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Learning through visual systems to enhance the urban planning process

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Abstract. The number of web-based systems for urban planning using virtual reality (VR) and/or geographical information systems (GIS) is increasing rapidly. With increasing Internet access, a majority of the urban population will be potential users of urban planning systems in the near future. In this paper, we describe a methodology for analysing these systems. Our particular interest is the potential for such systems to be agents for change in attitudes and decisionmaking in urban lifestyles and urban policy. Our premise is that such change will come about only through widely held consensus. The building of this consensus is seen as a learning process. Thus, the construction of our methodology relies on well-established theories of learning. We also relate aspects of learning systems to the features of Internet, VR, and GIS technologies used to build models. We assess these models as virtual city models and models for public participation. We reflect on the potential of future models to build up a 'learning society' equipped to understand and act on complex urban problems such as sustainable development.

1 Introduction

Computer-based visual systems are now used to support the planning of urban areas. A good example of such systems are the virtual models of Bath and Edinburgh which play a key role in urban planning in these historic cities. Such systems are exceptional in that few local authorities regularly use them for planning; however, it is widely argued that new computer technologies could significantly enhance urban planning systems.

In the next section of this paper we discuss how involving the general public in the planning process has a significant role in answering 'the challenge of urban planning'. The rest of the paper is then concerned with the question of how visual systems can be used to enhance UK planning systems to enable them to meet the challenge of urban planning. We propose that for individuals effectively to participate in planning in their locality they need to participate in a learning process. We then go on to analyse virtual reality (VR), GIS, and Internet technologies in terms of how they can contribute to the various aspects of the learning process. We consider learning processes in terms of their main characteristics and then consider how well the technologies can support these characteristics. We avoid a detailed analysis of the technologies and their specific

¶ The views in this paper are not necessarily those of Leicester City Council.

attributes. Not only have such analyses been the subject of many other papers, but attention to such details could obscure the arguments we put forward here.

We believe that, as the technologies under consideration become commonplace, it is important to understand how they can be used to solve generic real-world problems. It is only by opening up a debate about the usefulness of the technologies in constructing urban planning systems that those in nontechnical disciplines, including the majority of decisionmakers in local authorities and elsewhere, will be able to participate and feel able to promote the implementation of purpose-designed systems.

2 The challenge of urban planning

Cities are dynamic living organisms that are evolving through an interplay of regulatory and entrepreneurial activities. The lives of 46% of the world's population and 89% of the UK population depend directly on the economic, social, and environmental fabric of urban areas (World Bank, 1999) and our rapidly changing society makes the task of accurately predicting the future needs of city dwellers, and those who depend on the services cities provide, ever more challenging. In addressing the complexities of city planning it is important to consider the physical structure of the city alongside less tangible economic, social, environmental, and cultural factors. Typical problems include transport, pollution, crime, conservation, and economic regeneration. Current thinking emphasises solutions which take a holistic view of both the future sustainability, as identified in Agenda 21, and the cultural heritage of cities.

The UK planning system has faced intense criticism for the urban planning policies of the 1960s (figure 1). European writers have interpreted public unease with development policies in terms of rejecting the dominance of industrialism and the rigid scientific rationale applied by planning authorities in assessing environmental issues (Beck, 1992; Hannigan, 1995). Tensions between concerned citizens, business, and government are exacerbated by their differential involvement in the planning process. For members of the public in particular, exclusion from the dialogue has led to frustration and, ultimately, conflict and confrontation. In the United Kingdom, the Department of Environment, Transport and the Regions (DETR) is leading a consultation process prior to new planning legislation. John Prescott, Deputy Prime Minister, advocates a 'participation culture', and is discussing with interested groups how to bring this about. It is unlikely, however, that radical changes to the planning structure will be implemented and so benefits will be realised only through enhancing participation within the existing processes of urban planning.

There is widespread enthusiasm for the use of new information and communication technologies, such as the Internet, VR, and GIS, to enable and strengthen participation. We share this enthusiasm but raise the prospect that the current practice of building and trailing prototypes makes it difficult to evaluate these technologies owing to the expense

Manchester provides a well-documented example of planning which failed to take account of a city's heritage. A large area of the city centre was demolished between 1968 and 1971 to make way for a retail centre. This area had contained many mid-19th-century buildings designed by leading UK architects and reflecting the ascendancy of the city of Manchester as a world leader in technical innovation and trade. In Manchester, as in other cities in the United Kingdom, there was considerable public opposition to these blanket redevelopment schemes. The principal author of this paper, as one of the people who helped organise opposition to the proposals for urban redevelopment at the time, can well remember the sense of jubilation at the defeat of a Manchester City Council redevelopment scheme at a public enquiry in 1973. Unfortunately, much of the unique Manchester heritage had already been replaced by the bland shopping centre. The unpopularity of the Arndale Centre is probably best revealed by the renewed sense of civic pride following major redevelopment after an IRA bomb attack in 1995. The damage caused by the explosion created an opportunity to correct some of the mistakes made during the redevelopment of the city centre thirty years earlier.

Figure 1. Manchester's Arndale Centre.

of developing multiple systems which prototype all combinations of information and communication technologies and the rapid rate of technological development. Inadequate evaluation will restrict our ability to optimise our use of technologies to meet the needs of a particular application.

It can be argued that the problems facing the planning process relate to a complex of communication and learning issues. In order to achieve greater participation within the planning process there must be an effective communication system to complement changes in attitude. For participation to lead to better decisionmaking, however, learning must take place, where learning is defined as the synthesis and analysis of information obtained through communication. Decisionmakers need to learn about the views and needs of stakeholders, and all participants need to learn about the likely long-term consequences of their decisions.

The objectives of this paper are:
(1) to outline a suitable methodology of learning for the context of visual systems for urban planning;
(2) to analyse how communication and visual technologies, (the Internet, VR, and GIS), aid learning when visual planning systems are used;
(3) by evaluating systems in use and under construction, critically to assess whether learning through visual systems is likely to enhance the urban planning process.

3 Learning systems and the planning process

The learning need outlined above could be satisfied in a variety of ways including:
(a) putting on courses at colleges, such as 'urban issues for planning participants' in a similar way that some local authorities run courses for their lay school governors; and
(b) public awareness campaigns, such as the promotion of the benefits system.
However, courses would be expensive and people may not want to go on them and a publicity campaign alone could not address the complexity of urban issues.

Another approach is to recognise that participation in the planning process is educational in itself and consciously to enhance the process to promote learning. This is the approach we are considering in this paper. We see the advantages of this approach as:
(1) experiential learning has been shown to be effective (Kolb, 1984);
(2) people would be well motivated (to learn) which will aid learning (Issroff, 1993; Lepper and Malone, 1987);
(3) the potential flexibility of the systems allows learning to be set up in such a way that would improve the quality of planning decisions;
(4) it will be less expensive than traditional teaching methods.

The planning process as a learning system can be considered within the framework of a theory of learning. There are many to choose from, but an appropriate approach for this context is "personal construct theory" (Kelly, 1955). Kelly states that personal constructs are formed in order for a person to make sense of their complex environment. In his words, "Man looks at his world through transparent patterns or templates which he creates and then attempts to fit over the realities of which the world is composed. The fit is not always good. Yet without such patterns the world appears to be such undifferentiated homogeneity that man is unable to make any sense of it" (page 8).

To relate this to urban issues, personal constructs are formed as we try to make sense of our direct experiences of city life, or our indirect experiences through informing media in text, numerical, graphical, and aural formats. Kelly also notes that personal opinions, built up from the 'building blocks' of personal constructs, are formed not just from interaction with the physical world but also from social interaction. Furthermore,

when social interactions take place within a group they are usually accompanied by 'norming'. Thus, by participating in the planning process, not only does experiential learning take place but, if group interaction is encouraged, consensus on courses of action can be arrived at. This phenomenon is well documented (Eiser and van der Pligt, 1988) and is exploited successfully in the Delphi technique (Fuller and Jones-Evans, 1994; Linstone and Turoff, 1975). Consensus building is seen as critical to the promotion of such complex issues as sustainable development (Curwell et al, 1998).

The formation of personal constructs through experiential learning is a qualitatively different process than learning facts by reading (or being told) information and remembering it (Norman, 1982). In this paper, we take 'learning' to mean the higher order of learning involving at least analysis and concept building. Learning facts is referred to in terms of access to information and comprehension.

How can a consensus-building learning system be achieved? This can be considered in terms of the aspects of the system needed for it to work. By relating the learning theory above to the context of participation in planning we have summarised these aspects as:

(1) access: access to information within a learning framework is fundamental;
(2) comprehension: making sense of information once it is obtained;
(3) interactivity: conveying viewpoints about a proposal and entering into a dialogue;
(4) learning: synthesising and analysing information obtained through comprehension and interaction.

These aspects are considered below in more detail in relation to the planning process.

3.1 Access

In a traditional planning process, development proposals can be viewed in council offices during working hours (9AM – 5PM). Making a visit during these hours can be difficult owing to loss of earnings and the time required to make the trip. Internet access cuts out the trip to the council offices, but introduces another barrier—that of ownership and skills in using the appropriate IT equipment. However, as transport problems generally get more difficult, Internet access is becoming cheaper and easier; Internet access through a games console and television set, or a mobile phone, gives a choice of access modes. Home Internet access is expected to rise from 25% now to 50% at the end of 2001 to 67% at the end of 2002 (Quirk, 2000). Systems where access takes a minute or two at any time of the day have to be useful additions to current access arrangements.

3.2 Comprehension

Whatever the mode of access, another way in which people can be excluded from participation is if information about development plans is incomprehensible. A key factor to comprehension is the style of language used. Technical jargon can exclude those not familiar with 'planners' speak'. Some councils have made a real effort to overcome this barrier. Although this is an important barrier to communication, and must be considered in the development of effective learning systems, it is not considered in detail here as it is common to both text and computer-based systems. However, it should be noted that, as reading from a VDU screen is more tiresome than reading from paper, jargon in electronic systems is even more of a barrier than on traditional systems.

Traditionally, all proposals for urban development are accompanied by plans of the area to be developed showing the area before and after development. However, it takes considerable experience in reading plans before one becomes skilled at interpreting them. Even so, professionals who regularly read plans often make mistakes in interpretation. To overcome this problem 'artists' impressions' of plans are often drawn up,

and, when expense allows, three-dimensional (3D) miniature models of the planned development are made. These techniques, however, have their limitation. When the Arndale Centre was opened the Mayor of Manchester, Dame Kathleen Ollerenshaw, who had done the most to push the project forward, commented, "I didn't think it would look like that when I saw the balsa wood models".

Interpreting 2D plans and elevations to form mental pictures of buildings is clearly a skill that has to be learnt, however, as can be seen from the example above, even a 3D representation such as a balsa wood model can easily be misinterpreted, particularly in terms of scale, and generally in relation to the context of the city as a whole. Thus, 3D modelling is not a simple answer to the representation problem. The nature of the model, the ability to take up viewpoints around it, and to see if in the context of the city as a whole are all considerations.

3.3 Interactivity

Once information about a planned development has been found and understood, in order for a consensus to be developed, stakeholders should be encouraged to express their opinion about the development and possibly to enter a debate. In traditional planning processes, expressing an opinion typically takes the form of writing a letter. Even when letters are acknowledged the writer may have little confidence that the views in the letter have had full consideration, and no knowledge of the opinions of other letter writers. Entering into a debate in traditional planning typically involves speaking at a public meeting; an intimidating process for those unused to it, and effectively exclusive.

IT offers great scope for interaction. On a basic level, e-mail can be used as an alternative to letter writing, but, apart from replicating traditional systems of communications, IT can offer interactivity not feasible by other means. There are a number of ways in which one person can address many people by using IT. For instance, if it is open to all interested actors to attach themselves to a list of people interested in a development proposal they can automatically receive information sent by any interested person to the list. An advanced form of interactivity is for stakeholders to enter a virtual environment and leave a message at a particular place (for instance, a dangerous road crossing) so that others entering the environment can read the message. This technique, and the nature of 'virtual environments' is considered in more detail when the "Openspace" project is discussed later in this paper.

3.4 Learning

Participation in fully interactive debate in which points are discussed and proposals and counterproposals are put forward and defended is not only in the best scientific tradition (Popper, 1974) but can also be a high-level learning process for all those involved.

One objection to greater participation in the planning process is that the complex issues are fully understood only by 'professionals'. Urban planning, however, is not a 'rules-based' discipline and does not depend solely on regulation. Thus, views on matters such as transport and crime vary greatly amongst professionals, and there are no definitive solutions to most urban problems. Indeed, there can be significant differences between experts; for example, in the debate on sustainable development Porritt (2000) wrote:

> "... sceptics are already asking if Sustainable Development isn't just another linguistic fudge to shore up inherently unsustainable systems. The government's 1999 white paper on sustainable development couldn't have encapsulated it more neatly, calling for 'social progress which recognises the needs of everyone, effective protection of the environment, prudent use of natural resources and maintenance of

high and stable levels of economic growth and employment.' Seriously crude stuff, unless you ignore the fact that much environmental damage is caused by those self same high and stable levels of economic growth" (page 4).

This demonstrates tensions between actors in the urban planning process. Although it may not always be possible to resolve conflicts of opinion, a society can seek consensus and development by becoming a 'learning society' in which conceptual models of urban areas are built by using computer software and used to simulate the outcomes from particular policies and actions (Hamilton et al, 1998).

4 Visual systems technologies: VR, GIS, and the Internet

The range and variety of information and communication technologies are increasing and providing a growing digital tool kit that can be applied to find solutions to real world problems. As with any tool kit, it is important to select the appropriate tools for the job. In relation to the construction of learning systems for planning we have already defined the aspects that need to be addressed. In order to analyse expected benefits of visual urban planning systems, the technologies used in such systems are classified in terms of their potential to enhance learning aspects in table 1. How this

Table 1. Relating the Internet, virtual reality (VR), and GIS to communication and learning.

Aspects of learning systems	Technology		
	Internet	VR	GIS
Access	high	neutral	neutral
Comprehension	neutral	high	moderate
Interactivity	high	moderate	neutral
Learning	neutral	moderate	high

assessment was arrived at for each of the technologies is considered below.

4.1 Internet

From table 1 it can be seen that the potential enhancement of access is assessed as 'high'. The justification for this is that Internet-based information can be accessed at any time with relative ease, as discussed above. The assessment of the Internet as 'neutral' for comprehension may seem more controversial. Hypertext is often seen as integral to the Internet and as an aid to comprehension. However, we consider that hypertext is primarily access orientated. Furthermore, the assumption that just releasing information on the Internet aids comprehension is unsubstantiated and there is an argument that hypertext links constrain browsing along precooked pathways or typical keywords (Kraak, 2000). It would follow that the Internet is neutral for learning. However, hypertext, e-mail, and the way communication technologies are exploited in the web, make the Internet highly interactive.

4.2 Virtual reality

Virtual reality, as applied to planning, can be divided into two types: 'immersive' and 'desktop'. Immersive systems are typified by headsets and VR rooms. Desktop VR can be achieved on standard computer screens. Although Desktop VR does not provide the same quality of sensory stimulation as true immersive VR it can be effective when used in planning applications. The advantage of immersive VR is the feeling of being part of the reality portrayed; in other words, feeling as if a view down a virtual street was real. Desktop systems give the user less sense of reality, having the same sensory impact as any image portrayed on a small screen. This can lead to the problems of scale already discussed in relation to balsa wood models. However, as with immersive systems, it is

possible to set up desktop systems so that viewers are given an eye-height view of a street scene as if they were standing in that street.

There is no need for separate classifications for the two types of VR. Both are neutral in terms of access. Although desktop systems are relatively cheap, VR does not aid access as the Internet does. However, the primary purpose of a VR system is to aid comprehension of an environment by displaying it in a 'real' or lifelike way.

VR systems allow the user to 'walk' or 'fly' through the virtual environment and thus they all support interactivity. Although there is good interaction between the user and the environment, interaction between two or more users within a virtual environment is generally not supported. Hence VR is classified as moderately interactive. With support for interactivity and excellent support for comprehension it would be expected that VR systems would support learning. Although VR is excellent at supporting lower forms of learning associated with comprehension, VR systems generally lack the analysis features found in other software such as GIS; thus, we classify it as moderate in this category, as there is little support for personal construct formulation, which is effectively the definition of learning we have adopted for this paper.

4.3 Geographical information systems

Like VR systems, GIS do not aid access and so are classified as neutral. However they do aid comprehension as the maps that are the typical interface to GIS represent real information or forecasts. But, as we have already discussed, the interpretation of maps is a skill that is not intuitive and has to be learnt. Generally GIS are tools for professional users who learn how to interpret the information presented. On these grounds we have classified GIS as moderate in terms of enhancing comprehension.

GIS have fewer features for supporting interactivity than VR. Although there is some interaction with the system it is effectively neutral in this respect. However, it could be said that the primary purpose of GIS is for the users to analyse information so that they can form an in-depth understanding of a particular environment, and conceptualise problems associated with it. Typically the wards that make up a city could be analysed in terms of social deprivation and this could be correlated with crime in those wards.

4.4 Technical constraints

It should be noted that table 1 is only a general guide to the potential of the technologies. The functionality of a technology is dependent on the data structures and algorithms employed, in particular: object-orientated or other data organisation (Kofler and Gruber, 1997; Lindstrom et al, 1997; van Teylingen et al, 1997); raster or vector graphics (Neves and Camara, 1999); levels of detail (Clark, 1976; Krus, 2000). Furthermore, the way the technologies are integrated is crucial. Tight coupling, particularly of VR and GIS technologies, is relatively difficult; however, loosely coupled systems, although easier to build, have restricted visualisation features and consequently comprehension and interactivity are restricted (Dollner and Hinrichs, 1998). Thus the full potential of the combined technologies is presently restricted, but these restrictions are being lifted as new software is developed.

5 A review of visual systems used in planning

Technical innovations in the 1980s, particularly in computer graphics and network technology, provided the tools for visual models to be built for use in planning. Most of these systems were used for city planning, these are reviewed in section 5.1. Of the other systems that have been produced some have been built with public participation specifically in mind; three current examples of this type of system are reviewed in section 5.2.

5.1 Virtual cities

Visual city models began to be used in the planning process in the 1990s (Hamilton et al, 1998). The first models produced generally combined VR and Internet technologies to allow those with Internet access to view proposed city developments. In recent years, city models combining Internet, VR, and GIS have been built to provide more information and analysis.

5.1.1 *VR city models*

The Edinburgh model was commissioned by the city's Old Town Renewal Trust in 1993 and built by ABACUS at Strathclyde University. Being one of the earliest virtual cityscapes, this is now well developed and also well integrated into the planning process. To obtain planning permission in the old town it is now mandatory to supply a CAD model of the proposed development in the appropriate format for it to be dropped into the virtual cityscape.

The Bath model was produced by the Centre for Advanced Studies in Architecture (CASA) at Bath University by using VR techniques. Architects and developers now buy sections of the model in which they can place their own proposals and display them to planners and the public. The Bath model was one of the first to be available over the Internet without specialist equipment. Inevitably the quality of the display suffers, owing to delays in transmission, but the model makes the point that public perception of a proposed development can be greatly enhanced by the use of this technology (Richardson, 1997).

It should be noted that both Bath and Edinburgh are historic cities with some of the best architecture in the United Kingdom. These early graphical models were commissioned out of a desire to protect unique cityscapes. As such they have been acclaimed as successes. The models have raised awareness of the rich cultural heritage that these cities offer and are now considered an important element in their conservation.

The production of this type of model has increased dramatically since 1995 with the growth of the Internet. Most new models are based on desktop VR and written in VRML. VRML—virtual reality modelling language—is essentially a VR version of HTML used to build web sites. Most of these models are relatively simple, but some offer more facilities, combining some of the analytical features found in GIS.

5.1.2 *VR/GIS city models*

Over many years GIS have been developed based on accurate digital maps with attached databases. Some recent city models have combined VR and GIS to gain the visual and analytical features offered by the technologies. However, as in most current systems, the technologies are not well integrated and the full features expected from the technologies are not available. Such systems are on the leading edge of technology; thus, in contrast to the more simple VRML-based models, no 'industry' standard has yet emerged. Consequently such models vary greatly in the features they offer.

Those who have produced these models claim great benefits to the planning processes in the cities concerned. The developers of Virtual Los Angeles claim their model, "allows the Urban Simulation team to include virtually everyone in the planning process, expert and layman alike" (Jepson et al, 1996, page 8).

The Austrian company GRINTEC claims, "For decades urban planning was done by drawing plans and building elaborate models from wood and plasterboard. The Austrian cities of Graz and Vienna are demonstrating that this is a thing of the past—its three dimensional computer simulations derived from information of the digital city map are revolutionising the planning process" (Ranziger and Gleixner, 1997, page 159).

Although those cities that are developing these complex systems—including Los Angeles, Vienna, Adelaide, Bath, and London—all claim significant benefits, it is clear that much remains to be done in the development of these technologies and their applications. The London team state that, "true virtual cities that provide effective digital simulation of real cities which give users a genuine sense of inhabiting an urban place do not yet exist on the web. Research in the field of Internet GIS and 3D urban modelling using VR, is creating the foundations for true virtual cities with realistic built form interface, a richness of georeferenced information content, and crucially, the ability to support social interaction" (Dodge et al, 1998).

5.2 Models to enhance public participation

Builders of current visual web-based models for planning generally make a feature of the interactivity of their model. However, the nature of the interactivity varies; it may be just interaction with the model but can be social interaction through the medium of the model. In the three models considered below, built by Leeds, Salford, and Manchester Universities, social interaction has driven the research agenda.

5.2.1 *Slaithwaite—Leeds University*

Social interaction was the main concern of the "planning for real initiative" conducted by the School of Geography, Leeds University, in Slaithwaite village in June 1998. This initiative is "a community led consultation process which aims to examine the sustainable environmental regeneration of the village and the wider community within the Colne valley" (Kingston et al, 1999). The experiment was set up "to assess the viability of 'cyberdemocracy' on the world wide web".

The technology used in this system is of interest. A GIS system was set up which provided 2D models of the village, and to supplement this a 3D model was built by planning consultants with the help of local school children. This hybrid technology worked in a context. In a small village, access to a physical rather than a virtual model is not difficult to arrange, and involving the school children raised their, and their parents', interest in the project. The GIS system was set up to be open to all. A key feature is that it allowed any visitor to the web site to leave their comments on proposals for future developments. Thus, all residents were allowed to 'have their say'.

5.2.1 *Openspace—Salford University*

In the "Openspace" model, built at Salford University in 1999, modelling social interaction was also an essential feature. The premise was that the planning process could be enhanced by use of a virtual environment that was open to all and which the public could both relate to and use to communicate their thoughts to each other. Openspace takes virtual environments beyond the concept of walking through virtual physical reality to an environment that is the basis for social interaction.

The demonstrator of this concept was built onto a sophisticated VR system constructed at Salford University for a previous project (funded by the EPSRC through the IDAC programme) which had data-storage and structuring facilities more commonly associated with GIS. The VRML and Java programming languages were used to provide the features of Openspace. In Openspace, particular attention was paid to the nature of the interactivity provided as this, and other human–computer interaction issues, are crucial to the way people relate to and learn from the models (Booth, 1989; Schneiderman, 1998).

The principles behind Openspace are:

(1) social inclusion—accessibility for all;

(2) interactivity—to facilitate open dialogue between planners, developers, and all interested parties;

(3) empowerment—opening the planning process to give all those affected by redevelopment active roles in creative decisionmaking.

The Openspace demonstrator produced provides a visualisation of the Chapel Street redevelopment area in Salford with renditions of proposed developments. The VR system used allows the user great freedom of movement; however, in early prototypes it was found that users easily got lost in the virtual environment. One way this is avoided in the final system is by entry into the 3D VR being constrained to entry points from a 2D map of the area. Once in the 3D environment the 'visitor' can 'walk around' it and view proposed new developments. If visitors would like to say something about what they see, (for instance, the lack of a controlled road crossing), they can leave a comment in the position they would like the crossing to be. Comments are left in the form of an icon which effectively becomes an addition to the virtual environment. A visitor can look at all the comments left by previous visitors and find out what others think of the proposed development; thus promoting social interaction directly related to the area of concern. Clusters of icons would be readily identifiable as areas of concern by all involved in the planning process.

5.2.3 *AtlasNW—Manchester University*

The AtlasNW developed by the Centre for Urban and Regional Ecology at Manchester University, is an interactive sustainability atlas for the North West region of England designed primarily "for exploring regional futures" (Ravetz, 2000). Although it is a complex system incorporating many modules that are loosely coupled together, at the heart of the 'atlas' is an adapted and extended version of the Lower Fraser Basin model (Vancouver and surrounding region) first developed as 'QUEST' by the University of British Colombia in Canada. This software, funded by the EPSRC, allows users to set their values, priorities, and policies as system parameters before calculating likely outcomes for up to forty years ahead. The software is specifically designed to stimulate debate about the consequences of our lifestyle choices and therefore promote a more sustainable future.

The core software has GIS features that produce output information in a variety of forms including maps, charts, and headlines for many indicators such as population density and pollution. The present system models the region in quarter kilometre squares through reference to an extensive database of spatial information about the region developed by using GIS.

Further developments, with project partners Sustainability NW and the Department of Geography in Manchester University, will enable users to visualise the underlying database and supporting information with the intention to produce a final model that can be accessed over the Internet. Other future plans, discussed with us, include detailed cityscapes and the use of 3D modelling.

In its current form, the sustainability atlas could not be used for considering the details of buildings. In contrast to the other systems considered in this paper, it is therefore not so much a site-specific planning model but rather a strategic planning system that deals with cities and their region. It claims to be "one of the most powerful awareness raising tools ever created—a 'Sim Region'"; and is "a major resource for policy and education". Thus although the atlas does not directly address the details of city planning, it focuses on, and makes sense of, the context of city planning in a highly sophisticated way. More information about AtlasNW can be found at http://www.art.man.ac.uk/planning/cure/atlas.htm.

6 An appraisal of visual systems used in planning

Considering the earlier city models based on VR and Internet technologies in relation to table 1, we would expect the models greatly to enhance access to information through use of the Internet, and comprehension of that information through use of VR, but to give little promotion of higher levels of learning, as no GIS features were provided on these models. Why then are the Bath and Edinburgh models, which are concerned with cultural heritage, successful? First, any model that enhances access and comprehension significantly improves on the traditional planning process. Second, an important part of our cultural heritage is its graphical image. Therefore, a system that gives access to this image and any proposed changes promotes informed debate.

In most cities the social aspects of crime, education, and health are of more concern than the visual image. It is common to find GIS used by councils to aid analysis of social issues. At present these GIS are normally stand-alone systems or in local area networks for use by council professionals only. However, some city councils have recently pioneered not just the integration of GIS and VR technology, but also a change of attitude in the way citizens are involved in the planning process. With access to GIS analysis tools, citizens will be able to use the same tools that council professionals use for policymaking in social areas, and thus be empowered to comment on policy as well as planning decisions. However, to participate effectively in policymaking citizens would have to learn about the issues being discussed.

As the inhabitants of cities are being offered the chance to participate, how will they act in cyberdemocracy? From the evidence on the Leeds University web site (http://www.ccg.leeds.ac.uk/slaithwaite) it can be seen that the map of Slaithwaite is well populated with comments from inhabitants concerned about the future of their village. Although building physical 3D models would be too expensive to replicate in every urban area, Salford Universities Openspace demonstrates that virtual 3D models that support social interaction can be incorporated into systems to enhance cyberdemocracy.

On the evidence presented here, it can be seen that there is a demand for cyberdemocracy and it is feasible to build the highly interactive 3D systems that make it effective. Furthermore, the evidence of the Manchester University AtlasNW shows that the necessary learning systems will soon be available, which, when coupled with 3D highly interactive planning systems, will provide the type of learning system that the public will need to participate effectively in cyberdemocracy (Argyris and Schon, 1978; Senge, 1992). Development plans considered on such a system not only could be seen and discussed, but also the long-term effects could be forecast in terms of economic activity, resource use, and so on; qualitatively enhancing the effectiveness of the planning process. Furthermore, it would be a real step towards 'joined-up government' in that the interaction between national, local, and street-level planning could be seen.

7 Conclusion

With increasing concern for the environment and for the preservation of our cultural heritage, it has become increasingly important to make planning systems work effectively. For the planning process to be effective the views of all the stakeholders need to be represented. We believe that participation in the planning process can be greatly enhanced by the appropriate use of computer-based visualisation and communication technologies.

It can be seen that all aspects of the theoretical learning system described in this paper can be found in current systems, but that no one system combines all the aspects. However, we can see that different systems fulfil parts of the expectations

raised by our theoretical learning system. Clearly, the technology is still developing in this area and thus any attempt to build such systems encounters difficulties. Sometimes these difficulties distract the design process of such systems. There is a need to stand back and assess what outcomes we want from the systems we build, and to evaluate what is possible. Consideration of the learning potential of such systems provides a suitable framework to make this assessment.

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