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Virtual Reality for Mutual Understanding in Landscape Planning

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Abstract**—**This paper argues that fostering mutual understanding in landscape planning is as much about the planners educating stakeholder groups as the stakeholders educating the planners. In other words it is an epistemological agreement as to the meaning and nature of place, especially where an effort is made to go beyond the quantitative aspects, which can be achieved by the phenomenological experience of the Virtual Reality (VR) environment. This education needs to be a bi-directional process in which distance can be both temporal as well as spatial separation of participants, that there needs to be a common framework of understanding in which neither 'side' is disadvantaged during the process of information exchange and it follows that a medium such as VR offers an effective way of overcoming some of the shortcomings of traditional media by taking advantage of continuing technological advances in Information, Technology and Communications (ITC). In this paper we make particular reference to this as an extension to Geographical Information Systems (GIS). VR as a two-way communication tool offers considerable potential particularly in the area of Public Participation GIS (PPGIS). Information rich virtual environments that can operate over broadband networks are now possible and thus allow for the representation of large amounts of qualitative and quantitative information 'side-by-side'. Therefore, with broadband access becoming standard for households and enterprises alike, distributed virtual reality environments have great potential to contribute to enabling stakeholder participation and mutual learning within the planning context.

Keywords**—**3D, communication, geographical information systems, planning, public participation, virtual reality, visualisation.

I. INTRODUCTION

THE importance of engaging the public in environmental issues is at the core of the Aarhus Declaration on access to information and public participation in decision-making (European Union, 1998). Reaffirmation to "… broad-based participation in policy formulation, decision-making and implementation at all levels" came from the 2002 United Nations (UN) Johannesburg Declaration on Sustainable Development [1]. Following that, the United Nations are now promoters of a Decade of Education for Sustainable Development (2005 – 2014) [2], the background to which states that "promoting the goals of a transition to sustainability is a major challenge for science and technology." UNESCO note that "… One of the lessons of recent experience is the need to establish effective communication strategies as an integral part of any major scientific inquiry or programme." This report [3] also suggests that, "access to education is the sine qua non for effective participation in the life of the modern world at all levels." Although most of the discussion on education in this report casts the general populace in the traditional role of the pupil UNESCO do acknowledge that "The engaged citizens of a democratic society can exercise a strong influence on behalf of sustainable development through their civic role as well as through their behaviour as consumers and producers."

However, there is a growing acceptance that education in the planning context is not a unilateral process (as will be demonstrated later) and that stakeholder participation is as much about communication from the stakeholders to the planners as the other way around.

There is a growing body of research in the area of VR as a communication tool, especially as an extension to Geographical Information Systems (GIS). VR as a means of communication is found increasingly both in education e.g. DiBiase, [4] and planning e.g. Bodum [5] and Miller [6]. However, the power of VR as a two-way communication tool has been less fully explored, but offers considerable potential particularly in the area of Public Participation GIS (PPGIS) [7], [8]. Both Ball and Yigitcanlar cite the potential for VR as providing a space for collaboration. New technologies such as VR chat rooms in which participants are represented by 3D avatar personas and collaborative multi-user environments (e.g. those offered through X3D using Octaga and Blaxxun viewers) are now a reality.

VR has been effectively used in education with some sectors such as medicine being particularly active in its uptake [9], [10] and it has proved particularly effective in communicating issues relating to intricate 3D space problems, engineering is a particular example [11]. Landscapes are equally complex 3D spaces and there are many examples of the deployment of VR as a medium for mutual understanding [12], [13].

Landscapes are 3D environments in which some of the complexity results from qualities and meanings of space (see Patrick Geddes, Lewis Mumford and Peter Kropotkin). However, virtually all efforts relating to the use of VR in landscape planning have concentrated on communicating the purely qualitative aspects of the landscape. PPGIS is an area that is anticipated to have an increasing level of importance in landscape planning in the UK [14] and elsewhere but if it is to

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be truly effective, greater account will need to be taken in VR simulations of the qualitative or 'soft-science' elements of landscape planning. There is a clear preference for a greater dimensionality of representation and/or use of multimedia depending on whether the user is interested in quantitative analysis or a phenomenological experience by Sarjakoski [15] and Bertin [16] the latter being more suited to qualitative aspects of landscape planning, as argued by Ball [7].

Information rich virtual environments that can operate over broadband networks are now possible and thus allow for the representation of large amounts of qualitative and quantitative information 'side-by-side'. With broadband access becoming standard for households and enterprises alike, this dissemination media can now be used to permit high data demand environments. In Europe the 2006 access for broadband averaged of the 25, post 1st May 2004, member states was 52% for households and 77% for enterprises with ten or more full-time employees, shown by the Office for National Statistics (ONS), figures for 2006 [17]. This is a self fulfilling justification of the intuitive knowledge of stakeholders as such technologies become integrated into society.

II. MUTUALITY OF COMMUNICATION IN PLANNING

Uncertainty is an inherent part of environmental and landscape planning. Decisions about coping with uncertainty, what risks are acceptable, what contingencies should be built into a plan, should all be informed by science but these decisions must be based on ethics and stakeholder preferences, which themselves are coloured by the socio-political context in which they are made [18]. Amongst several authors Papamichail and Robertson [19] categorise such problems as social decision problems. As such they are situations where the 'experts' cannot simply disseminate information but must interact with stakeholders and their representatives. This is not least because the importance of local knowledge as having equal value to scientific knowledge has been recognised for some time now [20], [21]. Conversely, to make sound decisions, the stakeholders must interact cooperatively with the scientific community [22]. Mayumi and Giampietro [23] concur with Ravetz [24] when they argue that public opinion is a crucial aspect in legitimising policy-making, requiring effective mutual communication, trust building, citizen participation and learning processes. The impact on the planning process that is achievable by public participation depends on the level of stakeholder involvement. This involvement can be categorised into three principal degrees as shown by Miller *et al.* [6].

1) *dissemination*, where information is almost exclusively communicated to the public by the 'experts';
2) *consultation*, where public opinions are sought and considered in expert or managerial decision- making;
3) *collaboration*, where representatives of the public are involved actively in developing solutions and directly influencing decisions to a greater or lesser degree [25].

Tools for supporting community participation (e.g. www.communityviz.com/) are becoming more widely adopted. In conjunction with this, increasing familiarity with computer games opens the potential for greater acceptability and understanding of virtual worlds, and it has already been established that multimedia and VR can enhance information management and the knowledge transfer experience (*e.g.* Appleton and Lovett [26]; Lange and Bishop [27]; Miller et al. , [6]). These authors report on the current developments of the use of virtual reality and GIS tools for public participation in planning. However, there remains a gap between exploiting the capabilities of GISs in public participation while at the same time reducing the need for a GIS expert as the interface between the public and the data, and linking the spatial tools with the visualisations of potential future landscapes. Nor has there been much, if any, evidence produced as to participant satisfaction with the current processes.

III. TECHNOLOGIES AND VIRTUAL ENVIRONMENTS

Differing types of virtual environment necessitate different technology in their construction and operation. The different availability of hardware and software, including the client application, provide the main scope for determining the virtual experience. At one end of this range, in cost and physical considerations there are specialised stand alone environments such as the Macaulay Institute's (2007) Virtual Landscape Theatre (VLT) [28] which requires a dedicated area to host the theatre and is supported by a system of multiple computers and projectors. At the other end are the environments that 'piggy-back' onto existing computer systems. These either run within applications on a non-dedicated machine, e.g. Google Maps [29] which is an internet browser based system or a stand-alone application such as Google Earth [30]. Between these extremes are a multitude of systems, including games systems, that use various levels of dedicated hardware which are an add on features to computers. These may include input devices such as wired gloves or Nintendo's new (circa 2006) Wii [31] and experience devices such as the omni-directional treadmill, stereoscopic displays (usually goggle based) and directional sound. Tactile feedback and olfactory stimulation have for some time been catered for in a very limited manner. Sines and Das [32] and Cater [33] show the stage of early implementational work which, despite slow progression, is similar to present day status of such technology. More development has been made with touch sensations rather than smell, which is in part linked to touch operating bidirectionaly, as an input and an output, but mainly due to the huge technological difficulties with smell regarding factors such as implementation, pervasiveness transience, etc.

What should be observed is that any virtual environment requires the participation of the stakeholder and a willingness to suspend belief in environmental realities. The degree to which this is achieved has a great influence on the virtual experience. The degree of suspension and willingness to do so in this environment is an intrinsic ability of technologically advanced societies who already do so regularly by use of entertainment media such as television, cinema, video games. This is nothing new to humans and not the sole province of technology as the same suspension of reality has attracted many participants in more distant times, as today, through theatre, books, and camp fire storytelling.

If each type of environment is addressed, it may be observed that different environments suit to different group experiences. Stand alone environments such as the VLT have a much lower exposure potential, in numbers of people, than browser enhancement environments. However in terms of costs per person their ability to provide an audience environment may result in a considerably lower cost than single user dedicated hardware systems. They have an additional feature, which is also traded upon by the other environments, namely “it is no fun to play on your own”. By nature of its theatre capability it is a group experience. Humans are naturally drawn to this, we usually go to the cinema in company and indulge in the experience with hundreds of people. Although we may watch television on our own, the television, having replaced the radio which itself replaced the fireplace, is often based in a communal area which is laid out to benefit group viewing and not give a single person the maximum viewpoint. It is precisely because humans seek interaction, even in virtual environments, that virtual worlds such as Linden Lab’s Second Life [34] have become so popular. Such human characteristics have not been missed by the developers of the browser based VR environments who have developed the facilities for virtual communities to exist.

The instructor control of the virtual experience varies hugely. In the VLT there is usually a one to many (group circa 20 participants) delivery method, with the instructor guiding and controlling the experience and their individual ability (performance) determining the quality of the experience. They must interact with the known audience to maximise this. Virtual worlds and browser based VR environments have a many (dispersed team) to massive (thousands to millions) delivery method. Here the audience is not captive or in a single location and the instructors are there to police and assist (protect and serve) the environment in which the audience reside and use as a medium to interact with each other.

Once the presentation hardware and software requirements are met, the participation requirements can be addressed. The VLT uses the single location to encourage active participation through discussion. This breaks the rules of audience observation and must be carefully controlled by the instructor to prevent the perception of the environment becoming secondary to group interaction. The use of Personal Response Systems (PRS) can control the level and time of interaction and channel person to person interaction to be through the environment rather than one to one. Google Maps uses various add ons to encourage the community development, as discussed below.

The advancement of public availability of VR and in this case specifically GIS systems have been promoted by freeware. Google Maps [29] and Google Earth [30] take advantage of this and utilise GNU Free Documentation License [35] to assist in doing so.

Google Maps is basically a global representation of the earth but is focused on urban provision. It allows a map view, satellite photograph view and a hybrid view which overlays GIS information on the satellite photographs. Community interaction is limited (circa 2007) where the main VR add on is a system called “Street View” which is limited to a small number of metropolis locations e.g. San Francisco. These locations have been mapped out in a system of interlinking panoramic photographs that the participant can observe and manipulate in a virtual walkthrough of the environment. These link into the real word by allowing Point Of View (POV) observation and the minor commercial linkage of seeking out points of interest which an urban business locator. Therefore although the participant can experience the environment they are limited to reporting this to the community by taking snaps shots of a particular view. Note that this system runs on an internet browser and does not require proprietary support. Spin offs from Google Maps include Google Moon and Google Mars, which allow limited GIS exploration of both.

Google Earth is a more advanced VR environment. Its one comparative drawback is that it requires its own application and full experience is not possible through a browser. The basic exploration methods are comparable to Google Maps, however there are numerous features which can be activated.

It is the ability for participants to share material they have created which extends Google Earth into a community VR environment. Google Earth includes Digital Elevation Model (DEM) data. This allows rendering of geographical features such as the Grand Canyon in 3D. A community feature included after this is capability to include 3D structures which consist of participant’s submissions using SketchUp (a 3D modelling program). Google Earth has integrated with other systems to include information to the environment. This is supplied by organisations such as Wikipedia [36] (including the community layer from Wikipedia-World), Panoramio [37] and National Geographic Magazine [38]. Each has its own icon placed on the specific point of the map. The community element is integrated through the use of information placed by individuals either through Wikipedia or Panoramio or directly by participants in the Google Earth Community (an online forum dedicated to producing place marks of interesting/educational perspectives.). Each of these have their own icons to indicate the source and therefore likely type of information.

Participation can be seen to be related to the environment, which is specific to the IT technology that it is hosted on. This makes the difference between 2D, 3D and 4D experiences whether live or updated, instructor led or community constructed. There is the potential for these environments to integrate with each other or present a different experience of the same scenario. It is the type of experience that should be determined by the technology rather than the content or purpose of the model.

IV. PHENOMENOLOGY OF THE VIRTUAL REALITY ENVIRONMENT

Over-reliance on technology and presentation of scientific analysis can actually lead to disenfranchisement of many sectors of society who would otherwise be active participants. This is because interpretation of such evidence and accommodation of unfamiliar technology requires the very expertise that sets the ‘experts’ apart from the stakeholders. However, despite the reliance of VR on computer technology its great strength in enabling mutual communication in participative landscape planning is that understanding is at the phenomenological level and therefore more readily accessible by a ‘lay’ audience. The technologies that it uses are also increasingly familiar.

There is a tendency to favour a higher degree of ‘dimensionality’ within a representation where that representation is being use as a phenomenological communication tool. Fig. 1 [7] is a reinterpretation of Bertin’s continuum from ‘map-to-read’ through ‘map-to-see’ through ‘space to observe’ to space-to-feel’ [16] and Sarjakoski’s analysis that shows how 3D visualisations are sub-symbolic and therefore understandable intuitively, thus reducing the risk of cognitive overload [15].

One important aspect of increasing the dimensionality of a representation is that, as abstraction is reduced, the scope for misunderstanding or misinterpretation of the information is also reduced. The virtual world, being less abstracted from reality than statistical indices or even 2D maps, provides a more familiar context through which all participants may experiencing the information being portrayed. As Miller [36] argues, information has no intrinsic meaning. Information only becomes knowledge against a backdrop of understanding and understanding is based on a multitude of contexts (e.g. culture, educational background, gender, personal history, politics etc.). Fig. 2 is a reinterpretation of Miller’s diagram of the equation “i = 0” in the context of bidding for jobs where the diagram has been adapted to represent the information-rich but often understanding-poor situation of landscape planning.

V. ROUTES TO MUTUAL UNDERSTANDING

Mutual understanding is developed by people synchronising their knowledge through communication. For example, Pask’s conversation theory developed a formal, cybernetic, approach to reducing differences in interpretation through dialogue and

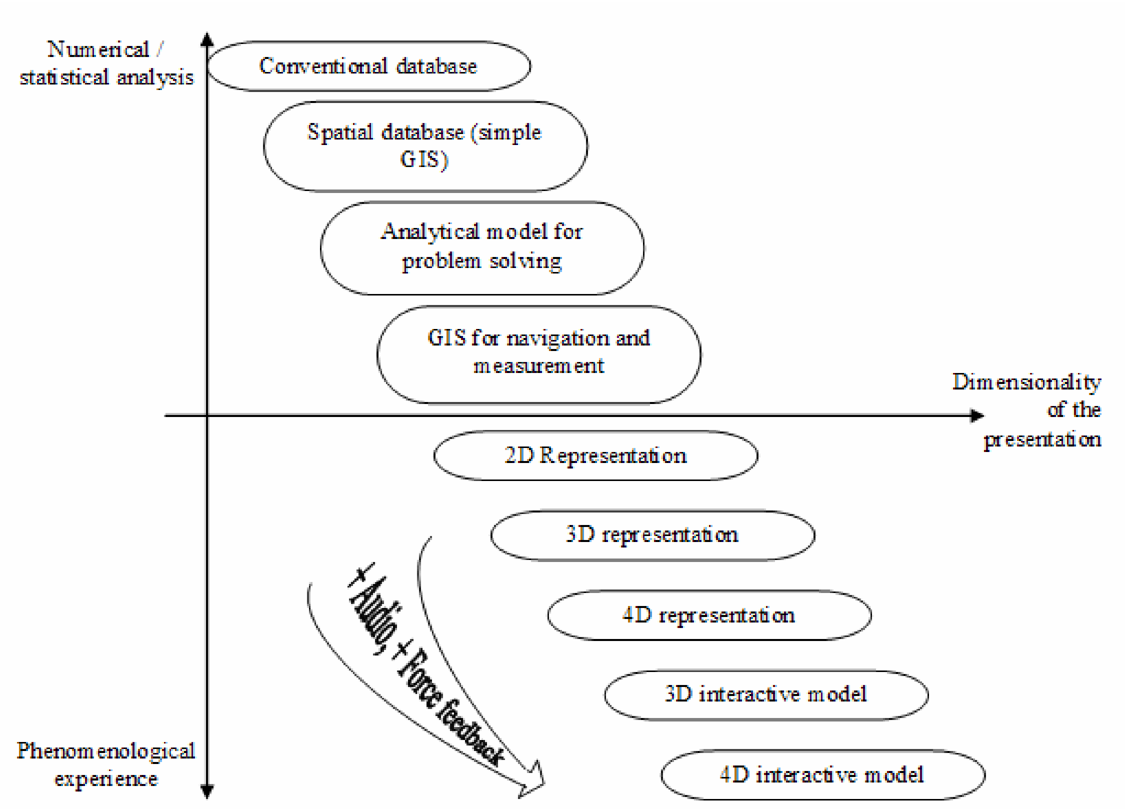

Fig. 1 Preference for increasing dimensionality in representations and visualisations where the data are used at the phenomenological level (extended from Ball [7]).

action, converging on consensus [40]. This model, developed further by Laurillard [41] as a conceptual tool for understanding learning dialogues, has been highly influential in higher education.

The mechanisms for the construction of meaning are a central issue in the debates on education. Broadly, there are several competing concepts of knowledge, leading to different views of learning. What we might call ‘good old fashioned teaching’, or instructivism, where teachers know stuff, and their job is to pass that knowledge on to the learners, can be set against constructivism, where learners build their own knowledge from experiences shaped by teachers, and others. Pask’s and Laurillard’s models are essentially neutral on this matter: they describe how people’s conceptual models are synchronised through dialogue and action

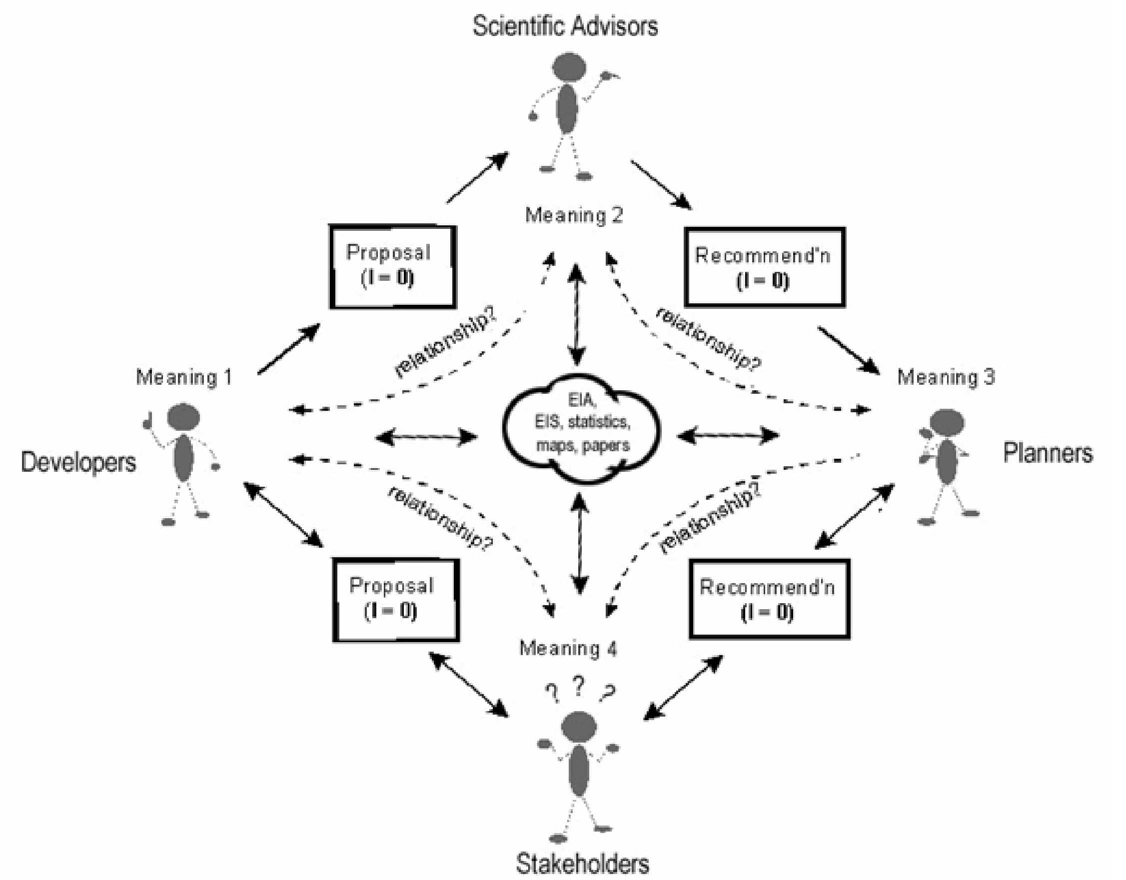

Fig. 2 I=0 – Information, knowledge and meaning in landscape planning (adapted from Miller, 2002, for the landscape planning context).

‘Traditional’ instructivist learning environments are perpetuated through tradition. The academic training process is based largely on apprenticeship, and students in one generation become part of a culture that they then continue in their turn. Today’s learners have grown up with a more questioning attitude to knowledge, and with ubiquitous access to the internet, mobile communications, and entertainment, that reduces learners’ motivation to overcome the limitations of instruction through independent exploratory learning.

Constructivist approaches to learning are themselves contested, with a notable confusion between situated learning and constructivism [42]. Situated learning essentially claims that learning happens in (usually realistic) situations, and doesn’t transfer well between situations. Learning in the abstract is less effective – which is why it is distanced from traditional instructivist methods, such as lectures. Virtual reality seems ready made to support situated learning. Realistic, but safe, contexts can be created, where learners can, for example, make mistakes designing a wind farm without annoying and alienating entire communities.

More radical versions of constructivist learning make stronger claims, even about the nature of knowledge itself [42].

For the radical constructivist, knowledge can’t be ‘taught’ through communication from a teacher, or even represented, for example in writing. It can only be constructed in realistic learning situations. Again, virtual reality is matched to this model. It can be used to create realistic and exploratory environments where learners can construct their own knowledge.

However, virtual reality technology does not come without risks. For example, Second Life can – and increasingly is – used to build 'virtual campus' type settings – complete with virtual classrooms and lecture halls. It is important to start out considering virtual reality as a new medium and not to borrow habits from old ones, as they are likely to be entirely inappropriate. As put by Lester, "If you want to teach biology, why build a virtual classroom with desks and a blackboard in Second Life when you could build a whole interactive human cell?" [43]. Virtual reality technology in GIS creates new opportunities for sharing meaning, but only if supported by opportunities for dialogue to enable the construction of shared understanding. 'Solo' virtual reality, therefore, is much less useful as a technology to assist learning; it can only be effective when wrapped in forms that truly enable the effective construction of meaning. For this to be effective through virtual reality, the following conditions need to be met.

1) The environment needs to be realistic, and representative of the kind of tasks that learners are likely to face in 'real life'. Note that this does not preclude the use of, for example, Second Life, where the tasks learners are likely to perform are similar to those in the real world, such as planning and digital media art. However, virtual lecture theatres add little value but a lot of complexity.
2) The environment needs to be interactive, and allow people to manipulate the (virtual) world in interesting ways with interesting consequences. Learning is actually driven in large measure by working with expected outcomes, trying things out, and learning when the outcomes don't match predictions – what Schank [44] calls "expectation failure". Without interaction, there can be no failure, and therefore, no learning.
3) The environment, or something external to it, needs to support dialogue – this is the other key channel in Pask's and Laurillard's models [40], [41]. It does not need to exist within the environment if (as in the Landscape Theatre) people are sharing a physical location. However, for distance learners this is unlikely to be the case, and the requirement for dialogue in parallel with action is central to effective construction of meaning.

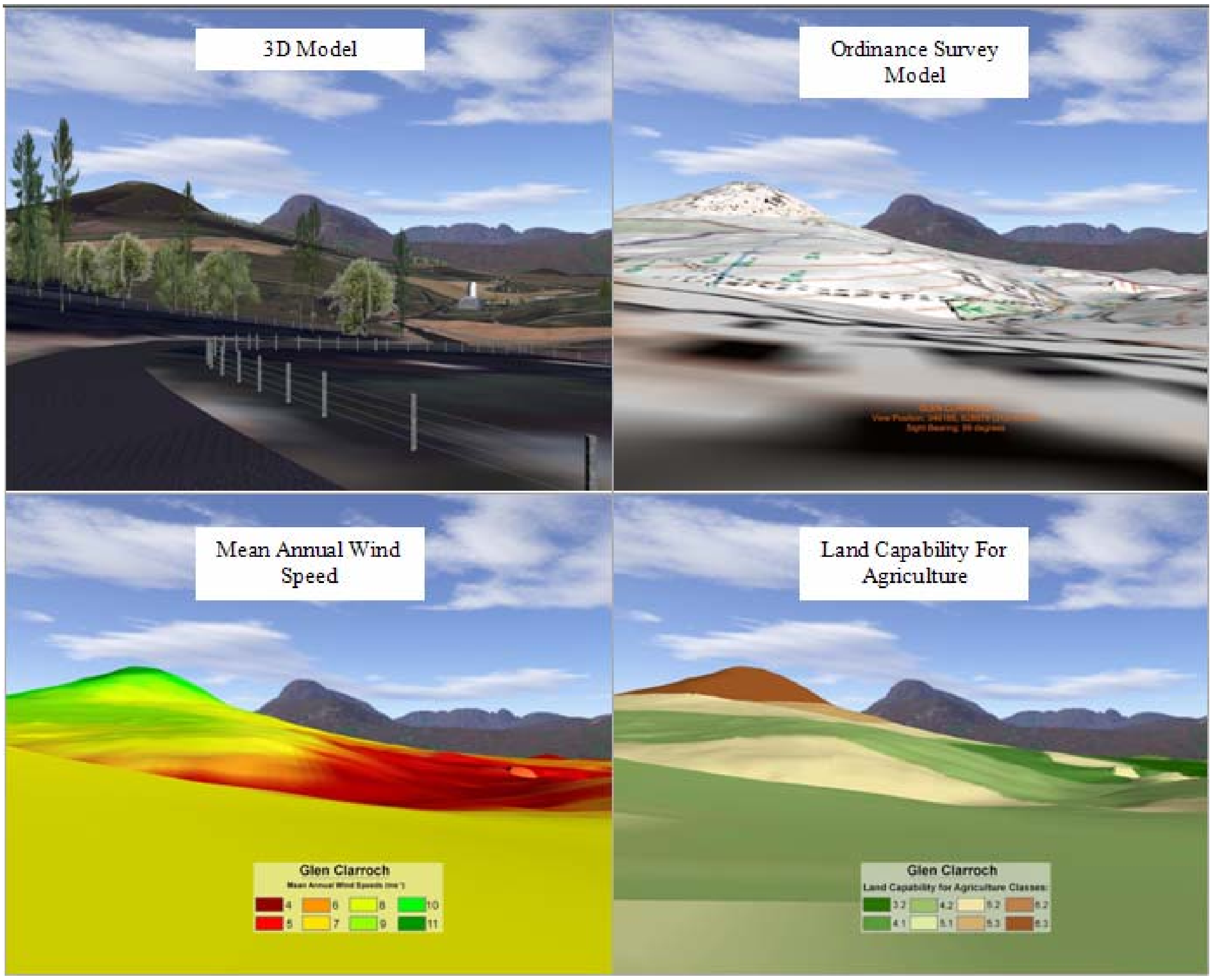

Fig. 3 Layering Information within a 3D scene to provide a geographic context.

4) The environment needs to maintain impartiality between tutors and students, at least as far as dialogue and action are concerned. This is important, as otherwise the environment drifts into an instructivist mode, and loses much of the benefits offered by virtual reality in terms of situated and constructivist learning.

A. We will now look at some examples.

1) *Layering of information.*

The question raised by Lester [43] above need not be restricted to a single cell and can obviously be applied in a much broader context.

Fig. 3 demonstrates how information can be imbedded in a 3D landscape. Such a way of presenting information allows it to be understood in its geographical context, which is important given the underlying influence of terrain on many issues for which public participation is being increasingly employed.

2) *Deepening phenomenological basis of understanding.*

Fig. 4, below, is from a model developed as a demonstration of proposals for the restoration of Pitstone Quarry in the South of England. The quarry was due to be decommissioned. The Local Authority and the site developers decided that the best way to discuss and then communicate the intended landscaping of the area was to commission a 3D model. Embedded within the model is the facility to view the 'before' and 'after' scenes in which some stages of tree growth are represented to give a fourth dimension. Non-visual clues as to ecological changes are also embedded using attenuated sound. As a participant approaches the diggers in the first scene, their engine sounds increase. In the 'after' scene various bird songs appropriately chosen for the lake area, the tree cover areas and the open grassland areas replace the sounds of the diggers, but at night both scene share the same owl and fox noises.

In this model the participants can also adjust the brightness of the lamps and so enter meaningfully into the discussion about the numbers and brightness of night-time illumination by having a sense of what the area will be like. For instance where might they feel uneasy because the path is dark and surrounded by trees that might hide a potential attacker. Similar questions were posed by Laing, Miller, Davies, and Scott [45] as part of a publicly trialled urban green space decision support system in which members of the public were presented with images of 3D model showing scenarios of options for change in a very similar manner (albeit an urban context). As Laing et al., state "The use of computer visualisation provides a genuine advancement in the presentation and delivery of information. Attempts were made to move away from a position where the computer models are used to manipulate the physical configuration of public space, towards a much wider understanding of how a holistic environment can be modelled. With continuing improvements in the capabilities of software and hardware,

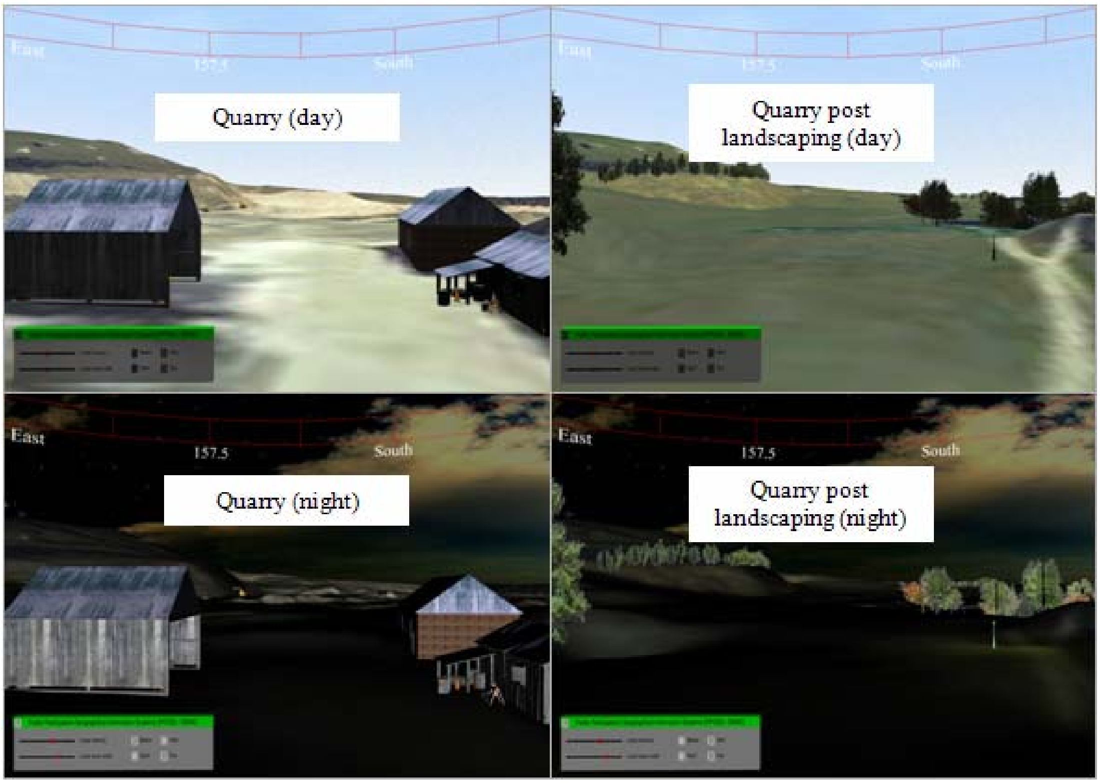

Fig. 4 Layering Information within a 3D scene to provide a deeper phenomenological experience.

the questions facing planners and designers can go beyond those relating to physical changes of spaces, and more towards how they might be used or perceived throughout the year or under different environmental conditions.

3) *Interactivity enhances real participation and debate.*

3D models are increasingly used in the context of landscape planning. One particular area is with windfarm developments in the UK. The Macaulay Institute is being commissioned on an increasingly regular basis to develop 3D visualisations of windfarms. Areas suitable for windfarms tend to be more exposed, which are often hilltops and therefore are commonly in very scenic areas of the country. This means there is a high level of potential conflict between the visual amenity value of a site and the potential capacity for renewable energy generation. 3D models such as the one shown in Fig. 5 have been used in public participation meetings to allow a greater

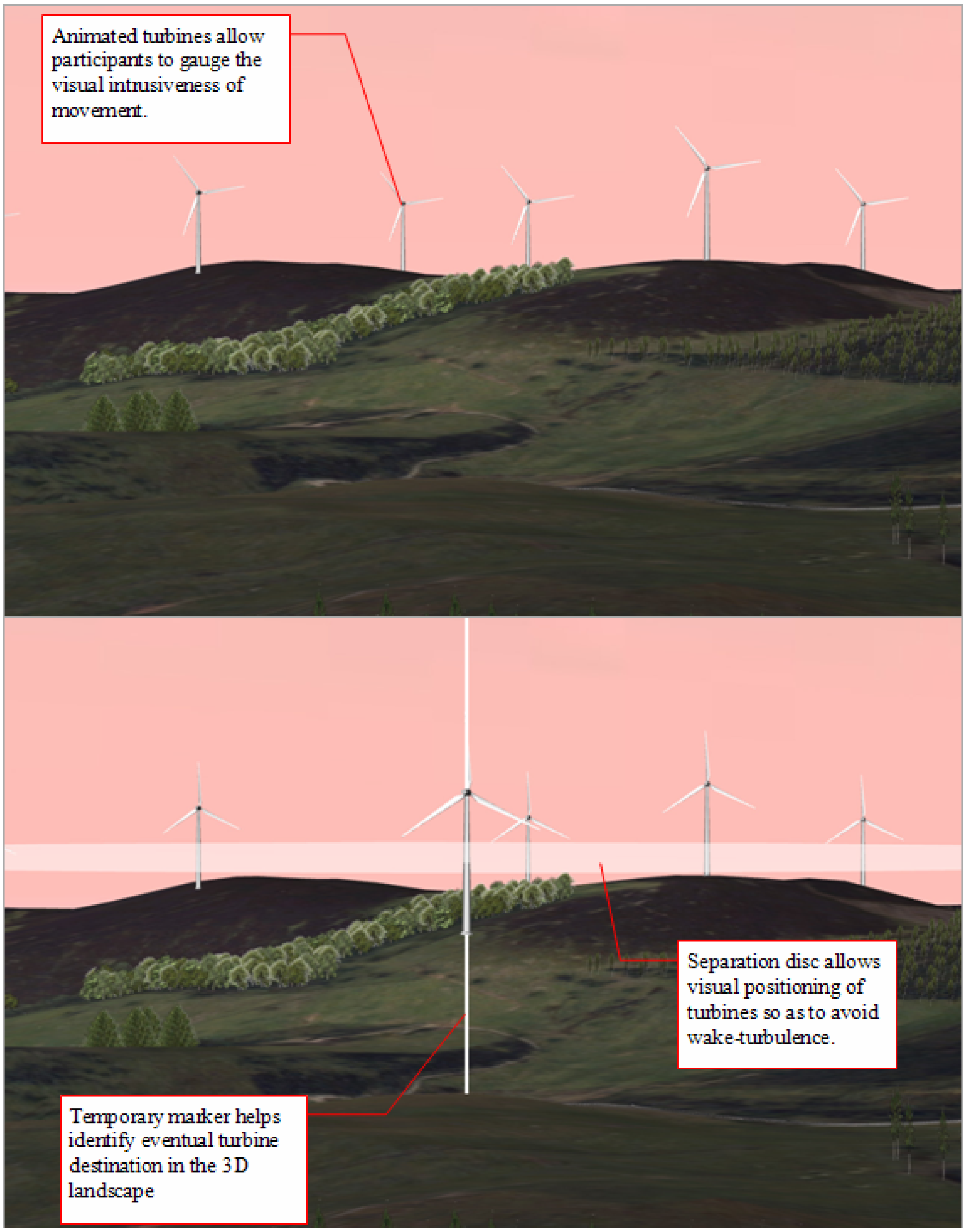

Fig. 5 Animation and interactivity can be used to facilitate both understanding and discussion of landscape planning issues.

flexibility than is possible with conventional Environmental Impact Statement documents. Some models have been built to allow turbines to be moved during the discussion.

As part of the information layering process, when a turbine is selected in the model a transparent disc appears that represents the minimum recommended separation between turbines. This allows a developer to explain a layout in terms of the engineering constraints. When that is combined with an overlay of windspeed data, as in Fig. 3 above, a very powerful communication tool is delivered.

4) *Extending the participative possibilities.*

Other models are currently undergoing live testing. These include models where 3D iconic symbols have been substituted for photo-realistic models. The symbols are colour coded to allow participants to select locations where, say, a windfarm, a shop, woodland, a car park, a conservation area and an 'other area' might be sited as well as those areas where they definitely do not want such a feature.

The sequence of images in Fig. 6 below shows how a landscape can be populated according to local participants' preferences. The turbine icons in the second image (top right) represent an area where a windfarm is not desired. In the third image (bottom left) an area for new broadleaved planting has been selected and the fourth image shows how the local community have decided on a range of additional planning elements including a (conservation area), an area for housing development (houses) but an area where shops are not desired (shop icon – note that while this is a real model of a real area that is currently undergoing testing in live participation sessions, the images shown here are hypothetical and posed for the sake of the explanation in this paper). The live system is full colour and the icons appear as solid green for "yes" or semi-transparent red for "no".

VI. CONCLUSION

Visual representations of the real world have always offered a better route to communication and understanding than mere description as the suggested by the adage: 'A picture paints a thousand words'. If that is the case, then a 3D model must represent 1000 x 10^3 and an interactive model 1000 x 10^4. This whimsical extension of an old saying is borne out by the popular preference for 3D environments. However, landscapes are dynamic and the addition of the fourth dimension adds the final piece of the puzzle.

The development of web and 3D technologies has been extremely rapid over the past few years and now allows for the distribution of real time interactive environments with the potential for multi-user interactivity and offers a very powerful medium for the communication of planning issues and related knowledge exchange.

The challenge for the development of such media is not so much the creation of the 3D models or the interactivity within them but ensuring that communication is genuinely two-way and that the model is not just used as a vehicle for the

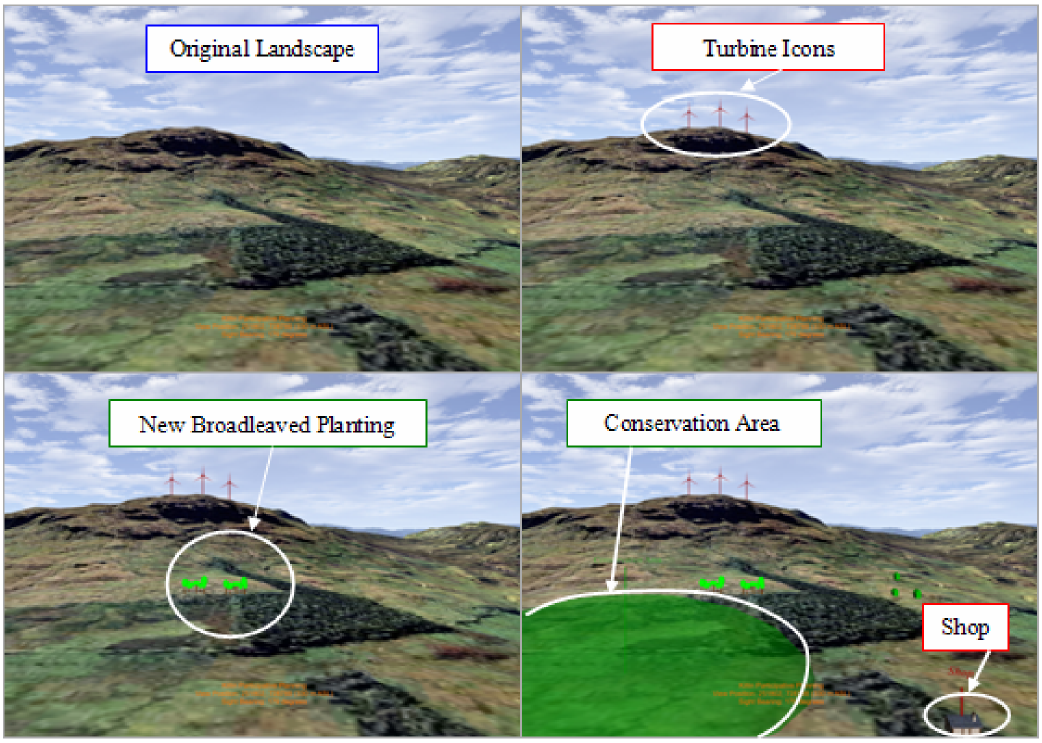

Fig. 6 Dynamic creation and placement of iconic representations allows a visual 3D representation of the development of participative planning discussions.

presentation of a *fait acompli* on behalf of the planners.

VR as a two-way communication tool offers considerable potential particularly in the area of Public Participation GIS (PPGIS). PPGIS is an area that is anticipated to have an increasing level of importance in landscape planning globally but if it is to be truly effective, greater account will need to be taken in VR simulations of the qualitative or 'soft-science' elements of landscape planning. Information rich virtual environments that can operate over broadband networks are now possible and thus allow for the representation of large amounts of qualitative and quantitative information side-by-side. With broadband access becoming standard for households and enterprises alike, this dissemination medium can now be used to support high data demand environments. This is a self-fulfilling justification of the intuitive knowledge of stakeholders as such technologies become integrated into society. Therefore, distributed virtual reality environments have great potential to contribute to enabling stakeholder participation and mutual learning in the planning context.

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