Intuition, evidence-based guidelines and user feedback in multimedia teaching: The *Physclips* project

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Physclips is a suite of online multimedia resources for the learning of physics and represents the most recent outcome of an ongoing collaboration between an intuitively oriented content expert and an educational-multimedia designer. The multimedia project has evolved from an earlier successful project on special relativity and a number of improvements regarding segmentation, user-control, re-usability, content representation and hands-on laboratories have been incorporated. An examination of the research literature reveals that the current design fulfills many of the cognitive design principles recommended for multimedia learning whilst also stretching some of the traditional boundaries regarding the style of animations and their implementation in a broader learning context. Innovative characteristics of the design, including a visually enhanced scrollbar, emanate from a characteristically creative process that involves input from the content expert, multimedia designer, educational researcher and the end-user.

Physclips is one example of how intuition and creativity combine with responsiveness to user feedback and an awareness of the research literature to produce an educational website that has received acknowledgement from various elements of the learning and teaching community. In this paper, we report our experience and what we have learned from teacher-developer collaboration, cognitive design principles and user-feedback. We do this by tracing the evolution of the multimedia design from its predecessor, *Einsteinlight*, through to the current volume of *Physclips*.

Einsteinlight: The prototype

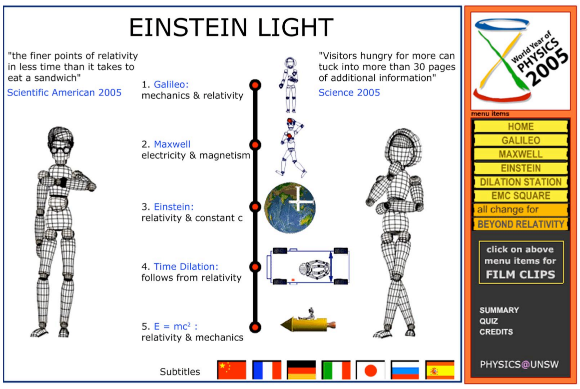


Figure 1: Screenshot from *Einsteinlight*
(http://www.phys.unsw.edu.au/einsteinlight)

Einsteinlight was made for the centenary of Special Relativity in 2005. It comprises short narrated multimedia modules incorporating stills, animations and video. A pair of animated pedagogical agents helped illustrate the concepts at hand whilst contextually embedded hyperlinks to HTML pages allowed the user to delve deeper into more detailed subject matter. User feedback suggested improvements could be incorporated in terms of providing a higher level of user-control and the availability of the animations as discrete downloadable re-usable learning objects.

The *Physclips* multimedia project

Overview of resources

Physclips is a set of integrated, hyperlinked resources for learning introductory physics. Here, the target audience is upper high school, first year university students, or enthusiastic amateurs, world-wide. Topics are introduced in narrated multimedia presentations that incorporate video clips, animations, and static diagrams. Each chapter has sections and each section is further divided into subsections whose titles and icons are distributed along a scrollbar. The rich-multimedia modules regularly use contextually embedded hyperlinks to web pages that provide deeper explanations or analysis and broader discussions and examples, together with further links. In the most recent volume, each chapter has a laboratory section to provide hands on activities utilising some common, inexpensive components. Animations and film clips used during the narrated tutorial and the web pages, and some virtual instruments for the lab sections, are available as downloadable, re-usable learning objects for use by teachers and designers. The project is funded by the Australian Learning and Teaching Council.

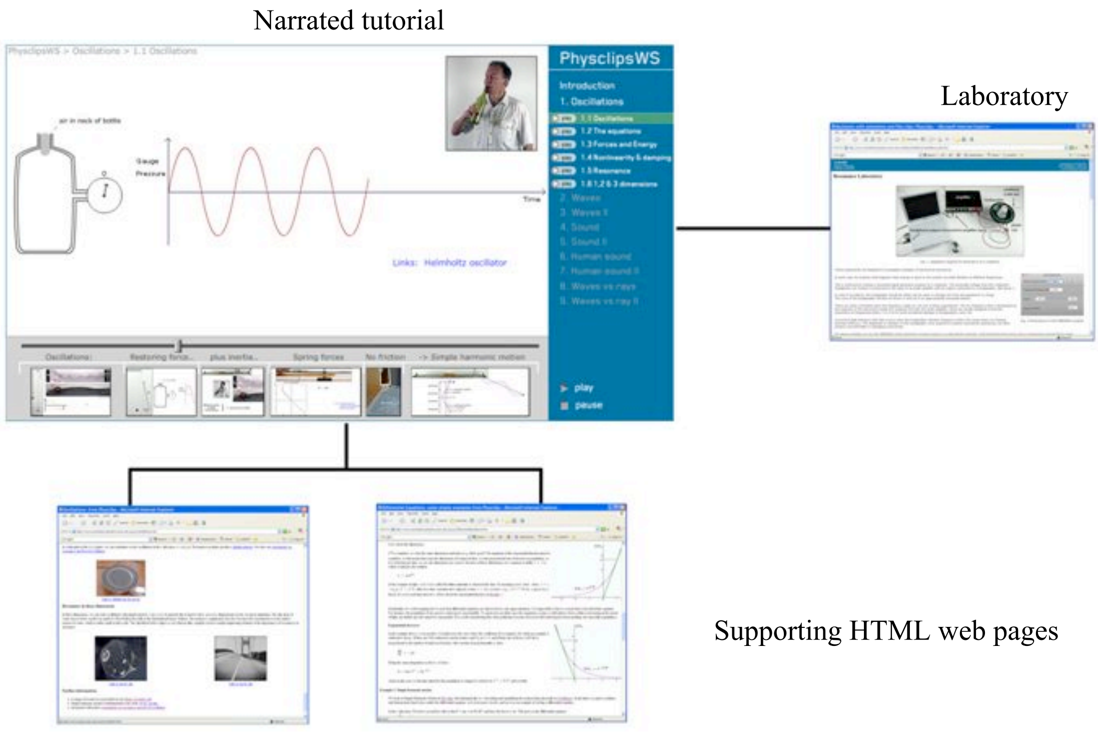


Figure 2: A schematic overview of resources accompanying each topic in *Physclips*

The research literature

According to cognitive load theory (Sweller, 1999), educators should ensure that the load on working memory does not exceed the capacity of the user and to this end a number of research-based guidelines have been formulated to assist designers and educators. Mayer (2008) draws our attention to ten of these principles that are particularly relevant to the challenges of learning with animations.

Here we point out how *Physclips* aligns with these guidelines. The synchronous narration is consistent with four of these principles: it accompanies film clips and animations (as recommended by the temporal contiguity principle and modality principle), has a conversational tone (personalisation principle) and uses a standard-accented human voice (voice principle). Consistent with the coherence principle, there is no extraneous material such as background music. The redundancy principle would argue against including a simultaneous visual text. However, we have considered using subtitles to assist students from a non-English speaking background. Consistent with the signaling principle, highlighting and arrows guide the learner's attention to key aspects of the visual material. Co-locating animations with any corresponding text is consistent with the spatial contiguity principle and the segmentation principle is followed by providing self-paced segmentation within a narrated animation. To some extent, *Physclips* also addresses the pre-training principle by providing several levels: the introductory screens provides a summarised overview, the multimedia tutorials introduce the key concepts and the links go to deeper and broader material.

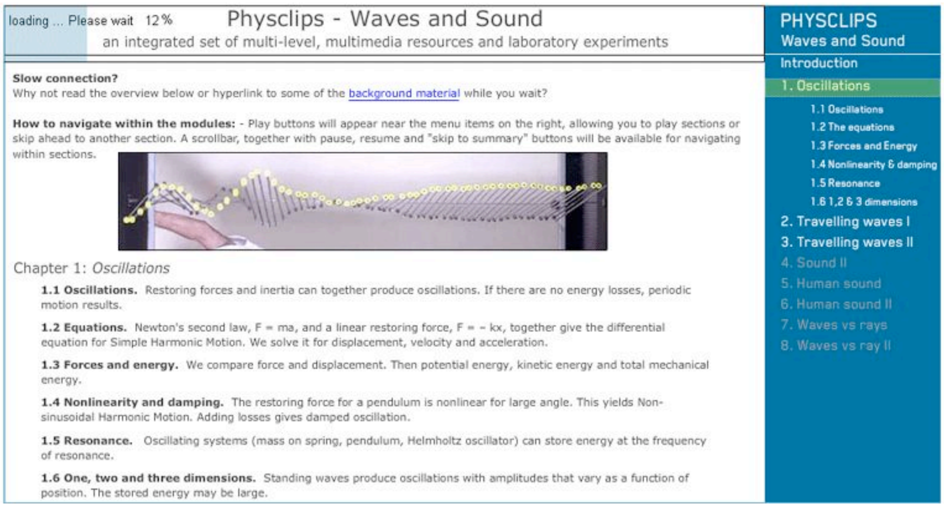


Figure 3: Screenshot from *Physclips* showing an overview of the various segments

Physclips and current trends in research

Tversky et al (2002) conducted an extensive review of studies addressing the stills versus animations paradigm and concluded that in many cases stills are at least as good, if not better, than animations. This finding helped fuel an ongoing debate between the relative effectiveness of stills versus animations, which has shifted in part to the use of critical snapshots in conjunction with animations. Arguel and Jamet (2009) conducted studies whereby video plus static pictures in the form of critical snapshots produced better results than either format alone. *Physclips* adapts this finding by placing critical snapshots, together with keywords, as a form of content representation under the scrollbar in order to minimise search-related behavior whilst also providing a conceptual overview for the user.

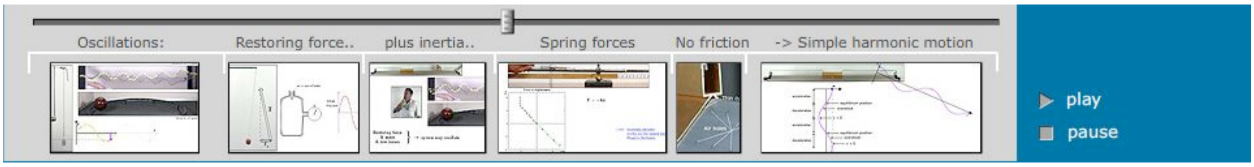


Figure 4: A visually-enhanced scrollbar is used to facilitate searching across a sequence of animations

Intuition and teacher experience: The role of the content expert

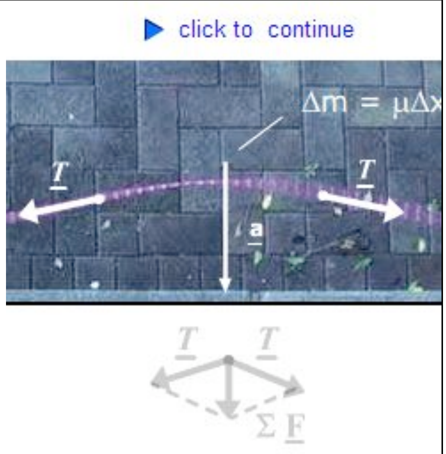
Our insistence on using film clips has several reasons: first, physics is an experimental science based on real-world observation. Second, two of the most important skills that physicists learn are to see, in the real-world situation, the relevant physical elements, and to model them in terms of physical laws. These are indeed difficult for the student, but they are vital skills, and well-rewarded.

Fortunately, multimedia has an advantage here: the film clip can be accompanied by an animation that shows the learner explicitly the abstractions that the expert makes immediately and often subconsciously. Two examples are given in Table 1.

Does *Physclips* work?

Typically, over 2000 users log on to *Physclips* each day. They regularly send in positive feedback and include students, parents of students, teachers, university staff, technicians, researchers, and interested amateurs. The availability of the animations for use by teachers and designers further facilitates dissemination and uptake by the broader education community. Tracing back the source of the statistics we find users that incorporate the material into blogs, *PowerPoint* presentations, lectures, school projects and so forth.

Table 1: From the world to the physical model to the experiment

<table>
<tr>
<td>Why does a wave propagate? On this freeze-frame from a film clip of a wave in a string are superimposed vectors representing the forces acting on it. Below the clip, these are repeated and summed (technically: a free body diagram). Now this part of the problem is just a simple application of Newton's second law: These forces applied to this mass produce this acceleration. A series of such applications explains wave motion.
The expert 'sees' these vectors in the 'mind's eye: the expert makes an abstraction that simplifies and represents the system observed in the world. This simplified model can be analysed to understand and to make predictions. This model-making and analysis are responsible for both the power of physics and for its inclusion in a wide variety of disciplines, but it is one of the most difficult things for the beginner to learn.</td>
<td>
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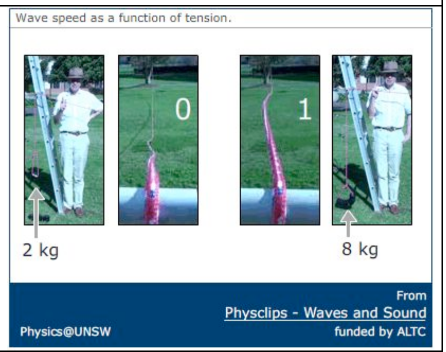
<tr>
<td>Physics is an experimental science and we are now including experiments in *Physiclips*. For the example above, applying Newton's second law gives the wave equation, which makes predictions that can be tested in experiment. These clips show one: how the wave speed depends on tension.
In the student's version of the experiment, using readily available materials, a bucket with a measured amount of water is used to supply tension to the rope. In this demonstration version, discrete masses are used so that the tensions can be quantitatively compared by inspection.</td>
<td>
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The Learning Federation of Australia is utilising the project website in order to provide targeted resources for use in the high school environment. Nominated for the 2007 Pirelli Prizes for Science Communication, *Physclips* underwent an evaluation procedure that considered scientific rigour, originality, interactivity, appeal and other features and won the Physics division. Although we have not as yet conducted controlled studies we nonetheless appear to have arrived at similar conclusions to the research community concerning the most effective use of animated material. Hegarty and Kriz (2008) recommend the use of textual explanations to supplement animations seeking to explain "invisible" forces, incorporating multiple learning experiences where interaction with animations is involved and treating animations as a component of a larger learning environment. By re-visiting the animations incorporated in the multimedia presentation during both the more detailed analysis in the supporting web pages and the hands on activities in the laboratory sections, *Physclips* is in effect moving towards the type of structured learning strategy that the research community is suggesting as the optimal design for conveying complex physical processes to relative novices.

Conclusion

The process of creating *Physclips* serves to reveal the importance of including input from various elements of the multimedia life-cycle. Together with the experienced teacher's intuitive input, user-feedback and an awareness of current debates in the literature the team is expecting to move ahead in both an informed and creative manner.

Acknowledgment

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