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An Online Resource for the Design of Instructional Videos and Animations

Abstract: Educators seeking to incorporate or design instructional videos and animations may benefit from an understanding of evidence-based guidelines in the field of multimedia learning and a consideration of techniques and ideas developed by practitioners. The current paper reports on a "work-in-progress" website that utilizes examples from a number of intuitively-designed multimedia projects and illustrates their alignment with cognitive design principles. The examples considered demonstrate alignment with research-based principles in terms of spatial contiguity, signaling, segmentation and a number of guidelines relating to the inclusion of a narration. The incorporation of animated overlays in conjunction with videos, together with techniques relating to the multimedia enhancement of hands-on activities, are also considered as further means of providing the novice with "food for thought" in the design of dynamic visualizations. A related worksheet provides a framework for an academic development activity to scaffold productive engagement with the online material.

Introduction

To account for the unexpected finding that stills are often as good as, if not better than, animations (Tversky et al 2002), cognitive psychologists have formulated a number of evidence-based guidelines in the field of multimedia learning to enable more effective design of dynamic visualizations. Nevertheless, for many designers of educational multimedia, such findings remain in the realm of theoretical constructs until adequately exemplified and illustrated with real-world examples. To address this issue we report on a resource that has been constructed with the aim of providing a visually-oriented quick-start guide for educators and designers seeking to design and/or incorporate instructional multimedia into the teaching environment. The instructional videos and animations used throughout the website, although intuitively designed by a physics educator in conjunction with a multimedia producer, nevertheless serve as examples to illustrate the basic fundamentals of incorporating cognitive design principles.

Animations and Evidence-based Guidelines

Animations are transient in nature and as such are not only difficult to perceive and apprehend (Tversky, Morrison et al. 2002) but are also prone to overwhelming the severely-limited capacity of the learner's working memory (Ayres and Paas 2007; Kalyuga 2008). As such, educational psychologists have sought to improve the effectiveness of animations by formulating a sizeable array of research-based principles. Mayer (2008) points to a number of these principles that are of particular relevance with regard to the optimal design of animations so as to ensure alignment with human cognitive architecture and thereby better facilitate student learning. These principles can be considered, from a designer's perspective, as relating to

1. the inclusion of a narration (modality, temporal contiguity, personalization, voice and redundancy principles),
2. the visual aspects of the presentation (spatial contiguity, signaling and coherence) and
3. the sequencing of the knowledge (segmentation and pre-training principles).

The inclusion of a narration

There are five multimedia principles relating directly to the use of narrations with animations. *The modality principle* has received the strongest support from the experimental data and simply states that animation and narration is better for student learning than animation and on-screen text. The reason for this effect can be understood through a consideration of how well the instructional design aligns with human cognitive architecture. When we attempt to process dynamic visualizations and static text we need to share our visual attention between the text and the animation. The information inherent in the textual explanation and visual imagery then needs to be integrated and rehearsed in working memory for meaningful learning to take place. However, this is very inefficient in so far as only the visual channel is being engaged and the phonological loop (or auditory channel) is not being utilized. On the other hand, narration and animations, wherein the words and pictures correspond (this is the related principle of *temporal contiguity*), utilizes the dual channels of working memory and thus enables the learner's cognitive resources to be more effectively apportioned. Speaking with a "standard-accented" human voice (*voice principle*) in a personalized tone (personalization principle) sets up social norms that usually require the user to listen attentively and thus effective student learning is more likely to ensue. Finally, in terms of principles relating to the use of an audio narration, the *redundancy principle* states that a narrated animation plus the textual version is not as effective as presenting only the narrated animation.

The Visual Aspects of the Presentation

Many of the multimedia learning principles appear intuitive as they are often utilized effectively in classroom teaching. Nevertheless, their incorporation in online dynamic visualizations is often lacking. Two such principles relating to the visual organization of the presentation are the *spatial contiguity principle* and the *signaling principle*.

The *spatial contiguity principle* is concerned with having the words and corresponding pictures closely located to one another. Consequently the learner's visual attention need not be split between two sources of information that are not co-located, thus enabling easier integration of the visual and textual information. In the example below, the learner would need to go back and forth between the legend and the numeric labeling in the scenario on the right so as to integrate the information, thus unnecessarily wasting valuable time and cognitive resources. The correct incorporation of the spatial contiguity principle into the multimedia design is shown at left, wherein the text and imagery are co-located.

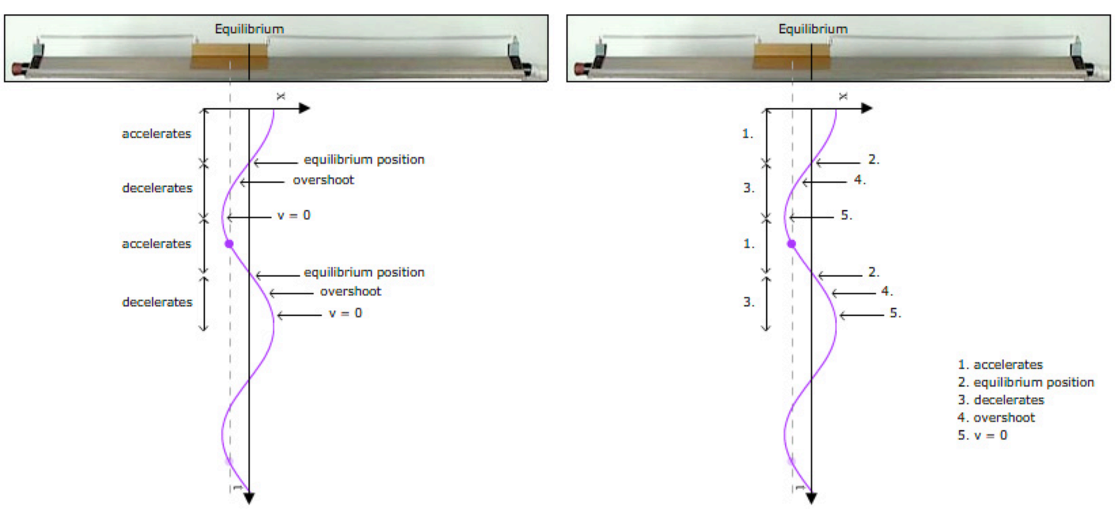

Figure 1: An example of an animation, with and without spatial contiguity of text and imagery.

The *signaling principle* basically states that people learn better when cues, letting them know where to focus their attention, are incorporated in the presentation. This technique usually takes the form of labels, arrows or highlighting. In the example below, the vertical movement of the bars is made more apparent by fading the background of all but one of the rods.

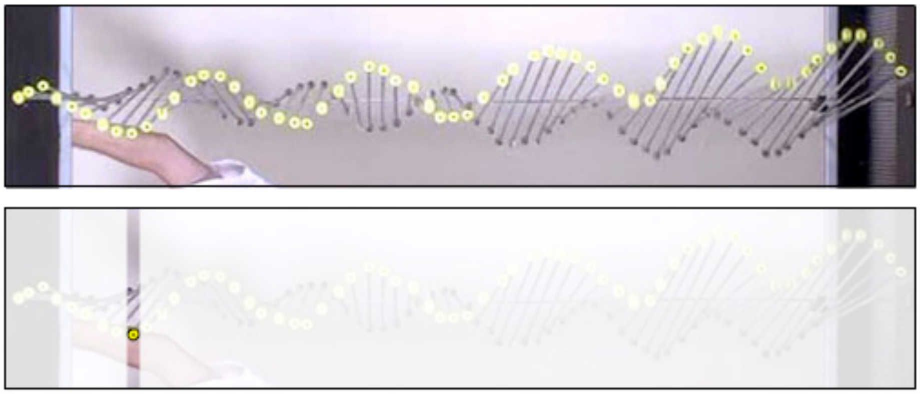

Figure 2: An example of an instructional video, with and without signaling.

The coherence principle is more concerned with what should be left out of the animation. Basically, anything that doesn't have to be included, such as background music and interesting but irrelevant information, should be left out of the design so as to ensure that what remains "gels together".

The Sequencing of the Knowledge

The final two principles referred to by Mayer (2008) are the *Segmentation* and *Pre-training Principles* which both rely on providing information in stages. The *Segmentation Principle* basically states that small re-playable segments are better for student learning than one continuous whole. By only replaying the more difficult sections the user is able to better utilize his time.

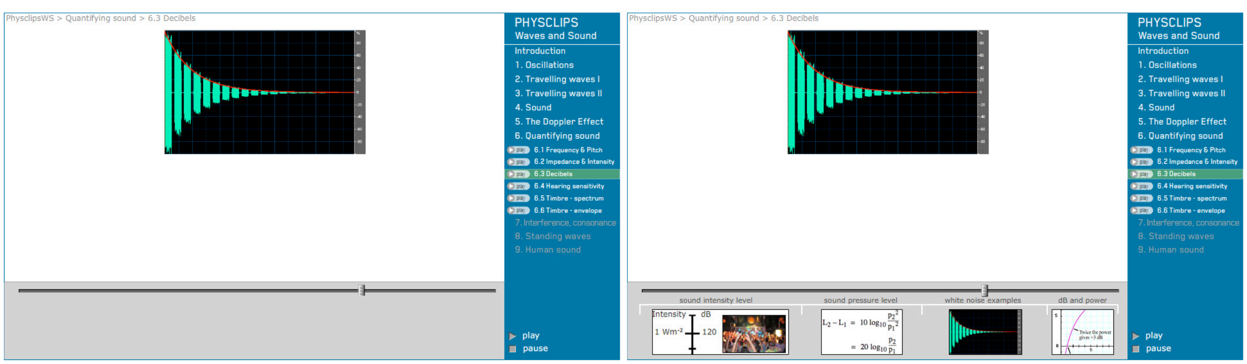

Figure 3: The version on the right shows the incorporation of visual cues under the scrollbar that show the learner where the conceptual boundaries for re-playable segments can be located.

The *Pre-training Principle* basically states that students perform better when the the characters and events of a multimedia message are introduced to the student prior to the learning task.

Animations and Real World Techniques

Here we use film clips as a first option when designing dynamic visualizations as video shows what actually happened. Animations and graphs are often incorporated as overlays or ancillary representations as they can visually represent scalar quantities that are normally invisible. This dual-representation effectively allows the novice to view the scientific phenomena through the "eyes" of an expert.

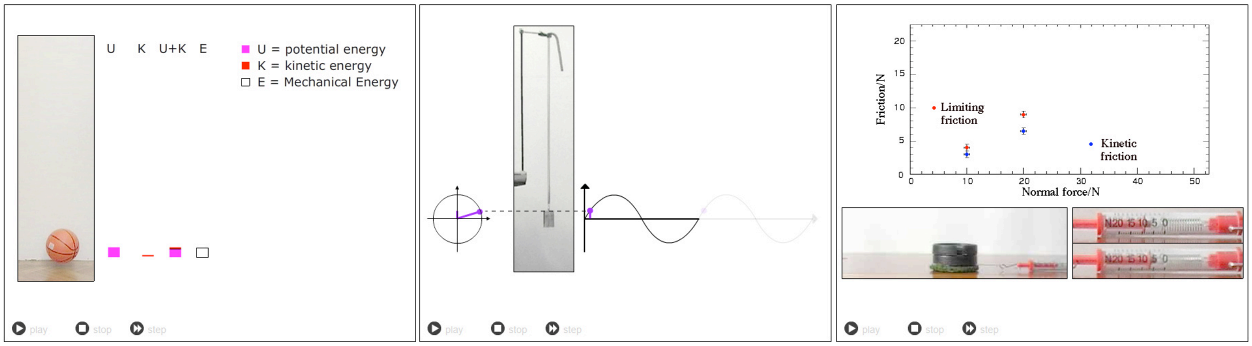

Figure 4: Several examples taken from Physclips that demonstrate the use of video in conjunction with animations.

Primary School Science – The Glimpses of Science Project

This project revolves around a set of multimedia-enhanced hands-on science activities that were designed for young school children. The topics covered include sound, energy, light and the pendulum. The catalog of resources can be found on the project website at http://www.phys.unsw.edu.au/primary-school-science/. The multimedia is designed to be used in conjunction with teacher's background notes which are available for download.

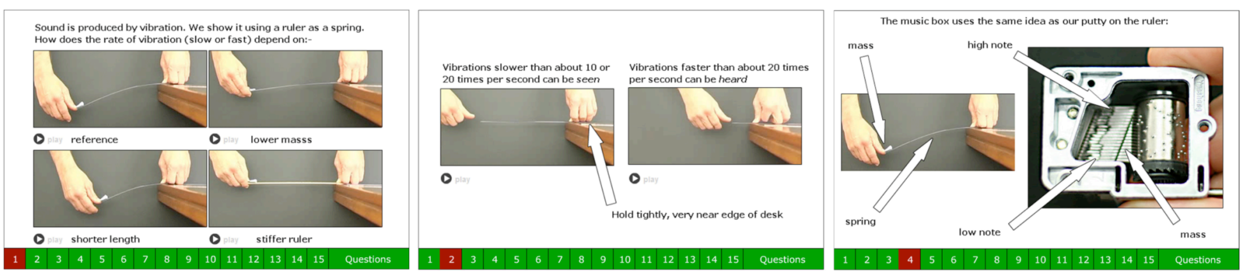

Figure 5: Hands-on science activities are demonstrated in a visual manner through a sequence of interactive slides.

The lessons involve "stepping" the students through a sequence of inter-related activities in a pre-arranged (logical) manner. The multimedia visualizations are presented in a manner akin to a slide show whereby each slide contains visual material in the form of film clips, animations and/or stills. This step-at-a-time approach provides adequate segmentation so as to ensure that the student's cognitive resources are not overwhelmed (Mayer and Moreno 2003).

Designing Instructional Videos and Animations (DIVA)

The DIVA resource is being developed to incorporate examples including those above (mostly from http://www.animations.physics.unsw.edu.au/educational-animations/) to be worked with interactively in association with a downloadable worksheet. This approach guides teachers through key cognitive design principles whilstthey are iteratively working on a blueprint to be implemented in their own context. The final stage of co-designing the animation in collaboration with a media producer may be reliant upon the institutional resources available to the teacher. Nevertheless the process undertaken will inform the participants with regard to choosing, embedding and designing dynamic visualizations within an educational environment.

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