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“Ground Control to Moonbase”: Communications technology in primary D&T

Dan Davies, Bath Spa University, UK; Steve Heal, Neston School, Wiltshire, UK

Abstract

This paper reports on a case study of a four-year project undertaken by a Wiltshire primary school, with the aims of enhancing pupils' use of information and communications technology (ICT) in their learning of design and technology, whilst increasing their confidence in speaking and listening. The work was supported by a grant of £36K from the National Endowment for Science, Technology and the Arts (NESTA) and took as its theme the topic of communication in space. Observations of pupils designing and prototyping geodesic structures in preparation for the moonbase construction have exemplified what Siraj Blatchford (1996) described as a 'design collective', in which children draw on earlier experiences and learned skills to design and make with autonomy alongside their peers. The school design and technology co-ordinator was observed to put in place elements of what Harrington (1990) described as a 'creative ecosystem', fostering a social or distributed creativity within the school by, for example, involving pupils in collaboratively prioritising design criteria. Observations of pupils working within the moonbase environment and its linked classroom interface have demonstrated methodical yet creative approaches to problem-solving, and a relatively high degree of autonomy, providing evidence of what Loveless (2003) refers to as the "conjectural paradigm" for learning experiences mediated by control technology.

Key words

control technology, primary, whole-school, context, cross-curricular

Introduction

The Office for Standards in Education (OfSTED) voiced concerns in 1998 regarding the quantity and quality of control technology in the primary school curriculum. Subsequently, the *National Curriculum for Information and Communications Technology* (ICT) in England (DfES/QCA 1999) included the heading 'Developing

ideas and making things happen', with the specification that pupils should be taught:

"...how to create, test, improve and refine sequences of instructions to make things happen and to monitor events and respond to them."

This kind of activity exemplifies what Loveless (2003) refers to as the "conjectural paradigm" for learning experiences. She regards this as more open-ended and of a higher order than many of the other uses of ICT by children, since: "the rules and relationships in the model are set up by the learner in order to investigate how they develop." (Loveless, 2003, p. 39). Children undertaking a control activity have to solve problems and continually ask the question: 'what would happen if...?' requiring a methodical yet creative approach, and a relatively high degree of autonomy. Since children often work in pairs or small groups in designing control programmes, the activity also highlights the role of collaborative learning (Yelland, 2003). Another study of children working with control technology found that:

"...typical learning processes were collaborative (62% of all episodes) as well as dynamic problem-solving processes, in several stages. Pupils worked quite independently of the teacher, as they learned to use the programming tool autonomously in their technology projects." (Lavonen, Meisalo and Lattu, 2002, p. 139)

However, achieving the 'holy grail' of independent, collaborative problem-solving through the use of control technology is difficult to achieve and places high demands on the teacher, requiring new roles as 'consultant, technician, project manager, assessor and evaluator.' (Loveless, 2003, p. 45). The ability to take on these new roles depends upon the teacher's expertise, their beliefs about teaching and learning, and their understanding of the role of ICT in teaching and learning (Cox and Webb, 2004).

Would a single primary school be able to bring all members of staff to the point where the learning benefits of successful control technology use were being enjoyed by a wide range of pupils? This was the question asked by the headteacher, senior teacher and chair of governors at Neston School: a village-based primary school of 156 pupils aged 5-11 in Wiltshire, England. Their subsequent project – the Neston ‘moonbase’ - was strongly driven by learning needs identified at local and national levels, including the weaknesses in use of control technology identified by OfSTED above and specific gaps in pupil understanding of the science topic ‘Earth and Beyond’. The project started in 2002 with an application to NASA to link-up with the International Space Station (ISS) through the Amateur Radio in Space Station Programme (ARISS).

The successful link-up led to a proposal to build a ‘Moonbase’: a geodesic dome containing technological applications which could be controlled remotely – in this case from the ICT suite in the school building. Built in stages, just like the international space station, the school wanted to create a lasting facility. The school used this proposal in their application to join the Bath Spa University /Wiltshire Local Education Authority (LEA) ‘Vibrant Schools’ project, which started in September 2002. This project aimed to provide support to selected primary schools in Wiltshire who were seeking to develop their curricula in innovative ways. The Bath Spa University consultant allocated to work with Neston School supported them in making a successful funding application to the National Endowment for Science, Technology and the Arts (NESTA). £36,000 was allocated to Neston – the largest award made to an individual primary school – to run from September 2003 for two years. The Bath Spa University consultant now took on the additional roles of researcher and evaluator of the project on NESTA’s behalf. This paper reports on the research undertaken over this period.

Aims and Research Questions

The aims established by Neston School for the Moonbase project were as follows:

1. to introduce primary-aged children to realistic and powerful applications for ICT in design and technology and other curriculum areas;
2. to promote greater confidence in pupils’ speaking

and listening through the radio link-up with the International Space Station and walkie-talkie link between classroom and ‘moonbase’;

3. to teach children to sequence instructions and use control technology at a distance, using a wireless link between the school ICT suite and control zone in the ‘moonbase’;
4. to provide children with a greater understanding of science topics such as Earth and beyond, conditions for growth and biological/organic pest control through various ‘zones’ developed within the Moonbase.

The aims for the research study on this project were as follows:

1. to evaluate the development and management of the Moonbase project as a potential model for other whole-school initiatives in this or related areas;
2. to collect and analyse evidence of pupil learning through the project, in order to evaluate the extent to which the project’s aims (see above) have been met.

This led to the development of the following research questions:

1. To what extent is the Neston Moonbase project a viable model for other whole-school initiatives in control technology?
2. What evidence is there of pupil learning as a result of the project against the four aims specified above?
3. What lessons can be learnt from the process, management and outcomes of this project to inform future work in developing control technology through D&T and other primary curriculum areas?

Methodology

This project adopted a case-study methodology – “the study of an instance in action” (Adelman et al 1984) – which has the advantages of being ‘strong in reality’ whilst giving attention to subtlety and complexity and recognising the ‘embeddedness’ of social truths (ibid.). It was also, however, an evaluative case study, employing Jenkins’ four-stage evaluation process (1976), examining *context* (questions 1, 3), *input* (question 1), *process* (question 3) and *output*

(question 2). The data gathering techniques employed included the following:

- Classroom observations (five half-day observations were carried out on 9-11 year old pupils between October 2003 and May 2005) – particularly relevant to research question 2.
- Video and audio recordings, photographs of children working and finished outcomes. These were collected by the researcher during observations and additional material was provided by the senior teacher.
- Analysis of documentary sources (e.g. reports to NESTA, planning documents) – particularly relevant to research questions 1 and 3.
- Analysis of email correspondence between members of the project management team and between the team and external personnel – particularly relevant to research question 1 and 3.

Data were analysed by selecting those portions most relevant to the research questions (whether supportive of the success of the project or not) and transcribing to provide illustrative material for the case study. The study itself was written in narrative form (excerpts are included in this paper) in order to be 'illuminative' for other projects rather than 'representative' (Parlett and Hamilton 1976).

Findings

Significant outcomes have been achieved by the Neston Moonbase project, both in terms of physical buildings and equipment, and in relation to the learning intentions outlined above. In the early planning stages, the senior teacher involved children in 'family group' (mixed age) groups designing the layout for the moonbase. All staff, pupils and governors of Neston Primary school continued to have an involvement in shaping the moonbase project as it progressed, though day-to-day decisions were taken by a small project management team. There was a closely linked industrial partner – Westinghouse Brake and Signal Ltd – whose representative attended some meetings and was closely involved in sourcing and setting up equipment. Another interested parent was involved in some meetings and initiated ideas, with a special interest in ecological sustainability and the engineering aspects of the project. Much technical work and

assistance was given free-of-charge, which enabled the project to progress in a very cost-effective manner. This involvement of all members of the school community with additional industrial support, provides a strong model for other whole-school initiatives of this nature (research question 1), though the external funding clearly made an ambitious project viable which would have been very difficult to achieve through solely voluntary means.

The following evidence has been collected against the learning aims for the project (research question 2):

1. Introduce primary-aged children to realistic and powerful applications for ICT in design and technology and other curriculum areas

A six metre geodesic dome, comprising 160 triangular sections, was erected in December 2003 to form the main structure of the moonbase. In preparation for this, a design and technology project on 'pop-up' shelters was undertaken with 9-11 year old pupils during Autumn 2003, researching geodesic domes on the internet, rating criteria for a design specification and constructing 3D shapes using triangles in preparation for designing the moonbase structure. The senior teacher commented:

"Over the weeks it was clear the children were getting very excited about making the prototype of the moonbase. The language they were using improved each week and their knowledge of which materials would be best for certain weathers and of making strong hinges was of a high standard."

One pupil described her choice of fixings for her group's temporary geodesic shelter, demonstrating the degree of decision making involved and the choice of materials and techniques available:

"We've chosen to use laces threaded through to join it; we could have used tape or buttons but we think laces would be stronger and easier."

The full-size erected dome contains a computer-controlled robotic arm complete with miniature camera, allowing remote imaging of arm operation. Batteries with solar panel charging are available to run equipment. The computers in the dome are wirelessly networked to the school network. Remote cameras in the dome and school

computer suite enable pupils to set parameters and zones around the dome with warning signals. They can also send instructions directly to 'astronauts' working within the dome and monitor their movements. Sensing software has been installed, with a portable PC enabling teachers and pupils to conduct wide variety of science experiments including impact testing, pH testing, temperature logging, sound analysis and light monitoring. 'Flowol' software enables pupils to learn control technology programming, for example of the full-size traffic light and 'Flowgo' has been purchased and available for independent experiments in the dome, for example controlling a micro-robot – 'Robo-sapiens'. An electronic message display board, controllable from the classroom, has been installed in the dome to give instructions to 'astronauts'. Remote cameras in the school pond and a nearby bird box provide opportunities to study living things. A willow tunnel was planted in February 2004 to link the dome with the first of the modular zones: a 'rocket' greenhouse for science growth investigations. An attached weather station measures wind speed and direction, rainfall and has three temperature/pressure/humidity sensors in different locations to enable comparisons. Weather data is further supplemented by images from the Eumetsat (Meteosat8) weather satellite. Additional zones such as a star-shaped sensory garden and mirror maze have been added more recently, which involved the pupils in further ICT-assisted design tasks:

"We designed it from the sensory garden (star shape)... we looked on the internet to find the shape of a mirror maze." (9 year old pupil)

"In maths we were finding out how many mirrors we need and how much each would cost... We got the tallest person in the school to measure to get the size of the mirrors." (10 year old pupil)

Whilst constructing a prototype, pupils used a laser pen to look at the paths light took through the maze with different configurations of the mirrors.

2. Promote greater confidence in pupils' speaking and listening through the radio link-up with the International Space Station (ISS) and walkie-talkie link between classroom and 'moonbase'

The amateur radio link-up with the ISS provided excellent opportunities for twenty children to speak

directly with an astronaut on board the station for around 10 minutes as it passed over the school. Pupils asked questions such as 'how do you know what time it is on the ISS?', 'What does it feel like to take off in a spaceship?' 'How do you spend your time onboard the ISS?' and 'What is the ISS for?' They were given very clear answers from the astronaut concerned, increasing their confidence in speaking and listening in such a public forum (the interview was filmed for BBC television with a pupil as the reporter). The senior teacher commented:

"After they had done the interview with the astronaut they felt really confident and wanted to talk to the news reporters."

By placing groups of children in the moonbase with specific tasks, and observing them over a live video link, 9-11 year-old pupils have been able to study group dynamics and how people respond to different situations. They have learned about teamworking skills and how to take on a variety of roles in a group discussion. By placing a 'ground control' group in control of the moonbase team, children have practised skills of managing and organising others. For example, 'astronauts' in the moonbase were observed being given instructions from 'mission control' in the classroom by walkie talkie:

"Get some rocks out then test them please to see if they're limestone."

The 'astronauts' demonstrated effective listening skills and trust in following the instructions, which were monitored from 'mission control' by the video link. Another factor in children's increased confidence in speaking and listening across the school has been the performance of two whole-school musical productions. Also, in July 2004 and 2005, pupils gave presentations to adult audiences at the Bath Spa University/Wiltshire LEA 'Vibrant Schools Conference'. In 2006, pupils trained visiting children from another primary school in the use of the robotics and control equipment. They commented on what they had learnt about giving instructions, revealing their developing understanding of using verbal communication:

"Doing it bit by bit so that we can just teach them."

"Once you've given quite a few of the same instructions they start to listen and do it themselves."

3. Teach children to sequence instructions and use control technology at a distance, using a wireless link between the school ICT suite and control zone in the 'moonbase'

Pupils have been able to experience control technology in an exciting, practical and innovative context. Whereas the experience of most primary school children is of small scale simulations of control technology in the real world, this project has involved researching and developing the possibilities of control technology in a futuristic setting. A group of six children of different ages were observed using a movement sensor camera, Flowol control software, and a sound-sensitive robot with enthusiasm and confidence to experiment with settings. Children aged between 6 and 11 were also observed programming two mini-robots ('Robo-sapiens') in the moonbase to pick up objects. When asked what they had learnt from this experience they responded thoughtfully, reflecting an understanding of control and the need for perseverance:

"You move him around or use the controls, then he'll, like, follow it as a program." (10 year old pupil)

"When I was using it it kept falling out of his hands. I expected him to pick up the cup, but the cup was too low, and once it was too tall, and once it was too close and once it was too far so you had to get the middle size cup and put it not too close and not too far." (6 year old pupil)

"When he picks up cups I've learnt not to stop pressing the button, when he's got the cup make him keep on pinching it." (7 year old pupil)

One pupil commented more widely on their learning from the control aspects of the moonbase operation:

"I've learnt how to use the camera, how to put the leads in, how to control lots of things. You can make words come up on the computer, controlled from down here. It's like email...I didn't know how to do it before, but I'm much better now. We're teaching (the younger age group) how to do it."

The use of peer tutoring to spread the expertise throughout the school is a particular strength of the project. Another pupil agreed about his growth in technical competence:

"I've learnt about starting up the (video) camera and laptop, making the computer work when it's not working...problem solving."

Learning how to deal with technical difficulties is clearly an important learning outcome for pupils using the complex equipment available in the moonbase. In their inspection of the school, OfSTED (2006, p. 6) commented that working within the moonbase environment:

"...enables pupils to develop their problem solving skills, using control technology and remote sensing, in an imaginative way."

Pupils throughout the school have been using light and pressure sensors with the control program 'flowol', together with a movement sensor for alarming the actual moonbase. They commented on their learning processes in this work:

"We started off with the easier boxes and symbols, then we went on to bigger ones doing lots of things at a time."

"When the sensor detects it and it goes over that number it will go on...it questions to see is it on or is it off"

"Sometimes you couldn't understand where the arrows were going"

"If you stand on a pressure pad and you have really heavy feet the alarm will go off"

4. Provide children with a greater understanding of science topics such as Earth and beyond, conditions for growth and biological/organic pest control through various 'zones' developed within the Moonbase

The whole school focus on Space in preparation for the ISS link-up raised awareness of a number of aspects of physical science:

"The children have understood the science behind the space station, the experiments and the

international collaboration that makes it successful.”
(senior teacher)

They have also appreciated the risks of space travel at first hand – the Neston School children, perhaps more than most, were particularly moved by the tragic Columbia accident in the Spring of 2003, involving astronauts they were due to interview. Work connected to a planned ‘impact zone’ has been carried out in the moonbase itself. Pupils in Y5 and Y6 have carried out investigations simulating meteor impacts, directed by instructions from the classroom via walkie-talkie.

They have also tracked the path of the sun across the dome at different times of the year, observed a partial solar eclipse by projecting the image onto a screen and experimented with energy absorption; one 9 year old pupil commented:

“The black table in the moonbase gets really hot because it absorbs the light from the sun”.

Through their work in the ‘rocket’ greenhouse and associated gardening projects such as planting the sensory garden, children have learnt about conditions for growth. For example, in conjunction with a BBC gardening programme, pupils conducted investigations to compare the growth of five different varieties of sunflowers. One pupil observed that:

“The sensory garden’s really good because young children can come out at lunchtimes and enjoy it, smelling and touching all the plants.. you can see loads of weird plants you haven’t seen before.”

In the moonbase itself, pupils have identified and catalogued all the small invertebrates that have found their way in. They have used a digital microscope to photograph these in detail. Work on photosynthesis has been carried out, likening this process to that of gathering solar energy from the panel and the testing of solar-powered racing cars. One 9 year old child explained that:

“It takes sunlight and turns it into electricity.”

The design and prototyping of the mirror maze has involved 8 to 10 year old pupils in learning some advanced scientific concepts about light and reflection, as evidenced in the following quotes:

“If you look at a mirror, the light bounces off and goes back in your eyes, and you see a reflection.”

“If you have lots of mirrors next to each other you can see more than one of you in each of them.”

“The light when it hits a mirror it just goes off in a straight line.”

“Light will just keep on bouncing off until it exits the maze.”

“The angle the light hits it...the angle between the light and the mirror is the same on the other side”

Unsurprisingly perhaps, the school’s annual Standard Attainment Tests (SATs) results for science at age 11 have risen consistently during the project, with 100% of pupils achieving national expectations and 50% exceeding them in 2005, by comparison with 91% and 41% respectively in 2002.

Findings against research question 3 will be covered under ‘summary and implications’ below.

Discussion

Fullan (2001) characterises innovative educational change as composed of four phases: *initiation* (the process leading up to and including the decision to innovate), *implementation* (first experiences of using the innovation in teaching and learning), *continuation* (the extent to which the innovation is either integrated into practice or discarded), and *outcome* (the degree of ‘improvement’ in, say, pupils’ learning or teacher attitudes). Ownership of any change by practitioners is clearly important, but may develop over time rather than being present in the initial phases. The most difficult phase – *continuation* – represents another adoption decision, and Fullan (ibid.) notes that only a minority of well-implemented projects continue after funding has elapsed. In Fullan’s model, this project can be categorised as moving from the ‘implementation’ to the ‘continuation’ phase. Although significant outcomes were initially restricted to the 9-11 age group, there is some evidence to suggest that the project’s wider impact on the whole school has continued to expand in the year since funding elapsed. For example, the ongoing

development of a 'Moonbase Usage Policy and Scheme of Work' considers the use of the facilities by younger age groups, and interviews with children in the 6-7 year age group indicate familiarity with programming 'robosapiens' (see above). Inservice training days have enthused other teachers, who have since experimented with some of the equipment with their classes. The school computer club has also been a vehicle for widening the impact upon pupils throughout the school, and pupils have acted as peer tutors to visiting children from another school, with further visits planned.

In terms of the D&T learning undertaken in preparation for the construction of the moonbase, Siraj-Blatchford (1996) refers to a progression from '*collective design*' – working as a group with support from the teacher, to a '*design collective*' in later years in which children draw on earlier experiences and learned skills to design and make with autonomy alongside their peers. The negotiations involved in jointly prioritising design criteria for the pop-up geodesic shelters exemplified aspects of the latter, whilst the classroom conditions put in place by the teacher met the following criteria specified by Harrington (1990) to provide a 'creative ecosystem' in which ideas could flourish:

- Norms and rewards for task engagement and for 'hands-on' work with project materials.
- Norms that encourage 'playing around' with ideas and materials.
- Quick and easy access to materials, space and time.
- Explicit or implicit expressions of confidence in the creative abilities of those within the environment.

When asked whether the project offered scope for creativity, one child commented:

"Yes, because it's a pop-up, like a tent but different, we'd never done anything like this before, the materials are light, using small things to make a big thing, life size."

In terms of children's learning through the use of control technology, there was some evidence of Loveless' 'conjectural paradigm', since they were continually solving problems with the equipment and implicitly asking the question 'what would happen if...?' in relation to their programming of the various robots and work

with 'flowol'. Several pupils demonstrated a methodical yet creative approach, with relatively high degrees of autonomy in working in a location remote from the classroom.

Summary and Implications

The Neston Moonbase project represents an innovative approach to the introduction of control technology at primary level within a motivating context. Several key features of the project can be recommended to other whole-school initiatives of this nature (research question 3):

1. The involvement of the whole school community – including children and governors – from an early stage in conception, design and implementation.
2. The setting of the project within a high-status, motivating context (the link-up with the International Space Station).
3. The close involvement of a small core team to drive the project forward.
4. The support of industry, local education authority, university sector and external funding.
5. The piloting of new technology within the 'safe' confines of an after school computer club.
6. The use of peer-tutoring for older pupils within the school to train younger pupils in the use of the control technology equipment.
7. Careful curriculum planning and staff training to ensure that new pedagogy and expertise associated with the equipment spreads through the school.
8. Visits from other schools, with further peer-tutoring of visiting pupils.

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