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Towards Online Immersive Collaborative Innovation Spaces

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Abstract. We live in an increasingly competitive world where success is closely linked to a person's or organisation's ability to innovate which, in turn, means that innovation has become increasingly important in education and business. One response to this has been the introduction of special environments, tailored to supporting innovation, namely Innovation-Labs (i-Labs). Research has shown that creativity thrives in environments that are playful and customizable, rather than in the somewhat sterile environments of most workplaces. In this paper, we describe our efforts to create a model for an online immersive environment that can be customized and dynamically adapted to the needs of individuals and specific innovation sessions. In creating this model we have been inspired by earlier pioneering work in innovation labs, virtual reality, HCI and the World Wide Web. This work-in-progress paper presents the output of our theoretical studies, and an initial specification for an immersive reality innovation space called iSuite. This environment is based on an underlying model that is made up of a number of innovative features which include a customisable template-based generic interfacing scheme which supports human-machine and machine-machine interactions and supporting systems to assist i-lab users during brainstorming

Keywords: Innovation-Labs, Creativity, Product Innovation, HCI, Templating, Reconfigurable Spaces, Personalization, Virtual Reality, Education

1 Introduction

This paper presents our research which aims at creating more advanced solutions for online immersive collaborative innovation spaces. We have developed a computational model for implementing dynamic reconfigurable spaces and plan to investigate whether this model when instantiated as an online immersive multi-user virtual environment can benefit people working in these spaces. We have chosen innovation-labs as an exemplar application for this research. Our research challenge arises from how this computational model can support successful space reconfiguration and how innovation activities within such a space can be enhanced. We introduce the iSuite model as an exemplar for this approach, which is later described in this paper.

1.1 Innovation Labs

A recent report of the World Economic Forum highlights creativity as one of the top ten skills required for students in the job market in the year 2020 [1]. Creativity has moved up from tenth place in 2015 to third place by 2020 generating an increased requirement to support this need in education. Another related report by Schwab [2] has also highlighted Cyber-physical systems as the fourth industrial revolution, following the third industrial revolution which was based on electronics, information technology and automated production. An earlier project by the UK Royal Mail and other partner universities [3] found that creative thinking functioned best in playful spaces, which followed a particular set of rules that engendered uninhibited collaborative activity. These finding motivated the design of a special online environment, tailored to supporting innovation, namely an Innovation-Lab (i-Lab). An innovation-lab (I-Lab) has been defined as an "*inspirational facility designed to transport its users from their everyday environment into an extraordinary space encouraging creative thinking and problem solving*" [4]. A related report by Powell [5] has also pointed out that place governs people's beliefs, behaviour and their ability to be innovative and creative in their thinking. Thus, i-Labs need to be well designed to be able to support creativity and innovation. This also brings about the need to personalise such spaces and the activities it supports for i-Lab users. Multi-User Virtual Environments (MUVEs) show great promise for visualization, immersion and enhancing users' experiences but the current evidence suggests that they struggle to compete with their physical counterparts. Therefore, in this research, we hypothesize that it is possible to create a computational model for dynamic reconfigurable innovation spaces and that implementing the model in an online immersive virtual 3D environment will bring benefits above and beyond real physical innovation spaces. In the following sections we review related literature in relation to our research and further explain our proposed model.

1.2 The Importance of personalising space

Earlier research has pointed out the importance of being able to personalise built-environments and the activities they support. According to Bentley [6], a built-environment should provide its users with flexible settings and opportunities to maximize the choices available in their environment. Such an environment, with these affordances, are said to be "responsive". A key design parameter for such a space is its ability to support personalisation, in which users can put their 'stamp' on such spaces. Research by Chin et al. [7] also explored how non-technical users can creatively construct functionality based on networked appliances within the home by using a programming-by-example approach. The research carried out by Sailer et al. [8] proposes the use of data-driven design as an emerging design approach for spaces. Our research also aims to explore these emerging space design methodologies. Some research [9, 10] have explored automatic customisation of rooms, creation of spaces from architectural plans and integrating virtual worlds with information systems and learning management systems. In this work, we are more concerned with the elemental creation of the space and its associated HCI issues. We propose a templating approach in which interactions occur between users and template interfaces and between computational components, leading to more personalised MUVEs which are specifically tailored to support required innovation activities. It is hardly surprising to find that employers tend to favour university graduates that have creative-thinking and innovation skills. Courses and programmes that enhance such skills need to be introduced more in traditional science and engineering curriculums. In this paper we are exploring a new approach to introducing innovation to the higher education curriculum through i-labs. This approach was first proposed by Callaghan et al. [11] at the 2016 immersive learning conference in Santa Barbara. This paper expands on this vision and provides more detail on a computational architecture for enabling customisable spaces.

2 Related Work

This section reviews related work in innovation labs as an environment for creative thinking, innovation lab design and some innovation methodologies that have been developed to encourage producing creative and innovative solutions to user problems.

2.1 Innovation labs as creative thinking environments

Research by Gill and Oldfield [3] proposed that an i-Lab should consist of three interlinking components; the environment, the technology and facilitation mechanisms. In this context, I-Lab activities include a mix of the following:

- Discussion and getting other people's perspectives
- Icebreaker and reviver activities
- Headlines, cut and paste collages and PowerPoint presentations
- Wall activities (doodling, collaborative writing etc.)
- Brainstorming and Voting
- Role play
- Scenario building

At the core of the process is the brainstorming activity. This was described by Wu and Callaghan [12] as "*a technique for unleashing a flood of thoughts by members sparking ideas off each other, or from carefully injected external stimulus*". After sufficient ideas are generated, a group then go on to categorise, rationalise and vote on the suggestions. The actual implementation of these ideas occurs beyond the session carried out in the i-Lab.

2.2 Innovation Lab design

The research by Lewis and Moultrie [13] examine the design of some innovation labs selected from a range of sectors including corporate innovation, university staff development and governmental policy 'futurology'. The labs examined are the Royal Mail Innovation Laboratory, UK Department of Trade and industry Future Focus laboratory and the University of East Anglia Staff Development Hub. The researchers mention from their findings considering these cases that the physical form of an innovation lab is significantly beyond its aesthetic value. It is integral to the functionality of innovation labs. For instance, they point out that it is important to avoid creating structures such as big curved walls that minimise the future flexibility of the space. This further justifies the need for creating flexible spatial layouts which our iSuite model addresses. Also, they emphasise in their research that the extent to which an innovation lab is successful is the degree to which it is a physical reinforcement of the strategic intent of an organization to be innovative or creative. The work by Moultrie et al. [14] developed a conceptual framework in which they also emphasize the concept of strategic intent. They mention that a key element of both creating and using an innovation lab is understanding the needs and type of people who will use the space. However, they also stress that the role of facilitators is important in enabling innovation labs to work effectively. Considering various strategic intents that may exist and the important role of facilitators in innovation labs, it is therefore necessary to create supporting mechanisms to create innovation labs to suit various intents which our iSuite model also aims at addressing.

2.3 Innovation methodologies

Some methodologies have been developed to encourage the generation of creative and innovative solutions to user problems. Science Fiction Prototyping (SFP) as described by Callaghan et al. [11] involves "*writing short fictional stories that imaginatively extrapolate current practices forward in time, leaping over incremental developments, exploring the world of disruptive product, business and social innovation*". This technique is able to create high-fidelity analogues of the real world adopting a rich story-based structure enabling it to serve as a type of prototype to test ideas. A similar and complementary approach to SFP is Diegetic Innovation Templating, which involves extracting creative innovation ideas from fictions that are created for entertainment rather than for technology, business or social innovation. Another Innovation methodology is Scenario-based User Needs Analysis (SUNA). This is described as a method for envisioning, clarifying and refining ideas for developing software products and services usually involving two or more parties. It entails opening up, encouraging creative thinking and systematically narrowing down to extract salient details ensuring collaborative agreement and documenting outputs that would then be used for software development [15]. An end-to-end product development approach called the Creative Innovation Development (CID) model (from concept to customer), which incorporates these ideation methodologies is described by Wu and Callaghan [12]. It combines process flow and cyclic iteration to create an agile evolutionary product innovation cycle. A product’s features and design is established as a result of continued tuned evolutional iterations. At the heart of all these approaches described above is the process of brainstorming and ideation.

3 iLab features

We have used a real physical i-Lab that is located at the University of Essex Southend campus, to capture information about the features of these spaces and how activities are performed within them. Figures 1 and 2 below show views from the Southend i-Lab. We then present a model of the natural processes that take place within the i-Lab as shown in figure 3.

Fig. 1. A view from the University of Essex Southend iLab (brainstorming room)

Fig. 2. Another view from the University of Essex Southend iLab (shared reception area

The i-Lab processes involve a facilitator and participants as key actors. As illustrated in figure 3 above, the role of a facilitator includes specifying session goals, coordinating i-Lab activities, providing resources that would be used during innovation sessions for participants, providing necessary information needed to drive innovation activities and leading participants from one activity to the other as they complete the different sessions. Each participant contributes innovation ideas that we refer to as ‘*idealetts*’ that are generated from their personal wealth of knowledge and other information sources. In our research, we introduce some additional features to this model which includes the following (as shown in figure 3 above with dotted lines). These are:

1. I-Lab space personalisation/customisation
2. Inputs and outputs to support i-Lab support of end-to-end activities such as the CID model [12] using SFP, SUNA etc.
3. Support of business pre-conditions as highlighted in the CID model
4. Deadlock assistance to support i-Lab users participants when they run out of ideas during brainstorming
5. A disruption engine to change ideas generated by participants meaningfully e.g. disruption of micro-fiction as used in SFP [11]

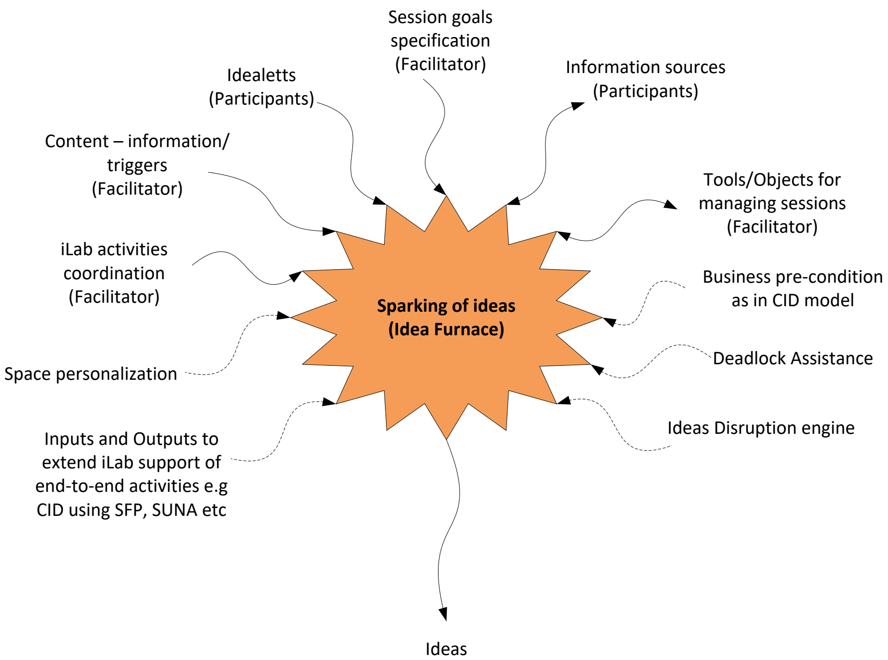

Fig. 3. Natural process model of i-Lab

These additional features are included in our proposed iSuite Model. We plan to implement these features in a number of development stages, and in the first phase of our research we will explore i-Lab space personalisation/customisation issues. These issues are elaborated in the following sections.

4 The iSuite Model

In this section, we describe some space personalisation/customisation issues and features of the iSuite Model. We explain the template based configuration approach and the underlying computational model, showing both human and machine processes. We then describe our current implementation of this computational model.

4.1 Phase I: i-Lab Space Personalisation/Customisation

We consider some issues relating to i-Lab space personalization such as features of the space itself, the tasks performed in the space, its support for group activities, tools and information accessible to users and interaction and communication issues. We view the conceptual innovation space in the real world and MUVE as the same. We go further to compare real world and MUVE affordances for innovation tasks based on these features:

1. **The Space attributes–** this includes the spatial layout, room ambience etc. Reconfigurations could be limiting in the real world but the virtual world could support more reconfigurations for innovation activities
2. **Tasks** – innovation tasks are manually monitored in the real world while monitoring could range from manual to automated approaches in MUVEs
3. **Support for people/group activity** – this is limited to the space available in the real world but there could be more people/group support for innovation activities in MUVEs
4. **Accessible tools/information** – this could be limited in real spaces whereas MUVEs could provide more support
5. **Interaction/communication issues** – the real world allows high fidelity communication while MUVEs can support the use of user interfaces and user devices for interaction during group activities.

Earlier research [16, 17] has investigated issues concerned with classroom design and the design of spaces for active learning [18]. From this previous research, it has been shown that changes made to the spatial layout of objects in a room and changes to room ambience can affect the performance of the active learning and group work that takes place within it. We build on this research and hope to incorporate these concepts in order to better personalise and reconfigure i-Lab spaces. We next proceed with the development of the iSuite model starting with implementing the following features:

1. Spatial layout – this includes changing the position and size of objects in the space, such as walls, displays, etc.
2. Room ambience – this includes changing wall textures to fit the theme for individual sessions, and includes changing the colours of the sidewalls etc.

4.2 Template-based Configuration approach

In order to achieve our aims for i-Lab space personalisation, we introduce the use of specified templates into which i-Lab users (specifically facilitators) can input data to create the i-Lab space. In this templating approach, the facilitator can vary the size of walls and wall displays that reflect the theme of the session, the position of the walls and displays in space and also the textures of the walls to create different spatial layouts and room ambience.

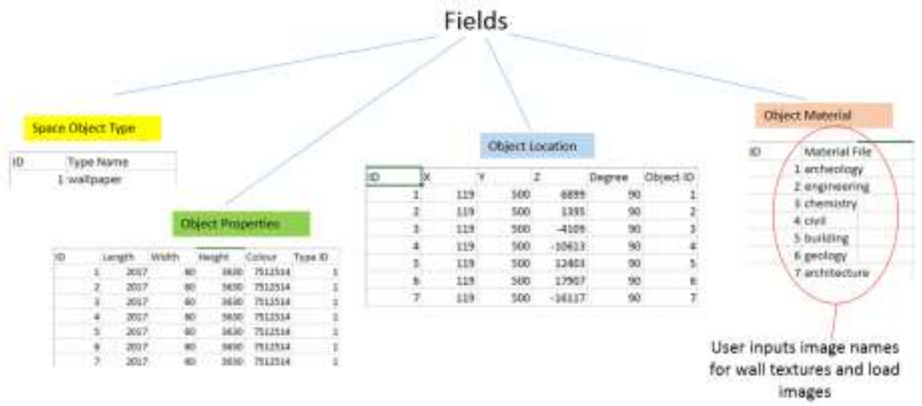

Fig. 4. Example space configuration interactive template

This template is then used by a space adaption engine to create the i-Lab space. The template thereby serves as an interface between the human configuring the space (facilitator) and the computational framework that creates the space (machine processes). Figure 4 below shows an example of such a template with some of its fields as described (being a tentative approach, we name this Innovation Protocol Version 1 – InPV1 for instance, as different variations/versions of this template may exist). This approach would be further improved and extended. We aim to use template views with different levels of detail and different modes of interfaces (e.g. visual interfaces).

4.3 Computational model showing human and machine processes

Figure 5 below shows the computational model in which the user interacts with the space adaption engine via the use of specified templates (an example template is shown in figure 4 above). The space adaption engine then processes the template specifications to create the virtual 3D space thereby creating a customised/personalised space for the user.

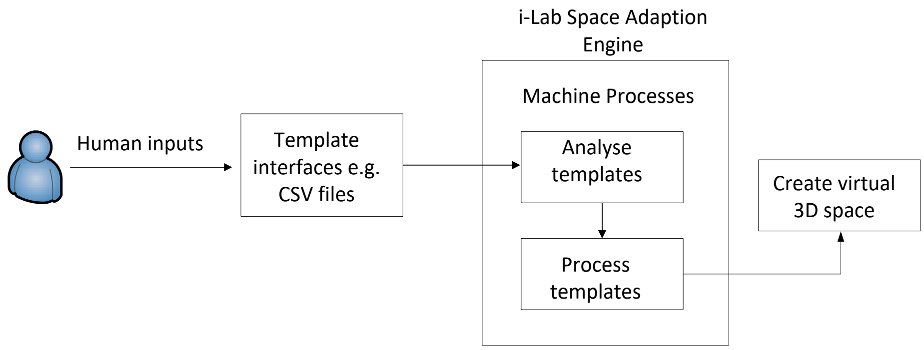

Fig. 5. Computational model showing human and machine processes

4.4 Implementation of the computational model

Figure 6 below shows an implementation of the computational model. The template in the form of .csv files are fed into a database server (MySQL server) which accepts specifications of dimensions and locations for objects to be created in the virtual world. The engine (implemented using Unity3D game engine) then creates instances of these objects in the virtual 3D space, getting information from an online application server (SmartfoxServer-SFS). Initially, a test script is used to check if the template object dimensions and locations in the 3D space are acceptable e.g. to check if objects are not overlapping in space. When the space has been created, various clients can then log on to the application server to view and use the 3D space resources.

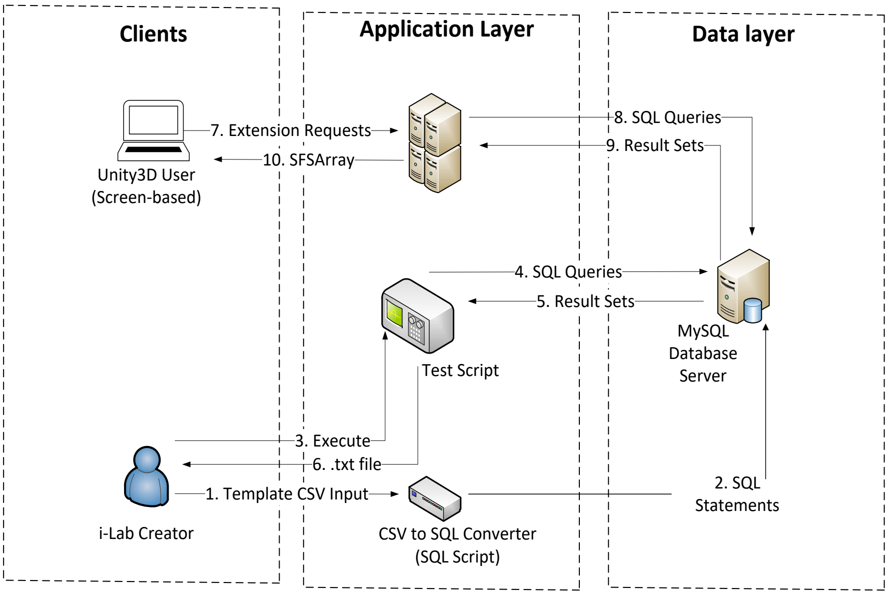

Fig. 6. Implementation of the computational model

Further stages of the iSuite model implementation would provide a platform to explore different ways of user representations and social interactions in the 3D space.

Fig. 7. Custom i-Lab space created by the space adaption engine

This may involve using avatars for example but, since anonymity is an essential element of brainstorming, their purpose would be primarily to indicate presence in the space and evidence to show user activity.

Figure 7 below shows an early example of a custom space created using the above architecture which will be refined considerably as the project progresses.

5 Summary and future directions

This work-in-progress paper was motivated by the idea that MUVE's can be reconfigurable and personalised to support desired user activities. An i-Lab was chosen to evaluate these ideas because, from the literature, there is much evidence that space has a direct effect on the quality of the processes being undertaken. Our vision is to develop dynamic and extensible systems to accommodate and support various user configurations with plug-in architectures. For instance, supporting immersive virtual reality devices as plug-ins. We have taken inspiration from the success of the World Wide Web, which is flexible and supports different communication protocols and plug-ins. The main contribution of this paper is the iSuite model. This includes a space adaption architecture and supporting template approach with human-machine and machine-machine interactions for creating personalised extensible spaces and activities to support creativity and innovation. Clearly, this is work in progress, with the intention of this paper being to present and justify the theoretical foundations of the proposed pedagogical activity and computational model, including an early implementation of the work.

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