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Science animations and video clips as teaching elements and in multimedia context: the Physclips example.

The use of educational multimedia such as film clips and animations enables the teacher to present scientific phenomena in a visually explicit manner, even in cases that are not easy to film because of speed and scale. The proliferation of such animations on the internet attests to their increasing popularity and the intuitive belief that they are inherently superior to static images. Research evidence suggests, however, that practitioners should be cautious with the use of dynamic visualizations and should follow certain cognitive design principles. Related textual or spoken explanations are recommended.

The present paper presents the logic and design considerations behind a set of physics resources that utilize video clips and animations in an integrated multimedia environment and that include narrated tutorials together with support pages that promote deeper understanding. The website (http://www.animations.physics.unsw.edu.au) includes two award-winning projects that examine Special Relativity and Introductory Physics (Einsteinlight and Physclips respectively). The animations align well with evidence-based guidelines, have been well received by the international teaching community and are downloadable for re-use under a Creative Commons license.

The rationale for the design of the website follows the content expert's philosophical outlook that, in experimental science, videos should be employed as a first option wherever possible because they show what really happened whereas animations depict the outcome of a theoretical prediction. However, where logistics such as scale and speed prohibit the use of video, animations are employed to represent the scientific phenomena. Often animations are used in conjunction with videos to add abstractions such as time-varying vector and scalar quantities. This helps the student to 'see' these quantities and to make the link between the world and the quantitative analysis of it (see Fig. 1).

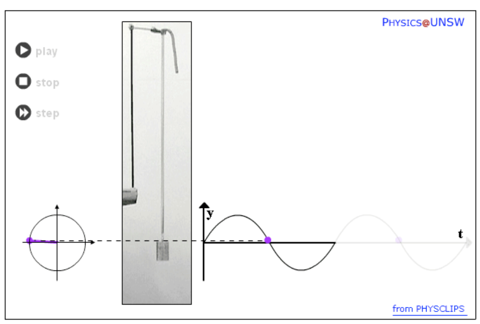


Fig. 1 Here, a video of a spring pendulum is accompanied by an integrated overlay of a sine wave in order to make explicit the relationship between the displacement-time graph and the motion of the mass-spring oscillator.

The design of the multimedia environment reflects the considerable teaching experience of a physicist who collaborates here with a multimedia designer. The animations themselves accord well with design guidelines formulated by cognitive psychologists working in the field of multimedia learning. Mayer

(2008) points to ten principles that he suggests are particularly relevant to overcoming the challenges imposed by animations. Animations are cognitively demanding and, in a number of laboratory studies, they have sometimes proved to be no more effective than stills (Tversky et al 2002). Essentially, the research suggests that animations are most effective when accompanied by a spoken explanation in a synchronous manner, using a conversational tone. Further techniques and considerations that work towards improving student performance in the comprehension of animations are segmentation, pre-training of key elements, spatial contiguity between words and diagrams and signaling through the use of arrows or highlighting. The omission of extraneous material such as background music is also recommended.

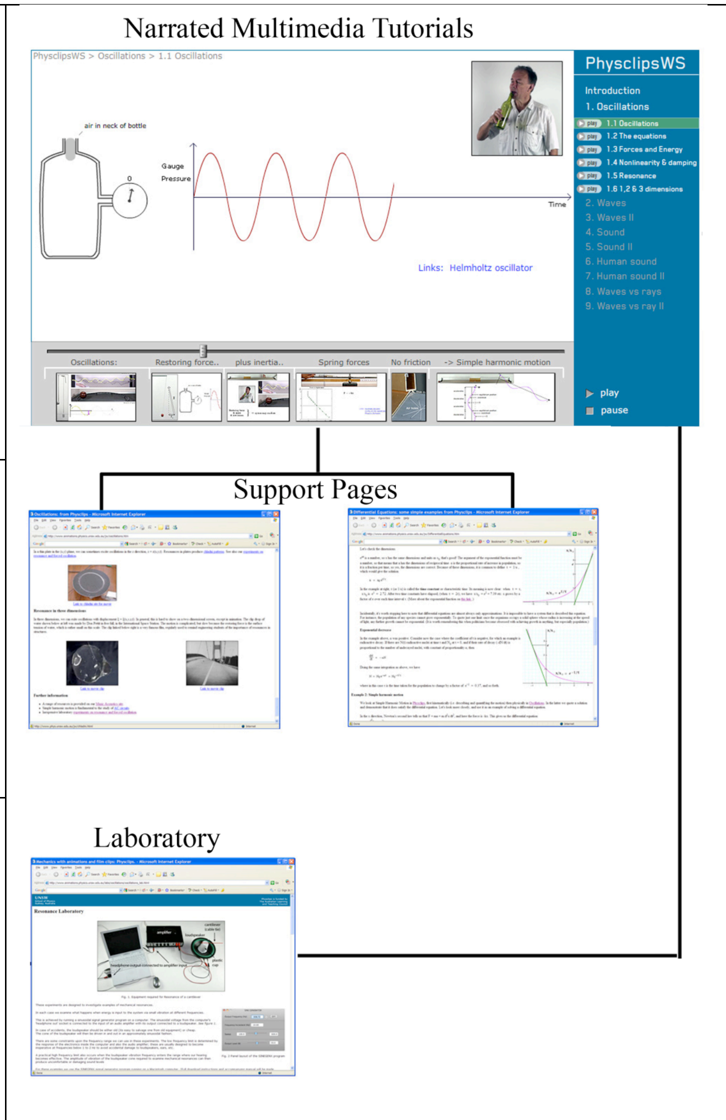
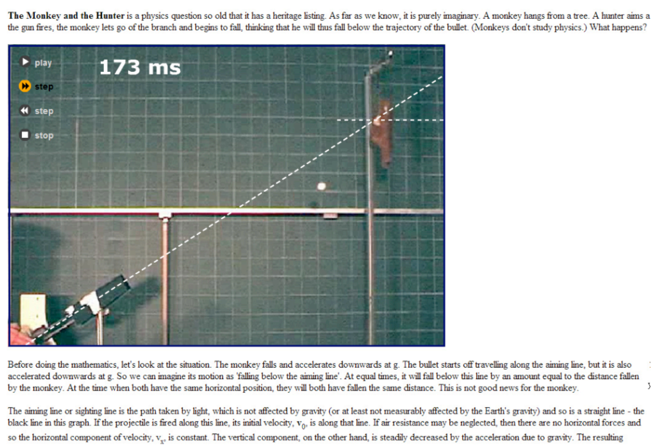
Narrated multimedia tutorials A carefully scripted narration accompanies animations/videos and stills. Contextually embedded hyperlinks allow the user to access support pages that cater for students who are either lacking in prior knowledge, seeking a deeper explanation or exploring related material. The scrollbar and its titles and icons facilitate repetition for understanding and navigation in review and revision.	
Supporting pages HTML pages provide an opportunity for deeper understanding through textual explanation and by allowing the user full control over animations/videos, some of which were presented during the narrated tutorial while others serve as supplementary material.	
Laboratories Hands-on activities utilize cheap, accessible components. Some are novel experiments while others replicate demonstrations that were discussed in the narrated tutorials. These activities are a new addition to Physclips and can be found in the section on Waves and Sound.	

Table. 1 Each volume of Physclips is comprised of a number chapters, each of which contain a narrated multimedia tutorial, support pages and hands on activities.

The elements of Physclips are shown in Table 1. The multimedia overview is brief. Some viewers will need more help on difficult concepts, while others will seek deeper or broader information. The overview also has its own tempo, dictated by the speed of narration and the level of detail in the script. Some users will prefer slower, more detailed delivery, while others will want to speed-read. All of these users are the targets of html supporting pages. These pages provide detailed textual explanations addressing issues that go beyond the visual display of the phenomena in both breadth and depth. Physclips and Einsteinlight both use many such pages, which are hyperlinked to the multimedia presentations at relevant points, and also listed at the end of each chapter. The support pages also give the user the opportunity to control the animations (see Fig. 2) that are initially shown during the tutorials. A recent addition to the Physclips design structure has been to include laboratory activities that encourage the user to make quantitative measurements and to test the laws and models. The lab activities have their own html pages, which in many cases use film clips or animated material presented in the tutorials and support pages.



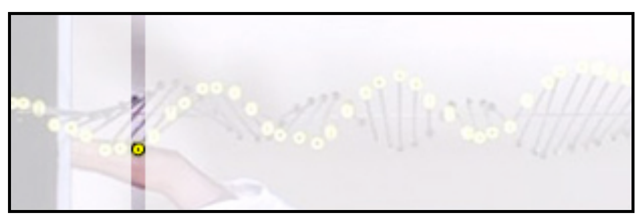
The Monkey and the Hunter is a physics question so old that it has a heritage listing. As far as we know, it is purely imaginary. A monkey hangs from a tree. A hunter aims a the gun fires, the monkey lets go of the branch and begins to fall, thinking that he will thus fall below the trajectory of the bullet. (Monkeys don't study physics.) What happens?

Before doing the mathematics, let's look at the situation. The monkey falls and accelerates downwards at g. The bullet starts off travelling along the aiming line, but it is also accelerated downwards at g. So we can imagine its motion as 'falling below the aiming line'. At equal times, it will fall below this line by an amount equal to the distance fallen by the monkey. At the time when both have the same horizontal position, they will both have fallen the same distance. This is not good news for the monkey.

The aiming line or sighting line is the path taken by light, which is not affected by gravity (or at least not measurably affected by the Earth's gravity) and so is a straight line - the black line in this graph. If the projectile is fired along this line, its initial velocity, v_0, is along that line. If air resistance may be neglected, then there are no horizontal forces and so the horizontal component of velocity, v_x, is constant. The vertical component, on the other hand, is steadily decreased by the acceleration due to gravity. The resulting

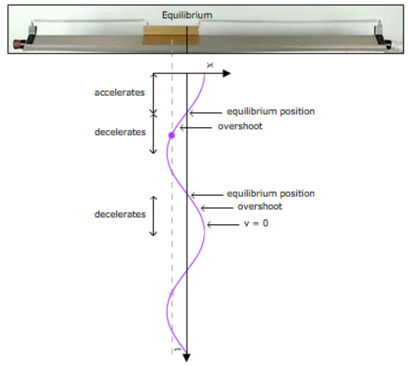
*Fig.*2 The monkey and the hunter – an ancient and famous physics question, is here presented in a quantitative film clip, with interactive control, and a detailed textual explanation and analysis.

In the next section, we give examples of some of the cognitive design principles (Signalling, spatial contiguity, segmentation, personalisation and redundancy principles, recommended by Mayer 2005, 2008) that we have tried to include.

Signalling The visual world is full of information and not all users see what the teacher regards as the important material. Here, Physclips discusses the motion of one particle in a torsional wave. In the clip, the vertical movement of one bar is more easily discerned (and the wave less distracting) when all the other bars are faded.	

Spatial Contiguity

Corresponding words and pictures should be near to one another to allow easier integration of different sources of information. In this example, arrows and labels are used in close spatial proximity to the graph, whilst a connecting, animated, dashed line matches position in the video to position shown on the graph. In the multimedia tutorial, the labels match (in time) the same phrases in the voice-over.



Personalization Principle

Cognitive psychologists have demonstrated that animations accompanied by a narration in a conversational style are more effective in engaging the user. Here we discuss work (the physical quantity) – while making it obvious that the presenter really is working.

Redundancy Principle

The redundancy principle states that animations and narration are better than animations, narration and text together. We violate this principle in some cases. Here, we offer the printed text in English for users who are not native speakers. For this volume, produced for the International Year of Physics, we also offer subtitles in several languages.

Segmentation

Re-playable, self paced segments are considered better than a continuous whole as the latter is more likely to overwhelm the cognitive capacity of the user. Here, Chapter 1 is Oscillations (top of the right hand menu) and its six subsections appear below it, each with a play button. Each of these sections is further segmented into topics, indicated here by the six titles and icons below the scrollbar. This division and the scrollbar facilitate not only repetitions for initial comprehension but also navigation during revision.

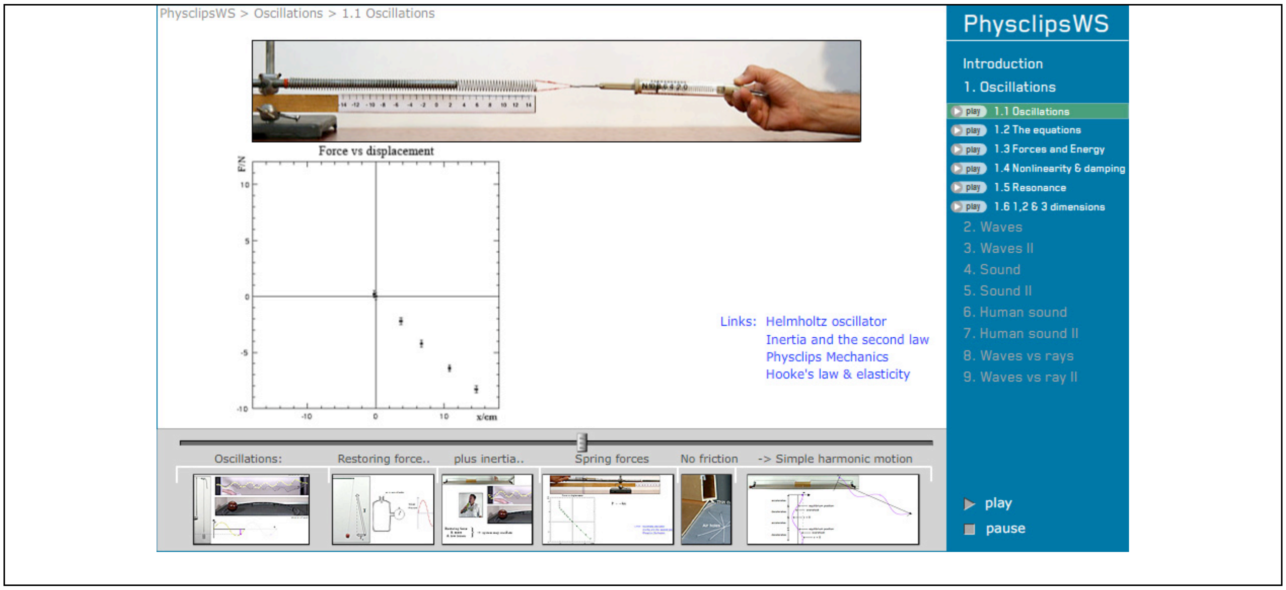


Table 2 Examples of videos/animatons from Physclips and Einsteinlight that align well with various cognitive design principles.

The Physclips website provides the film clips and animations as downloadable, re-usable, learning objects that teachers can use however they like. Users report that they have used such materials from Physclips embedded in online courses, blogs, powerpoint presentations, websites and so forth. The videos and film clips can be downloaded from the website in the form of a zipped file that is extracted into a HTML file and the flash component (swf file). Options for re-use include typing customized explanatory text into the HTML file to accompany the animations, embedding in powerpoint (search engines will turn up a number of sites to assist in this process) or simply use in the classroom with a spoken explanation given by the teacher.

*Fig.*3 Learning objects are available for download and re-use by teachers

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Einsteinlight website: http://www.phys.unsw.edu.au/einsteinlight/

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