

10 **Are you with us? The role of presence in Mixed Reality for Participatory Design.**

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Abstract. In architecture, life-like three-dimensional pictures are often used to portray to the layman how a particular design is going to look and fit into the surrounding landscape. Some architecture firms produce animations of key areas to provide a more complete picture, and one or two even dare to use VR for dynamic walkthroughs. In these situations, level of active participation in the actual design by end-users of the environment are, at best, restricted to giving feedback of these views. But what about presence? Given a view into a model, how well can an end-user think themselves into that environment? Are they able to really consider how that environment will function in daily usage? Can they obtain a full appreciation of space?

This chapter takes a look at the role of presence when using Mixed Reality for Participatory Design in a design context with specific examples from workplace design. Through descriptions of case studies in which VR and other forms of reality representation are used, we consider that participatory design, by its very nature, commands a high degree of presence by the participants. In this case, limitations of hardware, software and graphic representation are in fact overridden by the power of design by doing – the task takes over – if the participant is willing.

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10.1 Introduction

Participatory Design is a complex process of mutual learning, understanding, communication and cooperation. It is a process that takes much time and patience and is fraught with peril; spurious designs take time to discover, and people may have personal agendas and actively work to hijack or hinder the design process. However, the rewards are great; the final design includes ideas from many experts, especially the end-users, is acceptable by the participants since they were active in the design process, and is cost-effective since expensive redesigns are not required.

The main idea behind participatory design is that end-users have an intrinsic feeling for the thing being designed since they are involved with it on a daily basis, and that therefore, the end-users ought to be involved in the design process. This feeling is called *Tacit Knowledge* and is difficult to gain access to. It is not sufficient to say to an end-user; “here you go, design this how you think fit”, this knowledge must be drawn out and combined with expert advice such as practical, ergonomic and aesthetic considerations. When designing a workplace, for example, it is beneficial to involve the workers in the changes so that their knowledge of the workplace and work practices can be included in the design [9], [13].

The goal of the process is to produce a design specification which can be used to construct a final product. Various tools can be employed to support this process with the purpose of ensuring participation, aiding communication and documenting the design process. Our premise is that design-by-doing is an effective method of ensuring that people are active in the design process and that Mixed Reality tools are excellent in supporting this process. Furthermore, when people who will actually be using the thing being designed are actually involved in its creation, a strong feeling of ownership and acceptance for the design is generated. In addition, using various representations of the real environment allows different aspects to be considered without the distraction of detail.

This is important as people otherwise can become stuck on irrelevant details too early in the design process.

The concept of presence, in the context of participatory design using Mixed Reality, can have several interpretations: (1) The standard idea of presence in Virtual Reality, that is the feeling of actually being within the Virtual Environment [16]; (2) Being able to accept that the Virtual Environment being working with is a representation of a real one, in other words, being able to think oneself into an environment in order to design and evaluate it; and (3) actively taking part (being present more than just physically) within the design group working to produce a meaningful design. In this chapter, we consider all of these.

In section two, we describe the theory behind the participatory design process considering communities of practice, communication and the problem with people that either do not want to participate, or are too enthusiastic. In section three, we consider various Mixed Reality tools that may be used in the Participatory Design process, how they can be mixed together and what this means in terms of presence. Section four describes an example from our own work, using participatory design in workplace adaptations. Finally, section five brings these threads together and ties back to the role of presence.

Many of the ideas in this chapter come from our own work in the area of using Mixed Reality Tools for Participatory Design of work places [3, 5, 11].

In this chapter, we use the term *Virtual Environment* to mean all forms of representation of reality, such as a Virtual Reality model, a physical mock-up, or even a dramatization of a work practice. These different representations are thus combined in the minds of the participants and the tools or media for representing them is termed *Mixed Reality*.

10.2 Participatory Design

10.2.1 *Communities of Practice*

People co-operate using Participatory Design in order to solve a problem [6, 13]. The task is to design something. An important aspect is who has the problem, who the design is for. Is it for the end-users, such as in redesigning a workplace to make it more ergonomically acceptable and thus reduce sick-leave? Or is it to gather information for the designers, such as for a new product that will be acceptable to a wide range of potential users?

In both cases, there are two groups; the end-users and the designers, each are experts in their own fields. The end-users know about the thing being designed, they have tacit knowledge about how it works and is used, and are ultimately those who will be stuck with it in the end. If the object being designed is new, then perhaps these people have knowledge about other similar objects which can be applicable and useful for the designers. The designers include people such as human factors experts, builders, industrial designers, usability experts or architects who have the goal of helping the end-users to both find a breadth of designs, and to determine the best of these.

Participatory Design a learning process and a complex interplay of two communities of practice [19]. The one community is formed by the designers, who wish to learn about the end-users' needs, the other by the end-users, who have been asked to take part (or who may have initiated the process to satisfy a need). In this context, each group is essentially apprenticed to the other in order to gain experience of the other's area of expertise. The designers need to learn what the end-users know, and the end-users can benefit from the designers' knowledge. It is important to remember that participatory design differs significantly from expert design. In the latter, an expert group may work with end-users' needs to expertly design a solution or product, in the former, the experts act more as advisors and researchers, gleaning information from the users to help them reach the best solution and teaching them what they need to know to make a good design.

Participatory Design is a democratic process. In workplace design, for example, it is essential that the participants are chosen democratically, and that information generated is relayed back to the others in the workplace. This is to ensure that everybody feels involved and is given a chance to include their ideas. During the process, discussions are conducted in such a way that everybody is given a chance to have their say, both to ensure that quiet people are compelled to take part, and that boisterous people are held in check so as not to trample over other's ideas.

10.2.2 *A time consuming process requiring trust*

Thoughts take time to ripen and associations between ideas take time to gel. A Participatory Design process has many steps. The first is to get to know one another. The designers and facilitators must go out to the end-users' environment, try to get a feeling for it and convince them that they can be trusted and worked with. Then, the structure of the continuing process must be decided. Even in this, the end-users should be consulted, though they are often given a limited choice and the facilitators must make sure the structure will lead to sensible and fruitful discussions. After this, follows a period of mutual learning, discussion and designing. Ideally, the process should continue until all parties are satisfied that no more can be added, however, in practice, there are usually time and financial constraints. Normally, the participants meet several times, with periods to mull things over and discuss with colleagues in between.

Gaining access to tacit knowledge requires trust and a spirit of cooperation. Problems can occur if the designers have a hidden agenda, such as, for example, redesigning a work

practice to make it more efficient and thus reduce the number of staff. In that case, the designers are not working for the end-users and a true trust relationship will never be achieved meaning that the tacit knowledge will probably remain well hidden [19].

Further, in work-place design, the process can be taken to its full extreme using a method called *continuous improvements* [13]. In this case, the goal of the designers is to be able to withdraw from the design process after having taught the end-users all they need to know to solve their problems and to be able recognize new issues as they arise.

10.2.3 Idea Expansion and Consolidation

During the design process, many ideas will be generated and must be managed, stored and worked with (fig. 10.1). These ideas are created, made into designs and tested, thus creating new ideas which in turn must be processed, and so on. When a large group is cooperating, there may be many ideas which must be sorted and the most interesting taken further.

Furthermore, tacit knowledge, by its reticence, requires that many, even seemingly crazy ideas must be brought forward in order to awaken unpredictable associations which might lead to innovative solutions. Thus, the group must work through idea expansion phases to generate new ideas, and idea consolidation phases in order to choose those most interesting.

The process can, in fact, begin at any point in the design cycle. For example, several designs for existing products may be presented to the end-users as a basis for discussion about their advantages and disadvantages. Thus, the process is started with testing existing ideas. Perhaps the process begins with a brain-storming [7], in which case, it is entered with a large selection of ideas to consider and refine.

10.2.4 The role of the Facilitator

The job of the Participatory Design facilitator is to manage the process and to record important information and ideas. They have to guide the participants through the various stages, help them with selection and usage of appropriate design tools, and on occasion, break off unfruitful or irrelevant discussions. Generally, at least two facilitators are required, one to guide and provide the structure, the other to record and assist. Neither should actually take part in the design process as this can give a conflict of interests – the facilitator should act more like an impartial referee.

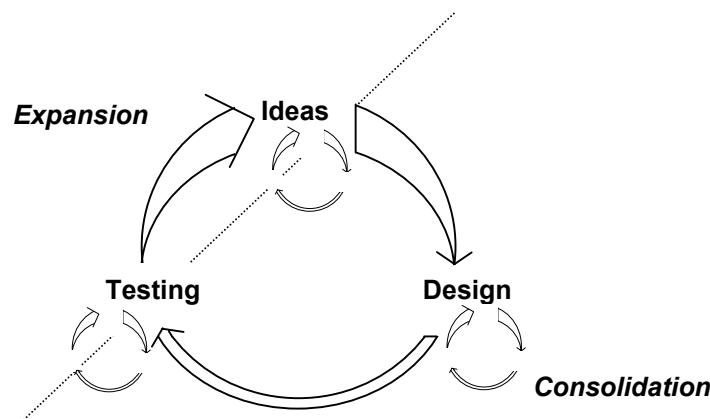


Figure 10.1 Phases in the design cycle; idea expansion and idea consolidation in an iterative process.

10.2.5 Group Dynamics

There can be many reasons for taking part in a participatory design process ranging from a real desire for change to being there because you were told to. People may come with a hidden agenda to ensure that the change doesn't take place; perhaps it threatens their job situation, or maybe they don't agree that such changes are needed [7]. Of a less difficult nature, are people who are merely quiet and have difficulty putting their views forward in groups where there are people who are more extroverted and used to being heard.

These situations must be managed properly since otherwise a participatory design process can become undemocratic with only a few people having their opinions voiced, or in the worst case the process may be sabotaged completely and not produce any useful information.

Perhaps the easiest way to ensure participation is to use turn-taking. For example, in a group discussion, each person should be asked for their opinions in a round-robin fashion.

This both forces people to think and dare say something, as well as keeping those with the loudest voices in check. Nevertheless, the facilitator must be sensitive to people's feelings. Some people may find it very difficult to speak in front of a group or act out a scenario, so they should perhaps be given more planning type tasks where they can still have a chance to voice their opinions.

Another aspect of group dynamics is getting people to work together as a team, and not just as a group of individuals. The techniques that are most effective are similar to those used to knit company employees together on inspiration courses. Playing games that are both funny and aim to increase physical trust can work well to break the ice and get the thought processes flowing. Mixed Reality tools can be used to support this part of the process as well.

10.3 Mixed Reality Tools

10.3.1 What is Mixed Reality?

Mixed Reality can be described as Virtual Reality and Reality combined, though as we shall see later, various representations of reality can be mixed without involving Virtual Reality. Nevertheless, in computer assisted Mixed Reality, the reality component usually forms part of the interface between the users and a Virtual Environment. Further classification can be made depending on how the Virtual Environment is presented to the users. For example, an Augmented Reality system may be achieved by presenting the Virtual Environment over the real one using a see-through Head Mounted Display [10], or perhaps using a large projector screen to show a continuation of a room from the real to the virtual. Furthermore, manipulation of objects in the real world is registered by the computer (perhaps through a camera or tracking system) and used to make changes in the Virtual Environment and thus the corresponding image shown to the users.

In terms of Participatory Design, Mixed Reality tools need to support dynamic alteration capabilities – the users have to be able to design, after all. This means that the computer must know how objects in the real world are being manipulated. This may occur through light tables and cameras [18], magnetic tracking, or even optical tracking with markers.

10.3.2 Participatory Design Tool requirements

To support the Participatory Design process, Mixed Reality tools, ideally, must be able to manage the following:

- support active design;
- allow both individual and group thought;
- support all phases of the design process – expansion and consolidation of ideas;
- aid communication between the communities of practice;
- allow inclusion of information from diverse sources
- store ideas for inclusion in later designs (maybe even by other people);
- aid the facilitator in managing group dynamics;
- allow ideas to be communicated to others in different locations; and
- be usable by the intended users for the intended task.

Some of these are more important than others, and some are only possible with advanced technological solutions. We shall now consider the implications of these requirements:

Support Active Design: Participatory Design requires that the participants are active in the design process. In the architectural context, for example, this is termed ‘design-by-doing’. This is based on the principle that actually building up an environment in full scale, for example, activates thought processes, taps tacit knowledge about the environment being built and thus allows the participants to consider the implications of the design based on their own experiences. Furthermore, the tools must support the ability for the users to think themselves into the environment being designed, or to be able to envisage the thing being designed in context.

Allow individual and group thought: Working together as a group allows people to discuss ideas, work through problems and make associations to other people’s ideas. However, one often also wants to work privately, expanding an idea before committing it to the group. Perhaps one is unsure how the idea will be accepted, or maybe an idea requires fleshing out in order to make it comprehensible to others.

Support all phases of the design process: Sometimes, the tool must allow for a mass of ideas to be generated and stored. Brainstorming, for example can result in many diverse and sometimes odd ideas that might later lead to innovative solutions. It is important that such ideas are not lost. However, the tool must also support the filtering of ideas and the identification of the most relevant and promising.

Aid communication: The tools will act as a common language between the communities of practice. A plan drawing, for example, is an easy way for an architect to show somebody how an interior may be laid out. However, not all people can use the same tools, some require a certain amount of expertise. Plans are easy for architects to understand, but can be difficult for a layperson to obtain a feeling for the space involved. The tools should be designed to be the common language between the communities of practice thus helping people with different backgrounds and areas of expertise to communicate. That way, all members can meet on an equal footing.

Allow inclusion of ideas from diverse sources: When working, a group may generate and record ideas in various forms; notes on paper and whiteboard, models, sketches,

drawings, computerized models, film sequences, etc. These must be stored together in the correct context so they can be found and understood later.

Store ideas for inclusion in later designs: Similarly, these ideas may be required at a later stage and be used by other people than those that wrote them. Thus, the tools should allow for communication across time and space barriers, and for the inclusion of extra information to put the information in context.

Aid the facilitator: The design tools can help the facilitator to manage the process. This may be in the design of the tools themselves, or in specifications of usage which limit this to a predefined manner. For example, a whiteboard can be used in many ways, however, when used as part of a brainstorming technique, it ensure the ideas are structured and recorded, and allows the facilitator to concentrate on managing the process.

Allow ideas to be communicated to others in different locations: Design ideas may be sent to others to be used in their designs, or to include them to ensure a democratic process.

Be usable by the intended users for the intended task: This is a standard usability concept [15], and is essential in this context. It is important to be aware of the abilities of the intended users of the system, and that they need not spend too much time merely learning how to interact with it. Furthermore, they should be able to perform the tasks that they wish to, and that the system supports the tasks.

10.3.3 Components of Mixed Reality Systems

Given the tool requirements above, what components may comprise a mixed reality system? Components are required for design, storage, visualization, communication and management of group dynamics. Since this is to be Mixed Reality, both physical and computerized parts are required. Here are some examples:

- Pen and paper which is then scanned or photographed with a digital camera. There are even products that capture directly what people write on a piece of paper. This is useful for single work or sketching and even showing and explaining ideas to other people. However, people need to be encouraged to work together rather separately. Small bits of sticky paper may be used in various idea expansion tasks or to facilitate grouping of relevant ideas. Once documents are inside the computer, they may be filed, have other information added, be sent by network to other people and be annotated.
- Electronic whiteboard where what is written on it can be stored in digital format. This may be used in various forms of structured discussions and for idea storage. As above, the resulting documents may be stored or transmitted further.
- A full scale model of an environment or object gives substance to ideas and aids communication to others in an unambiguous form. Physical objects may be scanned by a digital laser scanner which produces a 3D computer model. Larger environments are more problematic – photos and sketches allow these to be transformed to digital form, and thus combined with sketches and other documents for archival and transmission. A rapid prototyping tool would also allow a small object to be physically designed in one place, scanned and transmitted electronically to another and ‘printed out’ in 3D to be evaluated and perhaps further refined by other people.
- A scale model is more transportable, at least locally. The movements of small objects can be tracked and translated to a Virtual Environment. This allows for a complex

interface which several people can use at once, and also allows for designing by moving sections.

- An electronic 3D model. CAD models can be difficult for novice users to make, but also allow object and environment design to be portrayed in a form easier to understand for laypeople than rough sketches or plan drawings. A VR model adds further realism through more advanced interaction devices, multimodal representation (visual, auditory, haptic), and realistic behaviors.
- Dramatizations and stories allow objects and environments to be put into context and tested. Scenarios can be constructed to illustrate both typical and exceptional circumstances. The designs can then be considered in light of these and evaluated.

10.3.4 Ways of Mixing Realities

In the context of Participatory Design, any or all types of representations of reality may be combined and used together at the same time, or one after the other.

When Mixed Reality tools are used together, the participants must be able to easily switch and transfer information back and forwards from one to another. When used separately, each tool must support and layer an experience on top of a preceding Reality representation, and again, information should be easily transmittable from one tool to the next.

The facilitator must decide which tools are most appropriate at which stage of the design process, teach the participants how to use them, guide them in usage and help gather the ideas and information generated. Different forms of reality representation best support different stages of the design process (Table 1).

10.3.5 Mixed Reality, Participatory Design and Presence

In the context of Virtual Reality, presence has been defined as “a sense of being there” [20].

An expansion of this definition that has previously been used by one of the authors is “a sense of being there, reflected by engrossment with, and intuitive behaviour in, the VE” [14].

A number of factors have been suggested as having an influence on presence, including those associated with the system (e.g. physical enclosure of the display, resolution of the display or frame rate), the Virtual Environment (e.g. level of detail, photorealism, sound, level of interactivity) and the participant (e.g. immersive tendencies) [4, 17, 20].

The underlying theme of all of these factors could be described as the extent to which the participant is reminded that they are in the real world. Some of the ways to achieve this are physical, such as blocking out a view of the real world, and some attempt to encourage the participant to become so engrossed in the VE that they forget about the real world, even though if they wanted to they could be reminded by it, whether by looking around them at the real world environment, or sensing some reminder of the real world, such as hearing a noise external to the VE, or feeling their leg touch a cable or piece of furniture in the real world.

When considering the role of presence in Mixed reality, we may have to revisit our definition and understanding of what we mean by the term. Mixed reality is often used to enhance our communication in or behaviour with the real world, and therefore we have no wish to exclude the real world from the participant. We also do not always actually have an “environment” that the participant is moving around in independently, therefore they may not become “engrossed” in an environment, and may not obtain a sense of “being there”.

Table 10.1 The stages in a typical day of a Participatory Design process and the Mixed Reality tools that are useful. A full process may involve several of these and be spread over many weeks. It would be preceded by periods of learning for the participants about each other and proceeded by implementation and usage of the design specification.

Stage	Mixed Reality Tool	Purpose
Warm-up	Games such as tag, throw the invisible ball, simple drama exercises etc	To get people relaxed, laughing and working together. Help break down barriers due to, say, job position.
Introduction	Managed discussion, presentations, examples.	To introduce the participants to the idea of Participatory Design, Mixed Reality and the other tools.
Idea Expansion	If there is an existing design, this may be presented as a full scale model (or indeed the real object) or VR as a discussion object. Democratic meeting techniques (such as brainstorming or cognitive walkthroughs) may be used to spawn concepts and make interesting associations or to evaluate the existing design. Dramatizations can be used to consider how well (or not) a design works in practice and to allow people to move and express ideas freely.	To generate and gather as many ideas as possible about an existing design and about the desired features of a new design.
Idea Consolidation	Discussions will bring forward which design ideas are most interesting and relevant to continue with. VR, full scale and scale modelling can be used to consolidate a design idea. Dramatizations (role play) allow the resulting design to be tested.	To take a few promising ideas and work through them to a realistic design specification.
Debriefing	Managed discussions and presentations by participants of their designs to others.	To prepare the participants for returning back to their home environment, for preparing material for sharing with others and for giving 'homework'.

Perhaps then, the key element of the role of presence in mixed reality, is the fact that we assume that a person with a high sense of presence will behave intuitively, interacting with the Mixed Environment in a natural manner.

Presence is generally assumed to be a 'good thing' where an environment with a high sense of presence should be more usable and enjoyable. A possible contradiction to this is in discussion of the relationship between presence and VR-induced sickness, where it is thought that a high level of presence may be associated with a high level of sickness,

although there is contradictory evidence in this area [14, 17]. Certainly, it makes sense to assume that if a person is behaving intuitively in a mixed reality system, then they are likely to find it more usable, and may therefore have the opportunity to use the system more effectively.

In terms of being able to design in a group, it is essential that the participants can accept that the tools being used portray representations of the real environment. In this case, we are not attempting to make the participants believe that the Virtual Environment *is* the real one, but rather that using it allows them to discuss aspects of the real environment in a meaningful manner.

The important aspects of a real environment may vary from case to case, however, commonly, the users must be able to obtain a feeling for the space or size of the environment or object being built and be able to visualize this in context of its usage. For example, in architectural design, a room must be evaluated for accessibility. This requires that the participants can go into the space and feel, by comparison to their own body-space, how big the environment is. However, this feeling is difficult to capture since people have a tendency to experience distances as shorter in Virtual Reality representation of an environment than in reality [8]. Thus visual cues are required when using a Virtual Reality based tool to allow the size to be calculated [12]. Example cues are measurement grids, tape measures, familiar objects, objects related to a specific context (for example, lounge room furniture) or people-models. On the other hand, a real, physical model of an object or environment that can be interacted with directly gives the same feeling of size and space as the real environment. However, if an object is to be put into a larger context, particularly one that is too large to model in full scale, then Virtual Reality is then the best alternative since some feeling of context and space is possible. Ideally, a combination of the two is required so that an object can be manipulated and interacted with in reality, and at the same time, its relationship to the context viewed in Virtual Reality, in other words, a Mixed Reality.

10.3.6 Measuring Presence in a Group

There are many ways to measure a single person's feeling of presence in a Virtual Environment; these are summarized well in [16]. Measures are divided into; subjective such as rating scales, subjective report and comparison-based prediction (comparing experience of a real-world and virtual scene) and objective measures such as behavioural (actions which suggest that the cognitive program from a real environment is being activated) and psychological.

However, any such measures in a Mixed Reality environment for participatory design would be confounded by inter-personal team influenced behaviour - in essence, it is no longer possible to only examine the simple interaction between an individual and the system. Nevertheless, a group rating may be possible by considering, instead, for example, objective measures of time-on-task, level of engagement, quality of the final design or by evaluation of the design process from ideas to final design specification. The questionnaire approach may still be valid, but may require some alteration of specific questions in existing tools – for example – most presence questionnaires may refer to whether people have a sense of control in the environment – in mixed reality in a group situation, it may be the case that some participants are merely observers, and do not have the potential to control a viewpoint. We may also have a halfway house, where people can influence interaction (e.g. by moving visually tracked objects) but cannot influence viewpoint. This question is still the subject of active research.

10.4 An example – designing workplaces

In this section, we shall illustrate the concepts above with an example from our own work.

This is an amalgamation of several real participatory design case studies in which the objective has been to investigate various usage methodologies of a mixture of design tools in a variety of architectural design contexts. Both new designs and redesigns of an existing environment have been considered. Finally, we shall discuss an exciting new technology that further increases the ability for various Virtual Environment tools to be more tightly combined into a Mixed Reality system. The sum of these parts is expected to be significantly more conducive to producing a successful design than when the tools are used separately.

10.4.1 *The Envisionment Workshop*

The Envisionment Workshop is a collection of tools and methods of usage for the participatory design of work environments. Typically, a group from a workplace wishes to redesign their working environment, perhaps because of refurbishing, or perhaps due to the desire to solve an identified problem with the current environment.

After an initial period where the designers and facilitators learn about the workplace, the most appropriate tools are chosen for the particular project. These are then combined together in a series of Envisionment Workshops; the number of which depends on how much time the company is willing to spend.

Generally, a single Envisionment Workshop takes a whole day and consists of a number of sessions with one or more tools. Each session is led by a facilitator who is helped by an assistant and helpers. The following is a typical series of events and are interspersed with coffee breaks and lunch to provide time for casual conversation.

1. Arrival of Group Members.
2. Introduction to methods and plan for the day.
3. Warming up, discussion about the purpose of the day, early capture of ideas, brainstorming, thoughts about existing environment and summarisation of previous workshop if there was one.
4. Parallel or serial usage of envisionment and design tools, depending on the number of participants and purpose of the day. Sometimes a single idea needs to be worked through by everybody, and sometimes it is more important to capture a variety of ideas.
5. De-briefing, closing discussion, plan for future work (if relevant) and assemblage of material for the participants to take back to show to others.

Ideally, the participants need to return for several Envisionment Workshops, with a period of time between to allow the contemplation of the previous workshop and the gestation of new ideas. Each workshop may also deal with a different aspect of the general problem.

10.4.2 *Envisionment Tools*

The tools that we use are Full Scale Modelling, Drama, Virtual Reality and Democratic Meeting techniques.

Full scale modelling, as the name implies, is the modelling on a one to one scale of environments that people can enter and use. For our work, modelling is performed in a full scale laboratory, which is a large hall (18x15 meters with a height of 5.8 meters). Within its environs, wall, window and door elements can be put together to form rooms. These are

then furnished using a mixture of real and mock furniture. Complex objects can be built from polystyrene, cardboard and large, plastic, lego-like bricks, or if greater solidity is required, wood. There is a full-time employed technician and builder who helps with such objects. A platform can be lowered to provide a ceiling and a second floor. Ceiling lights can be selectively illuminated and the all-surrounding windows can be darkened to provide daylight only where required.

The full scale laboratory is used to build up environments from sketches so that they can be experienced in a more physical manner and for building environments during dynamic design in participation with the workplace experts. It has proven itself to be a useful tool in previous work [11], but suffers from some limitations such as a restricted area, so large environments cannot be studied in context. It is also difficult to build in scenery, relationships to other buildings, daylight in exactly the right places, colours on the walls and decorations. Furthermore, once the full scale laboratory has been emptied, it is a time-consuming job to recreate an environment for continued work at a later stage.

Pedagogical drama has many forms and is primarily used in education and theatre activities. It is used for sense training and to illustrate communication, roles in groups, status, norms, decision making, leadership functions and management of conflict [1].

Drama exercises can be used to help the participants become a group, to feel close to one another and to trust each other. They are activating, realistic and give direct and concrete feedback to actions. They allow people to act in new ways in environments that are safer than the everyday. There are various forms of drama exercises;

Warming-up exercises activate the participants and create a relaxed atmosphere. Such exercises include playing tag and throwing an imaginary ball to each other.

Prioritisation Drama exercises, are used to help the participants throw light on the problems they have together in a clear and active manner and force prioritisation of possible solutions. Such exercises include “Hot Seat” in which a statement is read out and the participants must show whether they agree or disagree by standing or remaining seated and “4-corner” in which a question is read out with three possible answers; the participants have to move to the corner for the answer they agree with, or the fourth if they have a different answer. Statements, questions and answers are chosen to be humorous or topical to the day’s work (or both) and usually controversial. Prioritisation exercises can also be used as warm-up exercises that get people thinking as well.

A third form of pedagogical drama is called *Improvisation Drama* and in our research, represented by the variety called “invisible room”. In this exercise, the participants go into an empty space which is the designated room and act out the usage of an invisible object.

The function of the room is usually pre-decided, though the participants are allowed to choose their own object – it is even permitted to interact with other people’s objects. The participants usually go in one-by-one so that the others can watch what happens and then leave again before the next person enters.

The fourth form used in this research, *Role-play* can take many forms. The first alternative uses a given situation, such as a conflict in the workplace, and the participants have to discuss and act out the resolution. The second variety uses a given environment, such as a model in the full scale laboratory, in which various work situations can be acted out and discussed. Thirdly, the group can be given completely free reign to fantasise about the dream workplace and act out a situation to illustrate this. Finally, caricatures of behaviours, jobs, workplaces, etc. can be acted out to clarify problem areas (like worst case scenarios).

Two forms of *Virtual Reality* have been used in this work, PC based Virtual Reality in which a three dimensional image from the computer is projected on a wall in front of a group of users with a straight-forward interface to allow simple models to be quickly built, and a CAVE™ system, in which images are projected on the walls of a three by three

meter room in stereo. Virtual Reality has been used to show an existing environment as a discussion generator and as a tool for designing a new version of a work environment.

In order to assemble ideas, reflect over the past sessions and get something down on paper, the above tools were interspersed with discussions, free-form brainstorming and structured brainstorming, termed collectively *democratic meeting techniques* [7]. The first two are self-explanatory, the last involves listing thoughts about a topic in three columns; positive, negative and visions. This works well for discussing existing environments and what changes should or could be made. In all these cases, a facilitator both leads and asks clarifying questions. Often, comments are sought in a round-robin fashion so that each participant is both forced to say something and gets a chance to do so. Topics are always clearly stated at the beginning, and the participants are led back on track if they stray onto peripheral issues. In some cases, though, discussions can go in unexpected, though important directions resulting in a complete restructuring of the subsequent sessions to explore a new issue.

A participatory design process for designing a new work environment is shown in Figure 10.2. Note that there are periods of idea expansion and consolidation in each workshop as well as a variety of tools in the different stages. This gives the participants the ability to use the advantages of each tool in a complementary fashion, layering the experience of the Virtual Environments to form a total Mixed Reality experience.

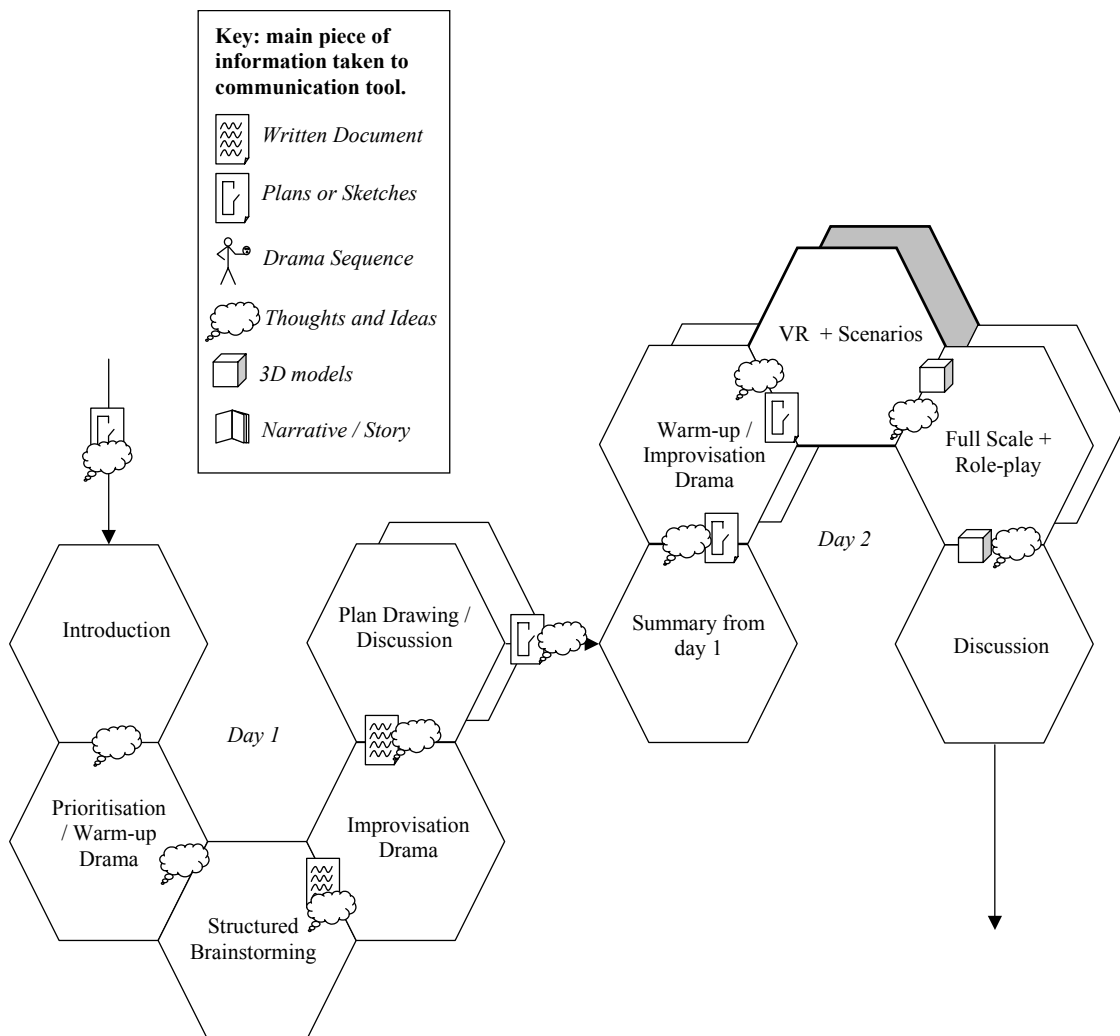


Figure 10.2 An example flow of events during two day-long Envisionment Workshops for designing a new working environment. During some stages there may be parallel sessions.

The design process is often split over several Envisionment Workshops over several days.

It was found that a full or half-day intensive workshop, though tiring, produces excellent results if the participants are sufficiently motivated. Furthermore, allowing some time between successive workshops allows ideas to mature which can be further incorporated.

10.4.3 Results

The Participatory Design Virtual Reality tool progressed through several prototypes during the Envisionment Workshops [3], and resulted in the following conclusions (amongst others): a simple interface was easily understood by users, but the design process was disrupted by having to share the input devices. This led to frustration and a need for alternative design tools such as pen and paper. This problem was alleviated somewhat by having an expert drive the tool (thus making the interface verbal), but there was still a bottleneck at the interface. Having the VR picture projected on the wall allowed all to see the working design and did facilitate discussion as well as later presentation of the resulting design. Textual labels on objects provided a common language and helped compensate for lack of detail, which was deliberately absent to force a focus on layout rather than details and to simplify the tool.

The CAVE™ Virtual Reality was found to be useful for initial criticism of an existing work environment and for visualizing situations that could not fit in the full scale laboratory.

Full Scale Modelling has been found to be well suited for participatory design as it is a hands-on activating experience which allows full participation by the workplace experts in communication with the design experts.

Free-form drama has been found useful for idea expansion in the early stage of the design process and role-play for testing environments using real work situations.

10.4.4 A tighter coupling of VR and Reality

The concept of the Envisionment Workshop has worked well in many participatory design situations and the selection of the tools has led to successful designs (as measured by worker-satisfaction). Variations in tool combination and usage have been proposed for re-designing a work environment as well as for designing a new work environment [3]

However, a number of limitations in the tools have also been noted, particularly, the difficulty for novices to use the VR tool despite a very simple interface, the bottleneck at the input devices for VR and the difficulty of transferring a design from the full scale laboratory to the VR environment.

After analysing the results, it was decided that a number of new research goals be concentrated upon:

- To develop a system for directly transferring a full scale model into VR without requiring user intervention.
- To simplify and integrate the VR system further into the full scale laboratory.
- To determine how best to involve other workers who could not participate directly.

Consequently, we have now acquired a system which allows the tracking of reflective markers within the full scale laboratory. This system is usually associated with gait analysis and recording realistic human movement for animation of characters in films.

However, after a considerable reprogramming of the real-time component of the system, it is also now able to be used to recognize patterns of markers related to specific object

types, track their position and rotation in the full scale laboratory, and return that information to the Virtual Reality system in real-time (fig. 3).

This system will give us many possibilities, for example, a group can design in the full scale laboratory, with the Virtual Reality image close by for reference. Placement of objects, experience of space, and role-play is performed in full scale, whereas, location in a larger context, extra objects, different colours etc can be performed in Virtual Reality.

Thus, we minimize the conflict over the input devices for the Virtual Reality system and combine the benefits of both to form a huge Mixed Reality Virtual Environment.

With this system, there are also other, more adventurous possibilities, for example, now we can truly include a participant group sitting at another location using the Virtual Reality version of the environment as the communication medium. And we can record an entire design process within the computer for later analysis, insertion of relevant documents generated during the process and for being able to go back to a previous design and continue from that point in a new Envisionment Workshop. These ideas present many exciting challenges and are part of our continuing research.

10.5 Conclusion

In this chapter, we have discussed the role and meaning of presence in the context of participatory design using Mixed Reality environments. Presence can have the following interpretations:

- The participants must be able to think themselves into the Virtual Environments represented by the tools. This is the standard Virtual Reality meaning of presence.
- They must be able to accept the Virtual Environments as models of the real environment in order to be able to discuss them meaningfully.
- The participants must in fact be present more than physically, they must actually take part in the design process and not try to take it over for their own means.

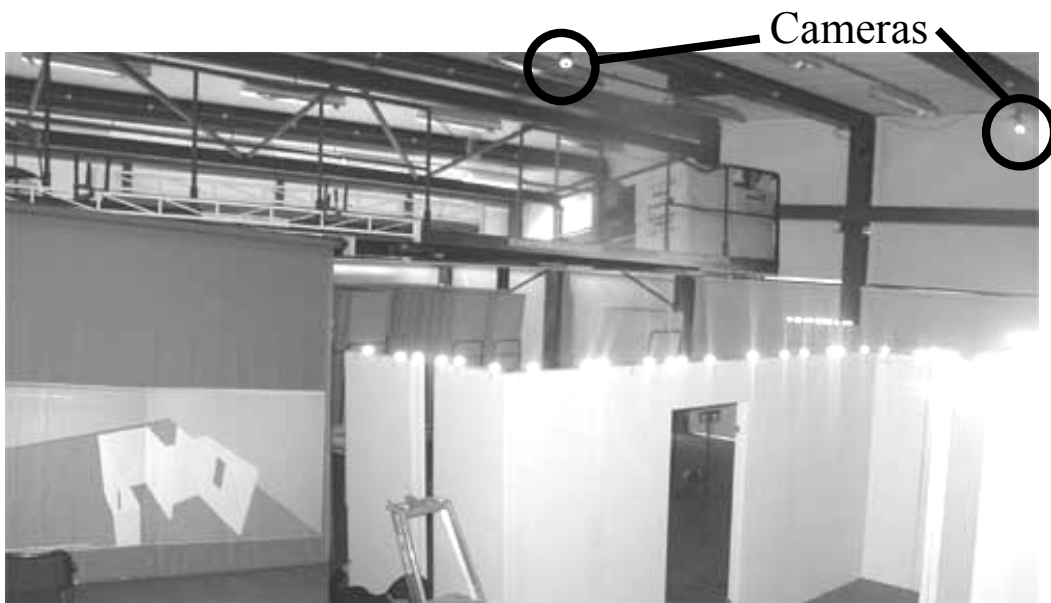


Figure 10.3 Objects in the Full Scale Laboratory are tracked with type, position and rotation information sent to the Virtual Reality system in real-time. Each object has three reflective markers in different configurations for each type. Cameras in the ceiling use visible red light to obtain reflections from the markers and triangulation to determine marker position.

The second is important if the participants are going to be able to use the tools for meaningful dialogue and for helping to get at tacit knowledge. In this case, careful selection of a Mixed Reality that has the features that the participants wish to consider, such as feeling of space, or lighting effects is important.

The third interpretation is mostly a matter of management of group dynamics. Even here, however, the Mixed Reality tools play a role in supporting the Participatory Design facilitator by providing a structure and encouraging the participants to take part despite themselves.

In our own work, we have seen that using a combination of tools that support active design, by mixing realities and finding appropriate methods of usage, participants become very engaged in the design process. This has even shown itself to allow the participants to overcome some of the limitations in the design tools, for example difficulties with the Virtual Reality tool interface, and even so, produce useful results.

This illustrates the ultimate goal in the development of these Mixed Reality tools – to facilitate a meeting of minds so that intelligent and valuable discourse can occur between groups of people that otherwise might have difficulty communicating due to their diverse backgrounds and assumptions of what is basic knowledge.

Nevertheless, there is still much research to be performed, for example, new ways of mixing different reality representations to allow exciting new tools to be created that combine the benefits of each; and ways of ascertaining the degree of presence for a group in a design situation.

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