Space Mission: Ice Moon

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Abstract

The new 21st Century Science curriculum in the UK seeks to develop all students' broad understanding of the main scientific explanations that can act as a framework for making sense of the world around us. The curricular emphases in science are transforming from content-heavy knowledge acquisition and fact recall to process-based inquiry putting more emphasis on making meaning.

Space Mission: Ice Moon is a real-time simulation of a space disaster in which students find themselves in the roles of scientific experts in an Emergency Response Team. Between eighteen and thirty students work in six or seven teams to rescue four astronauts lost in the ice tunnels of Jupiter's moon, Europa. Using video-conferencing facilities, they communicate with the mission commander who is in the space station, and work with real-time data feeds to devise and implement a rescue plan in a constantly changing situation.

The Space Mission: Ice Moon is about putting the power of creating meaning from evidence, and experiencing the process of creating science, in the hands of students in the form of a realistic role play where they are the scientists that have to collect and interpret data in real time and advise the mission commander.

Keywords: science education, space, simulation, role play;

1 Introduction

Futurelab[1] is a research and development (R&D) lab based in Bristol, UK. The lab was set up to bring together policy makers, the creative and software industries and educational practitioners to critically explore the future of digital learning environments within school and informal settings over the next five to ten years. A not-for-profit organisation, Futurelab is committed to sharing the lessons learnt from our research and development in order to inform positive change to educational policy and practice. Once or twice a year Futurelab runs a "Call for Ideas" (CfI) in which it invites people to send in ideas for prototype projects that demonstrate novel use of technology for learning. The "Space Mission: Ice Moon" project was brought to Futurlelab by Tim Boundy from the National Space Centre[2], through the CfI The National Space Centre is an educational science centre based in Leicester in the UK and has a range of educational activities.

Space Mission: Ice Moon was developed in partnership by the National Space Centre and Futurelab. Inspired by the existing e-mission "Operation Montserrat" that the National Space Centre run, they wanted a space mission showcasing the possibilities of broadband technology. The Space Mission: Ice Moon prototype developed a multimedia website with video-conferencing, pre-recorded video streaming, streaming data, a (currently paper-based) data 'research' library, and other resources to support a role-playing activity for Key Stage 3 science students (11-16 yr). It addresses the aims and vision of the 21st Century Science curriculum, with students working as scientists and developing skills of scientific literacy with an aim of becoming active and critical consumers of science. The role-play involves students acting as an Emergency Response Team on Earth, managing and overseeing the rescue of four astronauts who have become lost in ice tunnels on Jupiter's moon Europa. A facilitator at the National Space Centre plays the role of the Mission Commander who has been left safe on the space station on Europa, and controls the mission via video-conference, plays video and other media clips and guides the students' activities.

The prototype is designed for Year 8 and 9 science students. It will be available for use in science classrooms where facilities exist, city learning centres, and science centres. It is intended to demonstrate the potential for learning facilitated by a broadband-enabled learning environment.

The overarching aim of the project is to enable students to 'work as scientists', engaging with ideas about science that will enable them to be scientifically literate and well-informed consumers of science, supporting the vision and goals of the 21st Century Science curriculum.

2 Background

2.1 The changing science curriculum: 21st Century Science

Space Mission: Ice Moon is designed for use in science classrooms and science centres, and so addressing the aims and content of the science curriculum is important. The science curriculum in the UK is currently in transition, as it responds to widespread warnings that young people perceive it as 'difficult', and that it leaves many pupils uninterested and disaffected (Warwick and Stephenson 2002). The debate around the purpose and function of science education increasingly leads many to conclude that educating young people to see science as consensually-agreed 'rational truth' erects barriers to their understanding, and that a successful program of science education, rather, should seek to teach its processes, modes of scientific thinking, and the nature of uncertainty in science (Warwick and Stephenson 2002; Osborne and Hennessy 2003). These approaches, it is argued, will make science more meaningful to students.

The 21st Century Science curriculum addresses these issues through the curriculum in its 'ideas about science' strand. This covers issues such as what practices have produced it, how scientific arguments are developed, and what issues arise when scientific knowledge is put to use. The curricular emphases in science are transforming from content-heavy knowledge acquisition and fact recall to process-based inquiry; from an emphasis on 'rational truth' to an emphasis on making meaning. Space Mission: Ice Moon is about putting the power of creating meaning from evidence, and experiencing the process of creating science, in the hands of students. This will help them become more scientifically literate. Being scientifically literate means being able to juggle the multimodal aspects of any single scientific concept, and being able to translate amongst them.

Science is a particularly 'multimodal' discipline, meaning that its data and its arguments appear in forms as diverse as written text, photo and video evidence, statistics, diagrams, tables, and

[1] Futurelab: www.futurelab.org.uk
[2] National Space Centre: www.spacecentre.co.uk

graphs (Kress et al 2001; Jewitt et al 2001). Each of these modes communicates meaning in distinct ways. It is in the inter-relations of these modes in particular situated contexts that meaning resides, not abstractly in each mode taken individually. Being able to orchestrate multiple modes of communication in order to make meanings is an essential part of learning science.

2.2 Science in informal contexts

Science museums and centres have long been the favoured location for the school day trip. These offer some interesting and exciting diversions from learning about or learning how to practice science in the classroom.

It is important to recognise that the dominant view of learning in these contexts is one in which the learner is viewed as actively constructing knowledge, and that therefore the social, personal and cultural context of learning is increasingly significant. (Hawkey 2005).

Important emerging aspects of learning through museums and galleries that are augmented with interactive technologies are the two-way communications these allow. The expertise and enthusiasm of visitors, as well as curators, contributes to the work of the museum. As these technologies develop, these centres will increasingly allow visitors to access and interrogate databases, to experience direct communication with expert staff and peer-to-peer communication with other visitors.

2.3 ICT in science education

There is little consensus over how, when and where to make best use of ICT in science education. Murphy (2003) has catalogued the use of new technology in science as: using tools (spreadsheets, databases, dataloggers); using reference sources (CD-Roms, the internet); as a means of communication (e-mail, online discussion, PowerPoint, digital cameras); and for exploration (control technology, simulators, and virtual reality applications). The latter are, as yet, the most under-used of these categories.

For McFarlane (2003), simulations offer opportunities for children to interact with complex systems that would be impossible without technology. Such simulations, of course, must be built of accurate models of reality rather than oversimplifying or misrepresenting the situation. However, interactive computer models such as simulations can also encourage pupils to pose exploratory "What if…?" questions, to try out and observe what happens when variables are manipulated, and to revise both their hypotheses and their investigative practices if they have made mistakes (Osborne and Hennessy 2003).

According to McFarlane and Sakellariou (2002), the necessary skills for young people to learn in science are reasoning skills. Scientifically literate people should be able to ask, "How do they know that?", even if they have limited knowledge in the domain. In an age of information bombardment, having the ability to make informed judgments about the likely validity of a scientific claim and the credibility of its sources is essential in order to avoid intellectual paralysis.

These arguments, however, take little account of the potential for two-way communications that web technologies offer. Osborne and Hennessy (2003) suggest that "peer collaboration between students working together on tasks, sharing their knowledge and expertise, and producing joint outcomes, is becoming the prevalent model for the use of educational technology" (26-27). The same technologies can also, as in museum environments, be used to facilitate discussions between learners and expert scientists.

The potential role of video-conferencing facilities to support science education in the classroom has been under exploration for the last 15 years. Pea et al's (1995) CoVis (Collaborative Visualisation) project integrated desktop video-conferencing with a suite of other collaborative tools to allow students and teachers to conduct cross-school collaboration, to go on virtual field trips to museums too far away for them to visit in person, and to attend virtual 'briefings' with science experts, during which they could ask questions about the data presented to them, and seek explanations for anomalous information. A number of more recent initiatives, however, are in progress at a range of UK schools and museums, linking students with experts and peers (Monahan 2005). In 2004, Becta published a report on the use of video-conferencing in the classroom (Becta 2004).

3 The "Space Mission: Ice Moon" prototype

3.1 Design

At Futurelab we draw on what has been termed as informant design principles and methodologies (Scaife1997; Preece 2002). This approach employs the end user, in this case we held workshops with pupils and teachers, to test and improve the concept. Once the user group has been identified, we discuss key issues with them throughout the development of the prototype. The aim of informant design is to discover something not previously known. Rather than treating young people and educational practitioners as equal partners the design involves user groups at various stages when their expertise can be maximised and their knowledge is required. Young people and educational practitioners are conceived as 'native informants' who are able to identify problems from within their educational experiences, and separately identify kinds of problems that they encounter within specific subject-related contexts, as their views are likely to be quite distinct (Williamson 2004).

Futurelab worked closely with partners at the National Space Centre to develop the scenario, activities, user experience and user interface. An expert glaciologist was consulted to ensure accuracy of information on ice phenomena, medical experts reviewed the medical data and space experts made sure the data for the life support systems was realistic. A professional television writer was recruited to elaborate the story into scripts for pre-recorded video scenes of the astronauts. The National Space Centre and Futurelab held workshops with pupils and teachers to test and improve the concept. Year 8 pupils were involved in evaluating and developing the story, while a team of practising science teachers collaborated on planning and detailing the activities. The final trials with almost 100 pupils aged 12-14 took place in secondary schools and City Learning Centres (CLC).

3.2 Guidelines for development

The following guidelines for development of Space Mission: Ice Moon were drawn from the context of relevant projects and research and theoretical literature, and used to inform decisions throughout the project. As decisions were made, not all of these guidelines could be applied, for various, practical reasons. However, they stand as a useful list for developers and educationalists seeking to create similar learning resources.

- through the experience children should see themselves as participants and inventors in the creation of meanings in science
- children need to be engaged as producers of science and as critical consumers of science, not just passive unquestioning consumers of it
- students should have to deal with uncertainty in their data, and will need to use scientific reasoning, science process skills, and scientific thinking to resolve it
- children should be prompted with data and tasks that encourage them to ask, "how do they know that?", and to ask exploratory "What if…?" questions

- there need to be multiple pathways in to problems, presented in multiple media formats, to allow children to begin to identify with the multimodality of the science discipline
- there need to be opportunities for children to translate their discoveries into other, appropriate media formats that allow them to make meaningful sense of the data
- children need to be able to see themselves 'as scientists' using the instruments, practices, and discourses of the professional domain; they also need to be able to know what to do when they are stuck, and to ask, "What might scientists do in this situation, where might they look for information, how would they find out what to do next?"
- children should be encouraged by the experience to understand that scientific decisions have implications outside of the science domain itself
- the simulation needs to be 'real', that is, deal with problems that might be relevant in their personal lives, even though the scenario is fantastical (eg planetary science such as radiation and gravity, health monitoring, energy and power)
- children need to be able to interact with artefacts to support their investigations, even if these are presented to them virtually; they should also be able to create and upload artefacts and content that they have produced
- it is likely to be beneficial if sufficient resources are available both before and after the experience for children to be able to prepare and follow-up on the science investigations that form the basis of the mission.

The software prototype

The software prototype developed for the trials of Space Mission: Ice Moon included most of the functionality necessary for a final product. In the simulation a group of students take on the roles of an Emergency Response Team on Earth, connected to a space station on Jupiter's ice moon Europa by video-conference. At the start of the mission they discover that all the astronauts living on the space station, except the Mission Commander, have been lost on a routine exploration of the ice tunnels beneath the surface of the planet.

The simulation is remotely controlled by a facilitator from a video-conferencing booth at the National Space Centre in Leicester, who plays the role of the Mission Commander, the only astronaut remaining on Europa's space station. Students are divided into six teams, with the option for a seventh: Medical, Life Support Suit, Ice, Navigation, Satellite, Communication and optional Data Officer. Each team has a specific responsibility and requires a different number of students to complete the task. The teams have to submit their processed data to the Mission Commander via the user interface.

Each team has a PC, and as the mission progresses, students must process, analyse and interpret data received through their unique interface via broadband internet connection. The Mission Commander can see each team's inputs and so monitor how quickly and accurately they are completing their tasks. The data streams constantly and dynamically adapts to reflect the astronauts' changing situation and location, for example as they get injured, run low on oxygen and move through the ice tunnels.

The Mission Commander can also dynamically move events on the timeline or introduce further events. The mission is split up in self contained parts that all have their data and dialogue included in them; for example an astronaut's leaky oxygen valve will have consequences for his life support data through out the mission. The Mission Commander can active or deactivate various parts based on how the students are doing or to reflect decisions they take (when they find a solution to a leaky the data will reflect this from then on). If tasks turn out to be to difficult to keep up with, the mission can be simplified on the fly. Conversely if the mission turns out to be too easy the Mission Commander can introduce new events or problems.

The Mission Commander also has at his disposal a video library of clips of the astronauts in a range of different possible scenarios that he can show at any time. There is also a set of statements and responses from an 'avatar', a computer-generated character who takes a role of the space station's computer and occasionally answers students questions of provides information from the space station's computer.

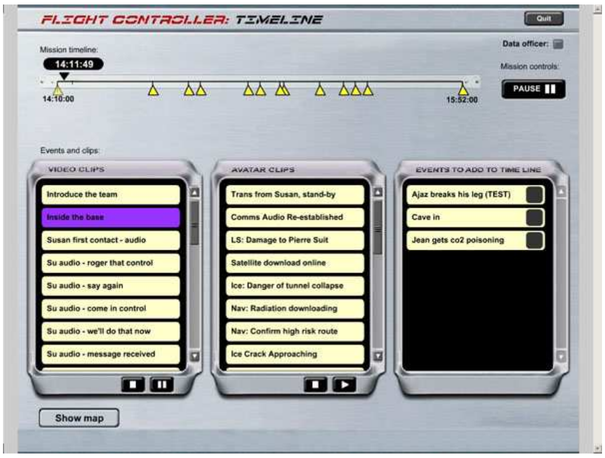

fig. 1 Mission Commander's control panel showing dynamic timeline

Teams do not receive their data feeds automatically; they must request them from the satellite team. In the scenario, data is transmitted from Europa to Earth via a satellite that orbits Europa every three minutes. Teams can thus receive a new set of data with each orbit of the satellite. In order to make students think about the value of different data, it was decided that they would not be allowed to download all available data every orbit. It is explained that the satellite only has a limited bandwidth of 20 KB per transmission, and every piece of available data takes up some of that bandwidth. Therefore students must negotiate within and between their teams to prioritise the most important data at that current moment.

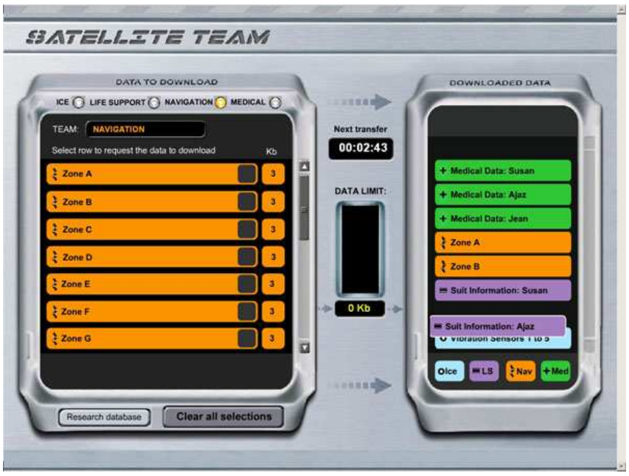

fig. 2 Sattelite team screen

The Medical team and Life Support Suit team monitor each astronaut, keeping track of several variables. Each variable is plotted on a graph to show change over time, and is divided into white, yellow and red zones, indicating its level of danger. To calculate the overall Medical or Life Support Suit status of each astronaut across all variables, students complete a table. Starting with 100%, they subtract 10% for every variable in the yellow zone and 20% for every variable in the red.

The Ice team receive data about tremors in the surface ice, which could indicate a likelihood of cave-ins in the tunnels in which the astronauts are traveling. Sensors placed on the ice give the time and direction in which a tremor was sensed. From this information they plot bearings on a paper map and triangulate the position of the tremors. They then input the coordinates of identified tremors to their computer, which appear on a digital map of the area.

The Navigation team are responsible for planning the astronauts' route back to base and calculating how long it will take. They are told the coordinates of the astronauts' current position by the Mission Commander, and given a set of coordinates to which they must plan a route. They have an interactive map in which they can see the main tunnels that the astronauts can travel through, and click to select sections of tunnels to indicate their chosen route. When a route is selected, the map shows the duration of each straight section of tunnel, based on the inputted walking speed of the astronauts. To calculate the duration of the total route, they must add up each individual section. The Navigation team also download data to show radiation levels across their map. The radiation data is given a very high data size, which is designed to force discussions about prioritisation of data downloads with other teams.

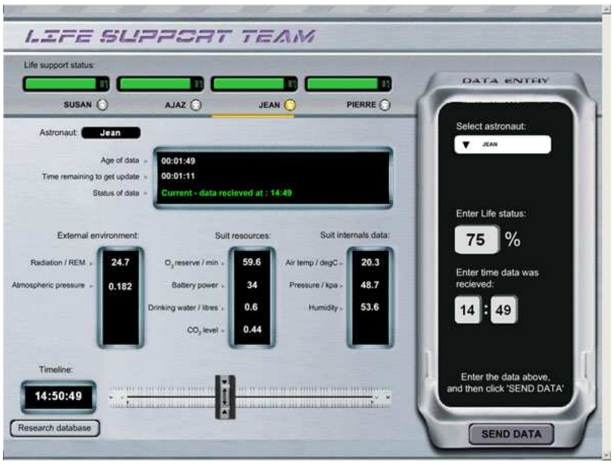

fig. 3 Life support suit team screen

The Communications team are responsible for ensuring communication between the Mission Commander and each individual team, and between teams. The optional Data Officer is responsible for ensuring each team submits their processed data when requested.

The software is a large loosely coupled distributed system as the various screens need to dynamically respond to each others actions. The system is implemented as a number of Flash movies connected via a Flash Communications server. Each of the teams have their own PC with their own data screen. Initially the session is started via a web server with a login system so multiple space missions can be run simultaneously. The Mission commander has three different screens to control the mission. One gives him a chat interface with the communication team and shows the scenario script and queues. Another screen is used to control the mission and shows the dynamic time line. The last screen shows the videos and Avatar interactions he decides to play. The latter screen is fed into the video conferencing system so the Mission Commander can play videos and avatar interactions to the pupils.

fig. 4. Navigation team screen showing radiation data

4 The trials

The prototype uses a mission scenario that lasts approximately 90 minutes. Before the students can use the software they need to undergo some training to make themselves familiar with the scenario, the roles and the tasks they need to do in the missions. They also need some practice to be able to perform the tasks in real time and under pressure during the mission.

In the trials the experience lasted a whole day. In the morning the students would come in and perform some training activities, while the real mission was run early afternoon.

The training takes around two to three hours. For the purposes of these trials, a lesson plan was created by a curriculum coordinator at Frankley CLC, which comprised the following main elements:

1. Research on Europa: students were given worksheets with a number of questions about Europa, which they were asked to research using the internet. Students produced presentations in Publisher or PowerPoint.

2. Context of scenario: teacher-led session explaining the overall role of the Emergency Response Team, the role of each team, and further information about life in space.

3. Practice: students were divided into their teams and, in teams, given a more detailed explanation of their role and a chance to practice analysing the kind of data their team will receive.

5 Conclusions

Space Mission: Ice Moon is clearly an engaging and enjoyable experience for the students who took part in the simulation.

The strong narrative, problem-focused approach and the impact of video-conferencing and video-streaming technology supported students in imaginatively entering into their roles as scientific experts with responsibility for rescuing the stranded astronauts. Students responded positively to this responsibility, with almost all remaining focused and on task for the entire mission. Acting in role, students began to try to think and act like scientists, understanding science as a process of interpreting evidence to make explanations, solving problems and working together.

The video-conferencing technology made a significant contribution to the experience. Because students could see and interact with the Mission Commander remaining on the space station, and see video clips of the trapped astronauts as if in real-time, the experience seemed authentic and supported the students in imaginatively entering into role. The two-way dynamic communication between the Mission Commander and the students also allowed variation of the level of challenge, as the Mission Commander was able to support struggling students with prompts and hints, and provide extra challenges when students were working comfortably.

Students analysed and interpreted raw data to create explanations, and some began to understand how valid interpretation must be based on firm evidence. Students worked closely together, cooperating within and between their teams to complete tasks and build an overall understanding of the situation. Space Mission: Ice Moon would benefit from further work to complete the prototype to a point at which it could be distributed more widely to schools, science centres and other institutions. Development of additional resources to support students' and teachers' preparation prior to, and reflection on learning after the mission would enable students to get the most from this experience. Consideration should also be given to developing a greater number of variable narratives and outcomes to the scenario.

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