Expressive Interactions – Supporting Collaboration in Urban Design

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ABSTRACT

This paper discusses technological interventions in support of planners, citizens and other stakeholders in envisioning and negotiating an urban project. A set of prototypal tools, including a tangible user interface, has been developed that allow users to create and manipulate visual/auditory scenes and mesh these scenes with the real environment of an urban site. The paper discusses how to support users – different types of stakeholders - in the collaborative creation of mixed reality configurations as an integral part of expressing their ideas about an urban project, distinguishing between different types and levels of cooperation. It also looks into how to use mixed reality tools for enhancing an already highly developed representational culture.

Categories and Subject Descriptors

H.5.1 Multimedia Information Systems, H.5.2 User Interfaces, J.5 Arts and Humanities, K.4.3 Organizational Impacts

General Terms
Design, Experimentation, Human Factors

Keywords

Cooperative work, urban design, tangible user interfaces, mixed reality applications, representational cultures, stakeholders

1. INTRODUCTION

Urban planning has for some time been in the focus of research on cooperative work. While before emphasis has been mainly on highly sophisticated simulation tools and on animated 3D renderings of urban projects, more recently more and more tabletop applications in support of urban planning are developed. These tools respond to a widely acknowledged need for stakeholder participation and negotiation in urban planning. Al-Kodmany [1] summarizes the benefits of public participation in planning – 'they include enhancing the capacity of citizens to cultivate a stronger sense of commitment, increasing user satisfaction, creating realistic expectations of outcomes, and building trust' (p. 37) Urban projects are vastly complex; they affect investors, specialists of all kinds, and citizens; and they play an increasing role in community politics. All this makes it desirable to involve all these stakeholders from an early stage on, in concept development for projects and exploring first solutions. While all these tools add to the possibilities of urban planners to involve citizens and other stakeholders in planning and decision-making, they have their limitations. Animated 3D renderings of urban projects are very

sophisticated and enable planners to produce seductive representations of a project, but they do not support stakeholder participation. Tabletop applications on the other hand often depend on costly hardware and intense preparation is needed for enacting real planning tasks with these tools.

While learning from these experiences, we are experimenting with a somewhat different approach to supporting collectives of planners, citizens and other stakeholders in envisioning and negotiating an urban planning project. The idea is to provide users with tools that allow them to create and manipulate visual and auditory scenes and mesh these scenes with the real environment of an urban planning site as an integral part of expressing and experiencing an evolving project. We have created a tangible user interface that supports several users in producing and discussing these mixed reality configurations. The challenges of such a project are manifold. There is the issue of scale – urban planning projects are usually large; of participation – what kind of contributions can stakeholders, including normal citizens, be expected to make; of 'content' – how can urban issues be represented in a mixed reality environment?

Early 'probes' of technologies were presented to users in a series of workshops with the aim to learn from their engagement with the tools and their limited but evolving functionalities in a process of iterative development. Exposing our design ideas to users, from an early stage on helped us to benefit from users' experiences and imagination, with each new workshop setting agenda for re-design. The urban planning contexts, in which we place and explore our technologies are highly complex and we are ultimately aiming at supporting urban planners in practicing more participatory forms of representing, exploring and constructing an urban project. In this paper, we take a narrower approach, examining the appropriateness of our technologies, with a focus on two questions: How can we support users – different types of stakeholders - in the collaborative creation of mixed reality configurations as an integral part of expressing their ideas about an urban project? How can we use mixed reality tools for enhancing an already highly developed representational culture?

The paper seeks to answer these questions by first describing the project, the technologies under development, as well as a specific workshop scenario; then highlighting some observations made during this workshops; and finally discussing how these experiences helped us better understand the issues of collaboration and representation we address in this paper.

2. RELATED WORK

Within CSCW we find different approaches to collaboration in urban planning. Well known is the work with UrbanSims that seeks to support public deliberation and collaborative decision-making by multiple stakeholders on complex issues, such as land

use and transportation. Borning et al. [4] developed a set of indicators, based on sophisticated simulations, with the aim to foster a debate which is value-sensitive and transparent. Other groups use UrbanSims for complex simulations that help explore different policy scenarios [15].

Arias et al. [2] have proposed a conceptual framework that stresses the fluidity of real-world problems, such as urban planning, and the fact that 'the very process of collaboration among stakeholders further increases the ever-changing problem context' (p. 90). One of their applications is the *Envisionment and Discovery Collaboratory* (EDC) [7], a tabletop application where participants work around a table, interacting with computer simulations through manipulating physical tokens, representing elements of the domain. They have, for example, in this way simulated the dynamics of a bus route, with participants engaging in 'what-if' games and being able to anticipate and discuss the consequences.

Another tabletop example is *Urp*, a physically based workbench developed by the MIT Laboratory that allows users to study light properties and flows of an architectural scene [25]. When physical models are placed on a table surface, the resulting shadows, reflections, and pedestrian-level windflow are digitally visualized on the surface. A second tabletop application developed by the Media Lab is the *Illuminating Clay* [21]. Users of this system may alter the topography of a clay model in order to design and analyse landscapes. The results of a modification are constantly projected back into the workspace. The *Luminous table* [12] is an augmented reality workbench integrating multiple forms of physical and digital representations, such as 2D drawings, 3D physical models and digital simulations. All of these elements are overlaid on the same table surface.

Caretta [24] focuses on the integration of personal and shared spaces by using a tabletop tangible user interface for group collaboration and personal digital assistants (PDA's) for each user. Within a shared space, participants manipulate scale models of houses, stores, or office buildings to redesign a town. Within their personal space, users can test a plan in private by redesigning one on the PDA.

Web based support for distributed co-operation and negotiation in spatial planning is provided by *GeoMed* [23]. Users have access to a shared, virtual workspace, a GIS viewer and discussion forums. Another Internet based virtual environment is the *Collaborative Urban Planner* (*CUP*) [19] allowing planning officers and other stakeholders to explore alternative designs, independent of time and place.

Our approach is inspired by previous research [3] where we experimented with simple tools (among them the *Texture Painter*) that allowed students of architecture to, for example, to change the properties of a physical model, by applying colour, inserting movement and context, and varying its dimension in relation to other objects in the physical space. Our idea was to bring mixed reality technologies such as these outside the lab to the real planning site, to explore how the context of the environment influences the way architect-planners and different types of stakeholders perceive their interventions and to evaluate the effects of being outdoors on the developed mixed reality tools.

3. THE PROJECT

The research presented in this paper is part of EU project IPCity, which has urban renewal as one of its showcases. In this showcase a multi-disciplinary team of several computer scientists, with a focus on mixed reality technologies and tangible user interface design, a social scientist, a fine arts person, and a musician specialized in producing and mixing sound, collaborate with experienced and highly engaged urban planners in exploring urban issues, developing concepts for technology design, developing scenarios for evaluation workshops, and re-designing, in a typical participatory design process.

Research started with fieldwork at three urban planning sites – the psychiatric hospital Sainte-Anne in Paris, the urban renewal office of Vienna's 16th district, and VIBRA, a master student project on connecting/rethinking the axis between Vienna and Bratislava. The fieldwork material was used for developing first scenarios of use. In parallel, developers worked on providing technology probes [11], to be used in early field trials with users, with the aim to test first concepts about technologies in support of collaboratively envisioning and experiencing an urban project. Altogether four workshops with users were organized within the first 15 months of the project, each of which contributed to further conceptual and technological development, involving architect/planners, selected stakeholders, and researchers as reflective co-designers, evolving from early visions to more integrated scenarios and prototypes.

Technology development as well as content creation for the workshops with users were guided by a set of 'urban themes' that the urban specialists in the project identified as particularly relevant for envisioning urban issues and illustrated by providing a number of visual examples: scale, temporality, borders and layers, fuzziness, ambience, and mobility [27].

The mixed reality tools we are developing are a rather complex assembly of *Colour table*, barcode application, tangible 3D visualization, sound application, and *Urban sketcher*, all of them hosted in a *MR (mixed reality)-Tent*. The *MR-Tent*, a formidable design task in itself, provides a shelter for the project equipment, also protecting projections from ambient light, with flexible openings and a view onto the site. Here we only describe those features of the technologies that are of relevance for our discussion.

Fig. 1 *Colour table* **with tokens and barcode application (left); See-through installation (right)**

The *Colour table* (Fig. 1) is the basis for a number of probes/prototypes. It provides users with the possibility to arrange and position tokens on a surface, representing a 3D scene. The tokens, currently cylinders of different colour, are used for associating multimedia content and for manipulating this content, varying position, scale, transparency, and colour. Two projections

visualize the composed scene. The tabletop projection augments the surface of the table by a map, which provides a bird's eye view of the site. A vertical projection renders the scene as seen by a pedestrian standing in the center of the working area (the place where the content for a scene can be manipulated). A customized infrastructure of the table enables rotating the surface of the *Colour table* in order to move the scene around the user.

The *Barcode player* was introduced to provide access to digital material through use of physical handles [12]. Users are provided with a number of cards, on which a thumbnail and a connected barcode is printed. These cards can then be used to display images, videos or assign textures to objects, to scale an object and change colour and transparency. Input from the *Colour table* and the barcode player is used to visualise the vertical projection. The images are components of visual scenes that are merged with a background. This background is produced by either a real time video stream, a panorama image of a site or a see-through installation.

The video stream is captured by a controllable camera that has been positioned anywhere close to the *MR-Tent*. The *panorama* is created by 'stitching' a set of pictures taken from anywhere within the site. The *see-though installation* is a projection onto an optical see-though screen. A white metal grid provides both, a reflective surface for virtual objects and a degree of transparency that enables a view onto the real scene. Depending on the lighting conditions, a grid with variable granularity may be used, or several screens can be overlaid. Although the see-through installation raises well-known problems concerning parallax and focus, it provides a unique augmented view onto the real scene.

The *Urban sketcher* is a collection of tools that allow users to directly 'sketch' or paint on an urban view. We use it in combination with the *Colour table*. A sound application is under development.

4. THE WORKSHOPS

This paper focuses in particular on the fourth workshop, which was carried out on the premises of the psychiatric hospital Sainte-Anne in March 2007, which is undergoing a ten-year renewal process. At Sainte-Anne we experimented with the latest version of our mixed reality tools (for analysis of fieldwork material from earlier workshops see [27]).

We worked with two different user groups. The first group included the chief architect for Sainte-Anne, the director and a manager of the hospital, as well as a representative of the urban heritage institution of the city of Paris (ABF). The second group consisted of two participants from Sainte-Anne, several architects involved in an urban planning institute ('Ville en mouvement'), a journalist with a focus on urban issues, an urban sociologist, and a sound specialist (who was invited to explore the possibilities of working with sound).

Preparing a workshop, which allows users to collaboratively investigate changes to an urban terrain proved to be an immensely complex task. Based on their research and a student project, our French partners had prepared a scenario for the workshop, which focused on the wall enclosing the psychiatric hospital. The wall evokes issues such as closure/openness, intimacy/exposure, safety/security. For patients, the experience of the wall is ambivalent. While feeling protected in a unified and quiet space, they also are locked in. For the medical staff, the wall helps structure the inside space and keep it under surveillance. For the neigh-

bourhood, Sainte-Anne looks like a fortress, like the La Santé prison located in the same street, a few blocks away. The wall protects them, shielding them from 'delicate' encounters. But the inhabitants of the district also have a feeling of curiosity and mystery about what happens behind the wall.

Fig. 2   The wall from outside and inside

The wall has architectural quality; it requires dealing with materials, transparency, diversity, and rhythm. Openings in the wall facilitate the crossing of sound and gazes from both sides (Fig. 2). The wall can also be considered as a screen, as an information support, a landmark, an icon for the urban situation. Knowing that there is a tradition in Sainte-Anne to encourage patients to express themselves through graphic means, an exhibition of the *art brut* collection of the hospital could be an interesting way to express a link between the world of therapy and the outside world. People passing could also be involved by being able to give and modify information, leave and remove messages, etc.

Preparing for the enactment of some aspects of this scenario meant first to find a place within Sainte-Anne for the *MR (mixed reality)-Tent*, from which participants would have a view onto the part of the wall, for which openings had been discussed. Multiple panoramas had to be prepared with photographic images that allow participants to explore the view onto the wall from inside and outside. The idea was to support them in 'cutting out' parts of the wall in several places, filling the openings with objects or transparent materials. Finally, all kinds of 'content' to play with had to be prepared: objects representing different materials and textures; exemplars of *art brut*; a set of towers with different textures (this had been one of the student projects); objects such as trees, bushes, sculptures, benches, and lamp posts; and all kinds of inspirational material that may help participants to better explore options and represent their ideas.

In the early stages of development, a lot of improvisation and good will on the side of all participants are needed. This also applied to the workshop in Sainte-Anne, which faced some restrictions, such as that the optical tracking system was not available and the *Urban sketcher* had to be operated by the developer; as well as extreme weather conditions (it was cold, rainy, and stormy) that made our first experiment outdoors, in a rented *MR-Tent* on the site, quite challenging.

The two workshop sessions, each of about three hours, were video-recorded, and transcripts of significant episodes were produced. We, in addition, used several digital cameras to capture interesting situations and included saved images of visual scenes in our analysis. As technology developers had been intimately involved in the workshop preparation, they were knowledgeable about the context and the issues at stake. Data analysis was carried out collaboratively in the team, with attention to the details of participants' interactions (as revealed in selected video clips) and to the intense discussions that took place during the workshop sessions, where participants addressed questions of the project – which interventions to carry out – but also commented on features of the tools and on their potential role in urban planning.

5. THE SESSIONS

As participants in the two sessions had a different approach and appreciation of the experimental stage provided by *MR-Tent* and technology prototypes, we here first briefly describe those two different modes of constructing interventions to then give a detailed analysis of some selected observations.

Session 1: The planner's interventions

The chief architect (R.) led the small group of participants through the first session, with the long and still unresolved debate on how to transform the wall surrounding Sainte-Anne at the back of her mind. She had already been part of our first workshop in Sainte-Anne and her approach was explorative, taking the scenario as an opportunity for exploring the potential and limitations of the mixed reality tools.

R. started with the *Urban sketcher*, directing the developer (M.) in implementing her interventions. Her first move was to create an opening of about 25m in the wall, asking what people inside will see when looking from the ground level of the main hall of the new building – will this be the pedestrian's view? And how would this look like from the city, when the historical part of Sainte-Anne is revealed? As the camera cannot look through the wall, M. skillfully collaged a photographic picture of the street behind the wall onto the camera view. He also improvised cutouts of wall images, manipulating the opening and vista.

Here the young heritage architect (Ch.) intervened – '*I think it is very large. I know the atmosphere of the interns of Sainte-Anne would be tense with such a big opening*'. While the chief architect pointed out that the opening would be covered by a glass surface for sound control, Ch. insisted on reducing it so that you can just look down the road along the big axis.

Fig. 3 *Urban sketcher***: visual scene with opening in the wall and (tilted) towers; R. explaining with her hands**

The second intervention consisted in placing two towers at both sides of the opening, playing with them, testing how the perspective will work. As M. tried to place the towers, R. approached the screen using her hands to indicate a place. When M. accidentally tilted one of them, which R. immediately accepted as 'a good idea', she directed him with her gestures (Fig. 3). Also, the next step, finding a texture for the ugly ground in front of the wall (currently used as a parking space) was carried out jointly by R., Ch. and developer M., and the ground was finally covered with a green grassy texture with a slight relief and a red carpet, which M. positioned at the opening to the road.

When moving to the *Colour table*, R. was immediately captured by the panorama. She turned the table, looking at the moving view. She grabbed some of the colour objects, searching for suitable objects in the printed-out material. At each move, R. looked for agreement with Ch., who contributed to the selection of images, also placing her own objects. But it was R. who clearly was in charge, while Ch. contributed in a silent way. They started by creating a park in the parking lot, placing bushes, some trees (to hide the hideous residential buildings on the street behind), and flowers. They also tried to place two of the towers (the ones with water textures) (Fig. 4). R. asked for a texture (pebbles) to cover the ground. She would like to tilt the tower, which is not possible in this application, and she added people to the scene. R. was also excited by the see-through installation, probing to place trees and a person, while trying to focus so as to capture the mixture between real and virtual scene.

Fig. 4 *Colour table:* **'Furnishing' the panorama (saved image)**

Session 2: Cooperatively imagining a place

Also the second group started with the *Urban sketcher*. One of the urban planners of the project team initiated and monitored the process, gradually trying to move control to the group itself. Their first step was to open the wall but this group did not care so much about the size of the opening. They immediately asked: 'Can we invent our own objects?' A discussion started around the idea of redefining the wall as a meeting point between those outside – '*so that they get over this disgust of having to be our neighbours ... because people are a little scared of what they might see*' – and those inside, '*something that is nice to look at from both sides*'.

The group decided to keep the wall and build a bridge, a kind of stairway up the wall – 'can this be made more transparent'? They expressed the need for a more sophisticated intervention, another type of material, and finally decided for a wooden texture that M. applied ('painted') onto the canvass he used as a stairway.

The next step was to make the wall higher on one side of the opening and lower on the other side. The group explained the idea

of the bridge or stairway as a 'belvedere' or 'mirador', for people on both sides to meet, have a view onto the other side without necessarily having to pull down the wall. So was the idea of placing the towers. They placed several of them, talking about that they would like to make them transparent, change their size, and so forth (Fig. 5).

Fig. 5 *Urban sketcher:* **playing with miradors and wall**

The group then moved to the *Colour table*, rotating the table to have a good view onto the wall – 'this is something to see from both sides'. They played with the idea of a 'mur vegetal' – 'does this have to be a parking lot'? – changed the floor to a mosaïque pattern, placed bushes, two benches, several lamp posts and populated the space with silhouettes of people. Their emphasis with these moves was on creating a story of changing the parking lot and their main focus on playing with atmospheres.

Fig. 6 *Colour table***: cooperative imagining**

Their way of cooperating was rather different from the first group (Fig. 6). Interaction was dense and not concentrated on the urban planning specialists (in contrast to the first group) but rather inclu-

sive (also one of the hospital doctors participated). The group started by discussing their interventions and selected objects together, browsing through the printouts of thumbnails and barcodes. They studied the projected map on the *Colour table* before taking the first colour tokens and placing them. There was a high level of concentration, selecting objects, placing them while looking at how they appeared on the panorama view, carefully rotating the table to change perspective, and all this in a highly cooperative way, commenting on each move.

A more detailed analysis of this group's dense interactions will be provided in the next section. When analyzing these interactions we have to bear in mind that participants constantly mixed talking about their interventions with commenting on the tools.

6. COOPERATIVE PRACTICES – AN ANALYSIS

The two sessions we briefly described illustrate two different approaches to exploring the project at Sainte-Anne with the technology prototypes. In the first session, the chief architect, together with her colleague from the cultural heritage institution, worked with a precise idea of an intervention. Their focus was on spatial arrangements and volumes - the size of the opening in the wall, the positioning of the towers.

The second group worked more with stories and ideas about activities – the parking lot as a place for walking, resting, encounters between inside and outside, and so forth. They saw the technologies as eventually opening up a space for mutual learning ('apprentissage collective'), where the different stakeholders may explore and confront ideas. They stressed the value of engaging in activities that are different from what they termed the 'ritual space of creating a program' ('l'espace rituel de programmation').

In our analysis we address our two main research questions:

- How can we support users – different types of stakeholders - in the collaborative creation of mixed reality configurations as an integral part of expressing their ideas about an urban project?

- How can we use mixed reality tools for enhancing an already highly developed representational culture?

Collaborative aspects – the tangible user interface

Our project's ambition is to integrate the possibility of creating visual and auditory scenes in direct contact with the site of a project with common work practices of planners, such as creating scale models, sketching and annotating. At the same time, the arrangement of the *Colour table*, as well as the immediacy of the scene production, are supposed to strengthen cooperation with stakeholders.

There are two issues connected to this goal. One, more immediate, is to do with the design of the tangible user interface of table and colour objects. The other, more complex one is about the place of collaborative practices in urban planning projects: which aspects of an urban situation should be opened up to stakeholder intervention and which kind of representations are suited for these interventions?

Several design issues arose from this and also the previous workshops. Working with *Colour table* and *Urban sketcher* illustrates what Dourish [6] and others have described as 'embodied interaction': through gesturing, placing tokens, rotating the table or sketching on the projection screen participants 'perform' a mixed

reality configuration, emphasizing particular interventions, and bringing an expressive element into a scene. Participants communicate through adding to a visual scene, and this highly visible, expressive enactment of ideas is in turn an invitation to others to participate and co-experience [22, 14]. The chief architect, although she found the tangible user interface somewhat unusual for 'a computer literate person', stressed how much she enjoyed 'the magic moment' when things worked out.

Several observations point to opportunities for strengthening participants' expressive interactions. First, the size of the table is relevant. As Patten and Ishii [20] observed, a large working space encourages or even enforces collaboration since there is no way for a single person to efficiently manipulate all objects. The size and materiality (haptic quality) of the colour objects clearly influenced the way participants interacted with them and how they actively engaged in building a scene. As one of the participants expressed it: '*I have the impression that everyone has their own object placed on the table and everyone identifies himself with his colour and his bench, and I have the impression that all of us negotiate projecting ourselves into the object*'. What we observed is a good example of haptic directness. Hornecker and Buur [10] have argued that haptic directness provides an isomorphy between manipulation and result – we can watch the effects of our activities while performing them - and that it enables simultaneous interaction (Fig. 7).

Fig. 7 Three hands collaborating

Moreover, interacting through the colour objects produced a feeling of familiarity in the group, as well as sensitivity towards each other's perspectives. The fact that different participants identified specific colour objects as their own presents an aspect of social coordination, which may be strengthened by the design and would also create the need for more collaboration to represent more complex interventions.

Also the positioning of the *Colour table* in relation to the surrounding space of the *MR-Tent* affected if and how participants collaborated in constructing the mixed reality configurations, their physical performance, how freely they moved. Participants mentioned the 'ambience' of the tent, the fact that their activities take place on site as encouraging dialogue and as increasing awareness of the sensitive aspects of the context.

Moreover, we could also see how individual participants used the colour objects in search of meaningful interventions, holding an object while observing from a peripheral position and thinking. One participant expressly talked about the colour objects as 'thinking tools'. One could say that the physical features of the *Colour table* encourage inclusion of the outsiders' position. They

also allow for people to stand apart observing to then re-integrate themselves to contribute. For example Fig. 8 shows one of the participants touching a colour token while the others are discussing the current scene. She is imagining a move without integrating herself into the flow of action.

Fig. 8   Standing apart imagining a move

This is contrasting with the next image (Fig. 9) where one of the participants is visibly performing an intervention as an integral part of talking while all the others are watching intently.

Fig. 9 Performing an intervention

We also witnessed fluctuations of active engagement across individuals as well as shifting group formations. In Fig. 10 we can see such a shifting constellation. While the two women to the left first watch the others who discuss and select content, they are part of this activity in the second image, while one of the urbanists (the one with the red scarf) has moved outside the inner circle, pointing to the visual scene and making a comment for all to hear.

Fig. 10 Shifting formations

In the next image (Fig. 11) this constellation has broken up, with two of the participants enacting what has been agreed upon. The man in the centre (the journalist) grabs a yellow token, while the woman to the left (a doctor of Sainte-Anne) searches the barcode sheet. This is a typical collaboration pattern, with two participants performing a particular task together, while the others shift to other activities, waiting for things to happen.

Fig 11 Two participants enacting the move

Finally, while in unmediated group discussions hierarchical relationships prevailed, e.g. between chief architect and stakeholders, working around the table with the same tools (that were new to all of them) introduced an element of equality into their interactions.

Types and levels of collaboration
Both user groups used the collaborative features of the *Colour table* in different ways. The chief architect collaborated with the cultural heritage architect more in the way of valuing her view and seeking her comments for each step she took. Both of them were standing in front of the table, taking up tokens, searching for material in the barcode tables, but it was R. who then placed the token on the table. She did not enter the kind of simultaneous interaction the *Colour table* affords. In contrast, in the second group we observed turn-taking, with participants using colour objects to literally place and argument, comment on the interventions of others, and so forth.

What we could also observe were different types and levels of cooperation that indicate different ideas about how and to which extent stakeholders should be involved in an urban project. The second group worked with the concept of the wall and the empty space in front of it, discussing different ideas of how it should be transformed – a meeting place between inside and outside, an area of tranquility and rest, and so forth. They felt attracted by the abstract and sketchy character of the visual scenes and argued strongly against any kind of realism. What should be avoided is 'working directly on the project'. Stakeholders should not act as designers but work on strategies. This group considered the collaborative learning process as much more important than the 'results' of their interventions. This is a pedagogical tool, they argued, which helps take different viewpoints, from very near, from far away. It is a tool for telling a story. This reminds of Erickson's elaborate argument [8] about stories as design tools. The group was less interested in the visual result as such than in the unfolding story. They saw the tools as part of an iterative process of stabilizing a design, with participants exploring a concept/ideas, designers then developing with their own tools, and coming back with new scenarios to explore with *Colour table* and *Urban sketcher*, and so forth.

The first group, guided by the chief architect, worked with a precise intervention. They first negotiated the size of the opening in the wall and the axis – 'to keep the perspective on the street' - to then play with the towers as mediating the resulting space. R. argued for an approach where architect-planners carefully prepare a scene, selecting the appropriate content, with participants then having the possibility 'to have a variation of very small things'.

Her approach was to limit the discussion to subtle changes of the ambience of the site and to explore these.

A third type of negotiation took place in both sessions regarding the possibilities and limitations of the technologies. While this may be partly to do with the unfinished state of the prototypes, it also points to the fact that the technology is not neutral to the negotiation but 'participates' in it. A key observation, which we will take up in the next section, was that participants experience and 'measure' the tools in relation to those they are familiar with. Participants asked for or explored seemingly simple interventions, such as turning a tree they just had placed or to extend the grass across the whole parking lot. These are actions that are either supported by other tools they know or that seem 'natural'. On the other hand, they accepted actions that were suggested by the technologies, trying to integrate them into the process of building a scene. For example, R. closely cooperated with the developer of the *Urban sketcher* (M.) in placing and tilting the towers, adding a grass floor and a red carpet. The visual scene emerged as a result of the architects' ideas, of how the developer interpreted them, and of what the technology offers. Participants expressed how the limitations and constraints imposed by the technologies (in their early stage) affected their interactions. Their engagement weakened, as soon as things went too smoothly but also when too many errors occurred and the sense of control got lost; whereas some amount of error or element of surprise helped them reopen a fixed path. In this way constraints may turn into occasions for discovery and lively debates and one effect of error may be that it stimulates the creative process.

Latour [17] uses the term *translation* for describing a drift or mediation in our intentionality while using a technology. A human agent using a tool in order to achieve a certain goal gets modified by the potential capacity of the tool. In this way we can say that the mixed reality tools enter the collaboration process, with their potential and limitations affecting participants' interventions.

Issues of representation
Many authors suggest that visualization is the key to public participation (see e.g. [16]) but the question remains how to enrich the available repertoire of representations – from abstract sketching to realistic 3D renderings - with visualizations that enhance stakeholders' understanding of an urban situation. Available tools do not support addressing all the themes and aspects of a complex urban situation. While ethnographers are very efficient in observing and describing how a site 'works', they have difficulties to represent these issues visually in space. Planners and architects, who master the techniques of graphical representation, often produce seducing images, which aim at convincing developers rather than support stakeholders' understanding and invite them into a dialogue.

Our observations point to partially contrasting ideas about how to use mixed reality tools for representing an urban situation. One of the perspectives is the one of the architect/planner. From the very first workshop on the involved architects defined as a basic requirement the exact positioning of objects and the right scale; they are considered prerequisites for an architectural argument. The chief architect R., for example, saw the *Urban sketcher* as the more accurate tool – '*with the screen it's easier, because you have already the proportion, you have already the translation, the correct scale*'. Her idea about how to extend the current prototypes was '*if you see the spatial scene behind the wall there, where there's all the buildings, and if it was possible to engage with the*

stages of depth that you see. So for instance to place an object behind the wall. For instance it would be good if you can put one tree before the wall and make the next tree as standing behind the wall'.

R. stressed the importance of visualizing volume and scale, as measured against the human body, so as to get a feeling for the impact of an intervention, with the possibility to switch viewpoint – looking at a scene from inside and outside, close and further away. Moreover, being able to engage with the stages of depth, placing objects, for example, behind the wall (a feature we already implemented) was seen as essential for the kind of spatial explorations, architect/planners want to engage in.

Again from an architectural perspective, the main problem with the see-through installation is how to get an understanding of the space: '*And what seems to be very difficult, is to use this, which is very interactive, but it needs like more effort by imagination to see the relation of this to the reality, than the screen (the Urban sketcher), because we really have to imagine that we are seeing the thing at the same level, colour and …. It's not very easy. For me it seems very difficult to have an understanding of the space with this*' (R.). The difficulty is to do with the lack of depth information, with the fact that users have to focus and to construct their own image, merging real and virtual into one. Moreover, currently the virtual objects don't adapt (their transparency, brightness, etc.) to changing light conditions outside nor to their distance from the viewer (the bright green person in Fig. 12 always stays bright) – this creates a lack of congruency between virtual and real.

Fig. 12 *See-through*: **How to merge real and virtual – how to understand the space**

Issues of scale, depth, and precise positioning are all resolved in 3D rendered environments; so, what do the new tools add? One of

their main attractions, as participants expressed it, is the possibility of superimposing a quite abstract and fuzzy visual scene – 'the imaginary' - onto the real scene. This was the fascination of the see-through installation in particular. The see-through effect is very different from a 3D rendered scene.

Participants appreciated the different backgrounds provided by the tools. The *Urban sketcher* with its real-time video captured by a rotating camera, provides a not only technologically mediated but also 'removed' - projected - image of the real site. The attraction of the (photographic) *panorama* lies in the possibility of exploring the whole site, rotating it (as a proxy of turning around), looking at interventions from different angles. It reflects a strong tradition within architecture. The *see-through* installation comes closest to the idea of making the site of an urban project present. The presence of the real site, even if blurred by the finely meshed projection screen, adds an important dimension to participants' understanding of project and site.

What also became evident is that animation of the visual, created by e.g. the movement of people and traffic, or of the wind and rain on the tent are important aspects of the real site. As the *MR-Tent* had been placed on the empty stage of an abandoned parking lot, 'liveliness' was added by sending one of the participants outside to pose on the scene. This not only brought the human scale into the scene, it also introduced an important reality element. More reality elements than just the static scenery – movement, sound, the contrast between dynamic/static, densely populated/empty, and so forth – are needed to strengthen the mixed reality effect.

This observation gives an interesting twist to the mixed reality tools. What all participants agreed on is that just 'putting furniture' – trees, benches, people - into a mixed reality scene is boring and not really worthwhile it. What else do you do put there? This evokes the issue of attractive, relevant 'content'.

In our research we already had identified central issues in representing an urban situation. One is the degree of abstractness/fuzziness of representations. Planners often present some of the elements of their projects in a fuzzy way; they need to give the idea of volumes and masses without getting into the detail of architectural shapes and styles. This does not mean that the idea or the concept is vague; it only means that his representation refers to some implicit knowledge, or to a shared know-how that does not need to be detailed at this stage. Erickson [8] talks about the 'roughness' of design representations that leave openings for discussion. Architects work with means such as modality (sketch, 3D rendering, photo), thickness of drawing line, movement and focus, textures, colour, transparencies, shadows.

The other issue is how to represent movement and change over time. Important aspects of the experience of site and project are temporal - urban rhythms, flow, movement, speed, and traces of history. Participants stressed the need to avoid working directly on a project – 'being too realistic' - and thought of the abstract, fictitious aspect of flow, movement, ambience, and fuzziness as more relevant for exploring an urban project together with stakeholders.

A final central observation is that, when exposed to the different mixed reality scenes, participants evoked the practice of sketching. They pointed at sketching directly on a scene, annotating it (something we already started implementing), as a desirable feature of the technology installation. This is an extension of a very powerful and efficient practice – the architect/planner explaining an idea, intervention or constraint by sketching and talking – into the imagined novel practice, with the specialist in his/her tradi-

tional expert role but interacting with imaginary interpretations of a site and project by stakeholders of all kinds.

Goldschmidt [9] and many others have studied the role of designers' drawings and sketches, arguing that these fulfill precisely this role. They are both, dense and ambiguous; they embody abstract and high-level design ideas; they allow a degree of uncertainty about particular physical attributes to exist and they impose constraints. But we also know that sketches are difficult to understand for non-specialists. This is why we can also not assume that 'abstractions', such as visual/sound representations of flow and fuzziness, can be easily interpreted by all stakeholders, for example also ordinary citizens, in a project.

Moreover, sketches (and other representational artifacts) are often created as part of the work, and intermingled with talk – giving explanations, telling a story [26]. How can this practice be moved to the practice of creating mixed reality configurations? From our observations it was evident that participants did not find it easy to integrate the 'content' (images, objects, sound) we had prepared for the wall scenario into their repertoire of expressions while building visual scenes and discussing their interventions. We had somehow expected that the transition from sketching and using evocative aspects of the material environment in support of an argument – a practice we had observed in other design contexts – to assembling 'content' into mixed reality configurations would be easier, almost 'natural'. There is an obvious difference between interacting with physical artefacts in an expressive way, exploiting their materiality [14], and 'picking up' digital content or physical representations of them. This is a point that needs to be more systematically explored in further research. Our main conclusion here is that practices of seeing and expressing are entangled and that achieving a fluid way of building visual scenes, using all the resources 'at hand', is far more complex than just providing the 'ingredients' of tools and content to play with.

7. CONCLUSIONS

Our project addresses two quite different aspects of urban planning. One concerns collaboration-support. CSCW research has examined the role of boundary objects in collaboration. In a recent paper Lee [18] introduced the notion of 'boundary negotiation artefacts', arguing that negotiating boundaries may be considered a special form of cooperative work, where actors discover, test and push boundaries. She refers to Boujut and Blanco, who in a paper on cooperation in engineering design [5] introduce the concept of 'intermediary objects', which they see as central to forming a common understanding of a design situation: 'More precisely we think that co-operation can be considered as a process of "disambiguation" if it is properly framed. Negotiation and compromise setting are particular ways for creating specific shared knowledge. The concept of intermediary objects can provide a tool that allows the production of a conceptual frame that formalizes and represent this shared knowledge through objects and various representations' ([5] p. 216).

We can think of the set of technologies we are developing as supporting the creation of 'intermediary objects' that help make the transformation process of an urban site more collective. But the scope of this collectivity – whether we can also talk of 'boundary negotiation artefacts' - is far from clear: Do participating stakeholders contribute to the concept formation process of an urban project, where certain qualities of a site are defined, or are they also involved in questions of design? Or is it that architect-planners get new tools for visualizing their concepts with carefully prepared scenarios, with stakeholders 'just' playing with very small details? Although the use of the technologies can go both ways, we know that they are not neutral but 'participate' in their use. Here we take deliberate design decisions that strengthen the collaborative aspects of the tools, improve their potential in creating 'intermediary objects'. This is reflected in our plans for re-design, which include:

- To design and experiment with different colour tokens (different sizes, materials, distinct and neutral shapes);
- To enlarge the projected map and give users more control of the scale factor of the map (e.g. by zooming through turning);
- To strengthen collaboration by providing two work areas on the table (instead of currently one) - these are the places where content for the scene can be manipulated.

The second question we addressed concerns the creation of novel representational forms: Can we extend current techniques of representing an urban situation? We already demonstrated that practices of seeing and expressing are entangled. On the one hand, participants were fascinated with the possibility of exploring an urban project on site, being able to simultaneously see the visual and the real scene. On the other hand, there is a gap to be filled between well-grounded and widely accepted representational techniques, such as sketching or 3D modeling, and the potential of mixed reality tools. We also here took a deliberate decision not to engage in 3D modelling, for two reasons. One is practical – currently, it takes much effort and time to prepare 3D models of complex urban environments. The other reason is conceptual. We think that the strength of our tools lies in providing more 'abstract' visualizations, that are to do with the atmosphere and experience of a place, which changes with light, colour, movement, density, the rhythm of volumes and voids, and so forth. We are currently experimenting with:

- Representations of urban rhythms, flow, and movement - this will bring more life into the scenery and probably also enhance the abstract/fuzzy appearance of objects;
- To include not only the possibility of sketching on a visual scene (using the *Urban sketcher*) but of creating 'sketch objects' on the fly and adding them to a scene;
- To add sound, which qualifies a space in terms of ambience, helping to perceive depth and distances, visual layers of the landscape, changes in temporal rhythms, like day and night, movement of people, vehicles, etc.
- Mechanisms to store and recreate scenarios, as well as multi-layered panoramas that can be travelled, opening up vistas and/or allowing to explore the history of interventions.

8. REFERENCES
[1] Al-Kodmany, K. Using Visualization Techniques for Enhancing Public Participation in Planning and Design: Process,

Implementation, and Evaluation. *Landscape and Urban Planning 45* (1999), 37-45.

[2] Arias, E.,Eden, H., Fischer, G., Gomann, A., and Sharff, E. Transcending the Indvidual Human Mind – Creating Shared Understanding through Collaborative Design. *ACM Transactions on Computer-Human Interaction 7/1* (March 2000), 84-113.

[3] Binder, T., De Michelis, G., Jacucci, G., Matcovic, K., Psik, T., Wagner, I. Supporting Configurability in a Tangibly Augmented Environment for Design Students. *Personal and Ubiquitous Computing 8* (2004), 310-325.

[4] Borning, A., Friedman, B., Davis, J., and Lin, P. Informing Public Deliberation: Value Sensitive Design of Indicators for a Large-Scale Urban Simulation. H. Gellersen et al. (Ed) ECSCW 2005, Springer, 449-468.

[5] Boujut, J-F. and Blanco E. Intermediary Objects as a Means to Foster Co-operation in Engineering Design.*Computer Supported Cooperative Work (CSCW): An International Journal 12* (2003), 205-219.

[6] Dourish, P. *Where the Action Is: the Foundations of Embodied Interaction.* MIT Press, 2001.

[7] Eden, H., Scharff, E., and Hornecker, E. 2002. Multilevel Design and Role Play: Experiences in Assessing Support for Neighborhood Participation in Design. *Proceedings of the Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques* (London, England, June 25 - 28, 2002). DIS '02. ACM Press, New York, NY, 387-392.

[8] Erickson, T. Notes on Design Practice: Stories and Prototypes as Catalysts for Communication. Carroll, J.M. (Ed). *Scenario-based Design*. John Wiley, New York, 1995, 37-58.

[9] Goldschmidt, G. On Visual Design Thinking: the Vis Kids of Architecture. *Design Studies 15,2* (1994), 158-174.

[10] Hornecker, E., Buur, J. Getting a Grip on Tangible Interaction: A Framework on Physical Space and Social Interaction. *CHI 2006*, ACM Press, pp. 437-446.

[11] Hutchinson, H., Mackay, W. et al. Technology Probes: Inspiring Design for and with Families. *Proceedings of DIS 2003*, Ft. Lauderdale, Florida, ACM, 2003 17-24.

[12] Ishii, H. and Ullmer, B. Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms. *Proceedings of CHI'97,* (Atlanta, March 1997), ACM Press, 234-241.

[13] Ishii, H., Ben-Joseph, E., Underkoffler, J., Yeung, L., Chak, D., Kanji, Z., and Piper, B. 2002. Augmented Urban Planning Workbench: Overlaying Drawings, Physical Models and Digital Simulation. *Proceedings of the International Symposium on Mixed and Augmented Reality (Ismar'02)* (September 30 - October 01, 2002). IEEE Computer Society, Washington, DC, 203.

[14] Jacucci, G. and Wagner I. Performative Roles of Materiality for Collective Creativity. In *Proceedings of the 6th Creativity & Cognition Conference*, Washington DC, June 13-15, 2007, 73-82.

[15] Joshi, H., Guhathakurta, S., Konjevod, G., Crittenden, J., and Li, K. Simulating Impact of Light Rail on Urban Growth in Phoenix: an Application of Urbanism Modeling Environment. *Proceedings of the 2006 international conference on Digital government research*, San Diego, CA, 2006, 135-141.

[16] King, S., Conley, M., Latimer. B. and Ferrari, D. *Co-Design: A Process of Design Participation.* Van Nostrand Reinhold, New York, 1989.

[17] Latour, B. *Pandora's Hope: Essays on the Reality of Science Studies.* Harvard University Press, Cambridge, Mass., 1999.

[18] Lee, Ch. Boundary Negotiating Artifacts: Unbinding the Routine of Boundary Objects and Embracing Chaos in Collaborative Work. *Computer Supported Cooperative Work 16/3* (June 2007), 307-339.

[19] Manoharan, T., Taylor, H., and Gardiner, P. A Collaborative Analysis Tool for Visualisation and Interaction with Spatial Data. *Proceedings of the Seventh international Conference on 3D Web Technology* (Tempe, Arizona, USA, February 24 - 28, 2002). Web3D '02. ACM Press, New York, NY, 75-83.

[20] Patten, J., H. Ishii. A Comparison of Spatial Organization Strategies in Graphical and Tangible User Interfaces. *Proceedings of Designing Augmented Reality Environments (DARE)* 2000, 41-50.

[21] Piper, B., Ratti, C., and Ishii, H. 2002. Illuminating Clay: a 3D Tangible Interface for Landscape Analysis. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems: Changing Our World, Changing Ourselves* (Minneapolis, Minnesota, USA, April 20 - 25, 2002), 355-362.

[22] Robertson, T. The Public Availability of Actions and Artefacts, *Computer Supported Cooperative Work 11/3-4*, 2002, 299-316.

[23] Schmidt-Belz, B., Rinner, C., and Gordon, T. F. 1998. GeoMed for Urban Planning - First User Experiences. *Proceedings of the 6th ACM international Symposium on Advances in Geographic information Systems* (Washington, D.C., United States, November 02 - 07, 1998). GIS '98. ACM Press, New York, NY, 82-87.

[24] Sugimoto, M., Hosoi, K., and Hashizume, H. 2004. *Caretta*: a System for Supporting Face-to-Face Collaboration by Integrating Personal and Shared Spaces. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Vienna, Austria, April 24 - 29, 2004). CHI '04. ACM Press, New York, NY, 41-48.

[25] Underkoffler, J. and Ishii, H. Urp: a Luminous-Tangible Workbench for Urban Planning and Design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems: the CHI Is the Limit* (Pittsburgh, Pennsylvania, United States, May 15 - 20, 1999). CHI '99. ACM Press, New York, NY, 386-393.

[26] Wagner, I. 'Persuasive Artefacts' in Architectural Design and Planning. *Proceedings of CoDesigning* 2000, Springer, London 2000, 379-390.

[27] Wagner, I., Basile, M., Terrin, J.-J., Wagner, M., and Psik, T. Integrated Project on Interaction and Presence in Urban Environments. D6.1. Urban Renewal Demonstrator. Report, (June 2007).