Welcome to the Neighbourhood – Space Signpost

A Futurelab prototype research report

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The Welcome to the Neighbourhood project is an attempt to develop a new approach to public understanding of science that empowers individuals to explore questions and ideas of interest to them in the solar system. The prototype is an experiment intended to discover what sorts of representational systems can encourage users to confidently explore questions of science and discover answers for themselves.

The installation itself consists of a moving signpost linked to a digital touchscreen. The signpost moves to point to an object within the solar system of the user's choice and displays the changing distance to that object on an LED screen on the sign. The digital touchscreen provides further information about this object, and offers users a range of different options for interacting with three-dimensional representations of objects within the solar system. The installation is designed to be located in an outdoors public space likely to be affiliated with a public institution (for example outside science centres or galleries) and to be usable by the full range of the public, with appropriate accessibility for individuals with physical disabilities. The installation can be described as a cross between street theatre, street furniture, installation art and science centre exhibit.

The over-arching aims of the project were:

- to empower users to conceive of astronomy not as a domain both literally and conceptually 'out there' (either in 'outer space' or in the scientific arena) but as a domain within which we live and breathe
- to facilitate confident engagement with scientific representations that can be interrogated by individuals in the ways they interrogate and interpret the signs and symbol systems of their local neighbourhood.

The Welcome to the Neighbourhood project consisted of two phases of development:

1. Concept development and prototype testing.
2. Design and build of first installation (funded by COPUS).

This report focuses on the first of these activities.

The technical development of the project was conducted in-house at Futurelab between Adam Nieman and Alex Burton (DTI-funded programmer), a process that enabled close cross fertilisation of ideas between programmer, content developer and research and technical teams at Futurelab. It uses open source software, Celestia, and has involved the development of a flexible HTML interface to allow modular changes in further development.

1. FIRST PHASE PROTOTYPE DEVELOPMENT

1.1 Research and development questions

Within the two over-arching research aims outlined above, the project development has focused on the following specific questions:

1. What are the key questions that a wider public audience is most interested in exploring about the solar system?
2. What representations will most easily enable users to answer and explore these questions?
3. Does the presence of a concrete external reference frame aid navigation through and understanding of the digital representation of space?

4. Does reference to actual objects and real distances help users make a link between a 'god-like' three-dimensional representation on the screen and an actual view of the sky?
5. What type of interface is likely to encourage confidence in users to explore and interact with a digital resource?
6. Which facts or ideas or tools stimulate enquiry or provoke questions?
7. How do pre-existing conceptions of space conflict with the language or mode of explanation in WTTN?

There are also three further generic research questions that each Futurelab prototype needs to address:

1. What does this prototype tell us about the best ways of designing digital resources for learning?
2. What does this prototype tell us about how informal learning processes can be transformed through use of these tools?
3. How does this prototype help us understand the potential of next generation technologies to create intrinsically motivating and engaging learning experiences?

1.2 Prototype development

1.2.1 First phase concepts

The first stage of any project is the development of its overarching aims and objectives as outlined above. In the early development stages, Futurelab staff and Adam Nieman worked to develop an appropriate 'metaphor' for the project. From the many initial ideas Adam brought to the table (including science centre star installations to outdoor physical sculptures showing moon movements), we focused specifically on the metaphor of the local signpost and on the solar system as the general framework for the project. In its first iteration, we considered a signpost with multiple arms, each of which could be directed to specific objects in space in order to allow users to explore the relationships between them. The image below is an early concept sketch for this idea.

During an early discussion, the possibility of drawing on the digital information points now to be found in city centres also emerged. The idea of using these resources, rapidly growing in familiarity across the UK, was one that had significant resonance for the team, offering the possibility of diverse users outside science centres interacting with 'scientific information' through the same mechanism as local information about the city.

Early discussions with developers of these resources and with electrical engineers, however, identified significant costs both in the multi-armed signpost model and in using these info-points as a basis for development. The decision was therefore taken to scale back the ambitions of this first phase prototype development to focus specifically on the possibilities afforded by the combined representational tools of a single moving signpost in interaction with a digital interface. What was retained from this early phase development, however, was the metaphor of the local signpost and of the touch screen interface drawing on the model of local digital information resources.

1.2.2 Initial public survey: September 2003

The second phase of project development was to develop a broad understanding of public perceptions of the solar system, and of key areas likely to be of interest to a wide range of users. While we also drew on existing research in this area in formulating our questions (eg PPARC, 1999) many existing research projects focused on interviews collected with visitors to science centres and museums. In order to counter this tendency, we developed a short questionnaire that we conducted with a selection of individuals encountered in public spaces in Bristol over one day in September. In the first instance we asked people to let us know where they might want to visit in the solar system, what they might ask an expert about the solar system, what their views were on 'good and bad' areas in the solar system, how they might feel on winning a telescope, when they last thought about the solar system and the most interesting information they knew about the solar system. These questions were intended to elicit existing conceptions and perceptions of the solar system, and to engage with the affective dispositions of people towards this knowledge domain.

This process identified a number of key points. In the first instance, it became clear that when asked about a general interest in space, many people professed little or no interest. Further, many people simply could not describe the solar system in any coherent fashion and there were a number of misconceptions (such as where stars could be found, what might be meant by the phrase 'solar system', what planets were, how the earth and the moon moved in relation to each other). However, when we asked when people last thought about things in space, many people reflected that it was relatively recently, when they were outside at night. When asked how they would feel on winning a telescope there was near universal enthusiasm and interest. This suggests that while people may not have a general interest in 'the solar system', there are specific areas of personal interest that they would enjoy exploring further (particularly with the aid of a telescope). The following quotes are drawn from these interviews, and suggest that for many people interest in this area is triggered by direct experience rather than a generalised more abstract desire to master a specific knowledge domain:

About three nights ago. A friend of mine was pointing out different constellations [...] my friend was pointing out the Orion constellation [...] billions of light years separating the stars and they are part of the same constellation.

I last thought about it, oh... Last night [...] I spend most of my time outdoors, so...

I saw Mars last night actually. It was really random because I was walking down the road and I

asked this bloke for the time and it was really dark and he went, "there's Mars over there" and I looked up and went, "oh my god". "That's quite strange," I thought.

I mean, I do sometimes look at the Moon on a very clear night and I think, ooh, it's interesting how you can actually see things on the Moon. I suppose it's the seas isn't it?

The main areas of interest in planets and space were in relation to their impact on life on earth, specifically, whether there was life on other planets and whether we would be able to visit other planets or live on them. Pop-culture was clearly an important framework for thinking about space (which may explain the interest in life on other planets) and the X-Files and Star Trek were frequently referenced. Other cultural references, often for older interviewees, were greek mythology and english folklore (often in relation to the names of planets and stars, and reference to a 'harvest moon'). In respect of the idea of the project, there was general, if guarded and somewhat bemused enthusiasm - primarily for the idea of the provision of a resource about science that was free and in a public space.

One striking fact that emerged was the speed with which individuals shifted from a discussion of the components of the solar system, to profound philosophical questions - why are we here? What does it mean to be alive? Is there a god? Are we alone in the universe? Indeed, the speed with which these questions emerged was often cited as a reason for not thinking about space, as it raised too many uncomfortable questions and feelings in the individual, which could not be resolved.

Well, the giganticness of it. It's so mind boggling, you have to wonder when it all started and [...] it's a very powerful thing.

As a result of this initial stage of the project, a clear emphasis was placed in the prototype design on the need to facilitate potential users' sense of engagement with other objects in space - such as, for example, what these places would be like to visit and whether there was life out there. This initial stage also highlighted a clear obstacle to the project's success, namely, the extent of confusion about the structure, language and meaning of different aspects of the solar system. This was so diverse that any tool risked increasing rather than overcoming misunderstandings. What this stage did encourage us to continue to explore, however, was the question of how we could develop a tool that was sufficiently open-ended as to allow users to choose areas of their own interest to explore, rather than imposing a constraining structure of key information. It encouraged us to think about three distinct groups when designing the resource:

1. Those who have a high level of formal knowledge and want to explore their particular interests further.
2. Those who have a low level of formal knowledge and want to be 'told' more information.
3. Those who have a low level of formal knowledge and want to find things out for themselves.

What these interviews reinforced for us, was a need to develop a resource that could be used 'on location' outdoors, when people would be likely to use it to answer and explore questions that emerged through interaction with the physical space around them.

1.2.3 Focused interviews (1) 9 October 2003

Following on from these informal surveys in the street, we decided to focus specifically on groups who are excluded (through education or income or cultural capital) from access to formal sites of science education, in which we include science centres. In order to focus specifically on this group we contacted a local community project (the SOFA project) which serves the needs of low income groups by providing low cost second hand furniture and electrical goods. This project also employs a number of people on New Deal, a number of people on community service (mainly young offenders) and a number of people with few or no

formal educational qualifications who go on to manage and run significant parts of the operation. Having identified that we needed to develop a resource to support those with low levels of formal scientific understanding of the solar system, we decided to focus these first stage interviews on attempting to capture people's existing conceptions of distance, size and relationships between objects in the solar system. We visited the project for one day, during which we worked with a number of staff, volunteers, clients and trainees at the project, asking them to carry out a number of different exercises designed to elicit their understanding of the solar system. Each of these 'interviews' was audio recorded and photographed.

A number of key issues emerged from these interviews. First, the lack of confidence felt by many people with no formal scientific or other educational qualifications, in developing conjectures and playing with scientific ideas, particularly when they felt there was someone with significantly more formal understanding present. They were frequently concerned about making mistakes, often embarrassed when asked to guess answers to questions they had no understanding of, and sometimes refused altogether to explore ideas, saying simply "I don't know, I don't know anything about all of this". This contrasted markedly with other groups we worked with informally during the course of the study who, although with little scientific experience, were confident in themselves as educationally qualified, and were more happy to make guesses and conjectures in areas of which they were uncertain.

A second issue that emerged was the complexity of different strategies and understandings that different individuals drew upon in order to conjecture about the solar system. When asked to guess how far away earth was from the sun, for example, some individuals drew on a remembered understanding of the diameter of the earth and went through complex calculations to try to derive earth's distance from the sun. Others remembered something about the speed of light and estimated from that figure. Others guessed at the size of the sun, and used this as an indicator of its distance from earth. Others again drew on science fiction references. Many, however, were reluctant to guess and eventually said "I have no idea, this looks about right". When discussing the relationship between the earth, the moon and the sun, at least half of interviewees were not able to accurately describe the relationship, some placing the moon inside to and parallel to the earth's orbit, for example. One interviewee, a Somalian worker who had only recently moved to the UK, engaged us in a long discussion about the relationship between the earth and the sun, resolutely arguing that in Somalia (where you could see the sun, he said, with a wry smile indicating the grey Bristol sky) it was clear that the sun went round the earth. He described this as akin to travelling on a bus, with the houses looking like they were staying still while you moved. He argued that he would need to "see it with his own eyes" to believe that the earth went round the sun. What the interviews highlighted was the extreme difficulty of conceptualising the solar system as a three dimensional dynamic environment and of beginning to think about distances and scale of solar system objects.

One striking finding from this research was the high level of latent interest in the solar system amongst this group. Many said that they had no means of access to scientific information and resources apart from television, and that the cost of science centres and museums was prohibitive to them (even had entry been free, the costs of travel discouraged them from visiting). The idea that a resource in this area might be created that would be free to access and placed in a public site was of great interest to them. Indeed, even this short visit apparently generated high levels of interest in the project and in the subject area of the project. Supervisors at the SOFA project, for example, reported high levels of discussion of space in informal conversation during the day and for several days afterwards; they also reported that many of those involved in the interviews asked on several occasions when we would return with the first stage of the prototype.

1.2.4 Focused interviews (2) 30 & 31 October 2003

Following these interviews and initial research by Adam Nieman, it was decided to use existing open source astronomical software (Celestia) to model the solar system in three dimensional space to enable users to conceptualise distance, scale and movement in the solar system.

Celestia is a well known open source environment for exploring astronomy but generally requires a mastery of astronomical terms and concepts before users can engage with it. It does, however, hold all the functionality required to create 'scripts' of particular ways of looking at objects in the solar system.

The second phase of the trials were to take draft scripts created in Celestia to model different ways of looking at representations of the solar system, and to refine these with potential users of the resource to ensure that they helped answer some of the questions and difficulties experienced by users in first phase trials.

We returned to the SOFA project for two days of trials, in which we had a paper version of the interface that we asked users to interact with in order to provide instructions to Adam who was controlling the Celestia system. We explored the questions that users raised during this process and the limitations of Celestia in helping users to make sense of what they were seeing on screen.

1.2.5 Subsequent prototype development

Following on from these interviews we created a series of requirements for Celestia and a draft user interface that would allow users to explore features of the solar system that they were interested in without having to have prior astronomical knowledge.

The first phase of the interface was designed with the three audiences we outlined above in mind and therefore needed to enable users to take a number of different routes through the system - as both playful explorers of the representations and as researchers of information provided 'on demand'. This led to a design that encompassed both playable tools (such as moving in or out from an object, or speeding up time to see movement) and information resources (such as a tour of the system encompassing an explanation of key features, and descriptions of the planets). The need to allow flexibility in perspective clearly arose from the interviews we conducted which emphasised the number of different ways in which individuals come to think about solar system objects and the number of different solutions individuals use to make sense of them. The need to 'provide information' in a just in time manner arose from the number of questions of a factual nature that were prompted by our initial interviews.

One of the key challenges in designing WTTN's interface, was how to enable users to create a coherent picture of the solar system, without simply 'telling' them how it all fits together. Drawing on our early interviews and exercises, we decided to employ the principle of juxtaposition in order to offer users a way of comparing other planets and objects with earth as the primary reference point. This justaposition would be in evidence both in showing relative sizes of objects and in showing distance and time to travel to these (a request that came up continually from interviewees). The hope was that this combination of user control of the interface, with information provided 'just in time', with juxtaposition of 'alien objects' with the familiar reference of the earth, would serve to enable a wide range of users to make sense of the representations we were offering.

2. DESCRIPTION OF FIRST PROTOTYPE

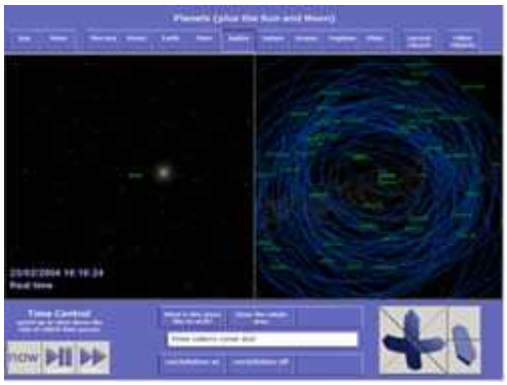
2.1 Signpost

The signpost consists of an LED screen mounted onto an 'intelligent' telescope base. A user selects an object that the signpost should point to and the signpost moves to that direction and indicates with an arrow either on the left or right of the display, the direction of the object. The signpost displays the distance of the object in kilometres, and continues to show the changing distance of the object for as long as it is pointing at it. In practice, this means that the last three numbers (100s of kilometres) are constantly changing as you look at the sign.

2.2 Digital interface

The opening screen of the digital interface in this first prototype offered users a list of planets, the sun, the moon, and 'other objects'. The user could click on any of these objects to be taken to it.

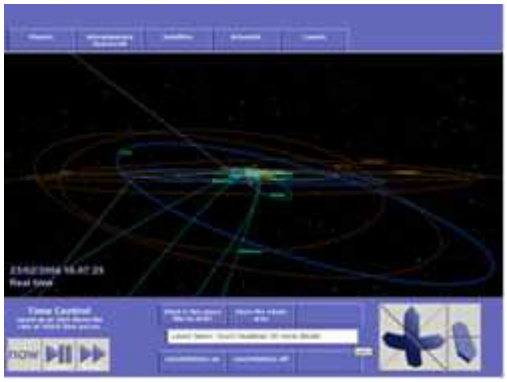
On clicking on an object, the user is presented with a view of the object on the right hand screen and a view of earth on the left hand screen (both of these from the same distance to allow comparison in terms of size). At this point, the user can click on any of the other buttons at the bottom of the screen to explore the object further. This includes the Time control, which enables users to speed up time - this gives the effect of showing how objects move in relation to each other. This also includes the rotation and 'zoom' buttons (on the rhs at the base of the screen) - these allow a user to 'tilt' the object to view it from above or below, and to move in closer or move out to any distance.

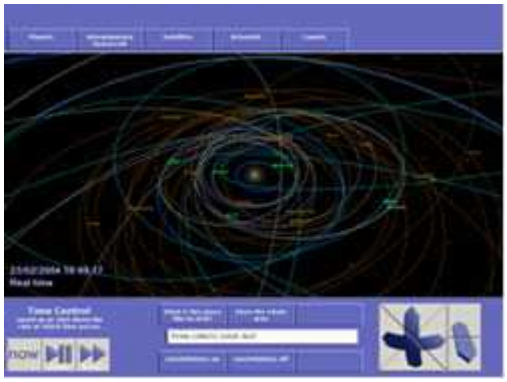


The previous screen shows a 'zoomed out' view of Jupiter. On the left hand side we can see the earth and the sun on the rhs we can see Jupiter and its moons. The blue lines on the rhs show the orbits of any moons orbitting the object selected.

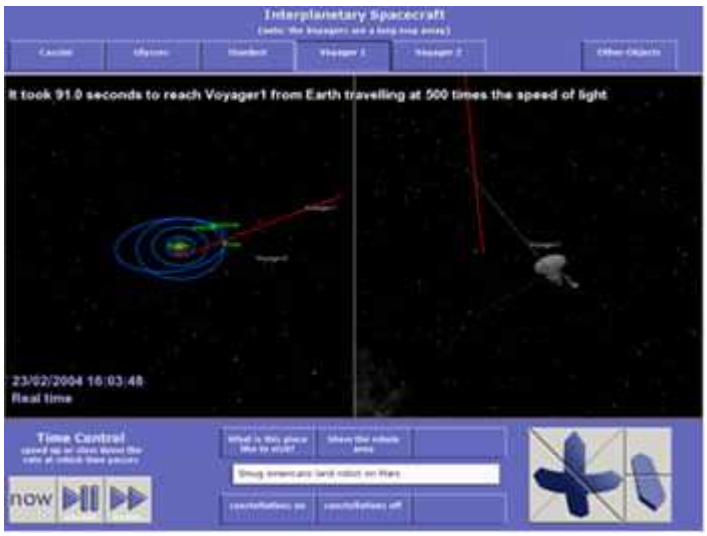
From this screen, users can also select 'what is this place like to visit' - which provides textual information along with (where available) an image of the object's surface.

At any point, users can also select 'show whole area', which shows the orrery view of the solar system, users can tilt and zoom in on this image to see the orbits of planets from a number of different perspectives.





From the opening screen, users can also select 'other objects', which refers to objects which are not planets, the sun or our moon. This takes them to a number of different choices including asteroids, spacecraft and comets. Within this section, if they click on spacecraft, they are shown the spacecraft on the rhs and the path of that spacecraft from earth on the lhs.



If viewers choose to view earth, unlike any of the other planets or objects, they are able to move into a very detailed view from satellite of the earth's surface. This appears to move as they watch it, giving an indication of the speed of earth's movement.

Missing from this prototype were several features planned for completion. First, 'the tour' which would allow users a scripted introduction to the solar system, presented in a modular fashion so that it could also be accessed from other screens; a 'where is this object' screen that would show the location of the object in relation to other planets; and a 'how do we know this' screen, that would explain the basis for the information provided. All these were key features of the installation intended to be developed in this phase, but which have had to be delayed until second phase of the project due to time constraints.

3. FIRST PHASE PROTOTYPE TRIALS

The final version of stage one of the prototype was trialled over four days in January 2004 with 76 users in the Watershed Media Centre, At-Bristol, SOFA Project and Luckwell Primary School. These early trials demonstrated significant potential of the system in encouraging engagement and confidence in exploring the solar system. They also demonstrated the potential of the resource to act as a cross between a 'toy' and a 'conversation piece'. The key features of the installation that supported understanding of the solar system were the signpost (and its counter-intuitive indication of objects 'below' earth); the 3D representational system that enabled users to view space objects from a number of different perspectives; the comparison

of different space objects that began to allow users to conjecture about relative distances and sizes of objects in space.

3.1 Sample

The research was conducted over four days in January 2003, with one day spent in each of four sites (Watershed Media Centre bar, Luckwell Primary School, the SOFA Project, Wildwalk @ Bristol). The sites were chosen to offer a wide range of potential participants in the trials, and in order to explore how the different sites encouraged different types of interactions with the prototype. All participants, with the exception of schoolchildren who were nominated by their teachers, were volunteers who were asked while walking past the prototype on location whether they wanted to use it.

Total number of individuals who trialled the software individually or in small groups: 76
Demonstration of software to larger groups: 2 x tourist groups, 1 x Year 3 class
Age range: 4-70+
Scientific expertise range: from primary school children recently taught about solar system, through adults with no formal educational qualifications, to education officers and researchers with higher degrees in scientific subjects. Average level of scientific qualification - GCSE/O-level science.
Employment range: from low income households with no employment and individuals on community service, to retired people, to highly-paid researchers and education officers in technology and education sectors, to students, to arts workers.

3.2 The features of the installation that were useful in encouraging engagement and confidence in exploring the solar system

As outlined earlier, one of the key aims of the WTTN prototype is to facilitate confident and enjoyable interrogation of scientific representations. This section of analysis explores the extent to which this was successful.

3.2.1 The signpost

Throughout the trials, the signpost elicited a high level of emotional response from the majority of participants on initial use. Frequently occurring language included 'whoah', 'wow' and, most often 'cool' on observing the signpost move. The following are fragments of observed language that give some flavour of the emotional responses to the signpost and the changing numbers on the signpost indicating distance:

Whoah it's going... watch this, it moves... cool, that's a long way... Ooh, there it goes, that's a hell of a long way... oooooh ha ha ha ha... It's going wheeeee like that... that's a long way... That's fab isn't it... that's disconcerting... that's really foolish, love it... You should have a great big one... Fantastic... oh wow! Oh Wow! That's smart isn't it (giggles)... That is immense... that is so scary... wow that's wicked... oooh... it's billions of miles away.

What was clear was that the movement of a physical object that linked the user with an object many thousands (or billions) of kilometres away was a powerful way of initially engaging users emotionally with the concepts of the solar system. In respect of the Nuffield foundations injunction to "foster a sense of wonder, enthusiasm and interest in science", the signpost clearly achieved its objective.

The users as a whole, however, could then be split into three groups. A first group who continued to be primarily interested in the signpost:

G1 *Oh, so that's finding Pluto now*
G2 *Oh, I didn't realise that's what that did - I thought it just pointed at Mars*
G1 *Wow!*
G1 [with big smile on her face] *I like that* [pointing at the signpost] *I really like that*
K *why do you like it?*
G2 *Because it moves... I'm simple* [laughs] *I'm simple and it moves... I don't know I just like the way it moves.*

I like the movement of the piece, cos it feels like its actually doing something.

A second group comprised those who 'toggled' between the digital interface and the signpost - finding the interaction between the two systems added value to both:

F *It's partly the signpost and its partly the feeling that you can control, that you can see what angle you can see things from, get closer, get further, rotate around it... it's both of those. There's something about the way it moves that's so very ordinary - its kind of clunky and makes a whizzing sound, and that connects you through the... one has a concept of space and that's ephemeral - the fact that this is so material, that you can look at that and think that the technology that's built it appears to be familiar - it makes it more real... it looks like Robbie the Robot. Metal Mickey.*
K *If you could see some of this on the web - would you be interested in something else - would you be interested?*
F *Yes, but I don't think - looking at stuff on the web is very removed from anything isn't it - but this isn't, so its different, so what makes it different it has very... On the whole anything you find on the web, I'm disengaged from it, but this isn't, this is engaging.*

And those who ignored the signpost after the initial phases of use and focused most of their attention on the digital interface, sometimes even finding the signpost a difficult distraction from the screen:

M *I think it's very impressive, I think it's very good, to have the little thing pointing like that. Not much point in that really, but I think it gets you into having a look at the rest of the program, if you've got that thing going there.*

I think it's really good this. I think it's almost a bit much having both [pointing at screen and sign] *in the same time, because there's so much on the screen, so it's quite hard to click on there and then have a look, it's almost like they should be two separate things. You could do one and then the other... possibly... I don't know, there's quite a lot there.*

I would use it, just for a laugh, and then probably realise it's actually quite interesting, and then realise you can zoom in and pan around the planets and stuff. I think this [signpost] *is more of an attention grabber, and then it draws you in.*

3.2.2 The digital interface

The digital interface (setting aside certain issues of interface design to be described below) seemed particularly successful in encouraging engagement and confident 'play'. Several features were notably successful:

1. The humour of the headlines
On reading the headlines, many users laughed and joked and used these to stimulate other comments. The irreverent nature of these headlines seemed to help get users 'on side', and help them feel that they were part of the community of users intended by the installation. It may be worth further exploring how this humour can be retained without some of the more extreme flights of fancy in the current version (eg Beagle stolen by Aliens...)

2. The experience of travel through space and time as the interface moved to show another object
The representations on the screen that showed the movement from earth's surface through space to finish up looking at the object were particularly engaging for many users, some described it as space travel, one user described it as being similar to out of body experiences she had had. The language used by users suggested close engagement with the experience - usually using first person and present participles, suggesting a projection of self onto the screen movement:

I like the way all that happens (the movement between the planets as you travel to a new one) yeah, it's like 'whoosh'.

Oh, we're flying straight into the sun [laughs].

I wanna do that galaxy thing again... it's very absorbing and you want to know more - you don't want to stop - just to be in the solar system, it would be... it is amazing.

3. The reference to concepts familiar with most users, such as weight and sunscreen, in the information screens
The information provided in the 'what is this place like to visit' was written in such a way as to allow users to link the information to their personal experience. The references to weight on the planets, for example, were particularly popular and the apparent contradiction between the temperature on planets and the requirement for sunscreen provoked discussion.

What I liked about this was that the facts you got were like really interesting without being overly serious and in depth, like the stuff about the weight, about how much you'd weigh there, that's just so engaging.

The weight stuff - I just can't believe that you'd be a pound if you lived on Pluto! And all the temperatures and things because you sort of have this notion that it would be a totally different environment from earth, but I don't think you have an idea just how different it would be. And also, are they - the Voyager - are they like man-made satelites? They're just so far away, it's incredible.

4. The diverse ways in which users could control the screens - allowing playful exploration through changing distance of view and angle of view
The buttons allowing users to move in closer to an object or pull back to an almost infinite distance encouraged users to both play with the objects on the screen and to play with the interface itself, exploring just how far it would allow the user to control it. These interactive features seemed to offer users a sense of power and control, not only over the system but metaphorically over the planets.

Oooh, that's very pleasing. Wow [as the images on both screens enlarge - she then plays with moving in and out and with rotation buttons for five minutes].

That's how fast... we're going in time... where the earth will be... I am moving the earth, I am moving the sun.

There were also some notable instance of users exploiting these features of the interface to create a narrative control over the representations, effectively 'making stories' out of the images they were controlling and attributing emotions and thoughts to the different objects.

B2 *Oooh - that's all the moons, all those blue lines are moons... so many moons*
B1 [looking at lhs] *There's earth and there's the moon*
B1/B2 *Ooooh I'm going to crash into Jupiter... The man's thinking 'why is the moon turning all over the place'*
B1 *All those lines - they're the moon*
B2 [as they zoom in] *We're going to crash into Jupiter - aargh*

B1 *Let's go to Starter* [Saturn]
B1 *That's one of the ones with the round thing round it...*
B2 *Tell me where to go*
B1 *Let me see know - is Jupiter is it going to fall or is it going to land on earth*
B2 *Go like that, go like that, that's how I want it.*

The following example shows a particularly enthusiastic user engaging closely with all the features enabling 'travel through space'.

F *Ooh 'Ha Ha Ha Ha' - watching it move...*
F *And it's*
F2 *Quite a long way away*
F *Four thousand million miles away* [laughs]
F2 *It's getting closer*
F *No, it's going wheeee, like that*
F *That's a long way*
F [clicks on something else] *Oh wow - look look look - that's nice*
F *So that's halle bop comet - what do these do?*
F *Does it make it bigger?*
F [sharp intake of breath] *Wow - it moves it*
F2 *That's cool*
F *Mmmm rotate up, should be able to... move back*
F2 *That's fab isn't it*
F *What does this do?*
F2 [laughs] *I think you've just gone into a black hole*
F *Oh no - you see*
F2 *Ohh wow*
F *I'm on the interior of the comet - hee hee - you see*
F2 [laughs]
F *Now let's go round and round and round and up and down.*

For almost all users, the WTTN prototype achieved its objective of encouraging confident and playful exploration of representations of the solar system. In many respects, the WTTN prototype can be compared with a toy that encourages play and facilitates users to project onto it their own ideas and conceptions of the solar system.

One exception, however, was a young female artist who was clearly left cold by the experience. She described the installation as "too sciency", and said that she simply wasn't interested in it. It is not clear how the installation might be redesigned to encourage her engagement, although there was a suggestion that the colours and style of the interface too closely resembled scientific instrumentation.

3.2.3 Engagement in isolation or conversation?

It is worth noting, although we did not explore this area closely, that there were different preferred styles of interacting with the resource. Some users clearly enjoyed working with other people and felt that this enhanced the experience:

I really liked it, I found it really interesting, it was really nice when you had another person there to help you out and be looking at the information. Plus, it's just that whole thing about communication, like me saying to [...] "oh, look what that is", whereas when you're on your own you can take it in but you've got no one to share it with. I think it's really interesting.

While others preferred a silent and personal journey through the installation. The question of how we can design the resource to enable more than one user to explore it at any time remains a moot question. In particular, when working with the primary school children there were battles over who had access to the mouse and resentment at not having control. At the same time, however, when there were multiple users, we often saw them taking on different

roles - with one person reading the signpost while another focused on the screen, or one person 'driving' while others directed. Given the signpost's potential location in a public space, the issue of how many users will be expected to watch/control/participate at any time requires further exploration if we are to ensure that the installation remains engaging.

3.3 The questions users brought to the installation and which were generated by users during use

3.3.1 Routes as a guide to areas of user interest

By tracking the routes taken by users through the interface, it is possible to identify the features they were most interested in exploring. What is noticeable, however, is the very wide range of different routes taken through it, which leads us to be cautious in any conclusions we might draw from this analysis as to the pre-existing questions users brought to the resource and our success in enabling users to answer them. Of the 24 routes we were able to track, we saw certain patterns emerging - for example, a high level of interest in spacecraft, in Mars (unsurprising given recent media coverage) and in both the exotic and distant 'Pluto' and in our local and familiar Moon. Neptune and Uranus, and the headlines offered on the screen, were only rarely explored by users.

In terms of the questions that users brought to the resource there are a number which could not be answered by the existing content and which we describe below in terms of areas that require development.

3.3.2 Questions and observations related to content generated by users during trials

What is perhaps as interesting as examining the extent to which the software is able to answer users' existing questions, is whether the installation in fact generates questions about this area through use. In our preliminary studies, for example, we had found that (other than questions about life on other planets) many people were at a loss to formulate questions that might be of interest to them about the solar system. From these trials, it seems that the installation can serve as a 'scaffolding' resource enabling people to formulate more specific questions and areas for exploration than when thinking in a more abstract fashion about the solar system. The following are a number of different questions generated by users about the solar system while using the prototype, these range from questions about the origins of scientific knowledge, to questions of how space technology is disposed of, to questions about the nature of planets and the solar system:

How do they know it [Jupiter] *doesn't have a surface?*
Would that crush you? Would you be strong enough to walk on the surface? (visit Jupiter screen).

Find out where Halley's comet is at the moment then.
When's the next time it comes round?
About sixty years or something?

Let's go to Mars - apparently we're all moving there in 2030 aren't we? How are we going to live on Mars?

Are they all the satellites? What's the Friendship? (on the orrery screen).

What happens to the old ones [satellites] *when they're done, when they don't want to use them any more?*

Where do the names come from?

Have they stopped building that [ISS] *now that the Americans can't get up there? Cos I*

haven't heard of anything going up there lately.

What's the speed they are going round?

3.3.3 Eliciting existing knowledge

During the course of the trials, users also often volunteered information that they were previously aware of about the solar system. When there were multiple users, we often saw conversations starting that moved away from the screen to enable one person to share understanding and ideas with another. As well as a toy, then, we might conceive of the installation as that old-fashioned device, a 'conversation piece':

Bloody hell - Voyager's never that far away
Yes it is
Is it hell, I can see it with my binoculars
No, not Voyager, the space station...

I guess its because Hubble's found them [Jupiter's moons]. *They're going to burn Hubble... they're just going to 'splat' - drop it.*

This is Pluto, at the moment it's not the furthermost planet, it's inside Neptune, it's actual orbit goes inside Neptune so it's not actually the furthermost out... It's an actual fact that every seven or eight years it isn't the furthest planet out because it goes inside for a little bit.

Go to Mars and see if there's something on Beagle Two, cause the American one landed there... Not our Beagle... it's balloons didn't open... weird things like that.

So the question is - do you believe they actually put someone on the moon?
Er that's an interesting question
If you look at the old rickety spaceships they were using and the radiation and those dead astronauts that come up mysteriously and got killed and stuff
Oh right
And the flag flapping and no atmosphere... it's all a bit suspicious if you ask me.

This might be correct actually - cos the way maps are perceived, these continents are actually much bigger - Africa, South America - you know the way you've got a map of the world and America is as big as South America. It's all wrong, cos Africa is huge, the continents are just much bigger than what they are conceived on conventional maps and stuff... It's cos most of the action happens in Europe and America and stuff... But as far as landmass goes...

Aha, smug American lands robot on Mars [laughs]. I reckon they've done pretty well, caos all we've got is a Wurzel that's on ours.

The installation, however, did not only trigger conversations relevant to conventional scientific information, but seemed to allow some users to return to thinking about more philosophical or spiritual matters:

Did you see the eclipse?
I could see it through my window - it's amazing, it's so beyond our field of reach, but it affects us... Hundreds of years ago, thousands of years ago, people would have been terrified by them.

It's mindboggling...to travel that distance, if you could survive the machine to take you there... if you still had a machine that travelled at the speed of light, you'd still die of old age before you got there.

What other objects do we have?
Black holes or something

What about hell?

It's kind of scary.

3.3.4 The role of the different representational features of the installation in aiding understanding

While engagement and interrogation of different representations was a key objective in the design of WTTN prototype, we were also interested in exploring the extent to which the different representations could act as 'tools to think with' about the solar system. This section will focus specifically on the extent to which the different representational features of the prototype offered more or less fruitful ways of thinking about the solar system, whether it offered users useful tools for conceptualising the often abstract notions of three-dimensional and dynamic space.

3.3.5 The signpost as key feature in changing perception of space from two-dimensional to three-dimensional

From these trials it seems that the key contribution of the signpost to users' understanding of our place in the solar system, is in providing a tangible representation of the earth and the solar system as three dimensional. The most frequently observed moment of surprise during the trials was the point at which users were confused by the signpost pointing downwards through the earth to another object in space. As one user described it, many people's previous experiences of representations of the solar system are two dimensional and static:

To me GCSE science is a two-dimensional diagram... this is three-dimensional, these diagrams are three-dimensional... At school, well it was the picture - the sun's here, and the planets here, all in a row on a piece of paper...

In contrast, the movement and direction of the signpost, for at least half of the participants in the trials, offered a 'tool for thinking' about earth and space that enabled users to think outside their normal frame of reference of the earth's surface, and to locate themselves, and earth, as being 'inside' rather than 'underneath' space. The following examples highlight this process:

What's kind of surprising is that instead of being up there [pointing to the sky and above head], *because the stars are all kind of up there, that they're over there or there* [pointing in front and below] *you get the sense of earth being kind of like a round thing* [making sphere shape with hands] *instead of... completely flat... which I know is kind of obvious but you don't really think about it, you think the sky is kind of up there.*

S2 *Yeah, like when we clicked the moon, it took me a few seconds to realise why it was actually pointing like that* [pointing down] - *I thought it should be up there* [pointing up] - *and then* [laughs] *I was like 'oh wait a minute'*
S1 *Why is it down there?*
S2 *I was thinking yeah - it should be in the sky! And then I was like...*
S1 *I was like that with the sun - I thought it was up there and then we looked at the sign and it was over there* [pointing relatively horizontal and low in the sky].

A: *That was a surprise, when it pointed down and I was like* [looking at the sky] - *it's not just up there* [laughs]
K: *Is that kind of sciency or is that something you enjoyed knowing?*
A: *It was something I hadn't kind of thought about before... But* [smiling] *it's like blindingly obvious - cause you always think of the sky as up.*

M: *No - I always expect them to point up, but they don't, they point down, because of the position of the earth... it makes you appreciate that you're on something that's in constant motion - I mean we take it for granted don't we.*

M *It tells you how far away it is and where it is... but I would never have imagined that the Hubble was down there* [pointing down]. *You wouldn't think of it like that would you - cos it's the other side of the earth*
K *Cos normally if I said like 'where are the planets and stars and something'?*
M & F point upwards
M *You'd just say 'up there' wouldn't you*
M [laughs] *You learn something new every day.*

G2 *You do forget that the sky is* [making round movement] *that way don't you*
G1 *Yeah*
G1 *Yeah, cos you just think 'oh'* [pointing around]
G2 *It does, cos you're looking in relation and it makes you think that it is actually... the world's round and not flat* [with a wry smile]
G2 *If you get what I mean.*

[sign moves and points down]
[M looks confused for a while, and looks round at the sign and then at Adam]
M *Is that Australia or something?*
[silence and looks for a while longer at the sign, no comments and no clicks on the interface until, after some time]
M *It's just pointing through the earth, it's below the horizon or something.*

K *So there's Saturn*
M2 *So I have to dig that place down*
K *So does that make sense to you that it's pointing down?*
F1 *Does it mean, does it... er?*
M2 *That's the way to Saturn*
M *Underneath the ground*
M2 *You have to... it means it's on that side... it's that direction...*
M2 *To me, it's OK...*
K *Do you think that's a bit weird*
F1 *It's a bit weird to me*
M2 *That's the way, that's the way - the earth is spherical shape, this side to you, this way to me. The different way you get to Hanam, when you go to Hanam - it's like the Moon.*

3.3.6 The signpost providing a tangible connection between flat earth and three-dimensional solar system

The signpost also offered some users the opportunity to link their conceptions of physical space on the surface of the earth with physical space in the solar system. In particular, in trials at the SOFA project, users often commented on the features of the local physical neighbourhood and viewed them as routes towards solar system objects.

M2 *She says she wants to know what that means* [referring to the numbers on the sign]
K *OK - it says it's 191 million kilometres in that direction*
F1 *To Mars?*
K *To Mars*
F1 *From Earth?*
M2 *So if I take my car and head for Lawrence Hill...* [laughs] *and keep going!*
M2 *Quite a long way.*

S *This is Mars - let's try something a bit unusual... nope, maybe better click* - [signpost starts moving] *oh wow... So if I followed that trajectory in some kind of space vehicle, I'd get to Saturn?*
K *Yep*
S & J [laughs]
J *OK, well, your vehicle's out there* [points out of the window] *so...* [laughs]
S [laughs]

K *What's that? The bike?*
S *Yeah* [laughs]
K *Could take a while*
J *ET can do it.*

[signpost points to Voyager]
N *Woah - that's pretty long that I reckon*
J *13 billion km*
J *So, past the pub, past the flag, it's just over the green somewhere* [laughs].

These comments did not, however, emerge in any other research site and as a result it is difficult to conjecture about what triggered them.The most obvious explanation is that the SOFA trial was the only trial where the signpost was on street level and in easy view of 'the real world' outside. If this is the reason for these connections being made, it provides some cause for optimism that the location of the installation outside in a real world setting would serve to encourage these sorts of connections between the three-dimensional solar system and the perceived flat surface of the earth. This will need to be explored in the next phase of trials.

3.3.7 The digital interface as key feature in changing perception of space from two-dimensional to three-dimensional

As described above, the most common representational tool for thinking about the solar system is a two-dimensional static image of the planets in a line moving out from the sun. The dynamic three-dimensional imagery on the digital interface seemed to play an important role in providing a powerful alternative representational tool that enabled users to conceptualise movement, distance and the multiple dimensions of space more easily.

There's definitely a lot I didn't expect to see cos I've never had a chance to see it in that kind of perspective, cos when you see the solar system in a book, it's kind of hard to get an idea of the scale of it, whereas that's a really useful tool to get some kind of comprehension of the distances, whereas that's amazing, yeah, very impressive.

It's cool to be able to see the differences in the sizes, and to be able to flip it like that [demonstrates tilt on the orrery screen] *to actually see the different... You normally only see it in one view.*

Relative to what it all points to... it's kind of um... it's like, supposing it only had a back of the envelope scribble on the map to someone's house compared to an aerial photograph that had all the surrounding houses and it gives you a sense of how to get there and how it fits in with the other streets.

It gives you an idea of depth of where things are... Like earth, you think it's flat in books, it's nice to feel that kind of density/matter...

What several observers noted, however, was that it was sometimes very difficult to link these new three dimensional representations with their previous 'top down' static view of the solar system. Many users noted that it would be useful to be able to link all the different objects together, to pull back from one object to see its location in relation to other planets. This had been intended as a feature of each object screen, but unfortunately this feature was not ready in time for the initial trials. Moreover, the feature that might have assisted in this linking (the 'show whole area/orrery' screen) was unreliable for three of the four days of the trials. This question of how to link a three-dimensional dynamic representational tool with pre-existing two dimensional static tools will act as a key feature of next phases of development.

The point made earlier about how the rotation works is relevant here also. The ability to move around the model is vitally important to understanding its three-dimensional nature. As mentioned before, there are few distance cues in the individual frames themselves - just lots of confusing intersecting lines and isolated objects. The most powerful distance cue in human

perception is motion parallax, which is the way things in the distance appear to move more slowly than things in the foreground as one's point of view changes. Moving round a complex collection of overlapping orbits (eg the moons of Jupiter or the orrery view) allows us to perceive them as paths through three-dimensional space. Without moving, this is extremely difficult to represent. If the way rotation works causes confusion then the ability to perceive the scene in three dimensions is seriously damaged.

Seeing a static view of an object in correct relation to its neighbouring objects would not be enough to give users a sense of its location in three-dimensional space. The user has to see all the objects from a moving perspective and, preferably, be in control of how the perspective moves.

3.3.8 Comparisons and juxtapositions

One of the features that we intended to act as a resource for thinking about the solar system in WTTN, was the juxtaposition of different objects with each other and with earth. In some cases this seemed to work particularly effectively in giving users a way of thinking about differences between planets. For example, the information about relative weights on planets stimulated a number of conversations:

Ooh, listen to this - gravity is 2.5 times that on earth [on Jupiter] *so a 10 stone person would weigh 25 stone 1 pound - in Pluto you would weigh a pound.*

The changing distances represented on the signpost also seemed to enable users to compare different planets/objects' locations and to trigger some people towards experimental techniques where they would ask a question, conjecture and then move the sign to test their idea:

I wonder how far Pluto is?
How far was the sun?
There's no billions any more [looking at the sun].

Click on the sun
Read the distance and then check where the sun is in relation to them [looking out of the window]
Click on earth - read the distance and laugh
Click on Voyager
Whoah - that's pretty long that I reckon.

One unexpected comparison that emerged during use, was the decision by a number of users to pull back further and further from the sun until it looked exactly the same on the screen as any other star. Given that it is very difficult for people to conceptualise the sun as a star from their day to day experiences, this feature seems to have some potential worth developing.

It looks like a star... like a tiny spot [referring to drawing back from the sun]
Like the others, just like a star.
We also saw users moving between different objects and commenting on relative sizes as they did so:

M [looks in detail then clicks on Eros asteroid then stands back and watches the sign; then pans out] *Ah right, of course, it's really tiny isn't it* [then clicks on Gaspra and watches the sign with attention - again, zooms in and out]. *This one looks like it's bigger doesn't it* [zooms out]. *You can still see it there, that must be South America* [then clicks on what like to visit, then clicks on Ida and Dactyl]. *This is a big one as well isn't it... this is a very big one* [zooming out]. (S5)

N *I want to see the craters on the Moon*
J *I've never ever seen Pluto. Whoa...* [as view moves back]

N *There it is* [reads distance on signpost]
J *So how big is it in comparison with the earth?* [pulls back out to see]
J *So it's basically like the core isn't it* [about Pluto in relation to earth]
N *Well it's kind of like the earth in relation to the sun*
K *Is it?*
N *Go back out - go to the sun*
N *That's the sun compared to earth*
J *That's a surprise.*

Another unexpected juxtaposition, was between the digital representations of size and users own experiences in observing objects such as the sun and moon in everyday life:

When you look at it in real life, it doesn't seem like it would be that big.
Look's quite small really.

A key feature of WTTN was intended to be the constant comparison between earth and the objects selected. From our study, however, it was clear that there was a serious problem with our interface design as most users were unaware that what they were looking at was the relative sizes of earth and the other objects. This may have been because their existing conceptions of the size of some objects meant that it was counter-intuitive to them to assume that these were comparisons. Clearly the interface was lacking in this area.

Oh wait - I just realised the pictures were relative - I didn't realise that until now. We checked out a few planets - but didn't realise that the sizes were relative - because you can zoom in and out. Maybe if you could have 'relative size comparison' written at the top.

When we did point this out to users at the beginning of the trial, however, it was clear that this comparison has the potential to act as a powerful tool for thinking about scale:

A *One of the things that nobody has noticed so far, is that the picture on the left is on the same scale as the picture on the right, so that's earth and the sun on the same scale*
F *Bloody hell - wow that's wicked*
F [clicks on Venus] *Wow that's similar*
F [clicks on Mars] *Ah, Mars is quite small then.*

It is worth noting, however, that the design of our study did not allow us to explore the implications of these tools for users' conceptions of the solar system. It was only through verbalised discussions of relative size that we captured any of their understandings in this area.

3.3.9 The competing representational systems of signpost and screen

One key issue in the design of WTTN that caused confusion for some users, was the relationship between the signpost and the digital interface as representational systems. The 'time' buttons when linked with the ever-changing numbers on the signpost, for example, were particularly confusing for some. The key issue here appears to be that some users expect that if the digital interface controls the signpost in terms of object to point to and direction, then it should also control the signpost in terms of the time at which the signpost should point to the object (in other words, that if you speed up time to look at objects on the screen, then the signpost should also show the change in time).

S2 *Have you got it on high speed cos that keeps changing* [pointing to the numbers changing on the sign]
S1 *Yeah probably, yeah, is that* [pointing to numbers changing on the sign] *the wobble, yeah, it must be*
S2 *Is that on fast?*
S1 *Yeah it's on fast*
S2 *See if we put it on now - normal - it shouldn't change*

S1 *Do you reckon it's changing that way anyway*
S2 *Normal speed*
S1 *Must be travelling - it is going up - so it must be travelling away from us*
S2 *But we put it on fast* [they both turn back to look at the screen] - *put it back to now and it should jump back to what it said initially, before you put it on fast*
S1 *And at normal speed*
S1 *So that means it's travelling away from us*
S2 *But it didn't jump back to where it was see*
S1 *But it's going up - at like, 25 miles a second, so it's travelling away from us at 25 km a second*
S2 *But what I'm saying, like, is that when you put it on fast speed it suddenly went up by about 150k a second, and I expected that it would suddenly jump back like when you put it to now, because that's surely looking into the future*
S1 *So if we put it on fast, then it should go up faster*
S2 *Yeah it is - yeah, more than 25k a second - can you make it go faster still*
S1 *No, it's still the same*
S2 *See if you put it to now*
S1 *Has it gone down* [both laugh]
S2 *I dunno - that's my theory out the window then.*

M1 *That's how fast... that's 41 noughts...*
M2 *We're going in time... where the earth will be...*
M1 *Look the numbers are going up* [looking at the sign]
M2 *I am moving the earth, I am moving the sun...*
M1 *Oh - the number's changed - see we're still going further away from everything...*
[Then they click on something and the signpost moves]
M1 *That's amazing... that is so cool... that is immense... that is so scary* [while giggling]
[They are worried that if they turn the speed up that they will speed up the sign]

K *Did you notice why the numbers were changing on the signpost*
M *Because of the different distances where certain obejcts were*
K *If we have a look at this - you see the last numbers were changing*
M *Yes... all of that yeah*
K *Why would those last numbers be changing in relation to Mars*
M *Just as it finds its bearings* [the signpost]
K *But it's still moving now though and it's found it's target*
M *Its just the few last kilometers and we're moving as well.*

For another user (N below), however, the signpost pointing below the horizon provided real problems. What is not clear from the discussion that took place around the signpost, is whether his difficulty lay primarily with a lack of clarity as to how the signpost itself works (ie where it measures 'from') or whether his pre-existing concepts about space precluded him from thinking about the solar system and earth from another perspective in which objects being 'down' was unproblematic.

N *Why does that tilt that way?* [pointing at signpost pointing down to earth]
J *Cos that's where it is, that's below us really, its just er, due left of Australia if I'm correct*
K *Do you understand why that's down there?*
N *No*
J *It's pointing to the direction, where it is*
K *Where are all the stars and the planets, if you had to point to them now, where would you point?*
N *Up*
J *Yeah*
K *So why's that there?*
J *Cos we're probably in the centre of the earth, if you were on the edge or something it would probably be pointing down*
N *Ah, cos the earth is round innit, well, it ain't really - it looks straight dunnit*

K *So the earth is round - so what's around the earth?*
N & J *Atmosphere*
K *What's round that?*
N *Space?*
K *So if you had to point to the stars and the things in space - if you think of us being round - where would you point?*
N *All around us?*
K *All around us*
N *Uh OK - all around*
J *So wherever we point it could be there right...*
K *So if you imagine - this is us* - [making globe with hands] *so if this line carries on it goes through the earth and points out the other side below us*
J *Uh OK - I got you*
K *Cos the stuff could be all around. You might want to go back to earth. There you go - pull back*
N So it's probably here or something [pointing to the right into space]
N *So where is the core then?*
K *It's around the middle then*
N *Cos I watched the Core, I've got it on DVD and stuff and it's pretty cool.*

4. NEXT STEPS AND FUTURE DIRECTIONS

A number of interface modifications were required as a result of the trials of this first prototype. Additionally, the design of this prototype meant that we were unable to study its use in the site for which it was designed - outside, and in the way it was intended to be used - without any researcher intervention. In order to address these, and to progress the project further, COPUS were approached for funding for the second stage of the prototype. A major award was granted and the revisions to the interface, and the development of a robus installation for use in a permanent site on a city street, is now nearing completion. The signpost should be in place by the end of 2004 in Bristol, for any passers by to use. Images, descriptions and further evaluations of this 'robust' prototype will be available shortly. Adam Nieman is now in discussions with NESTA I&I team and is developing a wide range of potential applications for the 'Celestial Signpost' (as Welcome to the Neighbourhood is now known) along with a number of other ideas.

For further information about the project, please contact keri.facer@futurelab.org.