Public engagement with biomedical research through location-sensitive technology

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ABSTRACT

Augmented reality was used as an innovative way to engage the general public with biomedical and healthcare research information. Six research institutes in Melbourne's Parkville precinct were augmented with web-based information, and volunteers tested the usability of both this content and the augmented reality browser. Participants' feedback concerning the usefulness of the biomedical and healthcare information was very positive; over 75% of participants described the application favourably. Participants expressed a range of preferences regarding the types of information presented and its structure. Several participants felt they had learned something new from the application, and commented positively on the locative and mobile context of the technology. A challenge for science communicators is to provide user-friendly, accessible technologies that provide information of a suitable complexity and allow users to access that information according to their personal preferences. User feedback indicated that the application described in this study generally met these requirements, and shows that smart phone based AR has potential for use in science communication and public engagement with science.

Keywords

Augmented reality. Locative media. Scientific communication.

INTRODUCTION

Public engagement with science is an important aspect of society at a number of levels. Increasingly, scientific and technological issues dominate national discourse, ranging from environmental debates to the economic effects of new technologies, to the composition of the education curriculum of secondary schools. Having an appropriate level of engagement with, and understanding of, science is therefore increasingly important to navigating everyday life [1-3]. Individuals with a solid understanding of science have been shown to have a higher degree of civic engagement than others [4] and higher future incomes [5], benefiting both themselves and the societies of which they are a part. Being able to understand healthcare information is particularly important, as it has been shown that adults without sufficient health literacy are twice as likely to be hospitalised as people with an adequate understanding [6, 7]. In-patient spending for a person likely to possess low health literacy was found to be US$450 higher than for a person with adequate skills, even after controlling for health status [8].

Furthermore, public engagement with science is vital to scientific progress as well. It is well known that science relies on effective dialogue. As Isaac Newton said, "If I have seen a little further, it is by standing on the shoulders of Giants". Less poetically, "Progress in science has always been strongly dependent on how efficiently scientists can communicate their results to their peers and to lay persons" [9]. It is vital—to individuals, to communities, and to scientific progress—that public engagement with science is fostered.

The advent of new media technologies has increased the opportunities available for scientists to engage the general public in their work [10]. Of particular interest to researchers is establishing which new technologies are most suitable for engaging the public's interest. A significantly wider range of more personal technologies is required [11].

Previous work has shown that mobile learning—using wireless mobile technology to access information and learning materials from anywhere and at anytime [12]—is particularly effective for this type of engagement. The user can learn at their

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own pace and in their own time, following whatever information they find interesting, and therefore building a broader knowledge base [13].

Also, providing content that is relevant to a specific location to users in that geographical area may strengthen learning outcomes, by providing a sense of the physical contexts linked to that information. By creating associations between science research and locations within their communities, members of the general public may be encouraged to emotionally invest more in the science research being performed around them. This could help to develop an increased sense of ownership, engagement and transparency, and recognition of the importance and contributions of science to society.

This paper reports on an exploratory study of using smart phone-based augmented reality (AR) to increase public engagement with science through location sensitive media. In AR, digital information is projected over a real-time view of the real world, creating a "blended world" [14]. We hypothesized that AR is capable of providing the benefits of both mobile learning and locative media, providing public access to biomedical and healthcare information that users can follow at their own pace and strengthening the sense of investment with that information by linking it to locations in the area. Mobile AR also increases the opportunity for information exchange by exploiting people's curiosity about the buildings they pass during everyday life; users may be led to information they wouldn't normally choose to access. Augmenting reality may extend the kinds of learning that may occur by browsing serendipitously [15]. AR may support learning through the way it can combine just-in-time and on-the-spot resources for learning [16]. There are as yet few empirical studies of the effectiveness of mobile AR in education, and none to our knowledge that considers its possibilities for innovation in scientific communication.

The Parkville precinct is home to several internationally renowned biomedical and healthcare research institutions. This precinct therefore provided the opportunity to test the hypothesis that enabling people to discover information about science within the physical/geographical context in which it occurs may make this information more accessible and meaningful to them, and that AR offered a location sensitive way to support the dissemination of, understanding of, and engagement with biomedical and healthcare research.

METHODS

Selection of AR browser

Several AR browsers that were available in early 2010 on the smart phone platform (e.g. see [17]) were evaluated for suitability. The browser was required to be general-purpose, well supported, and capable of running on both Android and iOS phones to maximise potential public access to the application. Of primary importance was the ability to insert points of interest (POIs) and related information content, preferably easily and at no cost. Two AR browsers were found which met these constraints: Wikitude World Browser (wikitude.org) and Layar (layar.com). Of the two, Wikitude proved significantly easier than Layar to add content: it simply required small XML files containing the information to be uploaded via the website http://wikitude.me. For this reason, Wikitude was chosen for the current study.

At the time of the study, Wikitude World Browser version 5.0 was available. The current version is version 5.0.2.

Figure 1 illustrates data flow during the use of Wikitude. The phone establishes the user's position and the direction the user is facing via its internal compass and GPS receiver. It then contacts the AR server (A), which searches its database for POIs matching that location and direction (B). POI's are displayed as icons on the phone's screen. After clicking on an icon, the user can get additional information from a website referenced by the POI (C).

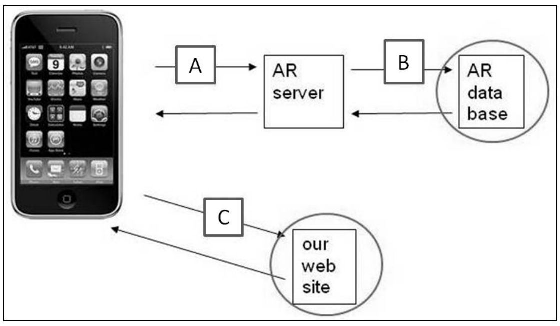

Figure 1. Architecture of the application.

POIs in Wikitude can be grouped by providers into sets known as "worlds". This enabled the creation of a single world of linked POIs within the Parkville precinct, to which additional biomedical research content could be added. Members of the general public could therefore, by accessing a single world, retrieve information about biomedical and healthcare research from a number of different research institutes as they moved through the precinct.

A pre-existing AR browser was used for two reasons. One, it reduced the amount of programming required. Second, passersby who already had the browser on their smart phones would see the Parkville world and might be tempted to see what POIs it contained. If the project had instead been developed as a standalone application, there is less chance that people would download and use the application without significant marketing on our part. This would reduce spontaneous access and the opportunity for public engagement.

Creation of the Parkville Precinct "World"

Six research institutes within the precinct were selected as POIs (**Figure 2**). These institutes were selected due to their identification as major research institutions in the state government's Parkville Precinct Strategic Plan [18]. Furthermore, rich web content already existed for each institute. This information concerned noted researchers associated with the institutes, their scholarly achievements and publications, and additional insights into their research activities and outputs.

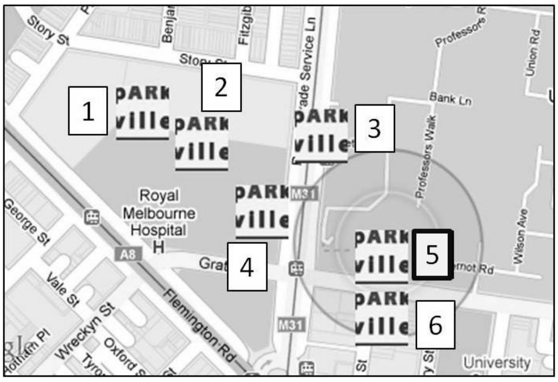

Figure 2: Map showing the locations of the six research institutes selected as POIs. The research institute for which interpretive media was provided (5) is indicated with dark borders.

For five of the six POIs, clicking the POI's icon in Wikitude linked the user directly to the institute's web site. However, for the final POI, the University's Medical Building, a more detailed information architecture was developed, to increase the degree of interpretation of the scholarly information provided for members of the general public. For this POI, information of several different levels of complexity was provided, to allow us to examine how users responded to each level, and which levels they found accessible. The front page contained brief, general information about the institute itself, including the design of the building. Deeper pages featured biographical information about past and present researchers, which was more detailed but still accessible by the general public. The most complex information was presented in the form of two scientific abstracts. The first was of a somewhat technical nature. The other was highly technical. These abstracts were not interpreted (reworded to make the information more accessible to a general audience) but were left in their original form.

Amongst the information provided were an audio recording of a public lecture, several photographs and paintings, and links to further information.

User acceptance testing

The study had Human Research Ethics approval.

Volunteers were recruited to test the acceptance of both the Wikitude browser and the information provided for the Medical Building.

Twelve participants were selected from 42 volunteers recruited from staff at the University. Eleven completed the user acceptance testing. Hwang and Salvendy [19] argue this is within the optimal range of participant numbers to test usability in a basic evaluation situation, when participants are provided only basic training and a limited evaluation time is allowed (the so-called "10±2 rule").

Participants' ages ranged from 18 to 74. About half were male and half female. About a third were born outside Australia, but all had lived here 5 years or more. None of the participants were directly associated with the institute or the research carried out within it. About half were iPhone users. Most were also users of other digital technologies.

Participants were observed and video-recorded for 30 minutes while using the prototype application on an iPhone in the vicinity of the POI. To ensure an adequate focus on the interpretative content provided for the Medical Building, other POIs in the Parkville World were not enabled, though a small number of other worlds in the vicinity were, to simulate a normal user environment. Participants also completed a short demographics questionnaire and a semi-structured audiotaped interview.

Data were collected and analysed using a framework adapted from Bevan [20] to assess pragmatic and hedonic goals, actual experience, performance and satisfaction.

RESULTS

Usability of the application

Figure 3 summarises the responses made by the 11 participants. Due to the semi-structured nature of the post-evaluation interview, not all participants responded to each category, and response counts do not always sum to 11. However, positive user feedback clearly outweighed negative feedback. More than half the participants commented that the application was handy, safe and enjoyable, and that they felt confident using it and would recommend it to others. Nine out of 11 commented that it was easy to use. All but one of the negative responses (that the application was not efficient, easy to use, handy, enjoyable, comfortable or able to be recommended to others) were provided by a single participant.

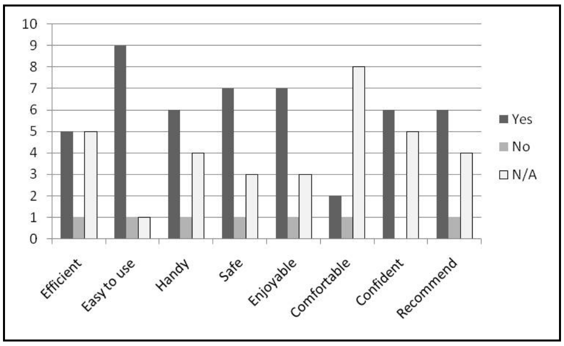

Figure 3: User comments on the general utility of the application.

General usefulness of application

When asked about the usefulness of the application to access locative-sensitive biomedical and healthcare research information, 8 participants responded favourably.

"I was very impressed with the app itself... I wanted to play around, keep exploring new stuff... It was a good experience, like this thing is actually very clever, so I do feel I was very impressed with it... If I actually come here and I have no idea what this department is doing—if I can actually have a look at the program and tap on that and get access to the internet at the same time that I have my iPhone with me, it would be pretty useful to get information—about what departments are in medical building, or... head of department—that's actually not too bad." (Participant 3)

"A good, broad introduction... It would be very useful, for example, for a general walk around the university... Knowing what to show visitors is a problem generally... it's useful to have a guide for them like this... An excellent starting point, I think." (Participant 4)

"Very, it was actually very good, being able to get information and see what was going on, see history, find out about people, see what was happening... There wasn't anything that was negative." (Participant 6)

"I wasn't aware of any of that research being conducted or the people who work there and it was interesting to see the people, seeing some background information on them." (Participant 7)

"A useful addition—a map doesn't tell you anything about it [the institute]... If I was travelling overseas to another university... it would have been wonderful... to have that with me and be able to point it to a building and hear—hearing I think is wonderful—hear what research, famous research, has been carried out there—I would have thought was a great way to tour a university... I think that spoken thing would actually be very attractive, just as somebody who knows research in this university... would show it off to a visitor—would be absolutely perfect because it would be like being taken on a personal, guided tour." (Participant 10)

However, 2 participants felt that the content was not aimed at a suitable level for the general public:

"The assumption of prior knowledge is far too high." (Participant 1)

"[It was] too in-depth for the general public... a brief summary would be better" (Participant 11).

Types of content

Participants expressed a range of preferences for the types of information presented and how that information was structured.

Participant 1 considered the historical information, for example, to be "annoying" and "irrelevant," but admitted that if they were a tourist, they might want to know it. In contrast, Participant 7 felt they were "lacking some information about the background" and found the historical information very informative. Participants 2 and 4 thought "it [the amount of information] was probably the right amount" (Participant 2) and "the main points need to be made" (Participant 4). Similarly, Participant 8 thought it presented a "nice picture" and wanted more information about the "big achievements" of biomedical researchers at the institute.

"The historical figures are really good—that brings it up to life a little more, gives it a little more uniqueness... I thought the biographies were good—pretty short and sweet, and also having that link to their scholarly work—I think it would be very useful for any visiting academic-type people... who might want to follow it up fairly quickly." (Participant 2)

"I don't actually know the people, so it brings up a nice little list of the people... That's useful." (Participant 11)

Participant 9 also felt that "information about the building worked well."

Several photographs and portraits, and the audio of a public lecture from one of the researchers, were also provided. When asked whether having images of the researchers was useful, Participant 11 responded that it was.

Several participants (Participants 6, 7 and 10) suggested that providing an audio version of the text would be more appropriate than just providing text, comparing it to "a museum guide that you pick up and take on a tour" (Participant 6). Participant 10 described this prospect as "stunning". However, no participants remembered anything from the audio of the lecture. Indeed, most participants simply followed the link to the lecture, checked that the audio worked, and then returned to the main page without listening to it. Participant 5 explicitly said they found the audio but wasn't interested in listening to the information.

Organisation of content

There was also little consensus among participants regarding the organisation of the content. Although Participant 6 felt the website was "nice and clearly set up," several other participants suggested restructuring the way information was presented. However, responses indicated a broad and often contradictory range of ideas of what was the most important information. For example, Participant 1 suggested reducing the amount of historical information, while several other participants said they enjoyed the historical information. Several participants liked the biographical information about researchers, while others felt the focus should instead be on "what the Medical Faculty represents" (Participant 4) or organised by subject, not people (Participant 7). Participant 2 felt that the order of information was not helpful, preferring a trend from general to specific content, "to get a vague idea about the whole place before I focus in on people". In contrast, Participant 8 felt the information was already too vague:

"Nothing told me what is really important or what I should focus on." (Participant 8)

Locative nature of experience

Of interest in this study was the hypothesis that public engagement with science would be improved by communicating scholarly information within the location to which the information relates. Two participants (Participants 9 and 11) commented on the locative nature of the application:

"You walk past the building and you get information about the building... so much faster." (Participant 9)

"It [being in the location] is very relevant to give you a good understanding of what's happening in the research department of the university at the time." (Participant 11)

Participant 2 said that they probably wouldn't use the application while mobile, or outside "in the cold." However, they might if sitting in a cafe or "waiting for a bus or something." Some participants suggested it would be better to make texts downloadable for later consumption.

Use of mobile AR: accessing information on smart phones

Several participants reported that they already used smart phones to access scholarly information (e.g. via the PubMed app), and expressed enthusiasm for smart phone-based science communication. Immediacy of access was seen as the primary advantage:

"I felt like there was a wealth of information, like everything was just instant, you just become an instant expert, you don't have to go to a library or sit at a desktop to become an expert." (Participant 7)

"You do browse on the phone, so when you're used to it, I think it's alright." (Participant 9)

"I think it's really good—most people have iPhones now." (Participant 11)

However, approximately a quarter of participants felt that a smart phone was not an appropriate medium for delivering scholarly information. A typical response was that interested users would have already researched the information before coming to the precinct:

"There's a limited amount of how much you can take in, on this sort of thing—so a general sort of picture, it's terrific... I didn't look at the abstracts—I would have probably done that beforehand." (Participant 4)

Participants again differed in what they thought was appropriate formatting for a smart phone: Participant 7 felt that everything was too large, and more information, especially more text, could be fitted onto the screen, while Participants 5 and 6 weren't concerned about the small screen or the size of the text, feeling it was "big enough" and suitable for an outdoor setting.

Using the AR browser

Evaluation of the Wikitude World Browser identified a number of user acceptance issues.

Although most participants initially described it as "easy and fun" (e.g. Participant 6), on reflection, some described the browser as "confusing" and "annoying." For example, Wikitude establishes user position and direction of facing using data from the phone's GPS and compass, and so provide POI information. The program does not attempt to identify the building in view: it simply displays icons for all the POIs in a certain range in that direction. Without prior knowledge, users were unable to establish which of the visible icons corresponds to the building in view. Participants referred to this as the phone "looking behind" the building or having "X-ray vision" (Participant 1). Five participants commented on how confusing this was:

"If you didn't already know what building it was, you wouldn't be able to work it out." (Participant 6)

"There was no way of knowing what it was without [using] the map [view]." (Participant 10)

This also caused an overlapping of POI icons. It was impossible to separate the icons by zooming, and impossible to click on icons hidden behind others. Furthermore, the browser sometimes failed to locate the user accurately, causing icons to be displayed in the wrong direction and adding to the participants' confusion. For this reason, all but 2 participants (Participants 9 and 10) preferred to use the map view rather than the camera view. This is important as the camera view is fundamental to the browser's claim to be an augmented reality system; without it, it provides only an "augmented map".

Learning outcomes

When prompted, 7 of the 11 participants felt they had learnt something new from the application. However, there was a wide range in the content and depth of the learning: Participant 2, for example, felt they had learnt something and had an impression that the University had a "long history of research in the area," but couldn't recall any specific details.

Most of the other participants who felt they had learnt something mentioned facts they had discovered in the information that had undergone the greatest degree of interpretation (i.e. that had the least complexity). Examples included the university departments found within the institute and the date of the university Open Day (Participant 3), the name of the current Dean of Medicine (Participants 3 and 8), and the "triradiate" design of the institute building itself (Participant 7): "It was interesting to learn... these special terms..."

Three participants mentioned learning something from the biomedical research and biographical information. Participant 6 mentioned learning about the building itself and its research. Participant 9 learnt from the biographical information that a famous past researcher had not only been a Dean at the institute, but had had another famous institute (not part of the Parkville precinct) named in their honour. Only one participant, Participant 11, could remember anything about the scholarly information that had undergone the least interpretation (the abstracts), and then could not remember any details. This information was in the non-technical abstract. No participants reported remembering information from the other abstract, which was written in a highly technical style.

DISCUSSION

Participants expressed a broad range of preferences regarding the types of information provided and its presentation

In general, participants expressed a high level of satisfaction with the utility of the application (**Figure 3**) and feedback about its general usefulness was very positive. However, when questioned about more specific aspects of the application, including the types of information presented and how that information was organised, participant responses were much more varied, and often contradictory. Due to these contradictions, it would be difficult to align the presentation of the research information with everyone's needs or individual preferences. This difficulty has previously been noted in the literature on health literacy; Nutbeam [11] and Adams [21], amongst many others, both discuss the need for "more personal forms of communication" for effective transmission of health literacy, while noting that this necessarily makes the content more difficult to deliver.

To some extent, this problem can be avoided by providing a information architecture which is sufficiently robust to allow users to pursue information that is interesting to them, according to their individual preferences for organisation. That is, different aspects of the content need to be accessible in different ways, so that users who prefer to work from general cases to the specific can access all of the content in as natural a progression as those who prefer to start with a specific case and generalise from there. Designing this information architecture is a major challenge in this type of science communication.

The need for translation of scholarly information—finding an appropriate level

Information was provided to participants with several different levels of interpretation. Although the majority of participants felt they had learned something from the application, there was a wide range in the content and impact of that learning, and several participants felt that the information presented was not at a suitable level for the general public. Only one participant recalled any details from either scientific abstract.

This illustrates one of the major challenges of working towards transparency and engagement with complex scientific areas: that the work must be translated to a level that makes clear its relevance and impact, in a way that is understandable to a lay audience, without changing its message. With that in mind, the fact that at least one of the participants was able to understand anything from the technical information indicates that there is scope for different levels of interpretation in this type of science communication.

Again, it is difficult in a simple information architecture to provide the level of complexity suitable to meet the needs of all individuals. For that reason, providing a number of layers of content of increasing complexity is important for engaging a broader cross section of the general public. It is important to bear in mind that information that is too easy is just as unengaging as information that is too hard.

This is a significant difference to other projects concerning the dissemination of biomedical and healthcare research, such as those promoting health literacy. Health literacy information is typically written at a level understandable by those with a junior high school education [22, 23]. However, one of the aims of this project was to engage the general public in the outcomes of research, not simply to provide basic healthcare information. Between 1997 and 2008, the average annual growth rate in the proportion of people graduating from tertiary education in the developed world was 3.4% [24]. In Australia, nearly 50% of people graduate from tertiary education [25]. There is clearly a need for the provision of high quality science information (with some translation for a non-specialist audience) at a level interesting to this educated public.

Presenting biomedical research via a mobile, location sensitive technology

Phone-based augmented reality was selected for this study because we hypothesised that it had the potential to increase public engagement with science, due to its being both mobile and location sensitive. This was predicted to increase serendipitous learning by providing a sense of the physical contexts linked to biomedical and healthcare research in the Parkville precinct. Several participants felt that being in the location where the research was performed was relevant and stimulated an improved understanding that research. Many participants could see an advantage in mobile learning. Immediacy of access to information was seen as the primary advantage, which is consistent with the literature (e.g. [13]). AR was therefore seen as a suitable technology for providing biomedical research information to the general public. Of those who disagreed with the use of smart phones to disseminate science information, it was generally because participants felt that those who were interested would have researched it beforehand. However, this application of AR technology was designed to exploit people's casual curiosity about research in their geographical location. It was intended to complement pre-existing methods of science communication (e.g. books, web sites etc.), not replace them.

Providing several different types of information (historical, biographical and scientific) should also increase the chance the casual users will find something of interest among the available content.

Future directions

Based on participant feedback, a further layer of translation of the scientific abstracts has already been introduced into the application. Furthermore, linking content to other online resources such as dictionaries may increase the application's accessibility, as well as providing further opportunities for users to perform self-guided research. In addition, providing an audio reading of some content is likely to be a good adjunct to increase the application's suitability to the mobile context.

Recent software upgrades to the Wikitude AR browser may better address some of the criticism arising from the user acceptance testing. Users are now able to limit the POIs displayed to those within a user-defined distance, which is controlled by a slider at the top of the camera view screen. Users are therefore able to limit the number of icons appearing, which should prevent many of the user acceptance issues discussed above. This was not available during our tests.

A principle in engaging the public with biomedical and healthcare research generally is to ensure that the content is clearly understandable without changing or losing the essential meaning. However, our results suggest that a more complex and nuanced view of the general public is required in order to successfully engage a broad spectrum of people. Information should be provided at several different levels of interpretation to suit different people.

The challenge for science communicators using technology is to provide user friendly, accessible, robust information architectures, as well as to allow users to pursue information according to their personal preferences. The largely positive feedback from our study suggests that our content, coupled with smart phone based AR, met these requirements. Smart phone-based AR therefore has potential for use in science communication and public engagement with science.

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