Using Virtual Environment Technology to Improve Public Participation in the Urban Planning Process

T.L.J. Howard[1], N. Gaborit[2]

Abstract: This paper explores the use of Virtual Environment (VE) technology in urban planning. The case we select is that of public engagement with the process of government, which in its traditional form suffers from several limitations. A 3D cityscape environment has been implemented, where people can observe planning changes, access information, and comment on proposed designs. Our research focuses on the mechanisms of interaction inside this environment.

We propose that VE technology will facilitate and improve useful engagement by the public in the planning processes, unlike the traditional consultation process. In order to test our hypothesis, we have built a VE city model. Early results have shown that the model was suitable for general public use, in terms of technological availability and usability. This paper presents results of experiments undertaken with the general public and urban planning professionals to judge their motivation in using this technology as a way to facilitate public consultation in the planning changes.

CE Database subject headings: urban planning, public participation, computer applications, computer graphics.

[1] School of Computer Science, University of Manchester, Manchester M13 9PL, United Kingdom

[2] School of Computer Science, University of Manchester, Manchester M13 9PL, United Kingdom

Introduction

The Consultation Process in Urban Planning

Public consultation has become an important task for promotion of urban planning projects. The idea of citizen participation has grown in the United States with the advocacy planning movement during the 1960's (Kurzman 2000). It has expanded during subsequent decades, being reshaped and redefined by politicians, planning professionals, developers, activists, and citizens. Planning theorists studied the behaviour of the public in their concern and involvement in planning issues. We can quote L.W. Milbrath (Milbrath 1965), and S. Arnstein who developed a theory in 1969 called the “ladder of citizen participation” (Arnstein 1969).

A public consultation is usually presented as a hearing, where people have access to information using different media, such as 2D images (for example paper or posters), video presentations, or physical small scale models. The information is exposed in public buildings, such as City Hall, and people can visit the exposition and leave feedback. The way they leave feedback is simple, usually writing comments in a notebook. Sometimes they can also engage in dialogue with planners or architects. There are now a few projects which are delivered over the Internet (Kingston 2002). However the process remains basically the same, as the only main difference is the medium used to transmit the comments. However the availability of the proposals on the Internet is a factor of increasing public involvement.

These ways of consultations have some limitations in common:

- First, there is a lack of interactivity. All used media are passive. There is no way for people to navigate freely inside the environment, to pick their own perspective, and there is no way to modify the environment.
- Then, there is a lack of feeling of immersion. Indeed, with a physical small-scale model because of its scaling limitations, and without the ability to navigate freely inside the model with static 2D medium or video information, it is very difficult to feel immersed inside the environment, because of the lack of a feeling of “freedom”.
- Finally, the comments are limited. As they are usually informally written in a notebook, they lack precision. It is indeed difficult to write a comment on a specific object or view without a clear reference. And, they are restricted to general comments. This is a direct consequence of the lack of interactivity, as it is impossible to get a specific local point of view, it is obviously impossible to comment from it.

These limitations lead to non-exploitable results for planners and can explain the lack of interest in urban planning from the public (Allmendigner et al. 2000, Laurini 2001, El Araby 2002). This paper presents an alternative way to consult people, by using a Virtual Environment (VE) to model the proposal area, in order to improve the consultation process and really engage public in the planning process.

Virtual Environments

The term “Virtual Reality” (VR) was possibly first used by Jaron Lanier, one of the pioneers of the field, in 1989 (Kelly et al. 1989). As it is used in many different contexts, it is not easy to give a precise definition of VR. Aukstakalnis and Blatner gave a general definition of VR (Aukstakalnis and Blatner 1992): “Virtual Reality is a way for humans to visualise, manipulate and interact with computers and extremely complex data.”

VR is about the use of computer science technology to simulate an environment, with which people can interact. This field has grown in the last decades with the rapid development of computer technology, especially cheap, but very powerful, consumer-level PC graphics cards.

A Virtual Environment (VE) is the space within which a VR simulation is undertaken. VE research is only a part of VR research, as it focuses more on the software rather than hardware. That means it does not deal with the use of devices to enhance the feeling of immersion of people. Therefore, VE research is about visualisation of 3D environments and interaction which can be performed using standard devices, such as a mouse or a keyboard.

There are many applications of VEs, such as data visualization, vehicular simulation, and entertainment. In this paper we focus on its application to urban planning and architecture. Indeed, with the recent increase of 3D hardware it has become possible to visualise large scale environments, such as cities, in real-time. Therefore, VR can be considered as a new tool for urban planners and architects (Schmitt 1993), extending the computer science technologies which are Computer Aided Design (CAD) and Geographic Information Software (GIS). We now review research in this field in the next sections of this introduction.

Stand-alone City VEs

First we explore the use of city VEs, which are stand-alone, meaning that they are not connected to any external database, which have been used in the urban planning context. Research in this direction includes the Virtual Edinburgh city 3D model, designed by the ABACUS group (Ennis and Maver 2001), accessing 3D data held electronically by the national mapping agency (Maver 1987), which has been used to show the visual impact of planning proposals. Another example is the work of the CASA (Centre for Advanced Spatial Analysis) group from University College London and the University of Bath, who have developed a VRML model of Bath (Bourdakis and Day 1997) and made it available on the Internet. These models are realistic enough for public participation, but have limited interactions, since it is not possible to perform real-time modification or leave feedback on the system.

VEs from GIS Data

A natural way of making VE technology available for urban planning is to improve existing software. This is the idea of building city VEs from GIS data. More overtly urban uses have included work by CASA on the integration of GIS data into cityscape presentations of the City of London (Dodge et al. 1997, Batty et al. 1999), by developing a 3D plug-in via VRML from the existing ArcView GIS software (ESRI 1992) to visualise the city in 3D over the Internet. Related work is the VRML-based interface to GIS called GOOVI-3D developed by Fraunhofer Institute of Computer Graphics in Germany (Coors and Jung 1998), which made available over the Internet a model of Frankfurt, allowing people to access and interact with a GIS database. KARMA-IV (Verbree et al. 1999), developed by the Delft University of Technology in the Netherlands, is a system which combines GIS, CAD and VE technologies, by using three representations of an urban environment, in order to ease the information access process. Another important work is CommunityViz software (ERSI 2001), a decision support system extending ArcView developed from 1997 to 2001 by the Orton Family Foundation, which is used by professionals for community planning. Finally, there is the idea of dynamic generation of a 3D model from a GIS database using a web interface, illustrated by the GeoVR system (Huang and Lin 2002) developed by the University of Hong Kong, the Sheffield Urban Contextual Databank (SUCoD) (Peng 2003) from the University of Sheffield (UK), and research work from Old Dominion University (Norfolk) and Southwest Jiaotong University of Chengdu in China (Zhou et al. 2006).

Resulting environments include the possibilities of information access, as they are linked to an external database, and some of them can be used by professionals for design purposes. However, for the general public, they are mainly limited to visualisation and data access, and do offer other scope for interaction such as 3D real-time environmental modifications and the ability to record feedback, which is a key interaction in the public consultation process.

Interactive Environments

The environments reviewed in the two last sections allow people to visit a 3D environment and access information about it, but they do not allow more advanced interactions with the VE. We explore in this section examples of more interactive VEs.

CASA developed the Collaborative Virtual Design Studio (CVDS) system (Dodge et al. 1998), using Active World (Active Worlds Inc. 1995) technology to make it accessible over the Internet. The idea of this application is to allow people to communicate and perform synchronous real-time modifications of the environment, which is an interesting idea. However, this system has limitations for real urban planning use because of the low complexity of the model, and does not include feedback recording.

The Urban Simulation Team at UCLA, led by Professor W. Jepson, are developing a large very accurate 3D model of Los Angeles, linked to the ArcView GIS software, and an urban simulator to interact with the model in real time (Jepson and Friedman 1998, Snyder and Jepson 1999). The aim of the urban simulator is to explore different planning scenarios, over space and time, by navigating and performing environmental modifications in real-time, and has been used in numerous urban planning projects, and in other areas, such as car navigation, tourism and historic reconstruction. The accuracy of the model allows people to view planning proposals in a very realistic way. However, there has been no further development for a public consultation use, as there is no idea of feedback recording. Furthermore, because of the size of the Los Angeles model (it is projected to reach 1 terabyte), it will be difficult to make the model accessible to a large audience over the Internet.

Finally, T. Manoharan from Heriot-Watt University has worked on designing a prototype VE to be used in the whole urban planning process, after having studied the general requirements of such a model by interviewing professionals from the urban planning field (Manoharan 2003). This is the most complete model regarding public participation, as it allows people to view information about the proposal itself, and is the only system that stores user comments. However the public consultation features from this application remain basic, as for example recorded feedback is only of general nature, not exploiting the spatiality of the environment. Furthermore, there has been no user-based experiment to test the application on general public. These experiments are necessary, as an application providing public consultation must have the approval from public. This paper focuses on this issue.

Applying VE technology to the consultation process

Motivation

Having reviewed in the previous section VE technology involving 3D city model representation, we saw that these technologies have proved to produce fairly mature software. However, this software is mainly reserved for professionals, providing none, few or at best basic public consultation features. Indeed, for most of the models there is the idea of showing to people the development of the city, but without other forms of interaction. There was only one model allowing people to record general feedback on the system. But no other forms of interaction, such as leaving precise feedback on the model or proposing environmental changes have been investigated. Furthermore, there is no example of an experiment with the general public to study their use of such technology. Thus, it seems interesting to investigate in more detail the idea of using VE technology for public consultation. Therefore, this paper explores this idea, by performing user experiments using a prototype model, to assess if the general public will be able to use such an application and leave positive feedback about the approach.

Unlike urban designers, who work mostly with 2D design, in the public mind cities are three-dimensional edifices, so people naturally expect a planning proposal to be presented in 3D, and find such a presentation easier to comprehend and work with than 2D models. This, of course, has been done with the introduction of physical models. However such models are often presented as “clean” architect’s models, unlike the situation presented as (possibly) unpleasant photographs of reality. A first advantage of the VE technique here is the possibility to show a neutral presentation for both the existing and the proposed situations. Combining the visual realism and the freedom of navigation offered by a VE, members of the public could more readily compare their direct experience of reality – using the VE model of the *existing*, and the VE model of the *proposed*. Furthermore, alternatives can be presented side-by-side. Another advantage of using a VE is to offer enhanced interaction to the participants of the consultation. At a minimum level, members of the public would be able to offer comments – a kind of “graffiti” – on the proposals. At a higher level, people could suggest design alternatives. Finally, the possibility to deliver a VE over the Internet will surely increase the number of participants in the process, as people can use their own home computer to visit and interact with the city environment, and do not have to attend hearings. More detailed reasons of using VE technology for increasing public consultation are available on a study conducted in the UK (Bulmer 2001).

Case study

We now describe a public consultation process example during an urban planning process which would use a VE. Figure 1 shows how the VE is used in this process.

First, an urban planner observes city data, and decides that an area of the city needs to be redesigned. This observation can be done using a GIS database linked with the VE. This is the stage of political decisions.

Then, he asks an urban designer to propose design alternatives of this city area. The designer proceeds with the design, and includes his proposals to the VE, editing the 3D model.

Next, the VE is opened to public consultation. This is the stage of urban planning we are interested in here. People visit the environment to observe the proposals, leave feedback on the environment, and may propose other alternatives by modifying the 3D model.

Then, the urban designer can collect this feedback by different ways:

- He can observe how the public modify the model.
- He can read the feedback they leave.
- He can communicate with them during the consultation. The communication process can be mediated by human mediators.

After analysing this information he can alter the city design or report the feedback directly to the urban planner who can then make new decisions.

Improvements to the process

As shown by the case study, there is the possibility of model modification during the consultation process. Indeed, as opposed to traditional consultations, which show a fixed representation, a VE permits the modification of the model, even in real time, within the process, making possible a more dynamic consultation process, as it becomes possible to refine the proposal during the process.

A second asset of a VE is the possibility to expose the user to different levels of detail, and so to be able to gather the different stages of the decision process, which are:

1. Design of the different planning proposals
2. Choice of a final proposal from the different alternatives developed
3. Refining of the chosen proposal

The first step uses a very low level of detail, as at this stage no precise decisions are made. People could be consulted at this step, entering the VE displaying a rough virtual “sketching” of the proposal. They could then leave their opinion concerning the proposal idea, and explaining their needs. Precise feedback could be used to show some local concerns. However, modification changes are unlikely to be proposed at this step because of constraints rules in urban planning concerning large objects.

It is also possible with a VE to simultaneously present different alternatives of a proposal, and so to carry out public consultation in the second step. Indeed, people would visit the different proposals and vote for the one they prefer. They could argue their choice by leaving precise feedback on each proposal, and so planners would have a better understanding of their choices, and then select the proposal having the best feedback from them.

A VE can render very accurate city environments. And therefore, using a very high level of detail of the environment, people can be consulted during the last step. Because of the realism of the model, it would be possible to leave precise local feedback, which could then be used to refine it. As said at the beginning of the section, the refining process could be dynamic and may be carried out in real time. Furthermore the idea of model modification could be used for small objects, as there are fewer constraints on them compared to larger objects.

Finally, as a VE can be persistent, unlike convention hearings which are limited in time, we can conceive the idea of a continuous public consultation on a whole urban area. Indeed, the environment could handle simultaneously multiple urban planning projects, and people would enter the environment and then select the project they are interested in. Small planning projects, such as the rearranging of a small square, which usually are not presented in hearings because of the cost relative to their size, could be included. This would increase the public involvement. Finally a persistent environment can extend the city model to other applications, such as tourism information, transportation map, pollution and traffic information. Commercial applications can also be envisaged. For example, it could be used by people wishing to buy a flat or a house to visit and get information on their future neighbourhood. Of course, many more applications are be conceivable.

From theory to practice

Having stated the aims of our research, we now describe our work, from the design of a theoretical environment the realisation of a prototype model to run our experiments with the public.

Theoretical City Environment

The environment has been described in detail in a previous publication (Gaborit and Howard 2004), and here we give a summary. The environment is “dual”, as it contains both a model and information. This is necessary because in a public consultation process, the model is always shown with additional information to guide the public.

The city model is in layers. At a high level, a logical layer provides a hierarchical description of the model, using data structures to subdivide the model into “areas”. Then, at a low level, a physical layer describes the different objects of the model, whose geometrical representations and location in the 3D space are handled by a 3D layer.

Information can be from people consulted (for example, their comments), or from urban planners (for example, a description of a building). We can consider a part of this information “linked” to the model, if it is information about an element of it. Alternatively, information can be more “vague”, and not refer to a specific part of the model, such as a comment from a particular view, which depends more on a location inside the 3D space rather than on a specific object in the model. We therefore do not include this information in the model, but define a separate object to contain it. We name such objects “information and consultation boards”, which are essentially information containers. They have two layers: a physical layer describing the object itself, and a 3D layer for its representation and position in the 3D space. We further classify information as shown in Figure 2. We have defined three kinds of information:

- General information about the different areas of the model, but which does not refer to a specific object of it. This piece of information is linked to the logical layer of the model, and we name it “logical information”.
- Information about an object in the model. This information is linked to the physical layer, and is called “physical information”.
- Information which is outside the model, located on the information and consultation boards. This is named “spatial information”, as it depends on the location of these boards in the 3D space.

Looking at logical information, we can separate it into two categories:

- Information which is totally independent from the physical objects of the concerned area. For example, it can be simply the name of the area. Therefore, we name this piece of information “ex-nihilo logical information”, as it is not generated from any object.

- Information which can depend on physical objects, for example the number of objects of a specific type, or the average height of the buildings of a city area. We consider this information as generated by the physical information of these objects, and thus name it “generated logical information”.

The introduction of spatial information is made possible by the feature of navigation brought by the use of a 3D environment. Therefore we can notice that the use of a VE, with the use of a new kind of information, permits to expand and enrich the information and feedback possibilities of a consultation. In the next section, we explore another feature of VEs, the possibility to perform interactions, which can also enhance the consultation process.

Interaction

In this section, we examine the different interaction processes which can be included in the environment for the purposes of public consultation. Because of the duality of the environment, we separate interactions related to the model from the ones related to information.

First, model-related interactions concern the modifications of the model, for example moving an object. This kind of interaction permits us to go a step forward in the consultation process, enabling people, instead of merely suggesting changes in their comments, to actually visualize the effects of the changes and show the results to planners.

Second, we have information-related interactions, which are about accessing and adding information. These can be subdivided into two categories:

- Interactions which are simply information access. We name them “passive interactions”, as they do not alter the environment.
- Interactions which add information to the model. As this information is the feedback from people being consulted, we refer to these as “consultation interactions”.

Figure 2 shows the different kind of interactions we consider. Model-related interactions are an asset of using a VE for public consultation, as the model is static in the traditional process. Passive interactions are already present in the process, but can take advantage of the VE by offering a more visual view of the information (for example displaying the density of a city by colouring its buildings), and permitting simple access to information (for example a simple click on an object representation to get all information about it). Finally, a VE can improve consultation interactions by allowing a more precise feedback – for example, permitting people to express comments from a chosen 3D viewpoint.

The prototype environment

A city model has been developed in 3D, using the Maverik system (Hubbold et al. 2001), balancing level-of-detail, in order to fulfil the two aims of visual realism and performance. Figure 3 shows views of the model. Different levels of details have been used to distinguish the area concerned by the consultation and other areas of the city. Therefore, buildings outside the consultation area are coloured in grey without any texture.

A panel of the different interactions we discussed previously was then developed. It was decided to use the mouse for navigation, as many VE applications and computer games have proved that it was an intuitive and quite easy to learn device to use for navigation.

A map window has been developed, to provide useful orientation information to the user. They can see their location, use a compass to navigate, and operate a zoom function, to obtain local or global views of the city on the map. Finally, these features have been embedded inside a user interface, as illustrated in Figure 4, integrating the 3D view, the map, text frames to display or add information, and buttons to engage interactions.

Experimentation and results

Evaluation of our research focused on three main issues. First, the technological aspects of the developed system needed to be evaluated. Therefore, a performance experiment has been run on standard home computers, in order to assess if the technology was made accessible to the general public. The results were encouraging (Gaborit and Howard 2004).

The second issue was to test was the usability of the environment, in order to determine if the general public would be able to use the technology. In order to do so, a usability study was conducted, by measuring the performance of people with different levels of experience in computer science and 3D computer graphics on different generic tasks they had to perform inside the environment. The results showed that people with a daily office automation level, whatever their experience with 3D is, could use the application by themselves without any help (Gaborit and Howard 2005).

Finally, we wished to evaluate interest of our approach in the urban planning field, so it is considered as an alternative to the traditional consultation process with great potential. In order to do so, two application-based experiments were performed, first an urban planning simulation and then a general public survey. The next sections describe both of these.

Urban planning simulation

First, an urban planning simulation was performed on 25 people who participated in the usability experiment, and so had experienced a tutorial of the application. We simulated a case of public consultation, asking people to visit the environment and leave feedback as comments. We used a non-existent city, as it allowed us to have better control of what we wanted to represent, and to anticipate public response. Thus, we designed in the city some test cases to check if people noticed them: a high security prison, a very high building (585 meters), a street without any trees, a square with cow statues, a day nursery, and the absence of a cinema. Using these test cases allowed us to assess the application, checking if it enabled a person's participation to be handled properly, by checking if they notice them. In order to do so, we asked people to play a role, telling them some of their preferences: they live near the concerned area, they want a day nursery and a cinema, they want trees on every street, and they do not want any hazardous decoration (statues) on the area. At the end of the simulation, we asked them to give some feedback about the environment, enumerating in particular the positive and negative points. We noted any recurring responses, given by three or more people. Table 1 shows the results of the whole experiment.

Looking at the simulation results, we first can see that people could easily access the logical and physical information, as everybody managed to find the prison and the day nursery, and only one person could not notice the lack of cinema. However, this person can be considered as a particular case, as it is the one with no experience in computer science who required a large amount of help during the usability experiment, and therefore would have needed external assistance to properly use the application. Then looking on how people did notice "visual" information, related to the 3D layer, and therefore requiring navigation skills inside the environment, we can see that everybody noticed the street without trees, most of them the statues, and only two thirds the very high building. This shows the difficulties that people experienced in navigation, as the navigation requirement for these three tasks was incremental. The people who experienced difficulties in navigation tasks are the ones who did not notice the very high building. Therefore, as a conclusion this experiment confirmed the usability experiment results in an application context, validating the application as a working way of public consultation. Some of the people who did not notice some of the elements are from the group of people who would need some assistance to use the application, and we can expect that, with this assistance, they would have noticed more items. Besides, the detection of more items could be made easier by the use of more boards, so people would have access to more "strategic" views.

Before looking at participants’ feedback, another way to assess the application is to look at the results of the consultation: the consultation data. This assesses the quality of people’s participation, and therefore the potential of the paper approach as an alternative proposal to traditional people consultation. In order to do so, we checked the results from the boards (as they are placed in strategic places), but also free comments and comments on objects, and check their relevance. For this task, we involved urban planning professionals, who read these data, and discussed them. First, analysing the comments from the boards located on strategic places, consistencies were found on some comments, which was appreciated by the professionals, as they are interpretable, unlike comments recorded in traditional consultation processes, which are mostly scattered. Observing next comments on objects, we were able to find the same idea of consistencies on some objects, such as for example the prison. Professionals appreciated the idea of these comments, because of the consistencies again, and the precision of them, as it is possible to comment on any object, including very small ones. Finally, considering free comments, which were mainly on visual details, professionals appreciated the idea of freedom which stimulates people imagination according to them. They also liked the idea of precision of these comments, as some of them were very pertinent. As a summary, this analysis of the consultation simulation experiment highlighted the potential of this work for improving the quality of public feedback, and therefore to improve the quality of people participation. However, in order to turn this potential into proved improvements, a larger scale experiment has to be done.

Finally, we consider the feedback from participants, first by looking at results from Table 1. The first aspect people appreciated is the possibility to record comments. The second more appreciated feature is interactivity, which is a good evaluation result of our approach, as interactivity is the main asset of a VE compared to static media used in the traditional consultation processes. Then, a large proportion of the people quoted the user-friendly side of the application, which is a good result, for an evaluation of the idea to increase public involvement by proposing such an application, as the user-friendliness was a requirement of the model. The idea of having three kinds of comments was quite appreciated, as it was quoted by more than half of the people, despite almost half of them were confused about where to use which comment, showing that future research is necessary to devise ways to clarify this process. Finally, some people appreciated the realism of the environment and the possibility of information visualisation. The “realism” score is a little disappointing, and can be explained by the current level of detail of the prototype implementation. Looking at the negative side, there are two main points, which include the confusion with the three kinds of comments we already discussed. The second point is about little difficulties experienced with navigation, which was to expect by observing usability experiment results, as six persons required some help for the navigation tasks. However we talk there only about “little” difficulties, which do not question the ability of most of users to be able to navigate by themselves, without any external help. Finally, participants were asked to answer if the availability of such way of public consultation would increase their participation to the planning process. Every participant except one answered “yes” to the question, which shows good support our approach as an alternative way for public consultation in the urban planning process.

For a conclusion, the feedback from people showed a good support of our approach. However, this support was expressed by people who performed two experiments before, and therefore had already knowledge of the application. Furthermore, the sample was not randomly selected, and therefore cannot really be considered as a representative sample of a targeted city population. Therefore, a more “neutral” experiment needed to be done, which is the general public survey we discuss in the next section. Furthermore, a next experiment needed to be done on people who did not experiment of the program, in order to know if they would use it, and not if they appreciated its use. Indeed, if an idea has proven to have a good potential, but does not have support from people because they are not willing to try it, although people who did try it left positive feedback, it can be useless.

General public survey

A survey on a general public audience was designed, using results and experience of the previous experiments. Two options were available. We envisaged an “on street” survey, where people from the street or a public space would be asked to see a presentation of the program, try it, and then answer a questionnaire. A second idea was to perform a presentation to a group of people, offering the possibility for each participant to try the program and give them the questionnaire. The second solution was selected. An event was organized on a weekend, at which 26 people participated. Invitations were issued within the neighbourhood, using letterboxes or forwarded through different associations, asking people to come with their families. A 15-minute presentation and demonstration of the program was given using a video projector. Then people could try the program, discuss it around a free buffet lunch, and then complete a multiple-choice questionnaire. 24 questionnaires were analysed (2 were incomplete), from people who all experienced using the program. Here is the information about these participants:

- Their ages were from 24 to 80 years, with a mean of 44 years. They were subdivided into two age classes, 13 people from 24 to 33 years old into the ‘younger’ class, and the other people (11) into the ‘older’ class.

- 12 were male and 12 female.
- 5 people had no or limited experience in computer science, 13 a daily office automation level, and 6 a more advanced level.
- A proportion of them had the internet at home, as 17 people had a high-speed connection and 4 a slow-speed connection.
- Their background was varied: 9 of them have a literary education, 7 of them a scientific education, and 8 people a mixed education between these two fields.
- Their level of participation in the urban planning process was varied: 6 people had a high level of involvement, 10 a casual level, and 8 a limited or no level.

The exercise to gather a representative sample of the population was very challenging, but the sample we obtained remains a fair representation of the adult class of working age, except maybe the level of participation in the urban planning process, higher than expected from a representative sample. This can be explained by the fact that people willing to participate to this kind of event have a higher involvement. This is (of course) the difficulty with this kind of experiment. However, most of the people have a casual or lower level of involvement. It can also be noticed that younger people are missing, showing maybe a lack of interest of younger generations to politics!

The questionnaire was subdivided into two parts, the first one comprising ten questions asking to rate the different features of the prototype with a positive or a negative mark, and the second being a single question asking if they would use such a VE program if it were available in a consultation process. Having gathered the questionnaire results, a statistical confidence interval estimation was done using the Clopper-Pearson interval (Clopper and Pearson 1934) with a usual error margin of 5%, in order to project our results on a larger population. This interval is considered as an exact confidence interval, meaning that it is suitable for sample of this relatively small size. Table 2 shows the results of this estimation. We now analyse the results.

First, we can observe that people would appreciate the different features of the prototype, confirming the results of the previous experiment. The least appreciated feature would be the navigation intuitiveness, especially for older people. Nevertheless, younger people would like more this feature, which is an encouraging anticipation of the future. Finally, there would be reservations about the clarity of the distinction between the different comments types, pointing out required improvements on the prototype.

Finally, and more important, a large majority of people would use such a program in the urban planning consultation context, especially for people with at least a casual level of participation in the urban planning process. However, a smaller proportion, particularly when considering older people, would be ready to use the program at home without any help, despite the promising usability results we had. But is it a bad result? Indeed, public consultation is essentially a connecting activity, and can therefore benefit from the communication stimuli brought by the reunion of people groups. So, the fact that people are not willing to use the program alone at home, but rather with family members, relatives, or in a public place is not really a concern. Indeed, considering the promising usability study results, and the fact that a majority of people from the younger class would consider using the program without any help, we can fairly expect that there would be someone providing the required help inside a family circle. Therefore, the result to retain is simply the proportion of people willing to use the program. As this result is encouraging, we are confident that the use of a VE will in the future increase people participation in the planning consultation process.

However, we observed that the sample from this experiment cannot really be considered as a strictly representative cross-section of a city population, as it rather represents people usually at least a little interested in the urban planning process. We can therefore expect that results would, maybe, be a little less promising on an entire city population. This is why, as discussed in the previous section, a large full scale ground experiment, we discuss in the previous section must be done, concerning the whole population of a city, in order to confirm the potential we have enlightened.

To conclude the analysis, we can say that our research had a good feedback from the general public, as they appreciated the different features brought by the idea, and are willing to use this method for planning consultations. Having previously shown the potential of our approach as an effective alternative to traditional public consultation methods, with this support from the general public, we are confident that the use of a VE will in the future enhance the urban planning consultation process.

Conclusion and Future Work

In summary, the contribution of this paper is a demonstration that VE technology can enhance public consultation in the urban planning process. Our methodology was to implement a virtual 3D cityscape environment prototype, which proved to be suitable for general public use in both technological and usability terms.

We then wished to evaluate the benefits of our approach on the urban planning process. In order to do this, first we performed a simulation of an urban planning consultation, which proved that the way data are acceded and created gives a great potential to VE as a new way for public consultation. Then we conducted a survey with the general public, which showed good support from the public community, showing a potential increase of their participation to the process with the availability of VE-based consultation software.

The next step will be to develop, from lessons learned from the experiments we ran, a full and enhanced application, bettering the environment features of the prototype, and use it for full-scale ground experiments, which will be with the collaboration of a city council, on a selected urban planning project. We are confident that these experiments will confirm the potential we have identified, and that such techniques may be applied in the future in exciting new ways for large-scale public participation in urban planning projects.

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Table 1. Result of the Planning Simulation

Test Case Detection	Number of People	Percentage
The prison	25	100%
The very high building	16	64%
The street without trees	25	100%
The cow statues	22	88%
The day nursery	25	100%
The lack of cinema	24	96%

Positive Aspects	Number of People	Percentage
Comments recording	24	96%
Interactive	23	92%
User-friendly	18	72%
The three kinds of comments	14	56%
Realism	8	32%
Information display	5	20%

Negative Aspects	Number of People	Percentage
Confusion with the three kinds of comments	11	44%
Navigation is a little difficult	10	40%

Table 2. Results of the General Public Survey

People from the sample	Feature	People who gave a positive feedback	
		From sample	Confidence Interval
All	Possibility to record comments	100%	86% to 100%
All	Interactivity	100%	86% to 100%
All	General information display	96%	79% to 99%
All	Objects information display	96%	79% to 99%
All	User-friendliness	96%	79% to 99%
All	Map use	92%	73% to 99%
All	Realism	88%	68% to 97%
All	Use of boards	88%	68% to 97%
All	Navigation intuitiveness	58%	37% to 78%
Younger class	Navigation intuitiveness	77%	46% to 95%
All	Three kind of comments clarity	67%	45% to 84%

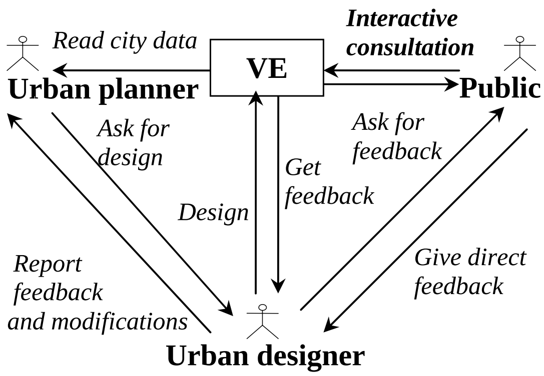
People from the sample	Action	People who would	
		From sample	Confidence Interval
All	Use the program	88%	86% to 97%
Involvement level at least casual	Use the program	100%	79% to 100%
All	Use the program at home	71%	49% to 87%
Younger Class	Use the program at home	92%	64% to 99%
All	Use the program at home alone	54%	33% to 74%
Younger Class	Use the program at home alone	77%	46% to 95%

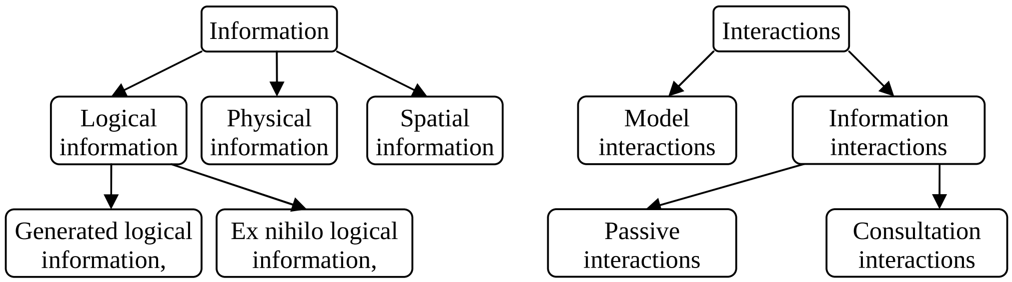
Figure 1. Case Study

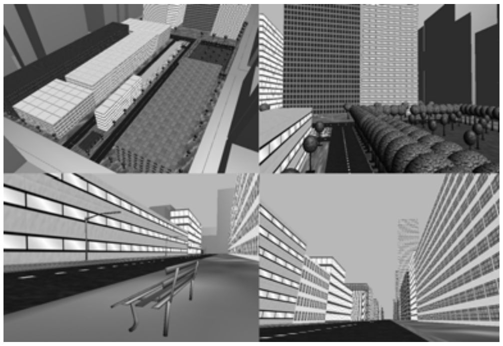
Figure 2. Classification of Information and Interactions

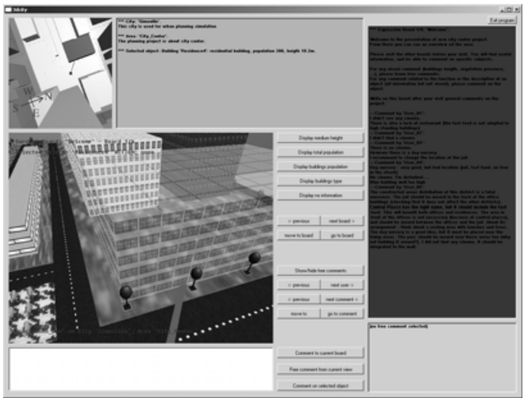
Figure 3. The 3D City Model

Figure 4. The user Interface


Read city data
VE
Interactive consultation
Urban planner
Public
Ask for design
Ask for feedback
Get feedback
Design
Give direct feedback
Report feedback and modifications
Urban designer


Information
Logical information
Physical information
Spatial information
Generated logical information,
Ex nihilo logical information,
Interactions
Model interactions
Information interactions
Passive interactions
Consultation interactions




Display median height
Display total population
Display buildings population
Display buildings type
Display no information
< previous
next board >
move to board
go to board
Show/hide free comments
< previous
next user >
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next comment >
move to
go to comment
Comment to current board
Free comment from current view
Comment on selected object