basis
- an information module

All three gases’ emission values are calculated, i.e. the quantity of gas emitted to the atmosphere by performing a certain activity in a year.
The source categories considered here are those related to activities of everyday life; only few industrial processes are taken into account in V GAS when a production process implies the emission of a GHG, e.g. power generation. The following are the greenhouse gas sources considered: fuel combustion from energy industry and transport; fugitive emissions from solid fuels; enteric fermentation and manure management; rice cultivation; agricultural soil; solid waste disposal on land and waste incineration.

2.2. VGAS INTERFACE

It is designed and implemented based on modern concepts of software engineering. A highly interactive and intuitive 3D user interface (figure 2), allows it to be used by ordinary citizens, NGOs and other stakeholders who wish to investigate their contributions to a global issue and explore alternative pathways to reduce their burden. V GAS was customised for 5 countries: England, France, Italy, Portugal and Spain.

It consists of a number of integrated modules (and functionality):

- A “personal barometer” - the V GAS BUILD PROFILE - that aims at accounting personal emissions of the 3 greenhouse gases considered in this product, based on personal consuming patterns and regional or national energy and other situations.
- A “WHAT IF” explorer - The V GAS Explorer - that aims at exploring alternative *lifestyles scenarios*.
- A game - The V GAS Game - whose objective is to attain a better “sustainable score” by adjusting lifestyles after a *launcher of surprises* triggers some events that could unbalance the “sustainability situation”. The game may be played by a single user or in competition with others where the scores are given according to overall performance of the strategy adopted after each event. Playing in multi-player allows adapting the game to set context for thematic / focuses discussions since the master can establish rules and events to be deployed (see figure 3).
- A Virtual Library - The V GAS Virtual Library - that aims at showing further information about climate change related issues, namely scenarios developed by institutions such as the IPCC. This library is a multi-media tool, whose design follows the Principle of *Progressive Disclosure of Information*, i.e. the information is provided in a multi-layer fashion from simple to more detailed, disclosed upon users’ demand. The information is displayed not only through text, but also through images, charts, animations and films.

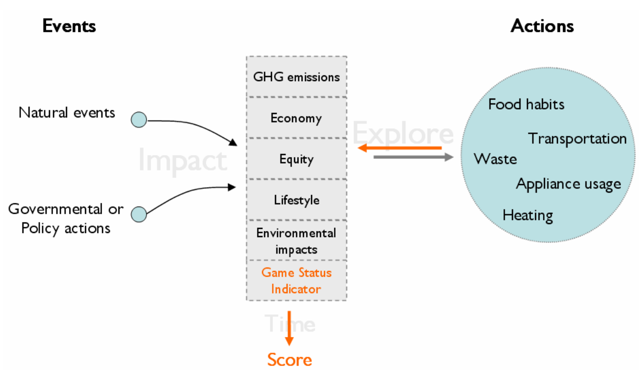

Figure 3: General scheme of V GAS Game Events

The main goal of these modules is empowerment and self-reflection and debate about connections of lifestyles and global issues, in particular climate change, as well as to develop a sense of what takes to do strategic decision making.

2.3. IMPLEMENTATION

The 3D environment was implemented with C++ programming language, DirectX 8 SDK and a 3D modelling tool (Lightwave®). VGAS uses a 3D engine developed specifically for this project. The application allows virtual reality navigation experiences and also has 2D menu bars where game’s options and functionalities can be selected by the user. The Virtual Library was developed using the multimedia tool Macromedia® Flash™ MX.

2.4. VGAS QUALITY ASSURANCE

The prototypes underwent several phases of quality assurance, the first being dedicated to software testing, following known procedures [Corral Quintana et al. 2002]. The VGAS prototype was proposed in different settings, all aiming at tuning it according to quality criteria established in a protocol for quality assurance. The quality assurance of software tools such as VGAS is done by setting up what we called ‘tuning contexts’ [De Marchi et al. 1998; Guimarães Pereira 2001a; Guimarães Pereira et al. 2001]. As “tuning contexts” it is meant contexts in which products and processes of research are scrutinised by those concerned, the participants to these evaluation processes being relevant for the evaluation of the tools. Indeed, a process of “extended peer review” [Funtowicz and Ravetz 1990] deploying Information Technologies based social research, a combination of group participatory methods and Information Technologies. This is important where the use is intended to be social learning, decision or policy formulation situations.

In practice, during group sessions (e.g. **focus groups** (See Morgan 1998)) participants are invited to evaluate the ICT tools they are interacting with, based on a set of criteria given by the moderators. Furthermore, the concept of “tuning context” can be extended to the very process of debate and deliberation, where convivial tools are proposed to debate a particular societal-policy issue.

Eight focus groups were organised with participants pertaining to the following groups: Students, Educators, NGOs and Policy makers (related to education). A total of more than 70 people were involved throughout all its phases of implementation, from 3 countries: Italy, Portugal and Spain.

3. FISHU@LIS

The Fishu@lis prototype is designed as a learning tool in which users adopt the roles of actors operating in the marine environment. Through immersion in the virtual world users are expected to develop greater awareness of the constraints and opportunities under which actors operate.

Three actor-roles are available for users to select from - the fisherman, the predatory fish (see figure 4), and the school of prey fish.

The Fishu@lis is a first trial to a multiplayer online game where players take on roles associated with the marine environment.

3.1. FISHU@LIS MODELLING

FISHU@LIS consists of a set of models (see figure 4) that relate marine environment, market pressures, policy actions and fish stocks.

The FISHU@LIS engine consists of two main modules:

- a Virtual World
- a Scenario Generator.

These two modules, together with users’ inputs, produce the Graphical User Interface (GUI) depending on the type of functionalities chosen by the user.

3.2. FISHU@LIS INTERFACE

Fishu@lis consists of a number of modules (and functionalities):

- Fishu@lis Personal Barometer (FBP) - the prototype relates the consumption and lifestyle choices of users with impacts in the marine environment. FBP considers the amount of eaten fish and the stocks’ sustainability in order to display a sort of sustainable diet indicator. The Principle of Progressive Disclosure of Information was followed in order to develop the tool (customised for three countries: Norway, Portugal and U.K.).

- Fishu@lis Virtual Visit (FVV) - Three actor-roles will be available for users to select from - the fisherman, the predatory fish (see figure 5), and the school of prey fish. Concepts for two further actor-roles - the decision-maker and scientist - have been developed and may be incorporated in the future given sufficient resources. Inside the game, players must face dangers and carry on tasks in order to survive and prosper. In the initial version of the game 3 types of characters (migratory fish, predator and fisherman) share a persistent 3D underwater environment and interact in a variety of situations involving cooperation, combat and negotiation. Each character type has unique goals, resources, and abilities, and has to face specific dangers. The game interface varies according to the type of character. One of the characters, the fisherman, has access to a tool that gives him an output based on Scenario Generator calculations.

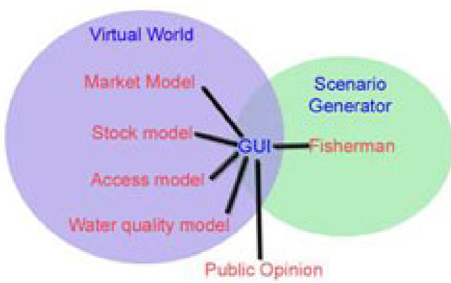

Figure 4: General scheme of FISHU@LIS models

- Fishu@lis Scenario Generator (FSG) - The FSG interface is embedded within the Virtual Visit, accessible by human characters within the virtual world. The Fisher, currently the only human character in the virtual world, accesses it from the bridge of his vessel. Users will explore the four available scenarios via key indicators which reflect the value of the resource, health of the marine environment, social climate, and the effectiveness of institutions. Due to the complex dynamics of the game world it is unlikely that stable scenarios will be the norm. More usually different indicators will give values that cross scenarios. For example, fish stocks may be close to zero, as in the Abandon the Ecosystem scenario, whilst the resource value is in the high range of the Abandon Fishing scenario. The first step in developing the FSG has been to examine the current and likely trends for a range of different fisheries around the world, discuss these possible futures with some of the people most closely involved and extract a simplified set to use as the basis for this project. Discussions were held with fishers, industrial owners, retail outlets, community leaders and government scientists and four scenarios have emerged. These include:
  - Abandon Fishing;
  - Abandon the Ecosystem;
  - Full Management - Local
  - Full Management - Industrial.

  These scenarios have been characterised in terms of a range of indicators and labels.

Figure 5: Predatory fish 3D model

- Fishu@lis MultiPlayer Game (FMPG) - It is designed for 2-6 players playing primarily over networked PCs. The purpose is to give an understanding the difficult issues faced in the governance of sustainable fisheries, coupled with an understanding of how the various actors influence the system. This is designed to include both as the fishermen and citizens who influence and take part in the deciding of the governance issues. The players will have to learn to carefully balance the a mount fish that they at catch in order to stay in business and maximise their profits with keeping the Total Allowed Catches (TAC) at a level where the fishery is maintained, or even allowed to grow. So for each season (turn) the player can make a series of choices. The player can also see the status of the other player's that are playing with him by going to the outside view. In this view he can see the boats of the other players and if he clicks in them the status of the corresponding player will show.

3.3. IMPLEMENTATION

3.3.1. FVV Technology

The game system consists of the balance and interactions among the three character types. Marine life includes player-driven characters, Artificial Intelligence (AI) controlled non-playing-characters (NPCs) and various sea species for added richness. AI will allow NPCs to behave realistically, creating a compelling gaming experience.
The FVV is set in a persistent universe: life in the game world goes on even after the player has logged-out. Creatures will go on living, interacting and doing what they have to do, all the time.

3.3.2. Client - 3D Modelling

Models in 3 dimensions of one predator fish and different schools of fish were made, in order to replicate and generate models for the predator player and school of fish player. These models had to consider not only the object itself and his shape, but also his movement and animation sequences.
A trawler and its bridge were designed and created so that tools and features of the game design could be included in the fisherman interface. So a unique type of boat appears in the game, mid-way between reality and fantasy, enhancing

the game experience. In the bridge special interactive elements were created like the direction wheel, GPS, sonar and a computer.

One of the main issues of development and more complex item was to deal with modelling the sea surface, underwater environment, and landscape. Level-of-Detail algorithms were used to implement the 3D sea model, and the natural movement of surface waters was also considered.

3.3.3. Server Side Computation

The servers for massively multiplayer games are designed to handle huge loads of data created by the large number of players. This load is increased if the game has some characters managed by artificial intelligence (AI). Besides managing the game itself, they also have to simulate the AI behaviour. For all this, the FVV was designed to be scalable.

In the current version of the game, the server is centralised on a single machine. Besides having all the information about the world, this machine is also responsible for the administration of the messages of the game. It receives messages from the players and according to the game it broadcasts information to one or more players. For example, if a player sends a command to move, all the others in its vicinity will receive a message informing them that that player is moving to some specific position.

The simulation of the AIs is executed exactly in the same way as real players. Each character is simulated independently and for the game server there is no difference between an AI and a real player. Because AIs can represent the primary consumers of computational muscle, they were implemented so that their simulation can be carried out in a variable amount of computers. Each machine receives a certain amount of players to be in charge of. These assignments are periodically rebalanced based on the evaluation of the power of each machine. By doing so, it is guaranteed that the system will be properly balanced. Since the FVV game is persistent, all the information is periodically updated into a data base.

All the server applications were totally written in C# and targeted to the Microsoft .NET® framework. For the communications it was used sockets and the protocol was TCP.

4. Conclusions

The types of tools developed here deploy networked virtual reality technologies (either desktop or immersion technologies). The great strengths of virtual reality systems to tackle environmental issues are the immediate visual feedback that these systems provide, as well as interactivity and tele-presence and in many cases immersion and so full focus into the problem of concern.

Clearly, such tools need to be adequately adjusted to the audiences of concern and also customised for the regions and social settings where they might be used.

They are not educational tools in the sense that they are not a one-way learning opportunity. They are meant to social learning, meaning that those engaged in a situation where they are deployed are all *learners* from each others walks of life. These tools are designed for discovering information, making relations, exploring challenges, questioning and eventually promote learning and empowerment.

These types of tools have great potential as platforms to stimulate dialogues and discussion. The applied technology was not considered exclusionary by the users, providing grounds for different types of use depending on user's needs.

In designing CSLoTs, two aspects are crucial: on one hand the application of the "progressive disclosure of information" principle, that is information is provided in layers of progressive information "density" (quantity and specialisation). The second principle is quality assurance of contents by "extended peer review", entailing not only the scientific quality of contents but also the fitness for function of such contents for the audiences and processes they are meant to.

These types of tools enable users to explorer different perspectives and dimensions of a *problematique*, stimulating discussion and negotiation between those involved in such processes.

5. ACKNOWLEDGEMENTS

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The Fishu@lis Virtual Visit was developed and implemented by IMR[3] and YDREAMS. The Fishu@lis Scenario Generator was developed by YDREAMS, IMR and CoMPLEX-UCL[4] teams. The Fishu@lis Personal Barometer was developed by DG JRC team and CoMPLEX-UCL team.

[1] http://alba.jrc.it

[2] http://www.ydreams.com

[3] http://www.imr.no

[4] http://www.ucl.uk

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[2] Georgia Basin QUEST
http://www.basinfutures.net/play_gb_quest.cfm

[3] FloodRanger
http://www.floodrisknet.org.uk/newsletters/2004-01/floodranger-intro