Games for interactive spatial planning:

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SPLASH a prototype strategy game about water management

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Alterra-rapport 667

Alterra, Green World Research, Wageningen, 2002

ABSTRACT

M. Wachowicz, L.A.E. Vullings, M. van den Broek, A. Ligtenberg. 2002. *Games for interactive spatial planning: SPLASH a prototype strategy game about water management.* Wageningen, Alterra, Green World Research. Alterra-rapport 667. CGI rapport 03-002 56 pp. 7 figs.; 4 tables; 48 refs.

The research project Games for interactive spatial planning is carried out within the Program Virtual Green Environment (VGR). VGR aims to explore new methodologies and technologies to deal with the increasing complexity of the Green Environment. An overview of games in general, characteristics and genres of games, differences between computerized and non-computerized games, research items and game design procedures are discussed. The interactive planning process and the role games can play in it are described. Finally a case description of the improvement of the prototype SPLASH is given.

Keywords: games, computer games, interactive spatial planning, game design, water management, SPLASH

ISSN Alterra-rapporten 1566-7197
ISSN CGI-rapporten: 1568-1874

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Project 12050 [Alterra-rapport 667/EvL/12-2002]

Contents

Acknowledgements

At the start of this project only one researcher had some experiences with games. To get familiar with the subject interviews with experts in designing games, facilitating games, interactive spatial planning and water management were organised. The following persons were interviewed:

Maarten Versteegh (Simagine)
Koen Roest (Alterra)
Mark van Elswijk (SERC)
Mathijs Maat (SERC)
Gert Jan Hofstede (WUR, Social Sciences)
Mike Duijn (TNO INRO)
Henk Ritzema (Alterra, ILRI)
Ine Neve (Alterra)
Willem Rienks (Alterra)
Marjolein Bloemmen (Alterra)

We would like to thank these experts for their help along the way.

Summary

Gaming can be defined and explained by a theoretical perspective and a system perspective. Both definitions are important to develop an overall perspective on the role of gaming in the context of interactive spatial planning. Gaming is relatively new in interactive spatial planning, and there are clearly advantages to the use of games that might prove the usefulness in interactive spatial planning. A game can be defined by its function, the message it conveys and the intended audience and a game can be categorised according to the genre it belongs to, such as adventure games, role-playing games, strategy games and others. Computerized games differ to non-computerized games because they can keep track of time, they automate rules, they offer replay options and levels of difficulty. In addition computerized games are independed of place and have extended possibilities to use anonymity. Computer games offer an accessible platform upon which serious cognitive research can be engaged. Research topics are intelligent games and artificial intelligence, collaborative games and virtual reality and the impact of games from the players perspective.

To describe the role of gaming in interactive spatial planning, three leading approaches are explored: the decision-oriented approach, the action-oriented approach and the search-oriented approach. These approaches have been previously identified in the literature and are used to describe the role of gaming in interactive spatial planning.

Actors in an interactive spatial planning process have their own definition of reality based on political, cultural and economic factors that are relevant for them based on the perceptions they have of a spatial environment. To be able to analyse this spatial planning is divided into two interrelated systems: Socio-spatial system and the individual cognitive system. The motivation to use a game in spatial planning is that a game improves insight in the socio-spatial system and it improves insight in and exchange of knowledge of individual cognitive systems. To define the use for games in the interactive spatial planning process types of situations in which gaming can be used have to be identified and an appropriate game suited for that situation has to be found or developed.

The gaming design process exists of an initiation phase, a design phase, a construction phase and a use phase. The main requirements involved in a game design process can be divided into functional, operational and implementation requirements. The functional requirements need to be defined during the initiation phase and they refer to the intended audience and the purpose of the game. The operational requirements are commonly defined in the design phase and cover the design principles, the vehicle and the repertoire of techniques. The implementation requirements need to be defined in the construction phase, They can be regarded as the building blocks for a game.

The concepts about games and designing games are put into concrete design recommendations for SPLASH. Currently SPLASH is a prototype strategy game about water management. A few settings (function, audience and message) are suggested for the further development of SPLASH. A detailed set of requirements is given for the function of communication of water management issues within spatial planning in relation to climate change thus helping to create awareness among stakeholders for each other perspectives about how to deal with the effects of climate change in water management.

1 Introduction

The research project Games for interactive spatial planning is carried out within the Program Virtual Green Environment (VGR), a programmed aimed to explore new methodologies en technologies to deal with the increasing complexity of the Green Environment. The VGR is part of the Strategic Expertise Research of Alterra. Alterra has a large number of scientific physiographic and social models in the fields of water, nature, ecology etc. and it also has scientists experienced in designing (interactive) spatial planning processes, but these two have hardly any links between them. The lack is felt of accessible, multidisciplinary models, which show mutual interaction and relations between the environment, industry, housing, economy and policy developments. Specifically practise models including the human factor, which simulates the impact of certain planning choices upon the environment and upon actors involved in a planning process.

In addition communication between stakeholders and the expression of the individual ideas during spatial planning processes is often a difficult process. It was suggested that games might be a good tool to use models in the interactive planning process and improve communication between stakeholders. There is clearly a need for a kind of artificial environment in which policy can be developed and tested in order to cope with the increasing complexity of reality (Cammen and Lange, 1998).

The project Games for interactive spatial planning was set up to provide an overview of the theoretical background of the use and suitability of games for facilitating interactive planning. The project was divided into three phases. Firstly an overview of existing theory and methods was created carrying out desktop research and interviewing experts. Secondly SPLASH a prototype of a strategic water management game is being regarded in relation to the findings phase one and suggestions for improvements are made. In the third phase of this project some suggestions for improvement, made in phase 2, are implemented in SPLASH.

The project is carried out by the Centre for Geo-Information in co-operation with Wageningen Software Labs (W!SL). Experts on games, interactive spatial planning and water management from other departments within Alterra or of external institutes are consulted by means of interviews.

2 Gaming

This chapter provides an overview of the current state of the art in gaming. With gaming is meant the playing of games. A game is a pastime with formal and predefined set of rules for the progression of a game session, with built-in and quantitative definitions of success and failure. Games might be computerised or non-computerised.

In the first section we describe gaming by formulating a distinction between game theory (i.e. the academic discourse of gaming) and game systems (i.e. the game design discourse of the game development community). The definitions are used to describe the differences in understanding of what games are. Sections 2.2 and 2.3 point out the main advantages and disadvantages of gaming. The aim is to outline the positive and negative properties of gaming in interactive spatial planning.
In Section 2.4 the main functions of gaming are described in terms of its message, function, audience characteristics, and motivations. Three main categories are used as an indication of possible roles a game can have in interactive spatial planning. These categories are also used in both contexts of computerised and non-computerised games.

Section 2.5 delineates gaming activities according to different game genres. Three main game genres are described as being adventure, role playing, and strategic games. Although there is a large amount of overlap between these different game genres, we made use of them to explain some of the games already being used in interactive spatial planning and other related applications.

An overview of how computer games differ from non-computer games is given in Section 2.6. Computer games can historically be described as introducing four main characteristics that non-computerised games lack of. They are time, complexity, replay, and levels. Our aim is to emphasise the important role of multi player computer games and their real-time interaction in providing a new communication mode for interactive spatial planning.

Section 2.7 describes the state of the art within the game industry. A number of techniques, graphic technology, and algorithms are being used today in game design that have led us to assume they might also be of interest in being incorporated into a game for interactive spatial planning. Therefore, in Section 2.8 we describe the current research topics in gaming having a focus on the technology as well as players' perspectives.

2.1 What is gaming?

There are two main perspectives from which gaming can be defined and explained.

Definition based on a theoretical perspective

This is an attempt to describe and understand gaming as an extension of the mathematical theory of games as initially proposed by Von Neumann and Morgenstern (1944), and presented in Luce and Raiffa (1957). Gaming is then defined as a *decision making problem* with two or more decision-makers – players – where the outcome for each player may depend on the decisions made by all players (Figure 1). Each player evaluates possible outcomes in terms of his best strategy in every possible observed state of the game. A *best strategy* for a player is a deterministic plan dictating his actions in every possible observed state of the game. A mixed or randomised strategy is a weighted average of best strategies, where the weights are interpreted as the probability of choosing the associated best strategy. Giving the probability distributions over available actions in each possible game state may also specify a mixed strategy. Many applications of game theory arise in the fields of economics and industrial organisation. For example, many game-theoretic algorithms have been developed for bargaining, auction, labour and financial economics.

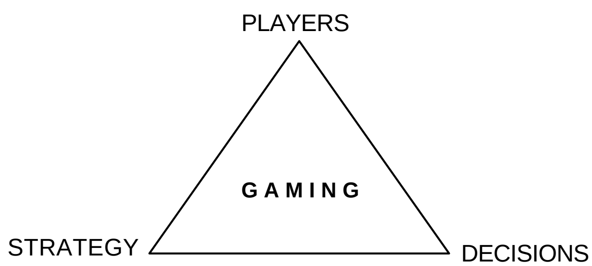


Figure 1: Main components of gaming from a theoretical perspective

The main characteristic of applying Game Theory in developing games for interactive spatial planning is that the players have no dominant strategy, and often a player's strategy depends on the strategies of others. The game would be usually sequential in which players make at least some of their decisions at different times. Moreover, the same players will play more than once since player's current actions depend on the past behaviour of other players.
It is important to recognise that a variety of computational tasks can be implemented using Game Theory. The list below is exemplary of computational tasks of having some relevance for interactive spatial planning.

- Determine whether equilibrium exists or, more commonly, since existence is usually guaranteed, determine whether there exists equilibrium with some additional property. The equilibrium occurs when each player's strategy is optimal, given the strategies of other players.
- Compute numerical estimates of the equilibria.

- Determine the topology of the set of equilibria, for instance by presenting a triangulation.

However, many of the algorithms based on Game Theory are quite complicated and involve issues of numerical stability and efficiency. One impediment to the routine use of these algorithms has been the lack of generally available software that can implement them. For games in spatial planning, this problem is very acute, since we have to select and implement our own version of a solution algorithm for each game that we encounter.

Definition based on a system perspective

Gaming is seen as a *communication mode* that contains a game-specific model, appropriate communication technologies, and a multi-player interaction pattern (Duke, 1974). Communication modes can be primitive, advanced or integrated:

- Primitive: few symbols, simple conventions, one-way pattern of interaction;
- Advanced: many symbols, complex conventions, multiple dialogue, two-way pattern of interaction;
- Integrated: multiple sets of symbols, parallel and complex situation specific conventions.

In the last two types of communication modes, the general function of gaming is providing players with a chance of having an experience through the interaction with each other and with the game (De Caluwé *et al.*, 1996). Players will play the game and get an understanding of the underlying model. They can find out what are the best ways to interact with the model, and they can get insight in each other's perspectives about the same model. Many computerised and non-computerised game-specific models have been developed including verbal models for teaching and publication in the social sciences; mathematical models for learning in natural sciences; and simulation models for showing dynamic representations such as automobile panels and landscape scenarios, as well as multi-person problems within a company when many workers are competing for one promotion (Figure 2).

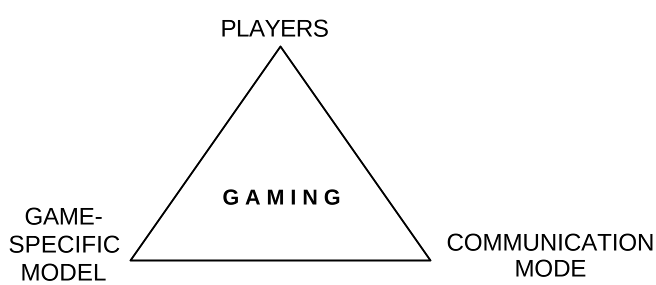


Figure 2: Main components of gaming from a system perspective

Overall Perspective

Both definitions are important to develop an overall perspective on the role of gaming in the context of interactive spatial planning. The first definition provides us with the notion that gaming operates on the basis of player's decisions during a game: players have goals, sets of activities to perform, constraints on what can be done, and pay-offs ("good and bad") as consequences of their actions. The second definition provides us with the notion that gaming operates according to the communication needs of players. Gaming becomes an important tool for consciousness-raising and motivation, skill training, knowledge development, communication and collaboration, as well as integration of learning experiences.

This overall perspective also plays a role in placing gaming in relation to other techniques which have been previously used in interactive spatial planning such as model building, system analysis, behavioural sciences, etc. Figure 3 identifies some techniques available for interactive spatial planning along two dimensions of rationality and calibration. This places gaming in relation to the other techniques and distinguishes it from the other quadrants as relatively uncalibrated and intuitive.

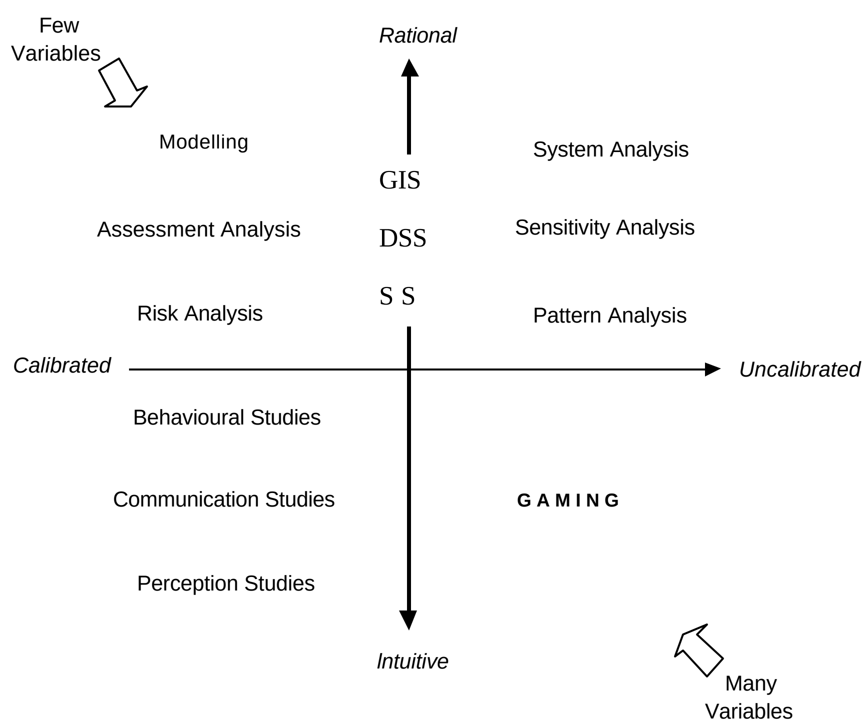


Figure 3: Schematic location of gaming in relation to other techniques used in interactive spatial planning (After Duke, 1974)

Gaming is usually voluntary and intrinsically motivating since it involves some level of active, often physical, engagement. It usually has the characteristics of challenge, fantasy, curiosity, and control (Malone and Lepper, 1987) and it should be fun to be played (pers. com.: Elswijk and Maat, 2002). These characteristics are usually not found in other environments such as GIS, Decision Support Systems, and Simulation Systems, which are currently being used in interactive spatial planning. However, the danger of gaming is the fact that it is a simulation of the designer's theory rather than of reality (Pournelle, 1990).

2.2 What advantages does gaming have?

Gaming is a new form of communication and with an expected impact across many fields and problem situations. In interactive spatial planing, new information is exponentially generated today and the problems of the world are becoming more complex. Gaming in interactive spatial planning is new, not well understood, and in its infancy. Nonetheless, there is convincing evidence that gaming will prove to be very useful to formulate a spontaneous solution by many stakeholders in many situations during a interactive spatial planning process (See Section 3.5 for more details). The main advantages are described below according to both theoretical and system perspectives in gaming.

Players and Game-Specific Models

- A save environment is offered to players to experiment with the future.
- A simulation gaming model is in general more attractive to do then reading reports or listening to lectures.
- During an interactive spatial planning process, gaming is specially suited to give insight in the relations between a large number of variables and an opportunity to develop a simplified view of a problem situation.
- Gaming motivates the players to use their own expertise actively.

Players and Strategy

- Gaming allows players to "try out" different strategies in a conflict situation that would not be possible in real-life.
- Gaming leads to increased insight into predicaments, pressures, uncertainties, and moral and intellectual difficulties of others.
- Players can gain a greater sense of personal efficacy and potency.
- Players can learn about winning strategies in the simulated situations.
- Gaming can typically encouraged cooperation in a tit-for-tat strategy. In this strategy, players cooperate unless one of them fails to cooperate in some round of the game. In other words, the other players will do in the next round what the uncooperative player did to them in the previous round.

Players and Decisions

- Gaming allows the exchange of decisions/actions among players.
- Players in simulation games can learn better decision-making skills.
- Players gain increased self-awareness of the effects of their own decisions and actions.
- Gaming makes it possible to observe and experience long term effects of the decisions and actions taken by the players.

Players and Communication Mode

- Players can use the concept of 'learning by doing'.

- Gaming can give direct feedback about behaviour and actions of the players. Thus they will learn about their behaviour and / or actions.
- Gaming can be used to exchange ideas or information focused on some are of interest by a group of players varying in size from less than 10 to more than 100 persons.
- Gaming can provide a variety of communication modes (e.g. spoken, multimedia, written, formal, and informal) to better make tacit knowledge explicit.

2.3 What disadvantages does gaming have?

Although gaming is a powerful tool for the alternative communication of situations that could not otherwise be managed, there are some problems to the use of gaming. They are mainly related to gaming being improperly conceived and employed. The main disadvantages can be one of the following:

- Gaming is prone to unfortunate misconception of play as being easy and only applied to small children. This reduces the potential use of games within learning environments with both children and adults.
- Gaming is a simulation of the designer's theory of a game and not of reality.
- The interpretation of a reality only exists in the mind of the player and the function of gaming can not create a shared representation of it.
- Gaming can have a strong tendency to stereotype and pigeonhole according to race, religion or social background.
- Many of the ill-conceived uses of gaming to date have not helped. The gaming technique has not been well understood and enthusiastic proponents have used it beyond its capability.

2.4 What functions can gaming fulfil?

Careful thought is needed when defining a game, its objectives and characteristics. Is it to be an isolated and free-standing game employed randomly as the occasion may demand? Will it be employed in a public policy program? Or for citizen use in discussion of public policy? What is the message (gestalt) conveyed by gaming?

Therefore, a vast range of functions can be defined for identifying the game context: its message, function, audience characteristics, motivations as well as pragmatic considerations to ensure a successful game and appropriate media choice. De Caluwé *et al.* (1996) have distinguished three main categories: basic functions, complex functions and very complex functions. This categorisation can also be used as an indication of possible functions of gaming in interactive spatial planning.

Basic Functions

- Consciousness-raising
- Motivation
- Knowledge development
- Overview construction
- Attitude and self-confidence creation
- Skill learning
- Teaching
- Communication

Complex Functions

- Integration of learning experiences
- Self-diagnoses of personal strengths and weakness
- Coupling between thinking and acting
- Experience of unknown reality
- Observation and test of a new reality (ex-ante evaluation)
- Development of semantic framework as a language reference

Very Complex Functions

- Adding more details to a (new) normative framework
- Cultural renewal
- Learn to learn.

The overall challenge is to define how to support these functions in gaming considering the variety of communication modes, as well the decision-making actions taken by stakeholders during an interactive spatial planning process. One approach to tackle this challenge is to make a careful definition of the needs of the intended audience. However, every game can only fulfil a number of functions and players' expectations out of the full list. The success of a game depends on what type of functions should be incorporated. For example, if a simulation game has to support an organisational change process, the important functions would include increasing motivation, providing a common learning experience and experiencing a new reality. As a result, our conception is more related to "How much success do we have in building games for interactive spatial planning?" rather than "How can we build games for interactive spatial planning?".

2.5 The different game genres

This section gives a description of some of the more important genres of games and their application in interactive spatial planning. The discussion will loosely follow a similar discussion given in Fairclough *et al.* (2001). The genres differ mainly in the sets of rules governing the play of game and in the type of scenario setting the game environment to constrain behaviours in the games.

Adventure Games

Game-play involves the player moving around a restricted locale, solving puzzles and interacting with characters in an attempt to further a story line. While the original examples of this genre were text based (commands were given through the player typing basic English commands – “eat the peach”, “enter building”, “open door” etc.), nowadays they are graphically stunning and the input is given in a variety of novel ways – the most common being the use of the mouse to direct the player’s character (from which came the name “point and click adventure”). One interesting application of this genre in interactive spatial planning is the creation of more realistic and engaging environment for the players by maintaining consistency in dynamic story lines. Adventure games can be powerful tools to combine aspects of DELPHI technique and survey research in a single gaming exercise.

One example is *HEX - The Human Settlement Game* used by UNESCO for the purpose of training mid-management public officials at locations throughout the world. This adventure game is focused on human problems such as housing, education, public facilities, and utilities. UNESCO sought to develop this game, which could serve as an icebreaker in conference meetings. The result was the development of three levels played simultaneously in a game section using hexagonal patterns. Players are told to solve the game in their own level and are left to "discover" in practice that this can only be done if ALL three levels are solved simultaneously.

The CONRAIL Railroad Deregulation Game deals with a policy question that represents national policy affecting a major corporation. The situation was little short of desperate, with CONRAIL requiring an enormous public subsidy each year to survive. The game design team tried to mimic a CONRAIL "war room" located in Philadelphia inside a computerised game. This took the form of a railroad route map, which underwent a series of simplifications. The original 4,000 terminals became 7; the 1,000+ competing transport lines became 3; the 10,000 shipments became 11; and the 7 district car-types evolved into 1. The computer game was relegated to a microprocessor, and the final exercises became very much like an "adventure" case study with the arguments of rate setting being highlighted by players playing against each other.

Role Playing Games (Storytelling Games)

Often seen as an extension of the adventure game style, Role Playing Games (RPGs) take place in far larger worlds and the player has more freedom to explore the environment at their own pace. The RPG format offers the same kind of challenges to a developer as the adventure games. However, extra complication is introduced due to the amount of freedom afforded to the player. Maintaining story consistency becomes a bigger issue and the level of sophistication required is beyond that required in adventure games.

Role-plays can be powerful tools in interactive spatial planning because they help stakeholders explore the consequences of day-to-day management decisions from the perspective of other stakeholders in the public and private sector, interactively. Participants play a role in small groups of people. They analyse options, take decisions, and receive feed-back on the consequences of both their own and other players' decisions through a computer simulation model.

NEXUS is an example of this type of game which is being used to communicate the options and feelings of citizen's groups to the decision makers as well as to communicate the professional expertise of a planner to both citizen groups and decision makers (Armstrong and Hobson, 1970). In this game, players are asked to comment on the impact of various decisions on carefully selected quality of life indicators from the perspective point of their real-life role or some other assigned role. The strategy is taken on the combinations of people's play in such a way that consensus agreements can be juxtaposed and fought over.

SNUS - Simulated Nutrition System is a game used by the Nutrition Division of the Food and Agricultural Organisation of the United Nations to familiarise national planning teams of the Third World countries with the impact of various policies, both manufacturing and non-manufacturing sectors, on national nutrition planning. For the game, a large board was created with movable chips representing a stylised flow chart of the process involved. The role-playing exercises happen in a simulated hypothetical country with the primary objective of training the players and sensitise them to the impact on nutrition among the poor.

CORONA is a role-play developed by Resource Analysis and the Coastal Zone Management Centre of the National Institute for Coastal and Marine Management. It's goal is to raise the awareness of integrated coastal zone management issues for the decision makers participating and it is used in the World Coast Conference '93 and as a training tool for courses, seminars or workshops. The players of CORONA are confronted with the fact that there is usually not one single entity that takes all decisions necessary to implement a coastal zone management plan. Rather, the implementation of a plan depends on the institutional arrangements that are operational in a specific coastal zone system. That is, who or which agency or organisation is responsible for what and what is their mandate to try to achieve their objectives?

FISHMAN is an instructive simulation game: a combination of a simulation model and a role-play. The simulation model consists of a computerised tool combining fisheries and economic models, and is used in a role-play facilitated by a game leader. FISHMAN centres on the fisheries activities in the imaginary setting of the country País Pesces. The objective of FISHMAN is to show crucial dilemmas related to international fisheries management. The game is developed on the basis of several "starting conditions", which determine the different outcomes.

Strategy Games

Strategy games cast a player with the ability to manipulate the environment – for example to raise or flatten mountains to make the land more hospitable, or to unleash the fury of a hurricane or earthquake. Strategy games needs to be applied both at the level of strategic opponents and at the level of individual units. At the strategic level it involves the creation of opponents (computerised or not) capable of mounting ordered, cohesive, well-planned and innovative campaigns against the human player. This is very challenging as players quickly identify any rigid strategies and learn to exploit them. At the unit level, a strategy is required in order to allow a player's units to carry out the player's orders as accurately as possible. Challenges at unit level include accurate path finding and allowing units a degree of autonomy in order to be able to behave sensibly without the player's direct control.

Strategy games are powerful tools to help with diplomacy among stakeholders who have different desires, beliefs, values and preferences about spatial and social systems within an interactive spatial planning process. One example is urban gaming, which provides mainly urban planning training tools for planners and administrators and learning tools for students and researchers. The aim is to simulate the effects of decisions made through assumed roles. These roles are subjected to rules where an urban model or, more in general, land use model, is used for actual urban planning and design, as instruments of analysis, prediction and negotiation (Cecchini and Rizzi, 2001).

SIMCITY is the classic example of this genre**.** The concept of starting with an undeveloped patch of land and an initial development fund and developing a city from scratch turned out to be a very interesting one.

METRO is another example of this genre of games in a complex gaming simulation of an urban area (Miller and Duke, 1975). It is a microenvironment for decision-makers in which an abstracted, simulated metropolitan area is represented via different roles played using a same model and database systems. Players take on roles of key decision-makers: politicians, planners, land developers, industrialists, and environmental control officers. They run a city for a period of five to ten years by making annual decisions that parallel those of their real-world counterparts. The decisions are fed to a series of simulations of natural and artificial phenomena to determine the immediate effect of each year's decision. The decision making process is repeated on the basis of the new computer printout (status of the city) for each year in the five- to ten-period. METRO has been a vehicle to communicate the nature of the urban system to students, policy makers, and citizen groups.

Others

Just like any attempt at categorisation, not all-gaming activities fit neatly into one of the niches defined above. There is a large amount of overlap between these different categories. The categorisation such as that above is useful an attempt to clarify some of the basic requirements of gaming for interactive spatial planning.

2.6 How are computer games different from non-computer games?

Literature suggests that computer games have four main characteristics that are different from those found in non-computerised games. Two of them are quantitative properties of gaming. They are time and automation/complexity. The other two are more qualitative in nature and therefore more subtle to be described. They are replay and levels. Two more characteristics are identified: anonymity and independed of location.

Time: The major change with computer games is that the computer can keep pace. You do not get pace in non-computerised games. With computer games we can create real-time games without having to rely on laws of physics. This opens up new possibilities for interaction, speed, and basically makes the player able to take a variety of actions he would not dare to do it in real life. This leads to the design of more interesting adventure games.

Automation/complexity: Computer games also automate the rules of games. As a result, more complex games can be created and real time games with thousands of units can be moved on each side. This leads to the real time strategy game genre.

Replay: The option of returning to the same game, both in the sense that the player can go back to exactly the same challenge and play a level of the same game again is a characteristic found only in computer games. This is not common in non-computerised games. Role playing games profit from being presented with an identical challenge more than once.

Levels: The game computer revolution really started with the creation of different levels in gaming where suddenly a player has a one-person quest, or can get better, or defeat an adversary, and move to new levels. This does not correspond to previous non-computerised games. Replaying of exactly the same thing creates levels of progressions in a game. This can lead to multi player gaming in interactive spatial planning.

Anonymity: Computer games have extended possibilities with regards to the anonymity of the players. Remaining anonymous can have the advantage of creating equality among players, while in real live hierarchy may influence the relationship.

Independent of location: A computer game can be played from different locations at the same time.

2.7 The state of the art within the computer game industry

Modern computer games are usually played for fun with the following characteristics:

- Real Time: There is only very limited time for reasoning.
- Dynamics: Computer games provide a highly dynamic environment.

- Incomplete Knowledge: A player has only incomplete knowledge of the world.
- Resources: The world's resources may be restricted.

The game industry has mainly focussed on graphics technology. Graphics have now reached such a level that visually stunning games are the norm rather than the exception. Usually the games can include low-cost 3D modelling, ray tracing systems, high-end features like spline surface modelling, 3D text, layered texture/bump mapping.

Other techniques being used in gaming are very simplistic that have led to the emergence of a number of very well established, well understood and robust algorithms that are in wide use by game developers (Woodcock, 2000). These include Fuzzy State Machines (Russel and Norvig, 1995**)**, the A* path finding algorithm (Stout, 1996), and a number of A-Life techniques including Craig Reynolds' flocking algorithms (Reynolds and Flocks, 1987). The fact that a number of core techniques are being repeatedly used in game design has led to a number of attempts to integrate them into a generic systems development kit (SDK). For example, Mathématiques Appliquées' *DirectIA (*www.animaths.com) and Louder Than a Bomb's *Spark!* (www.louderthanabomb.com). SDKs, however, have failed to take hold in the industry and Woodcock (2000) suggests current SDKs lack of flexibility as the main reason for this.

Another well-used technique in gaming is simply to cheat. This is particularly easy in some game genres. For example, in action games computer opponents can have perfect aim or the ability to see through walls and so, track a player. Similarly, in strategy games the computer opponent might be able to produce exactly the units needed without having to engage in the complicated resource management faced by a player. Cheating as a technique is very processor efficient and can be very successful. However, it has one major drawback. If cheating is done badly and is noticed by the player it ruins the illusion of playing against an equally matched opponent, and destroys any sense of immersion built up by the game. This leads to a very unfulfilling game experience and so should be avoided. To conclude, a small number of simple, deterministic and processor efficient techniques that are very well understood and repeatedly used by the game development community dominate the game industry.

2.8 Computer games as a research topic

Some might say that research into computer games is not the most satisfactory undertaking. But in fact, in terms of a research problem, gaming is unique in the challenges it offers. Games take place in dynamic complex worlds in which complex decisions, often based on partial knowledge must be made. We would argue that computer games offer an accessible platform upon which serious cognitive research can be engaged. Laird and van Lent (2000) go so far as to suggest that computer games are the perfect platform upon which to pursue research into human level.

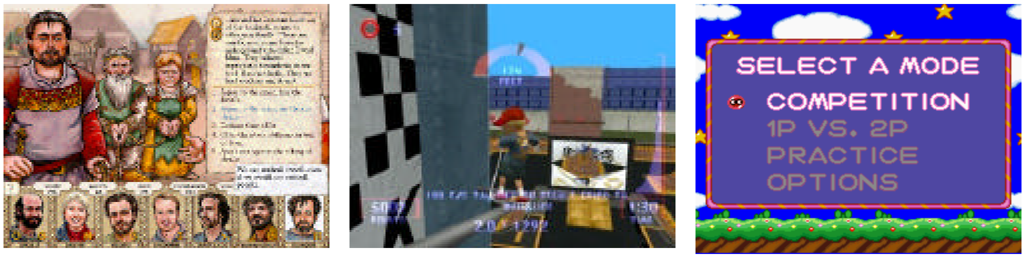
Up to now, most of the research efforts to improve the graphics in games has overshadowed all other research areas. However, graphics have now reached such a level that visually stunning games are available, causing games developers to look for innovations, other than superior graphics, to become the selling points of their games. This will inevitably lead to more time for research into areas such as artificial intelligence, human-computer interaction, and cognitive sciences.

Although the academic research in gaming has been rare over the past number of years, the level of interest is growing. A number of research efforts are currently underway and courses are being offered in some US universities. Much of the research being undertaken has emerged from work conducted with military institutions. Many of the goals are similar and so there is a large crossover of techniques. One such effort is the *Soarbot* project (Van Lent *et al.*, 1999) in which agents have been created to play the 3D action game Quake (www.idsoftware.com) using the rule based SOAR architecture. Forbus *et al.* (2001) describe another interesting research project in which a military system designed to analyse terrain in order to plan attacks. Another area in which a lot of work is being transferred to computer games is in the area of computer based story telling, a well-established research area. The Oz Project (Bates, 1992) is a successful research initiative that has been applying agent based AI techniques to the task of maintaining interactive stories.

The Excalibur Project (Nareyek, 2000) is another effort that is concerned with creating agents to populate virtual game worlds. Finally the work undertaken as part of the RoboCup robot soccer tournament (www.robocup.org) offers a number of insights into problems similar to those arising in interactive spatial planning. For example, multi-actor interaction and team effort for finding a consensus during a game.

Intelligent Games and Artificial Intelligence

The use of game applications has a long tradition in artificial intelligence. Games provide high variability and scalability for problem definitions that are processed in a restricted domain and the results are generally easy to evaluate. The main techniques being used in gaming are from the fields of autonomous agents, planning, scheduling, robotics and learning (Fairclough *et al.*, 2001, Russell and Norvig, 1995). These techniques can be applied to a variety of tasks in gaming. For example, a game that uses probabilistic networks to predict the player's next move in order to speed up graphics may be on a high AI level.
The notion of AI in gaming is primarily related to characters. These characters can be seen as agents, their properties perfectly fitting the AI agent concept. In this case, the main research question is related to how does the player of a computer game perceive intelligence of a game character (agent)? Important characters include physical characteristics, language cues, behavioural and social skills (See Figure 4).



(www.gamasutra.com) (www.gamemedia.co.uk) (www.classicgaming.com)

Figure 4: Some examples of characters in computer games

The most important question when judging an agent's intelligence is the goal-directed component. The standard procedure in AI gaming to implement a goal directed behaviour is to use pre-determined behaviour patterns. This is normally done using simple if-then rules. In more sophisticated approaches using neural networks, behaviour becomes adaptive, but the purely reactive property has still not been overcome.

Many computer games circumvent the problem of applying sophisticated AI techniques by allowing computer-guided agents to cheat (see for more details 2.7).

Collaborative Games and Virtual Reality

Lots of expectation surrounds Virtual Reality (VR) and Augmented Reality (AR) technology to bring new solutions to gaming with computers (Figure 5). Our literature review shows results confirming these expectations, mainly because the technology is appealing and everyone wants a personal experience (Szalavari *et al.*, 2002). Distributed multi-user VR systems like DIVE (Carlsson and Hagsand, 1993) try to incorporate communication for geographically distant users. Communication distribution is additional to application demands. Depending on the type of information that is communicated (avatar representation, text, audio or even video channel), high network performance and intelligent distribution strategies are needed to support these tasks.

Figure 5: An example of the hardware environment (pods) visible to a player. Each player wears a see through head-mounted display and interacts with a personal interaction panel.

Local multi-user systems like CAVE (Cruz-Neira *et al.*, 1993), Responsive Workbench (Krüger *et al.*, 1995), Shared-Space (Billinghurst *et al.*, 1996) and Studierstube (Fuhrmann *et al.*, 1997) focused on topics in scientific visualisation and collaborative work. Social communication is provided by these systems naturally, participants are located in one room. In these systems, the main challenge is the ability to display different information to each participant as a requirement for visual privacy. The CAVE environment provides one projected view to a group of users, thus privacy could only be on a group basis. The Two-User Responsive Workbench (Agrawala *et al.* 1997) extends the previous Responsive Workbench approach to two users. Multiplexed field sequential stereo projection provides independent views for participants.

This research work has identified the possibility to display different information to the two users. For individual view and interaction with the system each player has to have his own head mounted display and interaction tools. In this way not only individual views but also simultaneously and independent interactions with the game are possible. However it had problems to identify real world applications for this type of collaborative situations. The Shared Space and the Studierstube approach meets the requirements of customised views best, by providing stereoscopic head mounted displays to each participant. It describes a technology set up which provides both: unhindered social communication and the possibility of private behaviour.

Impact of Games from the Players Perspective

Many critics argue that games produce socially isolated people or promote violent behaviour. Games are assumed to be simple, mind-numbing entertainment and regarded as a waste of time (Squire, 2001). Fortunately some research is that contradicts at least some of the above statements. Several findings (Inkpen et al., 1994; Lawry et al., 1995) conclude that for children playing electronic games is not an anti-social activity. Due to the increase of violence among youth the impact of violent computer games (for example Doom) has become a research topic. However, the impact of games such as SimCity that has been around for over a decade as an educational tool, has not been investigated thoroughly yet.

Recently interest in the learning aspect of games is increasing and scientific research into this matter is evolving. In the project Games-to-Teach (http://cms/mit/edu/games/education) a team of researches have suggested the following three fruitful areas of research:

- Studying the role that games like SimCity and Civilization play in people's lives and how it relates to their understanding of other phenomena;
- Reappropriating commercial entertainment games such as the SimCity or Civilization series for use in formal learning environments;
- Creating games that can be used to support learning in other domains, such as advanced math, science, and engineering.

Games like SimCity have been used as a educational tool, but, as said, little is known about its educational impact. Research has been done, though, on what happens when one teaches with games by several researches (Stein Greenblat, 1975; Butler 1988; Randel et al., 1992)). Each of them made a series of claims, but the general conclusion is that games and simulations can be equally as good or better than traditionally classroom teaching (Mcgrenere, 1996). It must be noted however that the claims made, however, are supported by anecdotal data rather than empirical evidence (Stein Greenblat, 1975; Freedman 2001; Randel et al., 1992).

Researches of the Games to teach project are currently working on designing 10 conceptual games of next-generation educational games to support learning in different fields. They are convinced that games offer teachers enormous resources they can use to make their subject matter come alive for their students, motivating learning, offering rich and compelling problems, modelling the scientific process and the engineering context and enabling a more sophisticated assessment mechanisms (Jenkins, 2002).

In the above paragraphs a short discussion is given on the impact of games on peoples' lives. However, the cultural background of people (cultural factor), in its turn, influences the way gaming is approached (pers. com.: Hofstede 2002). The cultural factor summarises the influence of deeply rooted values or shared normative, moral, or aesthetic principles that guide action and serve as standards to evaluate (one's own and other people's) behaviour. Cultural distinctions are based in these deeply rooted values which, in turn, according to Hofstede (1980), can be delineated along five fundamental dimensions:

- Power Distance,
- Individualism versus Collectivism,
- Femininity versus Masculinity,
- Uncertainty Avoidance, and
- Long-Term Orientation.

Hofstede (pers. com.: 2002) points out that national cultures represent a nation's unique score on how to deal with social inequality (Power Distance), the degree of integration and orientation of individuals within groups (Individualism-Collectivism), the division of social roles between women and men (Femininity-Masculinity), the tolerance for the unknown (Uncertainty Avoidance), and the trade-off between long-term and short-term gratification of needs (Long-Term Orientation).

The impact of the cultural factor on gaming can be shown using the following generalisation:

> Dutch are feminine (they care about the weak), they don't like hierarchy in relations, they don't mind uncertainty, and they are individualistic (everybody needs to get a chance to say his opinion). Japanese on the other hand have a strong hierarchical society, are masculine and collectively oriented, and they have a strong tendency to avoid uncertainty. It is not strange that Japanese and Dutch experience a game in a very different way (pers. com.: Hofstede, 2002).

3 The role of gaming in interactive spatial planning

3.1 The Interactive Spatial Planning Process

The description of an interactive spatial planning process usually offers a theoretical notion to understand and co-ordinate decision-making in order to reach a mutual agreement among actors and prevent what is sometimes called "the tragedy of the commons" i.e. meaning the degeneration of common-pool resources as result of individual decision-making by stakeholders (Deadman, 1999). Three leading approaches have been previously identified in the literature (Geertman, 1996) and they will be used to describe the role of gaming in interactive spatial planning.

Decision-Oriented Approach

The decision-oriented approach has a strong relation with the Strategic Choice Approach (Friend, 1994). The central paradigm in this approach is that planning is a process of choice in a situation of uncertainty. This uncertainty is present in the knowledge of the planning environment. In this case, one is not sure about the physical and socio-economical structure of the environment and its response upon the actions of actors. Also there is uncertainty about what choices are to be expected in a related field of choice and there is uncertainty about the value of the judgements that are attached to the consequences of decisions. The decision-oriented approach discriminates between operational decisions and planning. Planning is defined as temporary support for the operational decision making. Such support is necessary because it is considered impossible to judge instantaneously all operational decisions in the necessary broader context of society and environment. The goal of planning is mainly to inform actors about future decision-making and make future operational decisions interpretable. A main critique upon this type of planning is it agency-centred view, which makes it less suitable in multi-actor environment.

Action-Oriented Approach

The action-oriented approach was developed mainly by the Catholic University of Nijmegen (Geertman, 1996). In this approach, the assumption is made about the spatial organisation as being the result of actions of and co-operation between numerous actors. As a result, the focus is upon relations that exist between actors. Planning is defined as the result of actions between actors, which are part of the socio-spatial system. Their actions need to be compliant to and embedded in the society. Decisions are based upon interactions among actors. This means that the focus of planning is not “per se” on a critical evaluation of the spatial organisation itself but on the analysis of the intentional actions and knowledge of the actors involved in planning.

Search-Oriented Approach

Planning as search for direction is an approach that considers interactive spatial planning as a kind of learning process. The process aims to investigate new opportunities for establishing socio-physical and spatial organisation. The aim of planning as search for direction is not directly to prepare for an operational decision given a well-defined problem, but to reveal alternative and new solutions outside the direct scope of the observed problems. It is meant to actors to learn and get a bit wiser (Kleefmann, 1984).

3.2 The Socio-Spatial and Individual Cognitive Systems in Interactive Spatial Planning

Actors in an interactive spatial planning process have their own definition of reality based on political, cultural and economic factors relevant for them and based on perceptions they have of a spatial environment. In order to be able to analyse this we split spatial planning up into two interrelated systems. It is imperative to have in mind the message of the game, actors characteristics and motivations, and their way of reasoning within a interactive spatial planning process to ensure a successful game. The two systems are the Socio-Spatial System and the Individual Cognitive System (Figure 6).

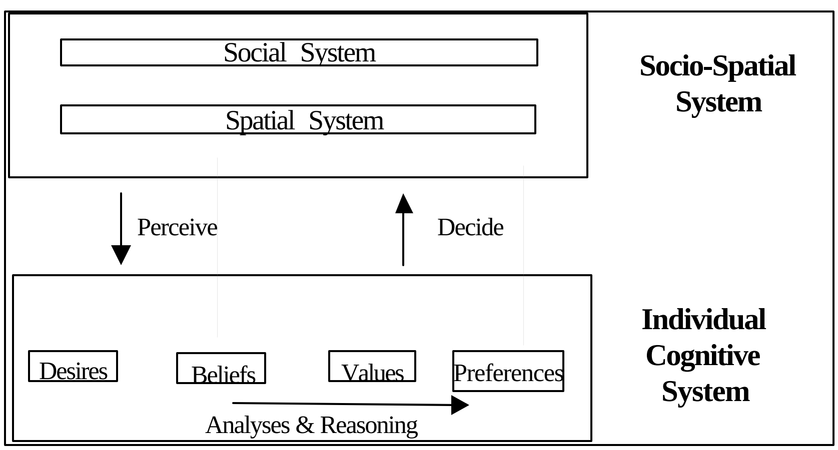


Figure 6: Levels of Interactive spatial Planning (After Ligtenberg et al. 2002)

Socio-Spatial System

A social system is constituted of political, cultural and economic subsystems. In general we can say that a society needs to continue itself. Maintenance and development of the system is therefore the central goal of a society. Economic processes form an important driving force for the maintenance and developments of a society. Production and distribution of goods and services are the main effects of these processes. A concrete social system consists of individuals, groups and organisations that maintain relations through intentional (co-operative) actions based upon a more or less common set of rules, norms and values and act within the boundaries of the institutions that are derived from it (Kleefmann, 1984). The spatial system is composed of biotic and a-biotic components, processes that alter these components and relations between them. An important difference between social and spatial systems is that the latter is mostly described in spatial terms while the first is not. The socio-spatial organisation concept defines social-actions in a spatial perspective (Wisserhof, 1996) and can be used to analyse the interactions between social developments and the spatial system.

Individual Cognitive System

At the level of the individual cognitive system, the ideas, desires and values of individual actors are taken into account. A cognitive system is defined as the general concept that is concerned with "…acquiring information about the world, representing and transforming this information as knowledge, and using this knowledge to direct our attention and behaviour" (Lloyd, 1997). Using its cognitive abilities an actor creates his own mental representation of the socio-spatial system. This representation depends on what Schutz calls a "stock of knowledge" based on which the world is put into a context of relevance (Van Lammeren, 1994). Each actor maintains a relation with the social-spatial system and among other actors using sensory inputs and speech in order to acquire information about the world.
Desires are considered mental representations of the spatial environment, as it should be in order to fit the "needs" of an actor. Desires are however not generated spontaneously. They are the result of driving forces. Driving forces refer to the motivational aspect of the involvement of an actor in a interactive spatial planning process. The driving forces itself are assumed auxiliary to the model. It can be for example demographic growth that generates spatial claims for new places to live. An actor is (probably) motivated to generate desires if these driving forces relate to his area of concern. In general terms we can say that an actor generates desires if there are driving forces that affect his "universe of discourse".

While observing a spatial environment, an actor encounters many objects. We assume a kind of top down search when identifying objects that are of interest for the actor (Lloyd, 1997). What objects are of interest is identified by the desires in a process of perception. *Perception* is a cognitive process that is involved with detection and interpretation of sensory information.

In the individual cognitive system model the term belief refers to the current state of the world that an actor beliefs is true. *Beliefs* are only true to one specific actor. They form the mental representation of the environment based upon individual perception. The beliefs of an actor are the only references he has to the socio-spatial system. Based upon the beliefs it is possible for an actor to compare to analyse and reason about a spatial environment. It is possible (and most likely) that various actors have different beliefs about the same spatial objects.

Values consist of the set of knowledge that an actor uses to compare its beliefs with desires. Using its values an actor analyses a believed situation to find out what spatial functions in a spatial environment are not inline with his desires. Values are part of the social reality and include not only individual values but also values that are common to a society and values that are the result of communication and negotiation. This process of analyses and inference leads to a set of preferences. *Preferences* determine what changes are possible and desirable to accomplish the desired world of an actor.

According to its mental representation of the world an actor takes decisions and actions. These decisions and actions are the result of a perceived difference between a mental representation of the world as it is (a believed world), and a mental representation of the world as it should be (a desired world). *Decisions* and actions of an actor are therefore intentionally oriented towards narrowing the gap between the "word as it is" and the "world as it should be".

3.3 Why Using Gaming in Interactive Spatial Planning Processes?

The ideas encountered in the action-oriented approach and the search-oriented approach match the purposes for which gaming can be used. The strength of the action-oriented approach is that it explicitly considers the organisation of space as the result of action and co-actions of a multitude of actors. This implies that gaming can be used to improve insight into the action, opinions and ideas of actors and the relations between actors. The relation with society is much stronger developed in the action-oriented approach then it is in the decision-oriented approach. Moreover, the strength of the ideas captured in the search-oriented approach is that planning is an explorative process aimed upon searching directions for future development and clarifications of possible states of the socio-spatial environment and the consequences of policy scenarios. The creation of a game-specific model, subsequently play with it and its systematic manipulation/interaction by actors may uncover new questions, and provide means of exploration and experimentation. For example, gaming may provide the possibility for experimentation via a simulation of a proposed or hypothetical system about "unreal" but hoped-for states such as non-violence, absence of war, and desired reality.

The motivation to use a game is two folded:

1. to improve insight in the socio-spatial system;
2. to improve insight in and exchange of knowledge of individual cognitive systems.

Considering the social-spatial system a game might clarify the effect of the socio-spatial system upon the actions of individual actors. Seen from this perspective a game simulates socio-spatial processes. Actors act and react upon these processes. As a result processes in the socio-spatial system change. For example the hydrological situation of the environment might change or the economic situation changes. The game needs to provide indicators that show the status of the various processes in the socio-spatial system.

Also the other way around is possible. Actors encounter by playing a game what restrictions and opportunities are offered by a socio-spatial system in a certain state at a certain time. This means they might learn from the effects of the socio-spatial system. It might be that certain actions are a treat for the economic, ecologic or cultural sustainability of the system. A game-player thus gains knowledge about the consequences of his actions and learns what is desirable or acceptable and what is not. Examples of such applications are found in games like SPLASH or SIMCITY.

If we look at the individual cognitive systems a game provide for a mean to explore individual cognitive systems of other actors. This means that it allows actors to explore and experiment with values and preferences of other actors in the game, without directly "stepping upon someone's toes". Beliefs and desires of others can be compared to own beliefs and desires thus facilitating the creation of a common understanding of a spatial problem and routes to solve this problem. A game in this respect is a model of communication. By modelling – a part of – the communication during spatial planning creates a save environment where effects of someone's decisions and action are virtual.

Another function of a game is that it blurs hierarchies that often exist in interactive planning processes. Such a hierarchy can exist because of differences in knowledge, assertiveness or just personalities. The person that plays isn't important during a game. He or she simply doesn't exist. Figure 7 depicts this idea.

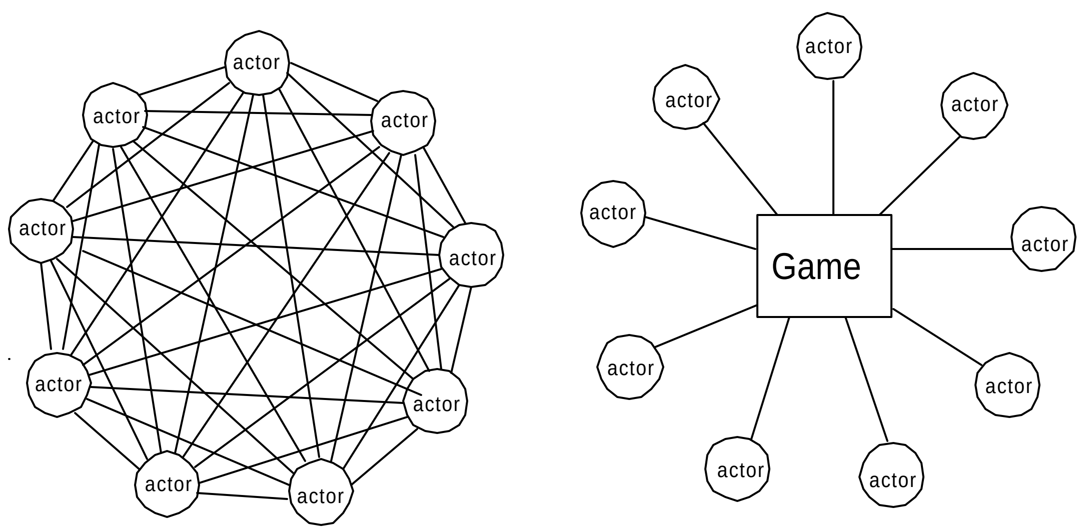


Figure 7: communication in a real world situation (left) and a game situation.

Gaming also opens the possibility to explore the set of values present in the social-spatial system. Players in a game might test those values upon their validity and flexibility.

Gaming, used in a interactive spatial planning process, eases the communication about complex ideas present in individual cognitive systems. A game might support this in various ways: it can offer metaphoric ways of expressing an (spatial) idea, it might allow you to post your idea relative anonymous and avoid the risk of a conflict with an opponent (its just a game isn't it?), it also offers you the opportunity to test your ideas against ideas of others.

Conclusion: games used during interactive planning provide:
- ways to express individual ideas through a shared environment,
- a situation without conflict and hierarchy.

3.4 How can gaming be used in interactive spatial planning?

The first step is to identify the types of situations in which gaming can be used in a spatial planning process (action- and search-oriented approach) and after, map these situations to an appropriate game (i.e. genre, intended audience, communication functions, and basic specifications). The set of situations identified can range from specific to general. For example, discrete spatial choice and the need to represent a spatial-social system; managing uncertainty; generation of alternatives and the expansion of the choice set; information processing; accommodating multiple individual cognitive systems; interacting spatial decisions; resistance to decision-making through consensus building; and education about the problem or decision-making procedures. Mapping these situations to specific functions of gaming proved difficult and some problems were identified including spatial search, representation issues, generating and analysing alternatives, process management, and the need to decompose the situation context to achieve the desired mapping to an appropriate game function.

Table 1 below provides a first indication of relations that exists between situations in a "real" interactive planning process and a simulated process using a game. The table is biased towards role-playing and strategy games.

Table 1: relations between real life and games:

	real life	*game*
Environment		
actors	stakeholders	players, agents
socio-spatial system	model of the real world using verbal expressions, maps, reports etc.	computer generated representation using 2d or 3d graphics, (internet facilitated) information sources.
Knowledge		
about the plan-area	static maps, reports, pictures. Individual based. Incomplete	computer generated maps. background information stored in databases. Complete information accessible by al players
about plan procedures	person dependent knowledge. Often incomplete or “coloured”	computer assisted . Procedural knowledge is stored in and executed by the game.
about others	notes, verbal expressions	chatting, sending messages
Processes		
perception	static maps and verbal expressions of some one else’s perceptions.	dynamic maps, computer representations of someone else’s perceptions
communication	spoken language, drawings, report	chatting (oral or written), broadcasting
generating alternatives	by other actors. Effects upon socio-spatial system are not directly verifiable. Linear process.	other players, agents and simulators. Effects upon socio-spatial system instantaneously visible. Iterative process
information processing	Search procedures and sources depend on the individual actor.	Independent of an individual. Searching procedures and sources provided by the game. Equal to all players
reasoning	about an individual representation of reality	about common representation of reality
interaction with other actors	direct, personal	through game interface, non-personal
consensus building	Based upon communication and argumentation and voting about an individual representation of reality	Based upon communication and argumentation and voting about a shared representation of reality
analyse	notes of meetings, SWOT. often dependant on post processing	log files, indicators generated by the game continuously and on the fly
resistance	discussions, veto, emotional arguments, moral pressure	discussions, veto, simulated emotions, no moral pressure
spatial decisions	effects are anticipated	effects are simulated

A number of issues need special attention when using a game within spatial planning

The first issue is concerned with the level of *intervention* that would be appropriate in a particular context. By intervention, it is meant that a game would possibly provide a context-sensitive structure that enables players who are otherwise unfamiliar with a socio-spatial system to navigate through it. The first, and most simple, is to replicate a path - the player is guided along a deterministic sequence of steps. The second is to present alternatives to the player who selects from among them. The third is to provide a critique of the spatial planning process.

A second issue addressed is related to *configurability.* Different actors, as well as groups, have different views of a socio-spatial system and its representation. One way to consider configurability is to specify a set of generic operations that would encompass the types of operations and player tasks that need to be supported by the game. Once this list is compiled and made available it can be structured hierarchically to provide different "depths" of intervention.

The *task analysis* would prove useful in accomplishing the goal of supporting intervention. A taxonomy of interaction patterns between players will be required. Task analysis would also help to identify a series of game specifications - generic procedures, indicators, rules, etc… that will support the player's tasks.
Finally, the *roles* would need to be supported in a way by the facilitator or mediator that would best enable to accomplish the tasks. One of the role assignments of the players, for example, is to understand a problem so that it can be defined and alternatives generated, communicated, and evaluated. A key element in this process is learning that enables players to understand their problem better.

Consider, for example, a complicated set of resource planning activities occurring in a watershed, which is largely privately owned and contains an internationally significant wetland site (e.g. a NATURA 2000 site). There is a considerable concern that this unique wetland community is threatened by agricultural land use practices. Gaming would be helpful to address the issues of natural resource management by prioritising natural resource problems and identifying feasible solutions among players. In this case, the set of situations can vary from introduction of a problem, creation of a common perspective to thinking out alternatives. The roles of farmers, conservationist and regional economists will need to be supported by the game such as,

- Farmers who 1) want to retain full control over their land (private property rights issue); 2) want to maximise farm revenue, and 3) have concern for erosion control.
- Conservationists (public and private) who want to conserve the ecological vitality of the wetland community,
- Regional economists who are looking for ways to diversify and bolster the weak regional economy of this area through agricultural, industrial, and recreational opportunities.

The level of intervention expected within the game should provide a critique of the spatial planning process and the allocated tasks to players need to be developed for the evaluation, comparison, and display of differences between competing scenarios. By structuring the game as a "society of decision making" players can develop conceptual representations for a specific socio-spatial system by defining a network of interacting human and an automated computer game. Players will achieve an understanding of how policy and management initiatives effect the socio-spatial system. Therefore, the central theme of the gaming exercise will be to convey the "big picture" at least to the extent that a correlation can be made among the players regarding the issue at hand.

4 General guidelines for designing a game

This chapter shows our first attempt in the identification of the main requirements involved in a game design process. Game design is primarily an artistic process, but it is also a technical process. The game designers pursue grand artistic goals even as they are faced with mountains of programming code. The gold rule in designing a game is to start with the choice of a goal and a topic. This vitally important step seems obvious, yet is ignored time to time.

A game must have a clearly defined goal. This goal must be expressed in terms of the effect that it will have on the player. It is not enough to declare that a game will be enjoyable, fun, exciting, or good; the goal must establish the message that the game will support and the types of communication modes it will engender in its audience.

How do you select a proper goal? There is no objective answer to this question; the selection of a goal is the most undeniably subjective process in the art of computer game design. However, it is possible to delineate the process of a game design by identifying its main distinct phases.

In Section 5.1 the overall game design process is described as having four distinct phases. They are the Initiation, Design, Construction and Use Phase. These phases are then used in the remaining sections to describe the functional, operational and technical requirements and their respective specifications. They have been selected due to their important role to complete a design of game that can be used in an interactive spatial planning context. Therefore, our list of requirements and specifications can be seen as exemplary rather than exhaustive.

4.1 The Gaming Design Process

Designing a game is a complex matter. Differences of opinion exist on what is the key practise in this process. Stating the message that a game has to carry out is regarded a very important first step by Versteegh (pers. com.: 2002). A proper system analysis to analyse the actors, their tasks and responsibilities and relationships between actors in a system is named by Duijn (pers. com.: 2002) as an important action to start off the gaming design process. Duke (1974) gives a general description of the gaming design process as an iterative process in practice with four main distinct phases

Initiation Phase

During the initiation phase, the designer analyses the communication/learning problem at hand. This requires taking into account the nature of the player, intended use of the product, the audience, the subject of the message, and exactly what communication purpose is to be served (for example, questionnaire, interdisciplinary dialogue, training). Pragmatic constraints of cost and time must also be considered. On the basis of this analysis, an appropriate medium for communication must be chosen.

Design Phase

If the choice is gaming/simulation, the designer continues to the design phase. A conceptual map must be developed containing the general statement of the ideas to be conveyed through the game. A review of the state of the art of gaming helps to determine the nature of the game being designed. The basic components (scenario, symbolic structure, and procedures) are developed in a concept map, which outlines the form the game will take and work that must be done to bring the game to completion.

Construction Phase

During the construction phase, the gaming vehicle is created and appropriate data loaded, calibrated, and tested. Finally, the game is reproduced and the game is put into operation.

Use Phase

The use phase entails a set of responsibilities of designer to player, and player to designer. Final effective use of the game will, in many cases, be constrained by mechanisms and associated costs. These should be thoughtfully anticipated since problems often yield to sophistication of the technique.

4.2 Functional Requirements

Functional requirements need to be defined during the initiation phase of a game design process. Functional requirements refer to the intended audience and the purpose that needs to be achieved by playing the game. Before designing a game it has to be known who is going to play the game and what they need to get out of when playing the game. Depending on the function, it can be decided which specifications the game can fulfil. A game is more situation-specific than any other form of communication, therefore it is important for a game designer to have in mind the message and the media used to convey it. This will also give some assurance that gaming is an appropriate media choice. Table 2 provides an overview of the main functional requirements and their corresponding specifications.

Table 2: Functional Requirements

TYPE	SPECIFICATIONS
Pragmatics	Resources Game Environment
Situation Definition	Intended Use Audience Subject Function
Dissemination	Game Genre Message

Resources: When considering resources for game design, both cost and time are essential factors. The resources required to design, construct, test, and disseminate a game must be considered, as well as the cost encountered each time the game is used. A game may cost as little as one or two manpower days or may run into hundreds of thousand of dollars.

Game environment: This includes the conditions under which the game is expected to be played.

Intended Use: Careful thought should be given to the context of use of the final product. Is it to be an isolated and free-standing product employed randomly as the occasion may demand? Will it be employed in a public relations program? Or for citizens use in discussions of public policy?

Audience: It is imperative for a game designer to have in mind his intended audience, their motivations for participation, and typical conditions of use. The game will be intended for a single player, or a multi-player audience.

Subject: The subject of a game must be specified in the most precise way. The specification of substantive content may take the form of written reports, abstracts, or detailed subject outline. The client who commissions a game without some such document may discover that the final product is not relevant to his purpose.

Function: There are several functions for which gaming can be employed (see 2.4 for the detailed list of functions).

Game Genre: Game designers will admit under close examination that they sought to produce a "fun" game, or an "adventure" game, or a "strategy" game.

Message: A game message attempts to define a multidimensional, simultaneous, systemic, complex, and interactive situation. A game always contains a message, either explicitly or implicit (conscious or unconscious). A game designer often fails to have the message clearly in mind at the outset, which results in an ambiguous product.

4.3 Design Requirements

Design requirements are usually defined in the design phase, which is the least understood, most underdeveloped, and most crucial of the entire design process. Games designer have often skipped the design phase (design requirements) to begin with the construction phase (implementation requirements). Table 3 provides an overview of the main design requirements and their corresponding specifications.

Table 3: Design Requirements

TYPES	SPECIFICATIONS
Design Principles	Models Game steps
Vehicle	Data Information Flow and Sources
Repertoire of Techniques	For controlling player involvement For information loading Staging the game run For a smooth-running game Techniques employed in learning through games

Models: In games three forms of models occur in games: systems, simulations and heuristics (see also operational requirements). The choice for a specific model depends on the audience, message and audience of a game. A balance exits between the simplicity of a game to make it workable and the complexity of the game to make the game attractive (pers. com.: Versteegh, 2002)

Game Steps: They are extremely important to a player as well as a designer. Games are iterative, meaning that the cycle follows cycle and that the happenings within a given cycle repeat and reinforce those that have preceded it. It is crucial, therefore, that players be carefully introduced to the steps of play.

Data: : It is important to define the data needs for the game such as the definition of data items, sources of each item, rules for determining accuracy, etc..

Information Flow and Sources: Players must be permitted to pursue any angle of the subject from any perspective which seems relevant to them at any time. They must be provided with both a system overview and sufficient detail. The information provided, in terms of quantity and depth, is dependent on the game function, the sophistication of the players, and the conditions under the game is normally expected to be played.

Repertoire of Techniques: The choice of techniques is extremely important because it must be in harmony with the purposes and characteristics of the players.

4.4 Implementation Requirements

Duke (1980) describes implementation requirements as game elements. He specifies 11 game elements that can be regarded as the building blocks for a game. Implentation requirements should be defined in the construction phase. Table 4 provides an overview of the main game elements and their corresponding specifications.

Table 4: Implementation Requirements

TYPES	SPECIFICATIONS
Game Elements	Format Rules Policy Scenario Events Roles Decisions levels Score model Indicators Symbols

Format: Format defines the structure of the game. A game consists of different levels and every level has its own function in the game. Versteegh (pers. com.: 2002) gives an example of a format of a game as being the following:

- play
- recall (the decisions made by the players, game steps etc)
- solve (the problems that arose during the game)

The above format can be seen as a cycle that can be followed up by another one.

Rules: Games always contain a set of appointments or rules that can't be changed or influenced by the players. These rules define the space the players have to play the game.

Policy: Policy can be defined as rules that may be changed by the players. These are the tools a player had to set his strategy.

Scenario: Scenarios provide the framework in which issues from various fields affecting the practical problem are integrated and bounded (Toth, 1988). The beginning of the scenario is always some time before the starting point of the game. A short history describes what has happened between the beginning of the scenario and the starting point of the game.

Events: Happenings that disturb the daily routine in the game. They can be regarded as updates of the scenario. Events provide an extra element of excitement in the game (pers. com.: Elswijk and Maat, 2002).

Roles: An overview of functions and activities that can be divided among the players during a game. A role is not limited to one player, having two players play the same role has the advantage that they can learn from each others mistakes and fortunes. They also have to make their own thoughts and tacit knowledge explicit, which makes them more aware of their own behaviour (pers. com.: Hofstede, 2002). Assigning players to a role other than their function in normal life can provide the players with better insight in the motive of people normally fulfilling the function (pers. com.: Versteegh, 2002).

Decisions: Decisions that have to be taken by the players themselves. Making a wrong decision can be a major learning event in a game. However, if a player makes to many mistakes and therefore is not able to compete anymore with the other players, interest in the game will easily be lost. To keep players motivated possibilities to undo or make up for a mistake are necessary (pers. com.: Versteegh 2002).

Levels. Games can have different levels of difficulty built in. This makes the game more interested for a larger audience, since the easy levels offer challenge to a beginner, while the difficult levels offer challenge to an expert.

Score model: An instrument to calculate, register and present the result of the players. It is a very important tool for making the game attractive to play (pers. com.: Elswijk and Maat, 2002).

Indicators: Indicators give the players hints about their achievements. They are an important tool to keep players motivated and focussed on the game.

Symbols: Visuals that symbolise an element, activity or decision. Well-chosen symbols help to understand and play the game.

5 Case study - SPLASH

In this case study we tried to transform the concepts which were discussed in previous chapters into concrete design recommendations. SPLASH, which is a prototype game about water management, was used as starting point. In the first paragraph the current status of SPLASH is explained. The second paragraph suggests a number of functions for which an adapted SPLASH can be used. Based on one of these functions design recommendations are dealt with in the final paragraphs of this chapter.

5.1 Current Status of SPLASH

SPLASH is developed with the purpose to give players insight in all (social, economical, technical and environmental) aspects related to water management. The current version of SPLASH is still a demonstration version to show how a game dealing with issues around water management can be implemented. The SimCity game served as a base for the development of SPLASH.

SPLASH is a single-player game. The player plays the role of a super water manager with extended tasks. He can designate land for nature, farming, housing, industry, recreation and he can wipe land clean. He can also build water pumps, water reservoirs, water cleaning installations, measuring stations, water towers, distribution centres, irrigation systems and dykes. At any moment he can check the current status of the region. He can view different map layers with the zoning plan, the water supply in general and for the inhabitants, the food supply, the work supply, happiness of inhabitants and the pollution and warning symbols. The amount of decisions, which the player can take, is limited by a budget and the height of the budget is determined by the progress in the game.

The happiness of stakeholders (environmentalists, farmers, industry, housing, recreation, union, food security and government) depends on the player's actions. Their worries or happiness is conveyed to the player by means of newspaper messages. In order to perform well he has to take the interests of these different stakeholders into account.

The water manager is confronted with weather events such as floods. He does not have any influence on the occurrence of these events, but he can take measures to cope with this type of events (e.g. building dykes).
SPLASH is a continuous game, this means there are no rounds in the game. Once the player pressed the start button, the time starts running. A time label shows the months and years, which are passing by. The player has the options to let the time run slowly, fast, very fast or to pause.

Different mechanisms (models/calculations) are built into SPLASH in order to calculate the effects of the player's actions (e.g. if people actually move to places where the water manager planned housing) and to let other things happen (e.g. a flood) in SPLASH. Because SPLASH was just a demonstration version, these mechanisms are not yet based on academic models such as hydrologic or economic models.

5.2 Proposed functional requirements for the improvement of SPLASH

SPLASH needs to be further developed before it can be useful for an audience. In what way it has to be improved, depends very much on the combination of audience, the function it has to fulfil and the message that needs to be conveyed.
The following audiences and their respective main functions and messages of SPLASH are identified:

Function 1. **Communication** of water management issues within spatial planning in relation to climate change thus helping to create awareness among stakeholders for each other perspectives about how to deal with the effects of climate change in water management.

Change in climate conditions have more and more major impacts in many parts of the world. Floods, droughts and other extreme climate events, such as hurricanes, add to the other major problems (such as population growth, urbanisation and land use changes) which water managers are facing. Every year climate events inflict severe damage on humans and the environment in many parts of the world. Unfortunately, we can do little to control the timing and intensity of such events in the short term.

In the short term the only solution is to increase the capacity to cope with increasing climate change. A simulation game can be deployed to improve the awareness about the impact of measures that can be taken among the relevant stakeholders. These stakeholders can be policy makers, water managers, representatives of industry, agriculture or consumers. A simulation game should bridge information and communication gaps between the water and climate sector (as well on scientific, policy and operational level), generate widespread awareness, and make knowledge available about policy and management solutions.

The central message of the simulation game would convey the impact of the economic, social and environmental measures which can be taken by the water and climate sectors for dealing with climate change in the future. This is particularly true in developing countries, where the financial, human and ecological impacts are potentially greatest. In these countries water resources may already be highly stressed and the capacity to deal with extreme climate conditions is weakest.

Function 2. Let policy makers **observe and test a new reality**, which is the (long-term) effect of their actions (ex-ante policy evaluation).

In general it is difficult to transfer research results to policy makers, especially when it is about long term effects of (policy) measures. A simulation game to convince policy makers of the seriousness of long-term effects would be very useful. During the simulation game policy makers will be confronted with the effects of their own actions in the long run and they will experience the new reality they created.

In Southeast Asia, for example, peat soils at the tropical shores are used for agriculture. Currently the policy makers have the tendency to start pumping the water out of these peat soils whenever these agricultural grounds are inundated. They do not realise, however, that this will result in serious subsidence of the ground after thirty years. This pumping policy also diminishes the capacity of the peat soils to serve as drink water reservoirs, which could capture the huge amounts of precipitation in these areas. In a simulation game policy makers have to deal with these long-term effects. Also knowledge about related issues can be transferred, such as that ground water level needs to be different for different agricultural purposes (e.g. the ground water level may be higher for growing oil palms). Other problems in the tropical areas where policy makers can learn about are what to do with the surplus of water or what is the effect of irrigation in the arid areas. A simulation game will confront the policy makes with a ground, which has become too salty because of this irrigation.

The main message which need to be conveyed to the policy makers is that it is important to consider the long-term effects of policy measures.

Function 3. **Development of knowledge** and giving an overview about water management to students (e.g. during water management courses)

A simulation game which students can use to test out different water measures or other policy options and to confront them with the effects, would be very useful for the learning process. Such a simulation game can also give them an overview of water problems in relation to other type of problems (e.g. housing, food supply, and health), it will provide them with a broader perspective on water management.

Most messages around water management will be useful for the students water management. A simulation game about the capacity to cope with climate change in water management can be useful (see function 1), but also a game about the long-term effects of water management in peat soils (see function 2) can be worthwhile. The overall message that needs to be conveyed to the students is that water management can not be dealt with in isolation.

5.3 Proposed functional and design specifications for the improvement of SPLASH

In this case study function 1 (**Communication** of water management issues within spatial planning in relation to climate change thus helping to create awareness among stakeholders for each other perspectives about how to deal with the effects of climate change in water management) is chosen to give an example on how this could be implemented in the operational and technical specifications. For this function it is a pre-requisite that the game becomes a multi-player, because communication among stakeholders is of prime importance.

Game environment

The game will be played at large events, such as conferences, workshops and symposia. Such large events play an important role in the communication of climate change conditions or other situations according to different stakeholders perspectives with regards to water management policy, issues and research.

Audience

The audience at conferences on climate change are expected to be a group consisting of members with different roles, such as policymakers, water managers and scientists. These roles will be made available in SPLASH. This means that interested stakeholders can play their 'own role' or choose to play another role. In this case the game helps to develop a better understanding of each others perspectives.

Function

Communication of water management issues within spatial planning in relation to climate change thus helping to create awareness among stakeholders for each other perspectives about how to deal with the effects of climate change in water management.

Game Genre

SPLASH will be a strategy game in which indicators will be used to communicate the success or failure of the water management decisions of the individual players according to climate change conditions that can provoke events such as flooding, droughts, fire etc.

Message

The message that SPLASH will convey the impact of the economic, social and environmental measures which can be taken by the water and climate sectors for dealing with climate change in the future.

Model

In analogy with SimCity, SPLASH tells the story of a map changing over time. Its primary narrative agent is geography. In order to incorporate above processes, it is necessary to change the main story line into the quantity and quality of water flows between locations. For this purpose a realistic but simplified hydrology model should be added as part of the overall model.
Furthermore, at least the following processes/interactions need to be included in the model:

- climate variability and climate change and its effect on precipitation,
- the coping of infrastructure with superfluous water
- the effects of floods (economic losses and number of casualties) depending on the precautions taken,
- price of water and the water demand.

Game steps

Distinct time slots will be implemented into SPLASH. Short breaks in between these slots are used for evaluation and feedback. During each break the players get the chance to focus at the same time on the current state in the game. This will help the players to integrate their learning experiences.

5.4 Proposed implementation specifications for the improvement of SPLASH

The list below gives a short description of the adaptations which need to be addressed during the design of a new version of SPLASH for function 1. The adaptations are listed for the relevant implementation specifications (see 4.4).

Format/Cycle

A game can never fulfil the function it is developed for without a debriefing phase in a gaming session. Currently there are no mechanisms in SPLASH, which can trace and evaluate the steps that have been taken by the player. However, this type information is needed in order to evaluate the performance of the player. Ideally, SPLASH is automatically re-played in the debriefing session. During this re-play, all the decisions are supplied with commentary about why these decisions were right or wrong and possibly also what alternative decisions could have been taken. At least a summary should be given about the performance of the player at the end of each gaming session, by showing the development of a few indicators over time: the happiness of the different stakeholders, the damage by floods, the budget. Finally, it would be useful to save the state in SPLASH whenever a player wishes to save it. In this way different strategies from this state onwards can be tested.

Decisions

Currently, the measures which players can take are mainly designating land for a particular purpose or build something at a particular place. All these decisions are geographically oriented. The players should however be able to take decisions, which are not directly related to building something new at a certain spatial location. Decisions regarding pricing, early-warning systems or improving the sewage system are also relevant. The game should be re-designed so that a player can take this type of decisions.

More feedback about the players' decisions will be generated. Feedback will be given about why a particular location is suitable for a particular purpose. After the player planned a destiny for a certain piece of land, the reason should become clear why (or why not) the simulation will start using this piece of land for this purpose. Feedback mechanisms and hints need therefore be added and improved.

Scenarios

Scenarios need to be developed. Especially attention has to be paid to the initial state of the game. The simulation game has to deal with the water management problems of today. Therefore, it is necessary to have an initial state which is a good representation of the land use nowadays (compared to the current SPLASH this means that much more of the land should already be in use at the start of the game. Consequently dilemmas such as that people have fewer possibilities to move away from flood prone areas (because most land is in use), will emerge sooner during a playing session. Furthermore, the history that led up to this initial state should be described briefly. This will help the participants to identify themselves with their roles. Also the assignments in the role descriptions should refer to the beginning situation.

Indicators

The map in SPLASH and its different map layers give an indication of the status in the simulation game (the locations of settlements/industry/agriculture, the water supply, the pollution). This visual aspect of the game needs to be made more appealing for the players implementing the current graphic technologies. Graphs give details about the way a few important indicators change over time (e.g. the national yearly income, the number of casualties per year etc.).

3D-visualisation can make the effects of actions even more realistic. Especially when effects such as subsidence of land or flooding are important, 3D-visualisation would have an added value.

Game Levels

The game will be built for only one level of difficulty. It is assumed that the players (policy makers, water managers, representatives of industry, agriculture or consumers) have already knowledge about many issues around water management, but that they lack a common understanding about issues around climate changes. For example, they do not agree if climate variability needs to be dealt with, how this can be dealt with and how possible solutions relate to other measures. The level will be based on an estimated average of knowledge of the intended audience.

Events

Multi-media effects will strengthen the impact of events such as floods and droughts in the game. During a flood villages, industry, agriculture etc. will be partly washed away. The production of agriculture, the budget, happiness of people will also be affected by this type of events. When extreme poverty is a result of the players' actions, terrorist attacks are included. These effects can happen suddenly and unexpected which adds an extra thrill to the game.

Roles

SPLASH will become a multi-player game, because the main goal of the simulation game would be to get a common understanding among a group of stakeholders. This objective can be reached if stakeholders play the game at the same time and undergo a common experience. The following two types of multi-player games will be built into SPLASH.

- Multi-player based on different stakeholders operating in the same region (farmer, government, industry, water manager etc). A separate set of decisions and a set of indicators that give information about performance will be defined for each stakeholder.
- Multi-player based on one type of stakeholder, most likely a super water manager, but each water manager acting in a different region. All the players will have access to the same kind of actions. This game will focus on the interaction between upstream and downstream problems. In this case the game must be organised so that each player can take decisions in only one part of the overall region.

Which multi-player type is used, will depend on the composition of the group of players. If the players are, for example, all water managers the latter option is chosen. (The multi-player type can be changed in the configuration).

Score model

The score model improves the competition among players because it provides information about who is winning and why during the game and afterwards. Therefore it is very important to develop evaluation tools such as overviews of the status of the various indicators and a transparent way of calculating the final score for each player.

Testing

The audiences in all three functions are stakeholders from different countries, policy makers in tropical countries or international students. Therefore, it is useful to let the game be tested by international students. Children are also a good test group, because they are very used to playing computer games and have developed a good sense for what is an exciting game and what is boring.

5.5 Concluding remarks

Future of SPLASH

At the moment SPLASH is a prototype game about water management. During this project a 'track and trace' module is built to support SPLASH. This offers possibilities to save and restore a game, go back several steps during a game and to evaluate the game in relation to the status of the indicators. These extra functionalities are extremely important during evaluation/debriefing sessions.

It is planned to develop SPLASH further into an operational game as described in chapter 5 in co-operation with UNESCO to be played at the 3rd World Water Forum in Kyoto in March 2003.

Why a game?

It is reasonable to question the need of a game to communicate impacts of economic, social and environmental measures that can be taken by the water and climate sectors for dealing with climate change in the future. Would a presentation or demonstration of a simulation model not be just as effective?

Advantages of using a game in this particular situation are that a game offers a safe environment in which can be experimented, that individual ideas can be expressed through a shared environment, but without conflict and hierarchy. In a game communication evolves differently (figure 7, paragraph 3.3) than in a real world situation. Stakeholders communicate through the game with each other, but do not have personal contact with each other otherwise. A game takes away effects of hierarchy and conflict, since communication only takes place via the game. In some cases the aspect of anonymity can be used to help to overcome problems of hierarchy, so that a player can not be sure which actor in the game is which specific player.

It is important though to realise that a game really is a game and differs from a decisions support system or a simulation. A game has to have the characteristics of challenge, fantasy, curiosity and control (2.1). Technical requirements such as events, scoremodel and scenario are very important to create these characteristics. Games and gaming do have a clear added value in a land use planning process. The step from just considering a game something that is nice to play alongside the serious work of doing spatial planning towards games as valuable tools that make discussion and decision-making more open and participative still need to be made.

Future Research

Computerised games are rarely used in the interactive planning process. Additional research is needed to find out more about the lack of interest for using such games. A start will be to identify appropriate stages of the interactive planning process during which a game can be useful: Question like till what extend are games useful during brainstorming and formulation of goals, solving allocation problems, designing spatial scenarios, supporting “tit for tat” processes amongst stakeholders etc. still need to be answered in detail. This kind of information will help to define the audience, function and message of the game and subsequently will help to decide what requirements those games need to have. An another important issue is the question how to build games that connect better to the way people communicate en perceive the environment. Issues like 3D representations, animated agents that show emotional capabilities and speech-recognition might help us to build games that are more intuitive and more natural to play with.

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