Human Aspects of Smart Spaces for Knowledge Transfer

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Abstract. During May and June 2011, we ran two workshops with a theme entitled "Smart Spaces for Smart People" [1]. Although organized under the auspices of the e-Science Institute, the participants came from a variety of disciplines and brought a range interests. The workshops themselves were run as experiments in running smart meetings with the intentions of exchanging and recording knowledge and decisions discussed in the meeting. A recurring theme in the workshops was not only that technology can be provided in a smart space to help in the knowledge transfer and recording process, but also that the technology will only be adopted and exploited if the users of the smart space can easily use it. There are other human factors that affect the success of collaboration in a smart space. These include the willingness for participates to collaborate if they have concerns over privacy and anonymity, particularly when discussions and decisions are recorded using technology. The dynamics of how participants work together in groups to transfer knowledge can also be enhanced through the use of smart spaces. The fact that the workshops were run in different physical environments also provided insights into how the physical design of the meeting space might have on effective collaboration and therefore effective transmission of knowledge. This paper is the second in a series of three, each dealing with different aspects of the workshops and how they influenced our thinking about knowledge transfer meetings, particularly in the context of sharing research outputs.

1 Introduction

A smart space is usually thought of as a meeting place where people come together to collaborate, to share knowledge, and engage in shared activities. The spaces are usually physical, for example, a meeting room, a classroom, a research lab, or museum; but they may also be virtual spaces, for example an online meeting environment. In a smart space the transfer of knowledge may have many different purposes, from the sharing of ideas and experience to solve problems or make decisions within a multidisciplinary organisation, the dissemination of knowledge in a research environment, to the packaging and transmission of knowledge for education to students or customers.

A search across the Internet or through the relevant literature for 'smart spaces' provides a myriad of definitions that equate smart spaces with the technology that is developed for them, for example ubiquitous computing, ambient intelligence,

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integrated devices and agents, and so on. The overwhelming focus on the technology can overshadow the human aspects of smart spaces that play an important role in the effectiveness and quality of knowledge transfer within such spaces.

Smart spaces and their associated smart technology can be used to facilitate the knowledge transfer process. However the effectiveness and quality of the knowledge transfer will depend upon the effectiveness of the smart space. Groups and individuals will only adopt smart things if they can easily exploit them and they add value to what they already do. Using the experience we acquired from running two *smart spaces* workshops, this paper explores some of the human aspects of smart spaces that succeed in helping users to collaborate and share knowledge, or alternatively, may inhibit their desire or ability to do so.

We ran the workshops under the auspices of the e-Science Institute with a theme title of "Smart Spaces for Smart People", with the original intention to explore interactions between the physical and digital worlds. The workshops also looked at strategies for successful planning and conduct of smart meetings by using the workshops themselves as an experiment in running smart meetings. The meeting deployed a variety of hardware and software in an attempt to capture the discussions in the meeting in various formats for later processing and use, for example, recording audio and video, or capturing notes and comments through different media including flipcharts used by the facilitators.

The workshop invited interested parties to attend and contribute their experiences and ideas about exploiting smart spaces and best practices. The discussion during both workshops was predominantly about the productive exploitation of spaces ascribed as smart, particularly the use of technology in making the space smart. However, a recurring theme from the workshops was the needs of the people using these spaces. Although we didn't set out to consider human aspects, the experience of running the workshops as smart meetings in locations with different technological challenges, provided an opportunity to observe the relative smartness or dumbness of these particular spaces and their facilities extending beyond just the functional capabilities of the supporting technology.

2 The Pain of Technology

Running a meeting where all the participants are in the same room should be a very simple exercise, but as demonstrated in the workshops can in fact become very complicated because of the difficulty of using technology. Successfully connecting a laptop to a projector to display some slides can often result in a small delegation of hopeful participants poking at buttons, pulling and pushing wires whilst the hapless presenter presses key combinations and maybe even reboots their machine. The speaker or other users may desire network or Internet connectivity that may take time and assistance to configure. All this activity wastes times, inevitably causes the speaker some embarrassment, and is disruptive and distracting to the purpose of the meeting. The technological frustrations are magnified with more complex gatherings such as teleconferences, videoconferences and web meetings when meeting participants are located in more than one location. There are features of the technology that would assist in knowledge transfer within the

meeting, or for participants that were unable to take part at the time, but that are never utilised because of the complexity involved.

In the workshops we certainly experienced some of the pain of technology that could be described as contributing to the dumbness of the space, rather than the smartness of it. In the first workshop the main technical difficulties revolved around making the audio and video equipment work. There were many more problems in the second workshop around more standard technology. For example, because many of the attendees were not present at the previous workshop, it was essential to share the background and experiences of the first meeting. The materials had been prepared and presented from a website, so the meeting couldn't start until everyone had wireless access, but this required device by device approval using mac addresses. This was complicated, time-consuming, relied on a single person to do it. These challenges with the technology resulted in disruption, distraction, and delay. All factors contributing to a potential failure of the planned knowledge transfer because of distraction and time limitations.

If these are problems experienced with familiar technology in a 'normal' meeting room, what about really 'smart' spaces? Similar problems affect smart high-end room systems that often have multiple displays, interactive whiteboards, robotic cameras and remote conferencing systems. Research shows that these technologies generate two main problems [2]. The first that users fail to engage with the technology, they don't know what technologies will be in the room, let alone how to exploit them. The second problem is that the technology in these rooms is so complex they need a resident expert or 'wizard' to maintain the technology, and to help the users to use it. These wizards have to be around for the room to be useful, again resulting in a loss of potential opportunities and effectiveness of knowledge transfer and collaboration.

2.1 Change the User or the Technology?

One suggestion from the workshops for overcoming the problem of hard technology is to train the users in the 'new language' in order to make it easier to design and create technology. This idea suggests that people's behaviour needs to be changed in order to make it easier for the technology! Should we really expect user behaviour to change so that the technology can understand the user? Although undoubtedly people's behaviour does change in reaction to technology, the change is difficult to predict at best, and almost certainly impossible to control. A user's frustration comes from needing to change the way they behave to fit the technology. The users need to understand how it works in order to use it. Although users can learn new interactions, those that are difficult or unnatural are more likely to lead to avoidance behaviour in the users. The goal of the user is also important in this discussion, for a role such as trainer or teacher, spending the time learning to use the technology to facilitate knowledge transmission makes a lot of sense, but in other contexts spending time learning the technology may have no personal value. As an example, participants have no personal benefit in learning to use audio or visual recording equipment for a meeting to support knowledge transfer for participants not present at the time.

2.2 Fitting into the Human Environment

A different suggestion for solving the problem of using technology in smart spaces is the progression of technologies that recognize human actions for the development of 'natural interfaces'. These technologies include motion tracking, gesture recognition, face expression, and gaze-aware interfaces, in addition to taking input from the users using more naturalistic methods such as captured writing and speech recognition [3]. These technologies allow the users to actively use actions and gestures that they are familiar with, or that passively observe user behaviour and change the environment based upon it. In addition to providing technology that can support the users in their collaborative or knowledge transfer activities, these technologies may be able to non-invasively capture information such as reactions and user behaviour that could be used to assess the effectiveness of the knowledge transfer or collaborative activities occurring within the smart space.

3 Collaborating in a Smart Space

There are ways that a smart space can help users to collaborate who might find contributing in an ordinary meeting situation difficult. However, there are also aspects of smart spaces that may inhibit contribution by users.

3.1 Privacy Concerns

A recurring theme that came out in the workshops was privacy, particularly as a consequence of the recording or monitoring of participants in a smart meeting. Key concerns regarded whether the data would be made publically available, who had access and control of the data, how was it going to be used, and what happens to the data once it has been finished with? In the workshops it was made very clear that audio and video recording was taking place. Participants agreed because they knew it was a part of the workshop, but also because the recorded data would remain private.

Initially the recording technology was very prominent, but by the second day the participants agreed that they were used to it and ignored it. The technology faded into the background and became a part of the space.

People often make their own notes on the conversation or the decisions that are made in a collaborative situation or meeting. In some situations, usually more formal meetings, a note taker is present to formally record what was said. These note-takers are in effect performing the same task as an audio or video recording, although potentially less accurately. Despite the better reliability of the recording taken with technology, the members of the workshop felt more comfortable and less concerned about their privacy with the recordings taken by the human note-taker rather than with the technology. Another advantage of the written record is that is it more accessible in the event of a query. Locating and replaying the segment of an audio record is difficult, especially if is has not yet been annotated, which is itself a difficult task.

3.2 Use of Twitter

Users in a smart space may have access to an Internet connection through a laptop or even via mobile devices. People can easily communicate their activities and words that have been said in that space to others who are not present. Twitter enables people to broadcast to anyone in the world what they are doing. There are examples where 'tweeting' of details of discussions or commentaries on presentations have had both positive and negative effects.

Twitter use was actively encouraged during the workshops and the results retained as part of the meeting record. Tweeting can be seen as an effective way to elicit interest, feedback, knowledge and experiences from the wider community when the tweets contain the right kinds of questions, links, or status remarks. The use of social networking in general within a meeting enables the participants to extend their knowledge beyond their own experiences and tap into the knowledge of the wider community. These interactions and sharing can extend beyond the boundaries of the meeting in both participation and time.

In the workshops, tweeting from within the workshop encouraged participation from people not in the room, including some who had never even heard of it before.

The same privacy concerns that are expressed for recording or monitoring activities in a smart space also exist for technologies such as Twitter, because the perceived privacy of the collaboration for one user may not match the expectations of another who can instantly share their thoughts about the collaboration with the rest of the world. Through the use of 'retweets' a tweet can spread virally in a matter of minutes with no way to stop it once it has started.

3.3 Anonymity

There is a potential conflict in any knowledge transfer environment if a participant desires anonymity. The use of smart technology has the potential to increase this conflict. A smart space can be much more smart if it can recognize and 'know' information about the individuals within that space, for example the smart space can support the users by providing context based on the needs of the individuals within the group. However, collaborators may want to share knowledge, experience or opinions, but feel more comfortable doing so anonymously. Often though the capture and dissemination of knowledge, ideas, and opinions does not requiring a need to know who gave the information. Not knowing the identity of the knowledge provider may mean the loss of certain context, but at the same time providing the ability to contribute anonymously can facilitate communication and honesty.

Software systems that allow the capture of information anonymously have been available and used in focus groups situations for decades [4]. These have an obvious benefit in group collaboration situations, but they are not yet in general use in smart environments.

3.4 Improving Collaboration Using Smart Spaces

The effectiveness of collaboration in a group is in part determined by the composition of the group, how equal the members are, and how much they have in common. Groups can be classified according to the following characteristics of their membership [5]:

- Homogeneous groups, where members are equals and have the same privileges
- Heterogeneous groups are unequal and members have different privileges
- Loosely coupled groups
- Tightly coupled groups

Knowledge transfer may involve any of these combinations of groups. For example, attendees at a conference are usually homogeneous but loosely coupled. They are equal as peers, but don't necessarily know many of the other attendees. A research team on the other hand may be homogeneous, but also tightly coupled. Homogeneous groups tend to have similar experiences and knowledge, and understand situations and facts within the same contextual framework potentially making knowledge transfer simpler.

Within organisations groups are typically heterogeneous, for example in multidisciplinary teams the team members have different roles with different levels of influence and authority. If they work closely together they will be tightly coupled, but could be loosely coupled if they have been brought together to solve a problem from different parts of an organisation. Knowledge transfer is likely to be easier in closely coupled teams even if they are multidisciplinary because they are likely to share the same goals and same context for the knowledge transfer.

In a learning environment the group is also be heterogeneous, the teacher has more authority than the learners. The group may or may not know each other. A school class may be tightly coupled compared to an adult education college where the learners are only loosely coupled. In a learning environment the knowledge transfer is somewhat one sided and likely to be limited in scope, but is very effective for the transfer from teacher to learner because the roles involved and the context are very well understood.

Another example of heterogeneous and loosely coupled groups may be multicultural groups. In a meeting environment the participants may have different abilities in the language being used to conduct the meeting. There may also be cultural differences such as a need for more or less context in the communication. This can lead to disadvantages for some in following the conversation, being able to contribute to the activity, and even potential misunderstandings.

Multidisciplinary teams may struggle to collaborate or share knowledge because unfamiliar jargon or terminology with different meanings may cause communication difficulties and misunderstandings. The context that the people in these roles have may be very different. It is not effective to simply share the information that is familiar and meaningful for your own role in order to help someone in another role to understand it. In heterogeneous groups problems may arise where the perceived knowledge or authority of some individuals are greater than another. Those perceived as having the greater knowledge or authority may be

listened to more, whereas others with equally valid ideas or experiences may not have the chance to share them, or may be held in lower regard. The less knowledgeable or lower ranking participants may feel inhibited and unwilling to share their knowledge because of this effect.

In loosely coupled groups communication difficulties or inhibitions can result from the members having a lack of knowledge about the other members of the group such as their background or shared interests. Others who may find it difficult to contribute are individuals with a disability, who are shy, or whose first language is not the same the language that the activity is being conducted in.

Knowledge transfer in large organisations where there may be many ranks or authority, levels of expertise, and distributed team members may struggle with knowledge transfer activities because of these types of interactions within groups. The groups are often multidisciplinary, hierarchically organised, and come from different backgrounds, cultures, and may even speak different languages. These problems can be seen in knowledge transfer between an organisation and its customers because their needs and level of understanding are so different.

A smart space can help solve some of these common problems of collaboration by ensuring the group and individuals have access to the information they need (and only the information they need) in the formats that are most appropriate to them, based on language, abilities, and role. Knowledge can be presented to the user in the form they are used to working with, for example, blueprints for an architect and MRI scans for a surgeon. The knowledge can also be made available in accessible formats such as in the user's mother tongue language, or in large print or audio. The smart space must have an awareness of the users in the room and their needs, as well as access to the relevant information and the different ways of presenting it.

For distributed multidisciplinary groups the use of virtual smart spaces can be invaluable as ways of enabling interaction between the members of the groups and the transmission of knowledge across an organisation. Important technology that is becoming more widely used in such virtual smart spaces includes real-time translation services, access to background information, as well as the usual methods of sharing information, and recording the visual, audio, text, and presentation elements of a meeting. These technologies can improve the accessibility and understanding for all the participants regardless of location and background.

The recording of activities and discussions in a virtual space is valuable for participants, for example those who struggle to keep up with the conversation in a meeting, or for those participants in different time zones, who may be unable to attend the meeting in person, but who need to acquire the knowledge from the meeting. Virtual smart spaces can have an existence that outlives the time of the meeting that actually occurred, enabling participants to continue their conversations, thoughts, and ideas over a period of time, and facilitate knowledge transfer to new comers on a project.

The workshops intentionally involved face-to-face participation, and there were no remote participants, but there were discussions about the difficulties of distributed meetings. Those meetings that are supported by smarter technology are more successful and lead to a better quality of knowledge transfer than those where

limited technology is available, for example web conferences with audio are more successful for meetings and education than audio conferences alone.

Within the workshops the teams were heterogeneous in some respects being from different backgrounds and disciplines, but there was a lot of commonality in terms of knowledge, goals, and interest in the topics of the discussion. The experiences of participants discussed in the workshops emphasised the difficulties in working with heterogeneous teams. One of the participants from the first workshop raised the kinds of issues often seen in heterogeneous teams, when describing their experiences working with multidisciplinary teams in a medical context. Specifically that it is a struggle to work in a multidisciplinary team, and in teams where everyone wants different information.

In the workshops there were differences between levels of participant interactions and also the methods of interaction. For example, some participants tended to verbalise their thoughts and ideas, whilst others wrote their own notes or made use of technology to capture and express their thoughts, opinions, and ideas, for example Twitter. Some individuals shared more knowledge than others. Although many of the reasons why some participants interacted more than others can be down to the dynamics of group behaviour, there are some elements of the space themselves that influenced the behaviour of the participants and the effectiveness of knowledge transfer in the workshops.

4 Physical Characteristics of Smart Spaces

An unexpected aspect of the workshops was the discovery that the physical characteristics of a space may influence the success of group collaboration. These physical characteristics can contribute to the 'smartness' or 'dumbness' of a space. The difference in the facilities between the two workshops highlighted physical characteristics that impacted on the effectiveness of the venues for collaboration including lighting, space, layout, and noise. These physical characteristics of a space affect the behaviour of the people within the space and therefore have an impact on the effectiveness of collaborative and knowledge transfer activities that take place within the space. Consider, for example, how the arrangement of chairs at an interview, the relative height of the chairs, relative position, and so on, can affect the relationship between the interviewer and interviewee. Chairs laid in a circle are more likely to encourage people to express their opinions than a forma layout. An individual can be made to feel more or less powerful, or more or less in conflict with another person in the room by something as seemingly trivial as the layout of chairs. The impacts of other physical factors are more obvious, for example, if the room is poorly lit or there is a loud background noise, individuals with visual or audial problems may find it difficult to follow a discussion or presentation. There is also potential for the physical layout of the space to be exploited by individuals for their own ends, which may lead to both positive and negative consequences.

The room in for the first workshop at Edinburgh was very spacious with room for everyone at the table. Layout of the room enabled the flipchart to be clearly visible at the front. This provided a central focus, and people weren't distracted.

The space was also extended because the participants could leave the room for breaks and lunch. This extension of space actually facilitated constructive discussions because the conversations were continued into the breaks (although many of these discussions and their ideas were probably lost with no mechanism for recording). Physical problems at Edinburgh were to do with the organisation of the tables. The tables were organised over the power supply hatches on the floor, so the tables had to be moved before the beginning of the meeting. Some of the chairs were a bit constrained by the legs of the tables. Square tables also made it difficult to see everyone and see who was talking. Overall though, the room facilitated effective knowledge transfer and recording.

The second workshop at Southampton, in contrast, was not a good example of a smart space. There were technological problems as previously discussed, but there were also logistical problems based strongly on the physical characteristics of the room. The room was very small and cramped, the layout was poor, and there were not enough seats for all the participants at the table. There was very little space even at the table, and you could not see the other people around the table, only the person next to or opposite you. Those people who were not sat at the table were effectively removed from the discussion. Other physical characteristics that contributed to the confined feeling of the room included poor lighting and noisy air-conditioning. There was no extension of that space, because all the activities were carried out in the room including breaks and lunch.

Furniture layout at Southampton also contributed to a colocation of activities, the flipchart was in the corner, and was therefore very difficult to see. There were also different things going on at the front, with two screens, one with a twitter feed and the other with the agenda or presentation plus the discussion at the tables. The participants of the meeting found the twitter feed distracting because of the movement, and the difficulty of reading something different to what is being said at the time. The multiple locations of activity resulted in multiple focuses of attention. This contrasts with the first workshop where the location of the flipcharts and facilitator was more successful, providing a stronger and more visible focus of attention.

It is difficult to make a direct comparison between the two meetings to know whether the physical conditions made a significant difference to the way that the meeting worked or the outcomes. Various differences between participant behaviour and contribution in the workshops could have been affected by these physical differences. For example, because not all the participants were sat at the table in Southampton, then not everyone was equally able to share their knowledge and contribute to the discussion. The impact of physical characteristics of a smart space on the success of a meeting would make an interesting topic for investigation in the future.

If a smart space and related technology are to be used effectively by a particular audience, then the needs and desires of that audience must be understood. If this is not done, users will avoid using the parts of the space that are difficult or that they do not see the need for. This can result in avoidance of the entire space. Ideally there should be participatory design where the future users of a space are involved in the design. The design of smart spaces will be better and more likely to be a

success if the designers experience the way that the users work now, and embedded themselves in that culture and environment.

5 Conclusions

A smart space is only smart if it enables the users of that space to use the space for its intended purpose. Participants must be able to effectively collaborate, share, and engage in knowledge transfer activities. Technology in smart spaces can be used in numerous ways to support participants and enhance the quality of knowledge transfer. There are many tools that can help facilitate the knowledge transfer by providing greater accessibility to the knowledge and presenting the relevant knowledge in the most useful context for each individual, as well as the group. Technology can be used to assist those who have a disadvantage in a group, for example those with language difficulties, disabilities, or less experience within the group.

The kinds of groups that are most likely to benefit from the support and assistance are also those heterogeneous groups that are also the most likely to be concerned about the privacy implications of using it. I am more likely to trust the other participants in the smart space if I already know them or we have a lot in common. Considerations need to be given to the potential privacy issues and how a particular group may react. It may be appropriate to enable participants to contribute anonymously if they are more likely to share their knowledge, opinions, and experiences under those conditions.

Although technology can be of great benefit to knowledge transfer within a smart space, it is important to remember that technology that is hard to use or understand is at risk of not being used correctly or even not used at all. Any benefits that technology may have had will be wasted, and can even have a negative impact on knowledge transfer by distracting the participants or taking valuable time away from the key activities through technical difficulties. Smart technology is technology designed with an understanding of the goals and needs of the users, and ideally with user involvement that fits into the human environment.

However, it takes more than well-designed technology to make a space smart. Even with the most functional, easy to use, and relevant technology in the smart space does not guarantee successful collaboration. Something as simple as the position of chairs around a table can enhance or stifle the inclusion of participants, and consequently the success of the knowledge transfer that occurs.

In conclusion, the physical characteristics of the space together with the usability and ‘calmness’ of the technology contributes significantly to the relative smartness or dumbness of the space.

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