Glimpses of Science: Multimedia-enhanced hands-on activities for primary school students

By George Hatsidimitris, Rick Connor, Jacinda Ginges and Joe Wolfe

Glimpses of Science is the outcome of collaboration between the University of New South Wales and four primary schools in the Sydney metropolitan region. A prototype kit on the topic of sound was developed and demonstrated by the team. This kit formed the basis for further science activities to be designed and produced in conjunction with the teachers. Students formed small groups to conduct hands-on activities that investigated the topics of sound, pendulums, light and energy. Instructional multimedia was used to illustrate certain aspects of the hands-on activities and also as a prompt to generate class discussion. Student and teacher feedback was positive. The resources are available on the web.

How can science be taught effectively and inexpensively in primary schools? A number of resources are available to aid the learning and teaching of science in primary schools: one excellent example is the materials, student topic books and teacher guides made available through the Australian Academy of Science's *Primary Connections Project* (http://www.science.org.au/primaryconnections/). These resources generally require considerable investment of time and effort from teachers who have competing demands upon their time and who, in many cases, have relatively little training in science and who sometimes lack confidence in, or enthusiasm for, its teaching. There is also the question of cost.

The web appears to offer some advantages. First, once resources are posted on the web, they are available at low cost to any school that has a connected computer and data projector. Second, multimedia can be used to provide learning materials that can reduce the demands on the time of teachers. Universities have been using web resources to support science learning but university staff rarely have experience with the needs of primary schools and their teachers.

The *Glimpses of Science* project utilised the specific expertise of university staff in the fields of science and multimedia, together with the teaching experience of a number of primary school teachers to produce, in collaboration, a number of multimedia-enhanced hands-on science activities. It began with a prototype kit developed by the university staff, then led to discussions between the school and university staff about how further activities could be developed, and culminated in the production of sets of hands-on activities for small groups that aimed to provide students the chance to discover by experimentation and multimedia supporting materials.

This paper gives a report of the ideas and processes behind it and some of the outcomes.

The Prototype

A prototype kit on the topic of sound and vibration was designed and constructed by a physicist and a multimedia designer at UNSW.

Why sound? Sound was chosen not only because of its importance to human communication. It also poses an interesting challenge in that sound itself is invisible. Even the vibrations that cause it are too fast to see: if it's faster than twenty vibrations per second, we can't see it, slower than that, we can't hear it.

Our first aim was to find simple activities to investigate sound and some of its properties, suitable for primary school students, using only inexpensive and readily available materials.

The second was more important. Although this chapter in *Glimpses of Science* is about sound, the most important lesson to be learned from it is the power of experiment. For that reason, we give a brief outline of this investigation here, and then only briefly list the other kits that followed.

Experiments are the source of much of the power and influence of science and science-based technologies. Therefore, one of our objectives was to show that it is possible to discover hidden information without recourse to authority: without asking parents or teachers, without looking up an encyclopaedia or the net. The children we consulted did not know how 'rate of vibration' was connected to high and low notes and indeed, it is not immediately obvious.

The first experiment uses a ruler, with a short section of one end held firmly on a desktop while most of the ruler protrudes beyond the desk. A small mass (a piece of 'Blu-Tac' putty) loads one end. (Technically this is a cantilever spring, loaded with a mass: the classic mass-spring system.)

Depending on the style of ruler used, the putty may be needed to slow the vibrations to about one or a few vibrations per second: vibrations we can see. In classic reductionist experimental style, the students are asked to vary, in turn, two variables, while holding the other constant. We vary stiffness, and see that vibrations are faster when the ruler is shorter (the spring is stiffer). We vary mass and see that the bigger mass slows the vibrations.

Next we shorten the protruding length of the ruler. Vibrations become progressively faster until eventually one can hear it as a note. After the experimental exploration, the children are asked:

- When can you hear a note from the vibrating ruler?
- What happens to the vibrations when the ruler becomes shorter?
- Do the notes get higher or lower when the ruler becomes shorter?

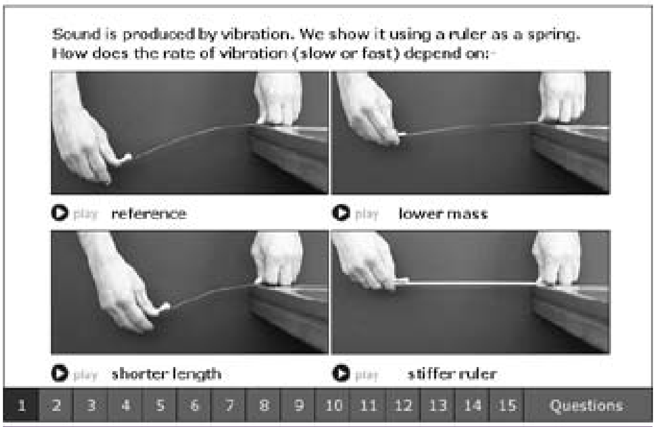


Figure 1: The opening animated slide from the multimedia visualisations that accompany the section on sound. Short re-playable video clips are shown in their initial freeze frame state and then played after the students conduct the experiment, in order to summarise, in one quick overview, their results.

In the prototype trial, the small groups nearly all made the observations we had hoped to see:

- Vibrations cause sound if they are fast enough;
- A shorter ruler produces faster vibrations; and
- A shorter ruler produces higher pitch.

More exciting for us was that the groups were also able to draw an indirect conclusion:

- Faster vibrations cause higher pitch.

Of course one could have looked this up, but it is rather nice to discover it oneself. Here the students have combined three different observations to discover, by experiment, something that we could not see.

The section using this cantilever spring finishes with a practical application: the ruler-putty combination uses the same principle as the tines in a music box (available for a few dollars). The music box itself introduces another idea: vibrations in this small object do not produce much sound in air, but when they are transmitted to a large surface, such as a tabletop, they produce a surprisingly loud sound. (Technically, this is a demonstration of an impedance transformer.)

The same principle of comparing slow, visible but inaudible vibrations with fast, invisible audible ones is used to explain how string instruments work: vibrations in a 'slinky' plastic coil are compared with vibrations in the string on a guitar (or other string instrument). Several different experimental exercises are suggested and compared.

Another section shows that air (which itself has both springiness and mass) can vibrate. These interactive slides show blowing over water bottles, slap tubes (described below) and double reed 'instruments' ('oboes') made from drinking straws.

In the trials we conducted, the session finished with a group activity: the slap tube concert. Slap tubes are just short sections of plastic plumbing pipe or electrical conduit, open at both ends. Slapped at one end, they briefly sound a musical note. Once notes are distributed among students, a teacher can then conduct a tune, in a fun, group activity.

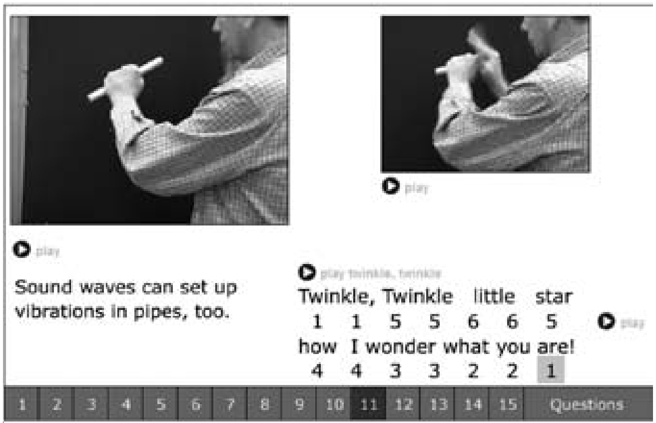


Figure 2: The video that demonstrates the use of slap tubes with videos. The Twinkle, Twinkle Little Star tune can be conducted as a group or whole class activity with the multimedia providing cues for each note.

The sound activity set was trialled, with multimedia support for a 1-2 hour period during class time at each of the participating schools. The lesson involved 'stepping' the students through a number of related activities in a pre-arranged way. The multimedia visualisations were presented in a slide show format. Each slide contained accompanying material in the form of film clips, animations and/or stills. The slides could prompt an activity, serve as a discussion point after an activity or raise related questions or examples for discussion. The students would proceed through the various segments of the module, alternating between the hands-on activities they undertook as part of a small group and the interaction they had as a class whenever the teacher was guiding them through the multimedia instruction.

This step-at-a-time approach provided adequate segmentation, in order to ensure that the student's cognitive resources were not overloaded (Mayer and Moreno 2003). Depending on the activity, the students could either work individually, in pairs or as a small group. Seating arrangements meant that there were about 5-6 groups of 4-5 students. Each activity concluded with team discussion followed by class participation in a short follow up facilitated by the teacher. This strategy aimed to ensure that all students kept pace with the lesson and had adequate opportunity to be involved in the communicative and interpersonal aspects of the lesson.

The Kits

After all schools had conducted this demonstration class, two workshops were run for school teachers, with assistance from the university staff, to initiate development of the remaining kits, which covered the topics of energy, light and pendulums. Teachers also took some of this time to discuss with their colleagues issues troubling them, such as the neglected status of science teaching in primary schools. They also had time to design science activities with the collaboration of physicists, an education consultant, a multimedia designer and their peers.

Wherever possible, items for the kits were obtained from supermarkets, discount shops, educational suppliers and various online retailers in order to ensure sustainability and to facilitate uptake by other schools in the future. Adhering to this principle proved easier for some activities more so than others e.g. the sound section didn't rely on 'scientific' materials but some activities involving light were difficult to design without utilising lenses and prisms. Fortunately, plastic lenses and prisms were available at low cost.

Unsurprisingly, teachers with a background in science made more progress in developing their kits whilst some of the other groups moved more slowly. The workshops were followed by email correspondence that assisted the teams from each school (teachers worked in pairs in a manner akin to a 'buddy' system) to finalise their designs.

The Trials

Highlights: Overall, the strategy of providing hands-on activities coupled with multimedia support for small-group work appeared to be an engaging and viable means of conducting science at the Primary School level. Typical of the feedback regarding the kits was this response from a teacher: *The children loved the lessons and we will definitely use these kits again, and share them and our knowledge with our other stages.*

Most teachers also commented that the short video clips were helpful in assisting them to conduct successful lessons. A number of schools commented on how the kits had encouraged other teachers to do more science in their classroom. One participating school had designed a science day around the kits. The kit components were described by the teachers as being highly tactile and child-friendly. Survey responses from teachers indicated that students not only enjoyed using the equipment in the kits but that using the kits was an effective way of sharing their ideas with others.

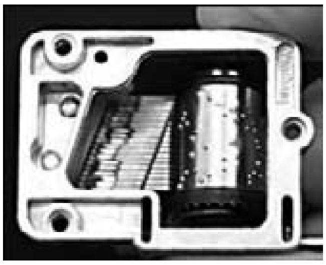
HANDS ON KITS	
1. SOUND Investigate sound and vibration. Do things vibrate faster or slower when they are heavy/light; stiff/slack? How does this tell us whether sounds will be high or low? Sounds and vibration from bottles, strings, pipes and straws.	
2. WORK, ENERGY, POWER AND FORCES Investigate energy, power and forces. You can measure your own power. Where does your energy come from? Do some sums! What about electrical energy and power? Toy and real cars? Some examples and experiments with forces.	
3. LIGHT Explores the properties of light with emphasis on lenses and colour. Exercises include the construction of a microscope and a telescope. "Why is the sky blue and the sunset orange?" is explored in the exercises on colour and colour mixing. The kit includes samples from nature and toys exhibiting the wave properties of light.	
4. PENDULUM The pendulum kit contains a series of activities designed to allow children to investigate the features of a pendulum that affect its swing (period T). There is also some simple equipment for investigating objects rolling down ramps. Children will primarily investigate how the length and mass ('weight') of a pendulum affect its swing. The equipment provided utilises simple, everyday objects that most children will be familiar with.	

Table 1: An overview of the four hands-on kits.

Challenges: One challenge was the tendency of professional scientists to set ambitious goals and to presuppose scientific backgrounds in the teachers. Nevertheless, we aimed to create activities/resources that could benefit primary school teachers across a spectrum of experience and skills in science. Teachers' notes were made available with each set of activities in order to provide some background knowledge in this regard.

In principle, one might try to incorporate a virtual teacher into online presentations. Two of the team members used this strategy for a project aimed at a much more senior student class http://www.animations.physics.unsw.edu.au. However, that would be a very different project, and might undermine the importance of hands-on experiment. Further, a large range of background material is available to teachers, and the authors prefer to hope that primary school teachers can teach science as just another example of human activity.

Extension: To date, this project has affected only four schools. No formal study of the effect of the project on the students involved has been made, in part because of the administrative and ethical complications this would entail, and in part because the funding was for specific purposes. The informal feedback from teachers was positive, but we did not aim to quantify this.

Can the project have a broader effect? The teachers' notes and the multimedia resources are available on the web at http://www.phys.unsw.edu.au/primary-school-science/. By using the online teachers' notes and using the slides to structure lessons and interactions, other primary school teachers may run and develop these or related activities in their own classrooms. While the complete set requires time and a modest budget, there are subsets of the activities that may be conducted with readily available materials (e.g. the rulers and drinking straws mentioned above).

One of the purposes of this report is to encourage wider use. If this occurs, the authors would be interested to receive suggestions for revising or improving the teachers' notes or the multimedia materials in the light of the experience of other teachers.

Reference

Mayer, R. E., & Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, 38(1), 43-52.

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Joe Wolfe is a Professor of physics at UNSW, where his research is in acoustics and biophysics. His teaching usually includes the large first year class. He has made a number of learning and teaching resources, listed at www.phys.unsw.edu.au/~jw/education.html