

Moovl

A Futurelab prototype research report



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EXECUTIVE SUMMARY

The Moovl prototype is an online drawing program with dynamic properties which allow images to be 'programmed' to move according to simple physics of mass, elasticity, air resistance and solidity. An online scrapbook component allows users to share their images.

Moovl was conceived, designed and developed by Soda Creative Ltd. Futurelab designed and conducted the research activities with children in school. The research and development process involved a workshop with subject specialists, and early stage usability testing and interviews with children to inform subsequent design and functionality modifications.

The final trial took place over four days early in June 2004 at two school sites. This report describes and analyses the data recorded at one of these sites, a primary school in inner-city Bristol. 31 children from Year 3 (aged 7-8) and 30 children from Year 1 (aged 5-6) used Moovl. Eight children (four from each year group) were chosen for case study analysis. Video recordings were made, and the children's Moovl creations collated. Research Machines loaned 12 tablet PCs to Futurelab in order to conduct the study.

Nearly all of the children in both age groups involved in the trial were engaged and motivated by using Moovl. Several students who had used Moovl in different iterations throughout the R&D process remained enthusiastic about it, suggesting it has long-term appeal.

Overall the interface and functionality proved intuitive to use by the children, who easily grasped the primary tools and needed very little tutoring. However, the children experienced some problems with certain aspects of the functionality and interface, most notably the air resistance function which they interpreted as 'bounciness', and there was also some confusion about two of the save functions.

There are some issues to do with Moovl's compatibility with children's natural drawing styles. Moovl requires children to be able to 'make ends meet' when drawing closed objects, and solid shapes usually need to be drawn in one continuous line. According to previous research, however, most children have trouble joining up figures, and find it easier to compose solid shapes out of multiple pen strikes. It was clear in the Moovl research that joining up figures and composing shapes out of single continuous pen strokes was problematic for some children, particularly the younger ones.

Using Moovl generated a lot of questions. Many of these were at the simple level of comprehending the software, though the children were also recorded asking questions where it was clear they were actually considering representation first and working backwards to discover what functions would be able to animate that representation.

Many of the children elicited hypotheses about scientific phenomena and predictions about how to use the software appropriately. They were often observed erasing and amending their images if the intended simulation did not work as planned, and often celebrated the completion of a successful simulation.

The learning that may occur using Moovl operates on several dimensions - firstly at the level of comprehending the properties and how these individually affect motion on the screen; secondly, understanding how different properties used in tandem affect the physical behaviours of objects; and thirdly, how those properties can be used to represent certain actions, ie weightlessness being used to simulate flight or elasticity to simulate hopping. Moovl was seen to generate a significant amount of dialogue, with children discussing their use of the software, describing their images to each other, and in some cases even generating ongoing narratives as a thread to pull through all their image manipulation activities.

The role of the teacher when it comes to using Moovl is very important. Almost all of the children generated images that had striking similarities to the models supplied by the teachers

during the whole-class whiteboard exercises. The children were then able to modify those models and to explore the consequences of manipulating variables.

Children were clearly influenced in the design of their images by those of their peers, and often design ideas were transmitted around the group through dialogue and simply by overhearing or peeking at others' images. The public scrapbook was therefore greeted very enthusiastically by the children, and should prove to be very useful if used over a longer period for peer-based work and the production of shared public representations.

1. CONCEPT AND AIMS

Moovl is designed as a dynamic doodling environment where it is possible to create interactive drawings that can be animated according to simple rules of physics. Users draw directly on to a tablet PC using a digital stylus, on to an interactive whiteboard using a stylus or finger (depending on system), or with a mouse on PC.

Images can be assigned properties which affect how they behave and interact with each other on screen. Each property has three options:

- a) mass/density – weightless, light, heavy
- b) elasticity/springiness – very elastic, a little elastic, stiff
- c) air resistance – no air resistance, some air resistance, fixed
- d) hardness – solid, semi-solid, not solid.

In addition to the doodling functionality, Moovl also utilises the networking capacity of the tablet PCs to allow users to share their simulations through a 'scrapbook' function. The scrapbook allows users to simply 'drag and drop' their images into a series of 'bins' that are then visible to others.

The Moovl prototype was designed as a tool for use in science, with an emphasis on science in Key Stage 1. Moovl allows users to create simulations of phenomena that the Primary Science curriculum requires them to understand, including simple forces such as Pushes and Pulls. The emphasis is firmly on the skills that children need to conduct explorations in science, and on their creation of representations which communicate their scientific understandings to others. In order to evaluate the prototype, Research Machines loaned Futurelab 12 tablet PCs.

2. RESEARCH CONTEXT

2.1 Science skills vs subject knowledge

In this prototype phase the focus for the evaluation has been on children creating representations of scientific phenomena, rather than a narrow focus on learning science content. Research over the past 15 years since the introduction of science as a compulsory component of the primary curriculum has strongly indicated that a narrow focus on subject knowledge in science can be demotivating and only provides children with the understandings they need to succeed in standardised assessment. Reports such as 'Beyond 2000: Science Education for the Future' (Millar and Osborne 1998) have suggested that the curriculum lacks a model for the development of children's scientific capability, and instead back an emphasis on teaching 'science literacy' which enables young people to develop the skills necessary for scientific investigation, to understand the impact of science on everyday life, and to be able to make informed personal decisions on matters concerning science.

2.2 Creativity in science

Along similar lines, others have suggested the importance of creativity in science, arguing that children must be given the space to work beyond the constraints of the curriculum, and to bring skills from other disciplines into the science classroom. "Creativity is a process, not an event", Overton (2004) explains, "so it is an essential part of being a competent learner" (22). In this respect, the learning that occurs can be seen as more authentic to children's experiences, and therefore both more meaningful to the child's own life and more motivating to further scientific inquiry. Furthermore, according to the National Advisory Committee on Creative and Cultural Education (NACCCE 1999), "The processes of scientific analysis and investigation can involve the highest levels of creativity and insight" (32), demonstrating that even at the governmental level creativity and science are seen to share a trajectory. Science should be no longer seen as pursuing 'rational truth' through positivist/empiricist methodologies (Warwick and Stephenson 2002), which close it off from the wider world of children's meaning-making activities. It is clear that science teaching in primary schools should have a creative, cross-curricular emphasis that does not ring-fence science as an isolated, meaningless discipline.

2.3 Image-making and representations in science

Moovl is an attempt to marry the creativity of children's drawing activities with their science inquiry skills. Image-making has been acknowledged as important both in its own right and in the science classroom. Kress et al (2001) suggest that the science classroom is a 'multimodal' environment in which text, voice, image, gesture, numbers and figures all play a role, while Cox (1999) argues that graphical tools and animating software in science may influence visual thinking and practices in the same way that word processing applications influence the process of writing. Further, Cox has suggested that understanding in science is often shaped by students' construction of public representations, where the understanding is embedded in the social interchange of ideas.

2.4 Science in the primary curriculum

We need to acknowledge that much of the primary science curriculum makes good sense for developing children's skills in science inquiry. The current curriculum aims to develop scientific process skills, foster the acquisition of concepts, and develop certain attitudes. Amongst the key skills identified as important are: experimenting, often in a trial-and-error manner; fashioning hypotheses or reasonable 'guesses' to explain events or observations; formulating predictions, or foretelling the result of an investigation based on observed results and measurements; communication - through a variety of media and modalities - to present what has been discovered or observed; and manipulating variables to control the conditions of a test and produce valid results. We would also wish to see pupils with co-operative and curious attitudes in their practical science work.

2.5 'Thinking like a scientist'

Ultimately, the aim of science in schools might be to give children access to the skills and understandings they need to be able to think like a scientist, to practice working as a scientist would, and to collaborate with other 'scientists' to develop shared understandings and representations which communicate those conclusions. Moovl provides children with a play experience which is both authentic to their everyday activities and, to an extent, the methods and processes which must be followed in science inquiry, namely raising questions and hypotheses, testing out the conditions of a study and revising these based on observations, and presenting conclusions to others.

2.6 Implications

Clear implications for the areas of research identified through a survey of the literature in primary science for the Moovl project include:

- *rehearsing hypotheses and testing out* the conditions for experimentation
- *creative, cross-curricular inquiry* that fosters children's existing understandings and skills
- *presenting the processes and methods* of a variety of practical implementations of science
- role of the *teacher as a participant* in dialogue with children, and as facilitator in children's dialogue with each other
- supporting *teachers' development* of scientific understandings
- approaching science not solely through language, but through a *multiplicity of modes* appropriate to the content and processes of science learning
- *collaborative practices* in the development of shared understandings of scientific phenomena

Additionally, Becta's short publication 'What the research says about using ICT in science' recently suggested that there is a need for more research on the use of newer technologies such as tablet PCs in science classrooms, as well as more broadly on the role of ICT in supporting primary science. There is clearly a role here for applications that support children working together on science problems, that can simulate science phenomena, and which allow children to present and describe their ideas, observations, predictions and hypotheses to each other.

3. RESEARCH PROCESS

3.1 Research questions

The research conducted to evaluate the Moovl prototype set out to answer the following overarching question:

How can the online, dynamic free-hand drawing tool Moovl support the learning of science concepts in key stage one?

As a subset of this question we were also asking:

How can Moovl support children's development of science inquiry skills, namely: hypothesising, making reasonable guesses, predicting, testing out in a trial-and-error approach, making observations, and presenting conclusions from experiments?

How can Moovl help to contribute to children's 'science literacy' skills?

How can Moovl help to promote children's thinking skills in science, particularly their ability to work together to solve problems?

Other issues that emerged through the course of the study which this report attempts to address are:

*The appropriateness of the specific drawing conventions that Moovl demands
Whether learning the software enabled or disabled engagement with the subject being investigated*

Whether there is a connect or disconnect between the children's perception and production of representations

Whether 'models' or 'scaffolds' supplied by the teachers and researcher during the trial affected the children's production of images

As with all Futurelab projects we are also interested in:

What this project tells us about the best ways of designing educational digital resources

What this project tells us about how learning processes can be transformed through use of these tools

How this project helps us understand the potential of next generation technologies to create intrinsically motivating and engaging learning experiences

3.2 R&D process

Early in the development of the Moovl prototype a number of activities were staged to help shape ideas, sharpen the focus, and decide on the precise functionality required.

A workshop was held at the Soda studio in London on 27 January 2004. Alongside staff from Soda and Futurelab, invitations were also sent to Paul Warwick from the Faculty of Education at Cambridge University, Jane Devereux from the School of Education at the Open University, two teachers from Whitehall Primary school in Bristol, and three teachers from Ilderton Primary school in south London. During the day the Moovl demo was discussed, and ideas for its use brainstormed. Its functionality was considered, and a number of modifications decided, particularly that the properties of an image should be manipulable rather than the drawing environment as a whole. A series of potential scenarios for use in the classroom were also floated.

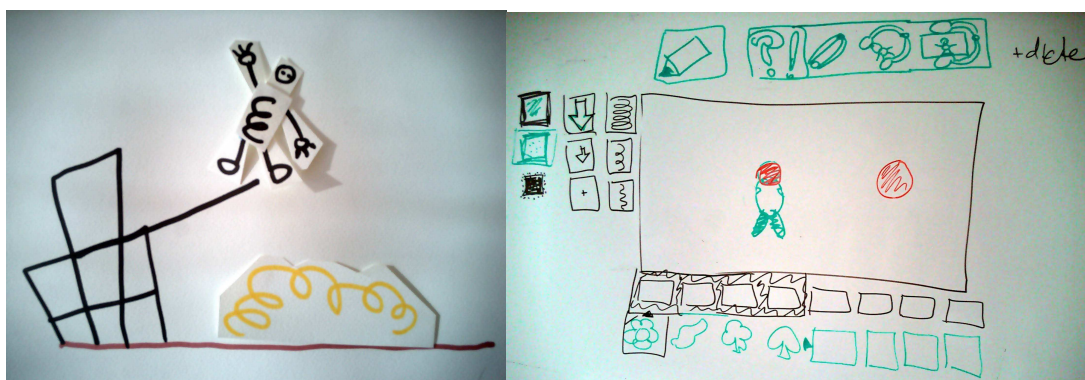


Figure 1: Outputs from workshop, January 2004

On 5 February 2004 the initial demo was taken into Whitehall Primary school in Bristol, where a class of Year 1 pupils were introduced to it on the interactive whiteboard. The task involved illustrating a scene from a storybook that the class were being read by their teacher, and providing solutions for rescuing 'Little Bear' from the top of a wardrobe. Small groups of children from the class were then allowed to use Moovl on a whiteboard in an adjoining room, and were informally interviewed about the features they liked, didn't like, found confusing, and what changes they would make if they were the designers. As a result, it was confirmed that the full prototype would feature colour, and that line thickness would be constant instead of 'inky'. The children also mentioned being able to share their pictures with others, reinforcing the rationale for including the 'public scrapbook' functionality. The year one teacher was also interviewed, and reiterated the importance of being able to manipulate object variables rather than environmental properties.

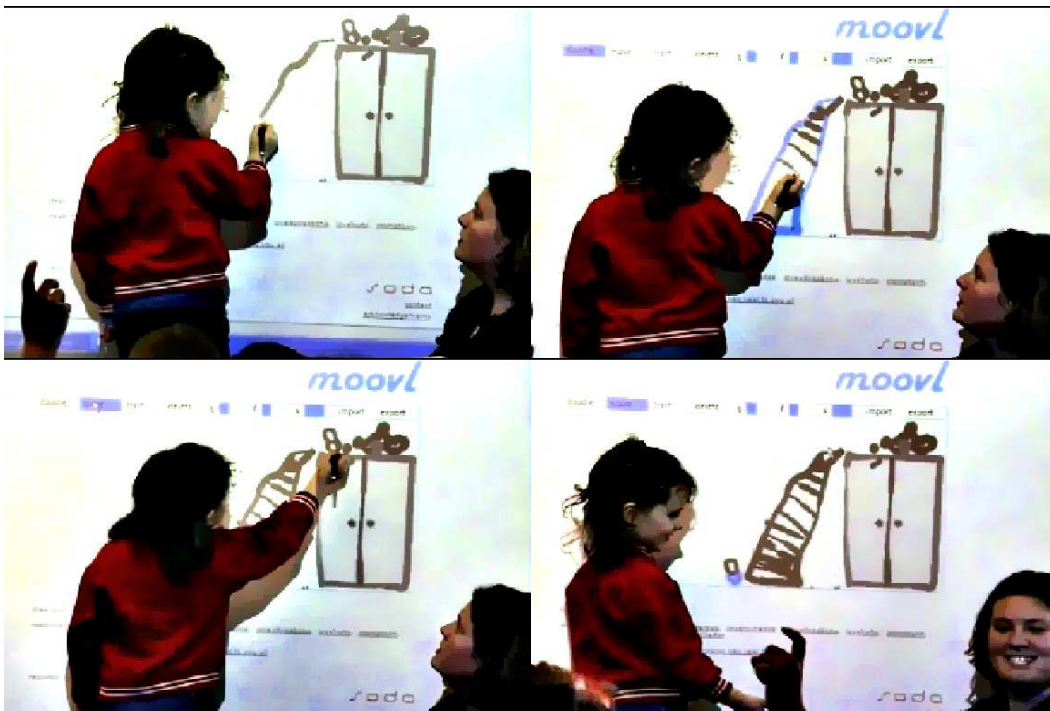


Figure 2: Year 1 pupil designs a ladder to rescue 'Little Bear', February 2004

3.3 Final trial methodology

The final evaluation of Moovl took place over the four days 7-10 June 2004. Although two school sites were used, this report focuses solely on one of them as the activities in the second school site were designed very differently to those in the first and were delivered by staff from Soda rather than featuring as elements of ongoing lessons.

Whitehall Primary school in the Bristol inner-city education action zone was the main site. Its catchment area comprises mainly terraced Victorian housing and an area of high-rise council housing. Whitehall school under-performs in national tests, and falls below the LEA average. 34% of pupils have a certificate of special educational needs. The school serves an ethnically-diverse local population, including a significant number of children from local Asian, Afro-Caribbean and Somali communities. Special classes have been arranged for the numbers of students arriving in the area with no English or prior formal education. Whitehall is well-served by technology, and boasts interactive whiteboards in every classroom, a wireless network, and every teacher has a laptop. During the week of the research a series of videoconference sessions were due to take place. The school also has a large register of classroom assistants and most classes have at least one classroom assistant at any one time.

In total 61 children from Years 1 and 3 used Moovl during this time - 31 from Year 3 and 30 from Year 1. These were all mixed-gender, mixed-ability, and mixed-ethnicity groups. Each task was organised so that the teacher would spend 15-20 minutes setting the activity with the whole class, using Moovl on an interactive whiteboard, and then small groups of children would join the researcher in a separate area outside the classroom to complete the activity. As Moovl was designed for use as a tool available in the classroom, it was decided that the best way to design activities would be to let the two class teachers synthesise Moovl activities with their ongoing lessons so that the children might begin to see Moovl as another classroom tool rather than as an exciting opportunity to be released from normal lessons. As a consequence, activities observed ranged from 'fair testing' in science with Year 3 pupils, to a Year 1 activity which saw the pupils designing new ways for the elephants from The Jungle Book to get across a raging river after a bridge broke.



Figure 3: Moovl on whiteboard in Year 1 classroom, June 2004

In each small group, one pair were selected for case studies by the class teacher. Over the week, these eight children all used Moovl daily, so that a broader picture of their use could be recorded than a single session could reveal. These children wore microphones and were filmed on each occasion that they used Moovl.

Table A outlines this process, along with the data collected and the equipment used.

3.4 Data collection

Two main forms of data were collected.

Two video cameras were used to record the case study participants. One camera was set up to record from a flat-screen monitor attached to a tablet PC, so that all interactions with the screen could be recorded and observed after the event. Another camera recorded the case study children from 'over the shoulder' and captured their physical gestures, their interactions and their speech.

Alongside the video data, the children's drawings in Moovl were also saved for later analysis.

3.5 Analysis

For the analysis, the video data were synchronised and played in tandem, allowing us to observe the range of classroom interactions and interactions with the prototype that were occurring at any one time. The screen camera allowed us to monitor which functions of the software the children used while constructing their representations, as well as capturing their drawing methods and the extent to which they tried out and revised their use of the various functions. The shoulder camera also allowed us to observe other children in the group, and in some cases their interactions have been transcribed and included in this report.

The children's completed images have been analysed in terms of the representational strategies recruited by the students, the degree to which they have concluded an exploration or left it unfinished, and the extent to which they have incorporated aspects of the models provided by the teachers during the task-setting activities beforehand.

Duration (mins)	Participants	Action	Data collected	Equipment
15	Teacher Whole class	Teacher sets up activity on whiteboard; 'models' activity	Video and audio of whole class activity	1 x interactive whiteboard 1 x camera 1 x microphone
The below activity repeated with each group				
30	4 child pairs 1 case study	Paired drawing activity	- Video and audio of whole group activity	4 x tablet PC 2 x video camera

	pair (inc)		<ul style="list-style-type: none"> - Video and audio of case study pair - Capture of complete Moovls from each pair in whole group - Capture of onscreen working process of case study pair 	2 x radio microphones for case study participants
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Table A: Session outline

4. FINDINGS

4.1 Engagement

Almost without exception, the children in the research trial were engaged and motivated in their use of Moovl. They were clearly delighted at being able to animate their illustrations, and in many cases spent a significant amount of time drawing, assigning properties, and observing their images in motion. Some of the comments by children included, "Cool, wicked," and "That is so wicked!"

All four of the case study participants from Year 1 had used Moovl before the trial, both in its initial iteration as a black-and-white demo, and during its subsequent development. Their enthusiasm for Moovl was still clear, suggesting that it does have long-term appeal. A few children were heard complaining that they were 'no good at drawing', or similar, and found Moovl difficult to grasp, although this may be related primarily to their perceived inability to draw well. One girl from Year 1 in particular struggled to draw what she planned:

Hanna: *I can't do it, it's too hard*

[...]

Hanna: *I can't draw. I'm no good at drawing*

However, this girl was able to help others with Moovl's functionality, and was an animated and supportive 'technical' tutor to children in her group.

Of course, not all children will benefit from drawing - indeed, some children cannot write very well either - so this is not meant as a criticism of the program, but flags up the issue that Moovl may well support some groups of children and not others.

4.2 Interface and functionality

The Moovl interface is easy to understand and children are able to grasp most of the functions very quickly. All of them recognised how to use the stylus on the tablet PC to draw, how to rub out, and how to move and colour objects. However, a number of concerns over the interface and functionality have arisen from this short research trial. Most of these are easily rectifiable and are described below.

4.2.1 Air resistance

The symbols for this function are highly misleading. Most of the children who were asked what they thought those buttons might stand for immediately assumed that they meant 'bounciness'. Both of the teachers at Whitehall School also interpreted this function as springiness. Even after they had been told what these buttons stood for the children clearly did not understand. This is useful functionality which should be kept in later iterations of Moovl but it needs better signposting. Maybe the image could show the objects falling at varying speeds, rather



Air resistance symbols

than travelling diagonally upwards as if from a bounce.

Additionally, the maximum air resistance function can be used, of course, to 'fix' items into place while drawing them. Almost all of the children found this function very useful, but they clearly did not see its relation to the other two buttons on this row. As a result, they would frequently fix items into place, then when trying to move them with the 'hand' the objects would sometimes (if composed of several parts) come apart. Many children interpreted this as them doing something wrong. It may be preferable in later iterations to have an entirely separate function which simply freezes the entire screen to make drawing easier, rather than forcing users to select 'fixing' as a property.

4.2.2 Elasticity

As most of the children interpreted the air resistance buttons as designating springiness or bounciness, many were unsure what the elasticity function was intended for. The teachers and researcher all attempted to address this but for most of the children the 'minimum air resistance' button did indeed seem to make objects more springy. As long as the air resistance symbols are changed as per the recommendation above, the elasticity function should become more obvious.

4.2.3 Saving

The three separate save functions need better signposting. Although the 'save screen' symbol is intuitively easy to understand, the children interpreted the other two functions in rather a literal way, seeing them as something to do with either pushing or picking up a ball or a man. Only one pair in the trial realised that the save object function could be used to duplicate part of an image (see later section 'Technical support' for transcript), but they instantly erased this duplicate. A longer research phase with activities sequenced to stage learning activities with Moovl might allow the benefits of the duplication function to be explored more fully.



4.2.4 General functionality issues

One of the key areas we were observing was whether children would use trial-and-error approaches to solving problems. Trial-and-error approaches were clearly in evidence in many of the children's use of Moovl, and without a doubt many of the children were able to elicit their ideas around the areas of science under investigation. However, as with any new technology being used for the first time, the children at this stage were mainly solving problems to do with their inexperience with the software; this often seemed to impact on their ability to really engage with the science activities that were intended as the focus of the study. A tutorial or other interactive mechanism for enabling users to 'learn' to use Moovl should be considered.

It is possible to speculate that the children's difficulties with the software do indicate that a great deal of conceptual thinking, or at least exploration, was occurring. In this respect, the physics principles that underpin the program were being interrogated by the children, and their assignment of properties to objects may indicate their attempt to understand both how the software/interface itself operates and how the underlying physics behaves. A longer period of staged research with clear learning progression would begin to unpack this issue.

4.3 Science skills and science literacy

4.3.1 Questioning

The role of questioning in science is highly important. Every scientific investigation begins with a question or a hypothesis. In schools, of course, most children are unused to developing research questions which they can then investigate, and in the trial too the main tasks and

questions for investigation were set by the teachers. However, a very large number of questions were asked by the pupils who participated in the study. These can be divided fairly quickly into those arising from children's difficulties with the software, and those more bound up in issues of representation, although there were occasions of questioning which appear to blur this distinction.

Questions more directly to do with the software included the following examples:

- "How do you get it to colour in?" (Martha Year 3)
- "How do you make it round?" (Martha Year 3)
- "What happens when you put it in there?" (Oscar Year 1)
- "Which one holds it?" (Hanna Year 1)
- "What does these do?" (Unknown Year 3)
- "How do I do that?" (Marley Year 3)
- "Why didn't you just join it up?" (Kelsey Year 3)
- "How do you stick it?" (Lucy Year 1)
- "What does this button do?" (Brianna Year 1)
- "How do you make it go up?" (Adrice Year 1)
- "What's this?" (Omar Year 3)
- "Urrr what's happening? I want it to [inaudible]. This is stupid" (Adrice Year 1)
- "What the hell?" (Unknown Year 3)

Questions which seem to indicate that the children are thinking about things occurring in Moovl which go beyond surface-level issues around their ability to use the software included:

- "Hey why did it fall down?" (Hanna Year 1)
- "How do you get this to bounce?" (Eloise Year 3)
- "Do you think it's extra springy?" (Marley Year 3)
- "Why's it still bouncing?" (Martha Year 3)
- "How did that happen? What's the mix like?" (Jack Year 3)
- "How come it isn't working?" (Jack Year 3)
- "Why did it go all up there?" (Jacob Year 3)

There are also a number of instances from the research where certain children were clearly thinking about their representation first, and then considering how to animate that representation using Moovl:

- "It needs to be thinner, dunnit?" (Unknown Year 3)
- "I thought, how do you get the river to move?" (Connor Year 1)
- "How do you make it fly?" (Maisie Year 1)
- "So now you see nothing happens.... So now what they gonna do? ... What's this one do I wonder?" (Marley Year 3)

These few questions reveal that the children are beginning to think about the properties and functions they need to manipulate in order to create representations that demonstrate their perception of the behaviours those objects would be expected to exhibit.

There are also a few longer exchanges which demonstrate how Moovl sometimes inspired lengthy question-and-answer dialogues. All of these sequences come from Year 3 groups, whose task was to design a scenario in which an animal was trying to get food out of a tree. Most of the children were working on drawings of animals such as kangaroos and rabbits which might be able to 'jump' high enough to get the food, although others drew imaginary animals, such as one with springs for legs. In this sequence, partners Jack and Sarah, and Marley from Year 3 are discussing how to make their animal "extra springy":

- Marley: [leaning over to Jack] *I know what these do. [points] That means it's soft*
[Marley leans over and watches what Sarah is doing on the tablet]
- Sarah: *What does that do then?* [pointing to feature]

Jack: *I don't know*
 Marley: *I know*
 Sarah: *What does it do?*
 Jack: *What?*
 Marley: *Squishes the [inaudible] underneath [giggles] ... No it means...*
 Jack: *That or that's got to be the speed of it*
 Sarah: *What's it really do?*

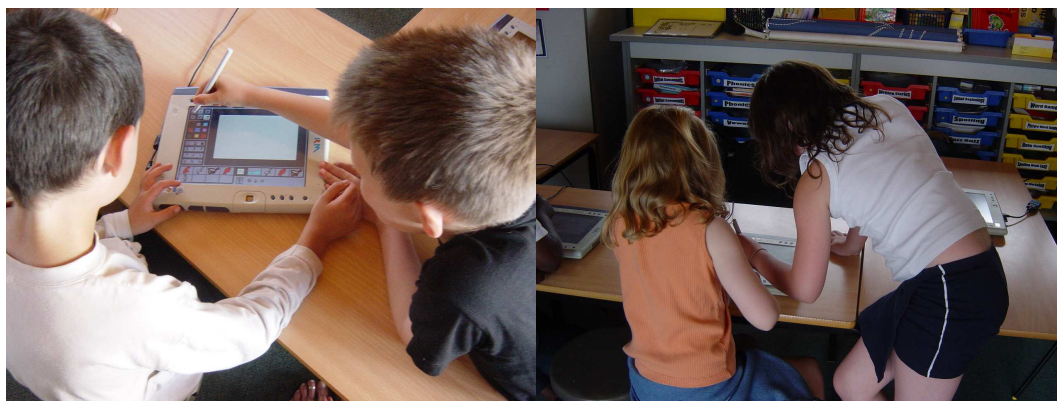


Figure 4: Showing each other what to do (Year 3)

In this exchange between Martha and Arron and Jack from Year 3, what seem to be fairly straightforward functionality questions result in Jack revealing to the other two a function they did not previously know:

Martha: [has been busy drawing for some moments] *OK now it's not colourful.*
 [leaning over to Jack] *How do you get it to colour in?*
 Arron: *Martha [inaudible – pointing] yeah join it up make it bounce*
 Martha: *No I need to... [tuts] How do you make it round? How do you make it round?*
 Jack: *I don't know but I know how to get that one back again [pointing to scrapbook]*
 [Jack takes pen from Martha and leans across]
 Martha: *That's in the bin [snatching pen from Jack]*
 Jack: *Wait wait [keeping hold of pen]*
 Martha: *My thing is in the bin*
 [Jack finishes what he was doing]
 Martha: [clapping] *Thank you [they both hold the pen together and guide something on the screen; Martha speaks to computer] Hello*

And in this brief exchange between two Year 3 boys, Everton has got up out of his seat to look at an image of the animal with springy legs that Marley has finished:

Everton: *How come it walks?*
 Marley: *It isn't it's jumping*

These exchanges indicate that the process of creating an image in Moovl during the trials was often highly dependent upon the inputs of several children all sharing ideas and understandings with each other at once. This works along at least two dimensions: firstly, the children are supporting each other to become competent users of the software by pointing out functions and demonstrating how to use them; and secondly, they are making predictions about the kinds of behaviours which assigning certain properties to objects will make them exhibit, as in the conversation between Sarah, Jack and Marley above. In the very short conversation that Everton has with Marley it is clear that Marley has created a representation of a phenomena which he perceives as 'jumping', though Everton perceives it as walking, that illustrates the perceptual work going on in the children both as producers and as audience to

others' representations. Similar findings can be found in an analysis of the children's statements.

4.3.2 Making statements and hypotheses

When children make statements which imply they know the subject matter at hand they are actually eliciting the hypotheses they hold about how the world that they perceive operates. Similarly, many of the statements they make concerning the functions of the software can be seen as their predictions about how it might work.

The following exchanges between Year 3 pupils Sam and Zoe, and another girl, Kelsey, all occurred in the space of 4 minutes, and demonstrate that a series of predictions and hypothesis-making statements were being articulated. This was the first time any of them had used Moovl, and occurred inside of the first ten minutes of being introduced to it.

Zoe: [to Sam] *It's going to be a cat, as big as the tree*
Kelsey: [to Sam and Zoe] *We haven't done it yet*
Sam: *Ah, sucker, you can't do it*
Kelsey: *We can but we just keep doing it wrong*
[...]
Sam: [to Zoe] *Why are you rubbing out the cat?*
Zoe: *Because it's too big, it's as big as the tree. It may as well not jump if it's going to be as big as it*
[...]
Sam: [to Zoe] *Do it, make it bounce more*
Kelsey: *That was funny*
Sam: [pointing to screen in front of Zoe] *Do it on that one, that one's bigger* [takes pen]
Zoe: *I don't know what to*
[...]
Zoe: [pointing to screen in front of Sam] *I wonder if you make this thing really high up here. Rub that out and draw something really high*
[Zoe tries to take pen]
Sam: *No wait, get off a minute*
Zoe: *That makes it go really small*
Sam: *Then...*
Zoe: *Put something really high up there*
Sam: *You're up in the air... Eats something, gets the food* [hands pen back to Zoe]
Zoe: *Can I rub that out?*

Both Sam and Zoe make hypotheses about the actual representation they are constructing (a cat that is going to jump into the tree to get its food) and in the process they revise it by making predictions about how the software itself will influence the actions on-screen, and trying out those options until they complete the representation and make the cat springy enough that they can represent it jumping into the tree. Zoe even recognises that her original proposal to create a giant cat would fail to illustrate the phenomena of jumping that she and Sam have decided is the best method for solving the problem.

Year 1 pupils Maisie and Connor also went through a similar process of hypothesising about a best solution to get their elephant over the river, and likewise they too predicted what options would animate their image appropriately and proceeded to try these out.

Connor: [quietly to Maisie] *Which one shall we do?*
Maisie: *Shall we draw an elephant, a aeroplane for the elephant to go in the aeroplane then we need to do a seat on the top*
[Connor drawing]
Connor: *I think they should, I think they should do another bridge*
Researcher: *Yeah?*

Maisie: *With lots of wood*
 [Connor draws bridge spanning ravine. He tries to move the elephant but finds that it comes apart when moved]

Connor: *Oh. I'll rub him out*
 [Maisie takes pen, draws elephant]

Connor: [takes pen] *Let's see if it works.* [Connor moves elephant across bridge] *We did it, we did it already*

In just this exchange we see Maisie demonstrate an understanding that an aeroplane might be a good way to transport her animal, Connor decide on building a bridge as the best solution, and Maisie reinforce that by suggesting they would use wood to construct this bridge. The activity also follows a process of hypothesising, followed by trying out the software to see if they have constructed everything correctly, which itself leads to modification, before finally concluding the activity by representing the action they intended. After this exchange, Maisie also tried out the aeroplane idea, so that both ideas had been tested out.

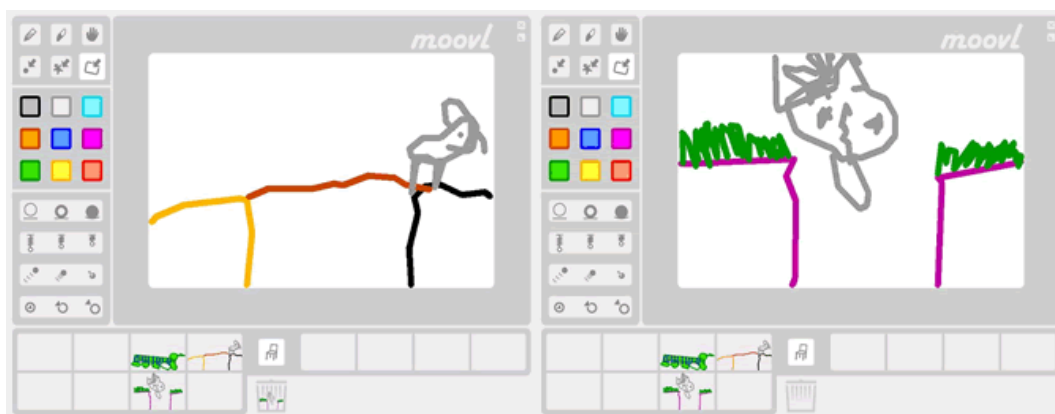


Figure 5: Connor's bridge (Year 1) Figure 6: Maisie's aeroplane (Year1)

In both the above dialogues, then, the children were beginning to engage in the process of scientific inquiry (ie the skills required to conduct a science investigation) that is the object of the primary science curriculum, and in such a way that it is focused on specific challenges rooted in scenarios from storybooks or real life rather than isolated as a specific science task. In this respect, on a few occasions the children using Moovl have, without direct prompting, moved through a process of questioning, hypothesising, making predictions about the software, to actual experimentation, revision, and finally presentation of their conclusions.

4.3.3 Trial-and-error

Many of the children were observed using a trial-and-error approach to solving the problems they had been set. They would illustrate a scenario and set up for objects for simulation, then try out the consequences of moving those items or changing their properties. Often this process would lead to attempts to revise the images.

However, most of the children observed preferred instead to delete what they had drawn and to start again. Maisie in Year 1, for example, had drawn an image of an elephant while on maximum air resistance which, of course, did not stay together when she tried to move it. Interestingly, her first response was to move each individual section of the image across the screen and to piece it back together. When this proved too time-consuming though, she instead opted for the 'rubber', stating that "I did it wrong 'cause I didn't even draw the thing that I was going to."

While we might state then that Maisie was here involved in some complex trial-and-error problem-solving, what will need to be addressed is how children can be taught that revising rather than replacing a representation is sometimes a better option. Indeed, Maisie's problem in the above case was that she had drawn her image while on maximum air resistance, which was the only thing preventing her simulation from acting as she intended.

4.3.4 Conceptual understanding

There is an issue around the extent to which the physics of Moovl contribute to children's understanding of science content. Often, a representation will require users to select properties in order to make an object behave in a certain way that are actually not similar to the real properties of the object being represented. An aeroplane, for instance, is a very heavy object, but can be represented in Moovl as weightless. This means that children need to develop conceptual understandings along multiple dimensions - firstly, understanding the four basic properties that can be manipulated; secondly, understanding how these properties operate together; and thirdly, understanding how the functions may be used to represent a phenomena while not accurately describing the object being assigned those properties (such as weightlessness being used to represent flying). Given that the focus of Moovl is primarily on helping children to develop skills useful in science rather than science content per se, this is not a huge issue; if Moovl is intended to be taken to market for primary science, however, this ambiguity may be noticed and should therefore be addressed.

4.4 Visual thinking

4.4.1 Children's drawing

According to Kress (1997) drawing in the early years is as developmentally important as writing, and according to Coates (2002) children's drawings grow in their complexity and references as children grow older, from objects such as buildings and cars up to about the age of 6, to cultural artefacts such as characters from TV, games or books from about the age of 7 years. Around this age range, too, she suggests, children's images can be increasingly seen less as 'snapshots' and more as 'narratives' with whole stories woven into the images. In her analysis of children drawing, Coates even observed children in this age range beginning to add vocals and gesturing with their bodies while in the process of image-making. At younger ages, Browne (1996) has argued, most children will only be able to list the objects they have drawn without weaving any narrative thread through them. This research suggests that drawing increasingly becomes an active meaning-making activity supplemented with the addition of multiple modes; it allows children to describe the visual world that surrounds them. Brooks (2002), in her analysis of infant drawing in Canada, suggests that drawings often reference multi-sensory experiences, and that the act of drawing brings "the experienced object into the symbolic realm", from where it can be shared with others and become the reference for wider discussions and further drawing activities. Brooks describes this as "interpersonal dialogue that includes drawing":

It is an exchange that aims to understand what the child is trying to show in his or her drawing and what the emerging ideas might be. [...] It is at this time that children's ideas, questions, and misconceptions are most visible. [...] When drawing is one of the modes of exchange these drawings can be preserved as a record of children's current thinking that can be reviewed and revisited by both teacher and child, but they can also serve as a vehicle of exchange within the wider learning community (online hypermedia article available at: www.une.edu.au/Drawing).

Brooks also suggests that such interpersonal exchange between children, teachers and peers can lead to intrapersonal dialogues at the cognitive level, where deeper understanding can lead to a more complex level of representation.

Moovl provides the potential for children to create visual narratives which do in fact move as real objects do, therefore, to an extent, offering the modalities of animation as a means of describing their perceptions of that world. For this reason the actual images the children create in Moovl can be seen as important visual statements of their understandings. These understandings might also be beyond their linguistic grasp to explain, or may provide a better foundation for interpersonal understandings where language alone would be an insufficient vehicle. Clearly, then, the children's representations created in Moovl should be seen as

statements of their understanding of phenomena, although we may want to caution against assuming that their production of images accurately depicts their perceptions of the represented objects.

4.4.2 Modelling

It was very clear in nearly all cases that the model provided by the teachers at the beginning of each session strongly influenced the children's production of their representations. In the first Year 1 sessions, for example, the scenario was one from *The Jungle Book*, with marching elephants trying to get across a gap where a bridge had once been. The teacher drew a basic canyon and an elephant standing on the leftmost bank on Moovl on the whiteboard, and asked children to think up ideas for getting the animals across, before sending groups out to work on Moovl outside the classroom. Once there, the researcher reiterated the challenge to ensure the children understood that there was a task to complete and that Moovl was not to be used simply for play. The figures below illustrate the similarity of the children's images completed in this session.



Figure 7: Year 1 images of the marching elephants at the ravine

In all cases, a canyon was drawn with two large banks, and the elephant was drawn on the top-left. Some children, as can be seen, then modified that basic representation by adding grass, river, sunshine and sky, as well as an illustration of their solution. Clearly then the model supplied by the teacher acted as a springboard for the children's construction of representations.

Similarly, the Year 3 students were asked to illustrate and animate animals trying to get food out of a tree. The teacher also created a model of this representation, with a tree far right and animal approaching from the left. All the children's images replicated this, but with modifications as illustrated by Figure 8 below.

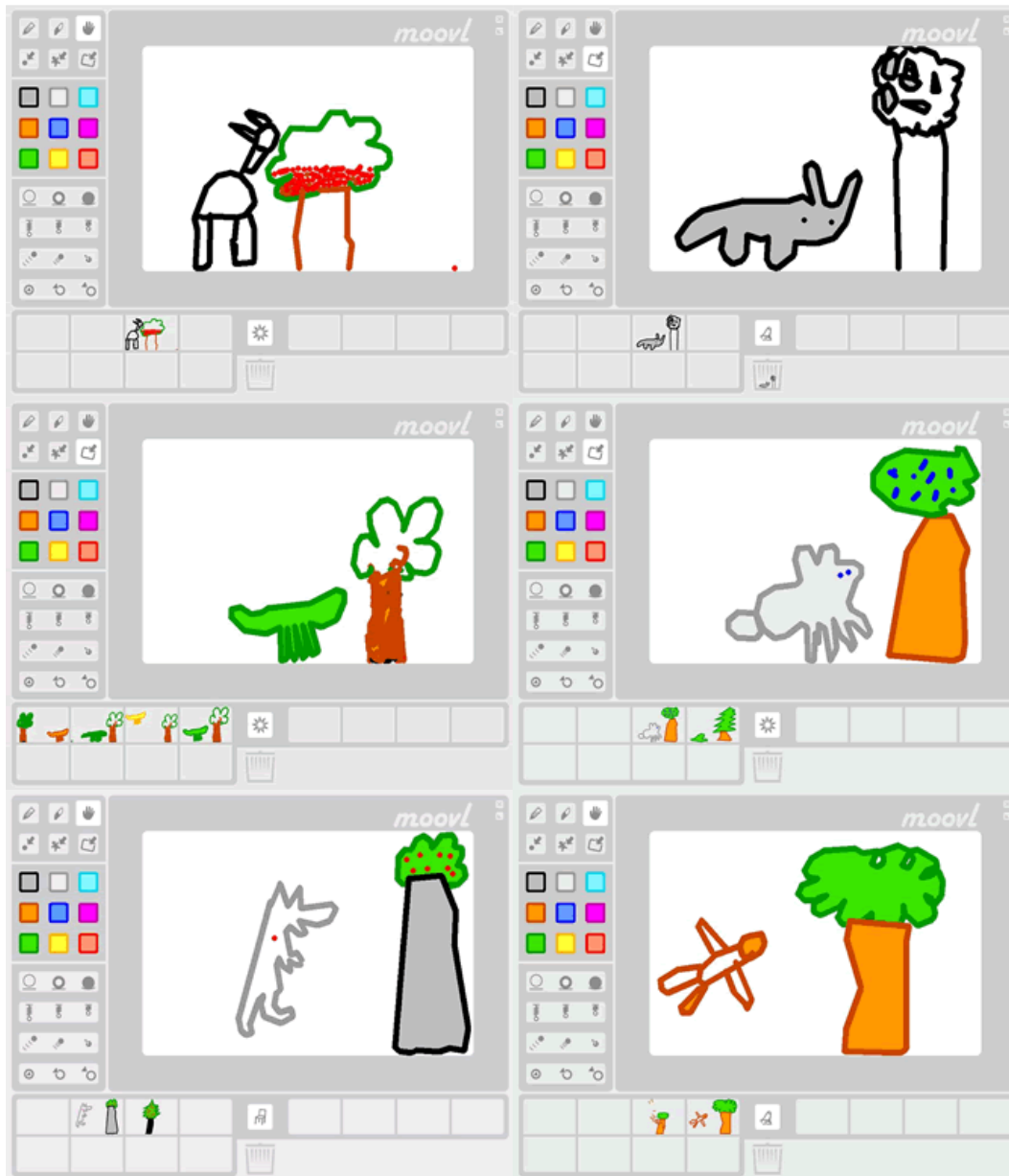


Figure 8: Year 3 images of hungry animals

It is important to note here that due to compatibility problems between the tablet PCs and the Promethean interactive whiteboards used in the school it was not possible to transmit images, via the scrapbook function, from the tablets on to the board, or for the teacher to transmit her models from the board on to the tablets for the children to work on directly. Given the obvious importance of teacher modelling it will be essential to be able to overcome this compatibility issue.

Peer modelling was also an influence on the children's representations. In the Year 1 group one girl, Hamera, had spent a considerable amount of time drawing the basic scenario of the elephants at the ravine, but had not thought of a method for transporting them across it. Two boys in the group, Benjamin and Liam, had just begun drawing a sailing boat:

- Researcher: [to boys] *So you're sailing across are you?*
 Boy [inaudible]
 Hamera: *So am I*
 [Hamera now draws a sailing boat in the river]
 Researcher: [to boys] *Oh wow that is a good idea, I'm looking forward to seeing that drawing*
 [Research Assistant is looking over Hamera's shoulders]
 Assistant: *That's really good. So what's going on here? How's the elephant getting across in this one?*
 Hamera: *OK... he's gonna jump in there then down the middle* [uses finger to illustrate what will happen], *and climb there to get to there* [pointing to right-most side of screen]

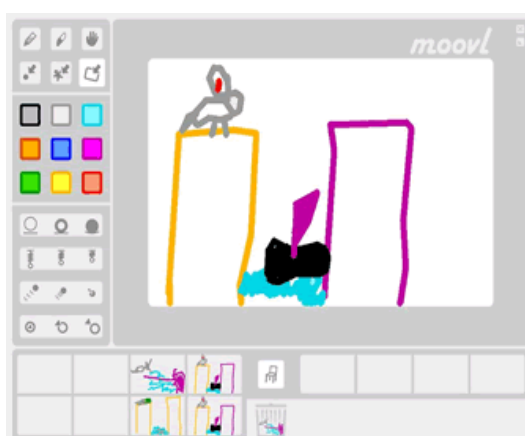


Figure 9: Hamera's boat (Year 1)

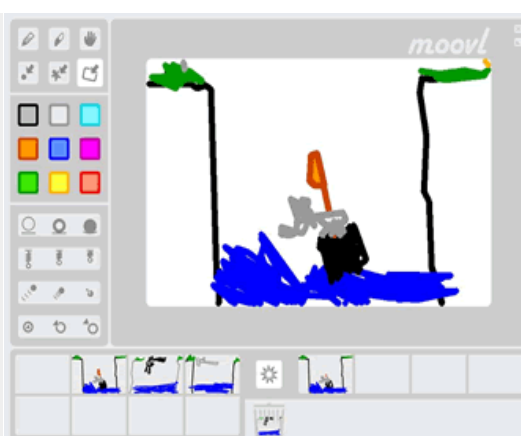


Figure 10: Benjamin & Liam's boat (Year 1)

In a similar way, during their first session Martha and Oscar from Year 3 created a series of animals which have many similarities. Partly, it is possible to conjecture, this is due to their discovery that drawing a single-line joined-up shape would be easier to move, but observations of the pair seem to demonstrate that they were also (without talking) imitating each other. Figure 11 below shows a series of images with many similarities—see particularly the two lizard images drawn from a top-down angle—Martha originally drew the grey version, which Oscar then imitated in red.

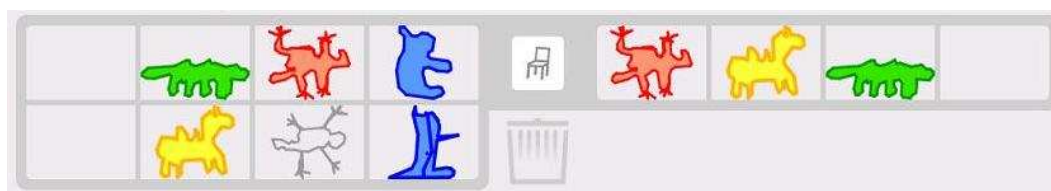


Figure 11: Oscar and Martha's scrapbook (Year 3)

4.4.3 Interpersonal drawing

As the work of Brooks (2002) would lead us to suspect, the children's representations arise in some cases out of "interpersonal dialogue with drawing", where chat across the table can lead to imitation, and perhaps even the emergence of new ideas. The following excerpt is from a conversation between Year 3 children from three different pairs as they discuss what other animals might be able to jump high enough to catch food from a tree:

Marley: *What other animals could we possibly do?*
 Jack: *Mmmm, a big blue whale*
 Marley: *No, listen* [inaudible]
 Emily: [whispers to Marley – inaudible]
 Marley: *An elephant? Elephants can't jump*
 Martha: *I might do an otter*
 Researcher: *An otter?*
 [...]
 Jacob: *The sea doesn't bounce*
 Martha: *It can jump*
 Jacob: *So? The sea doesn't bounce*
 [...]
 Martha: *Huh a dolphin can jump...* [louder] *a dolphin can jump*
 Researcher: *A dolphin can jump, you're right*

The conversation here has veered from Marley's simple question concerning what animals could be drawn, to Martha's assertion to Jacob that an otter or a dolphin could actually jump, which then becomes the inspiration for her next image. Jacob is clearly still operating on the fairly literal level of making objects elastic enough to bounce around the screen, whereas Martha and Marley obviously realise that using the physics of Moovl is often representative of real world actions, so that elasticity can simulate jumping or hopping.

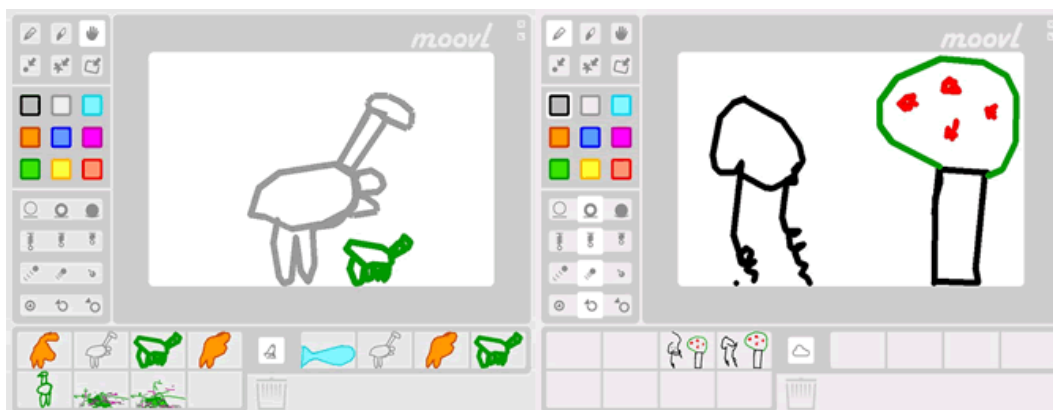


Figure 12: Animal gallery and spring-legged animal by Marley & Emily, Year 3

A much longer dialogue between Year 3 students Martha and Arron, with input from Jack, indicates that some children can also be inspired by their image-making to create complex and rich narratives too. Arron and Martha have drawn a lizard which they hope will be able to get food from the tree, and have begun changing its colour. This dialogue occurs over 11 minutes and has here been edited (marked as [...]) to remove lots of peripheral discussion:

Martha: *It's a jumping lizard. I meant to do a grasshopper but it's a bit difficult.*
 [to Arron] *Stop bashing.* [to researcher] *He's headbutting our tree*
 Arron: *We've done a chameleon*
 Martha: [giggling] *It's a jumping chameleon*
 [...]
 Arron: *This one's a bouncing chameleon. The colour of... nothing*
 Jack: *The sky*
 Arron: *The colour of nothing. White*
 [They are trying to do something – mainly inaudible. Jack always watching]
 Jack: *What you need to do is click on that* [pointing] *and then you'll have that*
 Martha: *Hey*
 Arron: *Cool*
 [...]
 Arron: *Are you on the hand*
 Martha: *No don't don't don't*

Jack: *I know how to make the tree back to normal*
 Martha: *Just press on that one there*
 Jack: *Just press on that then press on that picture*
 Arron: *Press on what?*
 Jack: [pointing] *That*
 Martha: [has taken pen] *This?*
 Jack: *Yeah*
 [...]
 Arron: *No sky doesn't fall down and bounce*
 [Arron trying to snatch pen from M; she doesn't let him]
 [...]
 Martha: [to researcher] *We got a chameleon, not a lizard*
 Researcher: *Ah is that why it keeps changing colour*
 Arron: *And it's a hairy chameleon look*
 [...]
 Martha: *Oh no, you've made it bounce and we need it to hibernate*
 [...]
 Arron: [to Jack] *It's not a lizard it's a chameleon*
 Jack: *I know. Chameleons are lizards though*
 [...]
 [Fits of giggles – their image bouncing a lot]
 Jack: *It's slowing down now*
 Martha: *It's jumping on the hand. [to researcher] It went a bit funny and now it's got little baby eggs jumping in it [they have filled the chameleon with dots]*
 Jack: *It's having babies while it's jumping*
 [...]
 Martha: *It's still bouncing. Why's it still bouncing?*
 Jack: *Coz the little ones are picking it up*



Figure 13: Chameleon by Martha & Arron, Year 3

In this excerpt, it is the interplay of the children's dialogue and the affordances of the software which allow them to create an on-going storyline to accompany their image-making, a storyline which concludes with their chameleon full of 'baby eggs' then giving birth while jumping around the screen.

What we might want to suggest, then, is that in some cases the children using Moovl have been able to progress from a basic understanding of Moovl's functions to a more complex understanding of its potential to simulate and represent certain actions, relationships and interactions between objects. For example, Marley's comment that "an elephant can't jump", and his construction of an animal with springs for legs, indicates his understanding that while Moovl can of course simulate absurd behaviours, it can also be used to demonstrate what real world behaviours might look like, or to simulate how the manipulation of properties can lead to strange actions. It is, of course, impossible to conjecture too much about the intrapersonal

nature of this understanding (what cognition is taking place in the brain) but what is clear is that some children are making some complex ideas visible, and in so doing offer us a glimpse of their thinking.

The interpersonal transmission of ideas using Moovl certainly confirms the rationale for including the public scrapbook function, which will be discussed in the section on collaboration.

4.5 Drawing style

There were several instances during the trial which revealed how some children find it difficult to create images in Moovl. Of course, Moovl is not a piece of paper, and offers very different affordances despite its intuitive appeal as some kind of 'magic paper'. However, it is likely that some kind of interactive tutorial will be needed in later iterations of Moovl so that children understand and are able to practise some of the more complex methods for drawing with it.



Figure 14: Year 1 children drawing

4.5.1 'Making ends meet'

According to Janet Goodnow in *Children's Drawing* (1977) there are several common errors that children make while drawing. Firstly, that when dealing with complex shapes most children will use several lines instead of a single line, and secondly that many children have a problem with bringing a figure to a close, or 'making ends meet'. Both these errors can prove to be fundamental to animating an image, or fixing objects together, in Moovl.

These errors recurred throughout the trial, even after modelling activities by the teacher and despite the intervention of the researcher during the sessions. Interestingly, the preferred method for some children on realising that an image was most reliably constructed out of one single continuous line was to ensure all features were included by 'back-tracking' with the stylus, re-covering the same lines they had already drawn. Oscar in Year 3 and Maisie in Year 1, particularly, were recorded using this method to ensure that they produced solid shapes with no gaps which then 'shaded' automatically.

4.5.2 Colouring in

On many occasions during the trial children were observed 'colouring in' images by scrubbing the screen with the stylus. Martha from Year 3, for example, had drawn a kangaroo which she hoped to be able to animate to get it to jump. The outline figure remained 'unclosed' and after Martha had coloured every white bit of screen in the interior of the figure she attempted to move it using the 'hand'. Unfortunately, the combination of different properties that she had given different parts of the image (unaware that she had only been clicking on parts of the image but never the entire image) meant that it exploded spectacularly.

These issues should be fairly easy to resolve with a decent tutorial or staged introduction, although the issue of 'making ends meet' is likely to remain a problem for some children, especially in the earlier years.

4.6 Collaboration

The word collaboration is used with some caution here, as in the educational domain it is often misused simply to designate some form of working together. The evidence arising from these initial trials, however, suggests already that there are transformative activities occurring in the dialogue and image-sharing of the pupils, ie new ideas emerging, spontaneous narratives arising, as well as more practical hands-on advice-swapping. In this short section the focus is firstly on the 'technical support' the children offered each other to manage the demands of the software, and secondly on their use of the public scrapbook function.



Figure 15: Working together on Moovl

There were multiple instance in both year groups of children supporting each other to accomplish certain actions in Moovl. Mostly this meant pointing or telling each other which buttons to press, but occasionally it was more complex and demonstrated the children's ability to informally tutor each other through problems. This example is from Martha, Arron and Jack in Year 3:

- Arron: *He got a double, a double. But then you got another. [inaudible] Erase it. Erase that. [pointing to screen, Martha following instructions] Whoa, it's not erasing*
[They have duplicated part of their image here by dumping it into the scrapbook then retrieving it]
- Jack: *There's a way to get it to erase. First you need to click on that. [showing Martha] Yeah, then move them into the bin*
- Martha: *Now I need to draw the lizard again*
- Arron: *[inaudible]*
- Martha: *Yeah but I have to draw it all over again*
- Jack: *No you don't. Drag the lizard out, and drag that*
- Martha: *I can't just drag the lizard out*
[Arron takes pen]
- Martha: *No drag this out drag it out. Press that [poking screen]*
- Arron: *Hand...*
- Martha: *No, not the hand - that*
- Arron: *That...*
- Martha: *Now drag it out [giggles]*
- Jack: *Yes*
- Martha: *No you silly. Oh. See what you done now [takes pen]*
- Arron: *You can start it again*

In the following two excerpts from a session with Year 1 children one of the girls, Hanna, asks for assistance to stop her image moving while she is drawing and then, having been shown

what to do, shares that information with Bethany and Hamera who are similarly stuck a few minutes later:

Hanna: *Hey why did it fall down?*
Bethany: [to Hamera] *Don't fall off. You have to first... you have to press the one that, umm, press the one that holds it, Hamera*
Liam: [from across table] *Hold it with the hand*
Hanna: [to researcher] *Which one holds it?*
[...]
Researcher: *Which one does what, sorry?*
Hanna: *We want it to stay up but it's not working*
Researcher: *You want it to stay up? Let me show you a little trick. You press that button [pointing]. Now try*

Between being shown how to fix an object into place on screen, and next showing Hamera how to do the same there is a three-minute interlude.

Hamera: [whining] *Oh mine falled*
[Hamera's attempt at an elephant has fallen down while she was trying to draw it and got stuck in the 'grass' – she throws down the stylus]
Bethany: *You need to press the hold button*
Hamera: *What do you mean hold button?*
Hanna: [leaning over to Bethany and Hamera] *Did it, did it fall?*
Caz: [to Hanna] *Let me try*
[Hanna leans right over to Bethany and Hamera]
Hanna: *Here's a little trick something. Gimme your pen [reaches across Bethany and Hamera and takes pen from Hamera]. Now just press that [stylus on the 'fix' button – but it's set to eraser]. No, no – pen, pen [clicks on 'pen' mode; Hamera takes pen back]. Now rub it. That one, now. [Hamera clicks on the 'fix' button] Now rub it out and try to draw it, a little drawing like some grass*
Hamera: *But we already tried doin it [she is erasing entire image from screen with the 'rubber']*
Hanna: *OK [reaches for stylus; points to screen to 'fix' function – still set to 'rubber'; Hamera changes to 'pen']. That one [pointing to 'fix'; Hamera selects]. Now, draw like some grass something. [Hamera goes to draw at base of screen] No – there, at the top, then you can see it's not going to fall. Do it there*

What is interesting here is that Hanna has borrowed some of the language used by the researcher ("a little trick"), but her tutorial to Hamera is much more complex than the researcher provided Hanna herself. The children in many cases, then, appear to be confident in showing each other how to use Moovl, and use a variety of methods to communicate that tutorial, including voice and gesture.

4.6.2 Public scrapbook

Due to time restrictions, the public scrapbook was not tested out very thoroughly. When the groups were introduced to it, it generated a significant amount of enthusiasm. Much of this enthusiasm, however, was directed towards accessing others' images as quickly as possible, as in the following example between Year 3 pupils:

Nadim: [to Martha, leaning over and pointing] *Give me that*
Martha: *That? That's Oscar's*
Oscar: [inaudible, trying to take stylus from Martha]
Martha: *It's my turn*
Nadim: *That one... the blue one [pointing at Oscar's first image of the blue rabbit]*
[...]

[Nadim has accessed Martha and Oscar's scrapbook]
 Nadim: *Ha ha we got a donkey*
 Martha: *It's a camel... he stole my camel*
 Jacob: [to Martha] *Have you still got your camel?*
 [...]
 Nadim: *Look at all of Marley's we got*
 Marley: *Oh you got ours, oi!*
 [Noise – inaudible]
 Nadim: *That's Marley's, that's Marley's, that's Marley's* [pointing into the scrapbook]

At other times, when their scrapbooks were full of existing images, we sometimes saw children picking up the tablet PCs and revolving them to show each other their new images.

It is clear from the sharing and supporting activities the children have performed without the public scrapbook that they are very keen to be able to show and share images as well as to support each other in their creation, and therefore indicates that the scrapbook could indeed play an important role in developing and presenting ideas. As the research of Cox (1999) has indicated, understanding of science is reinforced when it is socially embedded in the interchange and presentation of ideas between children. However, it is likely that a full evaluation of this feature would require a longer period of analysis.

As noted in a previous section, compatibility between Windows systems on the tablets and interactive whiteboard prevented any use of the scrapbook to communicate teacher models on to the tablets or the children's images on to the whiteboard. Being able to use the scrapbook in this manner would have allowed us to explore its usefulness further. It was initially envisaged that it might be used by the teacher to begin a model of a representation for children to complete, or to set challenges. Further, the children's finished images could then have been transmitted on the whiteboard and the children would have been able to present their simulations to the whole class. Both of these kinds of activities are good practice in the infant classroom.

5. CONCLUSIONS

It is very clear that Moovl generates enthusiasm and motivation, and that at its very simplest level it would make a great toy. The Moovl evaluation has begun to reveal its potential for supporting the learning of science concepts in Key Stage 1.

Generally, the Year 3 pupils who used Moovl seemed more quickly to grasp how to use it than the Year 1 pupils; however, many of the Year 1 children were able to complete quite complex simulations and representations with minimal support, so it seems likely that Moovl does have appeal at least across the entire Key Stage 1 range, if not beyond.

At a basic level the children were able to explore the key variables of mass, elasticity, air resistance and solidity in a playful way by exploring the consequences of manipulating properties and observing the effects on those objects. Issues with some of the symbols used to designate these properties led to some confusion but this should be easily rectified.

Many of the children were able to manipulate Moovl to create simulations or representations of phenomena. These representations sometimes used the functionality of Moovl to simulate physical phenomena that recruited the physics of the program metaphorically to demonstrate particular actions occurring.

Many of the children were observed proceeding through a process of making hypotheses and asking questions, trying out and observing their representations, revising their images or manipulating properties where necessary, and concluding their investigations by showing each other their representations. These methods roughly form the science inquiry process that the

curriculum requires children to understand and to practise. It therefore seems very positive indeed if Moovl can be used to help develop these skills in infant school children.

There was a great deal of cooperation and sharing evident throughout the trial. The children were often observed helping each other to grasp the functionality and to understand what effects pressing certain buttons would have, showing each other their images, and through their dialogue with one another often inspired each others' drawing. Some children surrounded their images with improvised vocal narratives to help explain the phenomena they were representing. In conversation with the researcher, some children stated that they would like to be able to make stories using Moovl. The ability to make narratives out of science concepts using Moovl should be explored further.

Greater teacher participation and direction once Moovl is available in the classroom will further develop science understandings and begin developing the children's science vocabulary alongside their ability to visualise their conceptions of science.

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