Blended Spaces for Collaborative Creativity

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ABSTRACT
In this paper, we reflect on our experiences of designing, developing, implementing and using real world, functional multi-touch enabled interactive collaborative environments (ICEs). Combining aspects of immersive collaborative environments with interactive collaborative surfaces, the design, implementation and use of these rooms raises some interesting issues of design. ICEs typically are intended to be flexible physical spaces that can be used for creative work including collaborative design work. The technologies and software provide a novel digital space that is intended to blend with the physical space to afford new, creative ways of working. In ICEs there are personal spaces, shared spaces and public spaces to consider. There is the ownership of objects and many social issues that surround control of interactional resources. There are issues concerning appropriation of the technologies and spaces, territoriality, and articulation of activities across cooperating groups of people.

Perhaps most importantly are the changes to working practices that an appropriate blend of physical and digital spaces can bring about. We present the principles underlying our design approach to ICEs and how these have been applied in the design of three ICEs. We conclude with guidelines for the interaction design of the next generation of interactive blended spaces.

Categories and Subject Descriptors
H.1.2 User/Machine Systems. Usability,

General Terms
Human factors, Design

Keywords
Blended Spaces, Collaborative Environments.

1. INTRODUCTION
Over the last few years we have been evolving an approach to the design of interactive collaborative environments that focus on achieving a harmonious blend of physical and digital spaces to produce environments that have emergent properties aimed at supporting and encouraging creativity at work.

The original ICE was a meeting room, with an interactive boardroom table, interactive whiteboard walls and five wall mounted multi-touch screens (Figure 1). The philosophy was that the ICE would be first of all a functioning meeting room. However, it was also designed as a space that brings together cutting edge technologies into a unique configuration. It was intended as a glimpse into the future of meeting rooms and office spaces when multi-screen, multi-touch and multi-user spaces are increasingly common.

Figure 1 The 'Future Meeting Room'.

Since then, through reflecting on a number of design experiences we have evolved a design approach and some useful principles for the design of these blended spaces. In this paper we elaborate on these and give examples of the different spaces that we have been involved with.

Our philosophy in creating the ICE was to provide a new space for interaction, a new physical space and a new digital space. From these new spaces, people would find a new conceptual space where they would be able to undertake new activities, or undertake traditional activities in new ways that would lead to new insights. We describe these as blended spaces [1]. [2] because the aim is not simply to mix the physical (or the analogue) and the digital, but rather to design a space that brings the physical and the digital together to enable new user experiences. The blended space has new properties that emerge from the right physical-digital blend and people will do things in new ways and get new insights into situations.

The ICE combines the analogue and the digital in a natural way, drawing on people's knowledge of tables, pens and whiteboards and augmenting this with interactivity and internet connectivity. We expect people to come to the ICE with their own laptops, phones and tablet computers. We expect people to take notes in notebooks and on paper. The philosophy of the ICE is to remove function from the *contents* of discrete objects (screens, laptops, mobile devices) and instead consider them as *portals* to function and content, enabling and facilitating real time, concurrent, local, and remote collaboration. This is facilitated through the use of cloud-based services such as Dropbox [3]) and wireless internet.

In this paper we describe our experiences in building and using the ICE as a blended space. We look at the philosophy behind the room and present a design approach that aims to achieve new blended spaces for collaboration and creativity.

2. THE ICE
As noted above, the ICE is a meeting room, with an interactive boardroom table, interactive whiteboard walls and five wall mounted multi-touch screens. A 46" n-point HD (1080p) multi touch LCD screen is mounted on the end wall of the room. This screen uses the diffused illumination (DI) method for detecting multi-touch and is capable of detecting finger and hand

orientation as well as distinguishing between different users' hands. A 108" n-point multi-touch rear projection boardroom table, also using DI, is the centrepiece of the room. The table can recognize and interact with objects placed on its surface such as mobile phones, laptops or books using infrared fiducial markers. Four 42" HD (1080p) dual point multi-touch LCD screens utilizing IR overlays are mounted on the room's side walls. Each screen is driven by a dedicated computer, which can triple boot into Mac OSX, Windows 7 and Linux (Ubuntu 10.0.3). Most commonly these screens are running Windows 7 due to the native mapping of multi-touch events (e.g. pinch to zoom) to traditional actions such as scroll-wheel activity in any application.

The table runs Windows Vista (due to camera driver requirements) and makes use of various development and operational environments that support the TUIO (Tangible User Interface Object) protocol. TUIO defines a common communication protocol for tangible multi-touch surfaces. The TUIO protocol allows the transmission of an abstract description of interactive surfaces, including touch events and tangible object states. This protocol encodes control data from a tracker application (e.g. based on computer vision) and sends it to any client application that is capable of decoding the protocol.

A Crestron™ room control system allows for an IP based interface to manage video and audio sources plus control of temperature, lighting and the window blinds. The interface has been designed with a map metaphor to enable novice users of the room to control the sophisticated capabilities of the room in an intuitive fashion. This interface is available on all screens, a dedicated wall panel or over IP on mobile devices. A screenshot of the Video Source page can be seen in Figure 3.

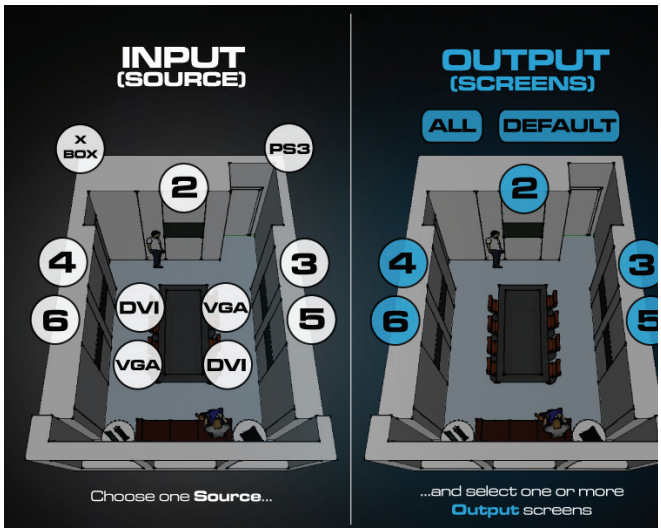

Figure 2. Screenshot of room control panel

An important part of the ICE's philosophy is illustrated here. Rather than representing "computers" in the traditional sense, the ICE is split into interactive "zones" representing the 6 screens (table and 5 wall screens). The rationale here is to remove the notion of computers as discrete objects within which data is stored, and instead promote the idea of computers as portals, windows to (potentially) shared digital spaces. The screens can be configured as independent devices, or they can be mirrored. Thus a typical configuration where screen 4 mirrors screen 3 and screen 5 mirrors screen 6 has proved effective. Since they are connected through the internet these screens could be anywhere and hence the room can demonstrate remote collaboration as well as providing views on the same data for people sitting on different sides of the table. The table demonstrates a similar feature as the TUIO generation and screen display functions are handled by two independent PCs connected over IP. This means the TUIO stream generated by interaction with the table can be simultaneously distributed to remote participants, plus external TUIO streams can be amalgamated allowing for remote interaction with the table and allowing seamless remote collaboration within the connected digital space.

These issues for multi-touch cooperative activity have been examined in a number of room environments (e.g., [4]. [5], [6]. The Roomware project in Europe has developed and evolved since the late 1990s producing a number of prototype future-looking devices and environments [7] and the NiCE project [8] developed a meeting room with an augmented whiteboard with a projected overlay and tracking capability. They quote Plaue and colleagues [9] in arguing for the 'conference room as toolbox' and point to the importance of floor and access control through multiple input and output devices. A second challenge concerns the physical and perceptual aspects of the whole workspace. The third challenge concerns issues of public and private spaces. In some settings, people like to have their own space so that they can prepare material privately before releasing it to their collaborators. However, public spaces need to be accessible and truly shared so that everyone can manipulate the shared content. There needs to be facilities to move content between the private and public spaces. A successful work space will support multiple types of content and a history of the interaction enabling review of previous work and content [10].

3. BLENDED SPACES

A blended space is a mixed reality environment of any scale in which the real and the virtual worlds have been carefully and considerately brought together with some content, or access to content. The physical space can be described in terms of the objects that exist in the space, the topographical relationships between those objects the people and that populate and move through the space and the volatility of the space. The digital space can be described in terms of its ontology and topology (information architecture), the agents and other people in the space and the volatility of the space to change.

A blended space consists of a physical space and a digital (or information) space that have been brought together to create the opportunities for new experiences. These may be designed for entertainment such as the work of Blast Theory [11]. They may be primarily for information such as many of the augmented reality apps that overlay information onto the real world according to a person's direction and location. They may be cyber-physical systems where a physical space is covered in computational devices. They may be purpose-designed rooms in which technologies have been integrated to provide particular functionality, such as the ICE in Figure 2.

Fauconnier and Turner [12] see blending in terms of four mental spaces (domains). Two input spaces have something in common with a more generic space. Blending is an operation that is applied to these two input mental spaces which results in a new, blended

space. The blend receives a partial structure from both input spaces but has an emergent structure of its own.

For example if we take the concept of a window in a computer operating system, this is a blend of the concept of a window (as in a house) and the concept of computer operations. This results in a new mental space of 'window' that now includes things such as a scroll bar, a minimize button and so on that you would not associate with a window in a house. The blended space of a computer window has inherited some shared characteristics from the generic space of 'looking onto something', but now has its own characteristics.

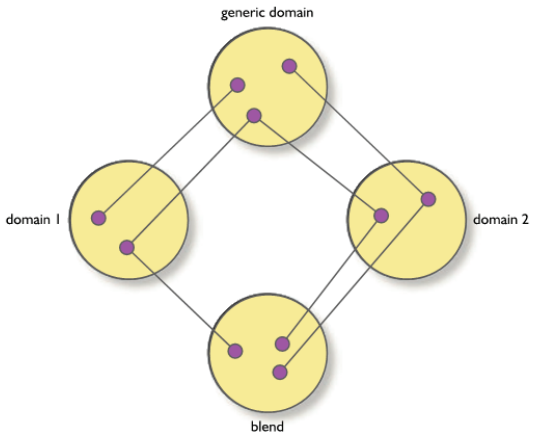

Figure 3 Concepts of Blend

The main principles of blending, are that the projections from the input spaces make new relationships available that did not exist in the original inputs, and that our background knowledge in the form of cognitive and cultural models allow the composite structure to be experienced in a new way. The blend has its own emergent logic and this can be elaborated to produce new ideas and insights. This blended space may then go on to be blended with other mental spaces.

Imaz and Benyon [13] have applied the ideas of conceptual to analyze developments in HCI and software engineering. They argue that designers need to reflect and think hard about the concepts that they are using and how these concepts affect their designs. They emphasise the physical grounding of thought by arguing that designers need to find solutions to problems that are 'at a human scale'. Drawing upon the principles of blends suggested by Fauconnier and Turner in [13] they present a number of design principles. These include designing to preserve an appropriate topology for the blended space, allowing people to unpack the blend so that they can understand where the new conceptual space has come from. There are principles for compressing the input spaces into the blended space, aiming for a complete structure that can be understood as a whole (the integration principle) and for keeping the blend relevant and at a human scale.

Benyon [1] argues that in terms of blended spaces the key components of the generic space, that are shared by both digital and physical spaces are the objects in the space (the ontology), the relationships between those objects (the topology of the space), the amount of change that happens in the spaces (the volatility) and the people who populate the spaces (agency).

The ICE is a good example, we believe, of a blended space where there is a sensitive alignment of the physical and the digital that demonstrates new emergent properties. Meetings take on a different structure in the ICE because there is simple and readily shared exposure to media on the wall screens. People have experiences in the ICE that they have previously not had. We can see how this changes the activity of creative work, providing new perspectives on information (such as an overview on the wall screens and a detailed view on the table) and offering new ways to articulate tasks and work together.

4. DESIGNING BLENDED SPACES

We are already designing other rooms for collaboration. At a neighbouring university we have designed a 'lean back' ICE based around a large shared wall display and a 'lean forward' environment based around the new Microsoft surface. We are developing interactive wall displays for a library in central Edinburgh and for our own campus foyer. We have undertaken consultations for large banks, software development companies and insurance companies. The briefs have varied across the domains but have all focused on the potential and impact of various emerging interactive technologies on work practice, specifically local and remote collaborative and creative activity.

Every use case and client is different as are their needs, wants and budgets so it is important for designers to remain software, platform and hardware agnostic. The aim is to implement the best and most appropriate products and solutions to meet a client's needs. We have developed five maxims for the design of ICE-type spaces: be people not technology led; be design not engineering led; design for simplicity, elegance and joy; the end product should be fun, productive, engaging and effortless; robustness and ease of use above all else.

Our design method is broadly a human-centred interaction design approach, but of course one that takes into account physical and digital space.

1. Identify and understand the purpose
This needs to focus on function, the nature of the installation, the impact and the audience. Designers need to understand why the ICE is being created, e.g. as a showpiece, a productivity tool or both and what problems it is expected to overcome. The designers need to know who will be using the ICE to do what and, importantly, whether remote access is required.

2. Examine the current practice
A design ethnography is critical to understanding what is not happening that the ICE-type space is meant to make happen and what is inhibiting that currently. For example is the ICE intended to encourage more creativity, or otherwise change working practices? Find out how people currently work.

3. Determine the project constraints
In every project there will be constraints (e.g. timeline, budget, legacy software/workflow, support and maintenance, environmental factors). In particular there will be constraints on the physical setting, the "unchangeable" and impactful physical factors such as window light direction, door locations, heating considerations and fire escapes that will affect the design.

4. Determine appropriate technologies for the space. What is the most appropriate for software-hardware blend are there

requirements for mobile and remote integration and will the budget run to bespoke solutions.

5.Model and map the space, from the big details (layout, furniture and lighting options and impact) to the smaller details (environment control e.g. lighting, power and cabling outlets and architecture) right down to the tiniest detail (e.g. what screws are used, how big should the shadow gap be between screens to ensure symmetry).

6. Bring these together considering the features of the physical and digital space in terms of the ontology of the space, the topology, the volatility (or dynamics_ and the agents (both human and artificial) who will inhabit the space

5. CONCLUSIONS

Clearly room environments such as the ICE will soon become commonplace. Indeed we have had much interest and enthusiasm from industry who can see the advantages that interactive rooms have over traditional videoconferencing suites and for creative collaborative activities. The table is a natural medium for activities such as compositing, collaborative sorting and for sharing complex figures and diagrams. Coupled with the wall screens, people in the ICE can have views onto a situation at several levels of abstraction at once, moving from an overview on a wall screen to the detail on the table. With all devices connect by wireless Internet, services, content and control can be spread across devices rather than tied to them.

The design of interactive environments is a key consideration for interaction design over the next few years. Designers will need to understand how to blend digital and physical spaces into engaging experiences. It is the sensitivity to bringing out the correspondences between the spaces that is critical. These correspondences can be understood with respect to the ontology, topology, volatility and agency of the spaces. The key feature of a blend, however, is tis emergent structure. The blended space will allow and encourage new ways of working and it is here that new forms of creativity and new forms of collaboration will arise.

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