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Designing Physics Video Hooks for Science Students

McHugh, M. 1*, McCauley, V. 1

1School of Education, College of Arts, Social Sciences, & Celtic Studies, National University of Ireland, Galway, Ireland.

*corresponding author: email address: m.mchugh2@nuigalway.ie

Abstract

This article offers an insight into the design structure of physics video hooks that were developed by the Science Education Resource design team in the School of Education (SOE) in National University of Ireland, Galway (NUI Galway). A hook, is an instructional technique used to stimulate student attention (Hunter 1994, Lemov 2010), interest (Jewett Jr 2013) and engagement (McCrorry 2011, Riendeau 2013). The physics video hooks followed a design framework that is illustrated below by breaking down the Centre of Gravity (COG) hook. Various design principles and elements embedded within the COG hook are presented with examples and the time they occur within the video. The intention of this article is that the design can be replicated and modified to aid teachers and designers in the development of a multitude of classroom based multimedia resources.

Introduction

In 2012, the SOE in NUI Galway set out to create innovative science hook videos for Irish science students (age 12 – 15) based on the Irish Junior science syllabus. The video hooks were developed by a collaborative project team comprising of lecturers and students on initial teacher education programmes within NUI Galway. These former courses are initial teacher education programmes within NUI Galway. The hook videos offer science teachers a collection of resources that capture novel and engaging aspects of syllabus based science topics. They are primarily directed at secondary science students (11 – 15), although have applications at other tiers of science education. As part of this project, the first author and another science teacher were recruited to design ten physics hooks. This article delineates the specific design strategy used in their creation. The design is broken down and presented in this article to aid teachers in designing classroom orientated multimedia. The overarching theoretical principles used in the video hook design can be adapted to any form of classroom resource, from PowerPoint presentations to interactive computer simulations. The design is illustrated by reverse engineering various aspects of the COG hook. All of the hooks can be
Development

The development of the hooks took place over the course of an eight week collaborative project. Videos were based on a series of relevant topics from the Irish Junior science curriculum. Before filming, physical phenomena were tested and verified in the laboratory to establish their ease of use and visual suitability. Once testing was finished, a list of ten physics based topics with ten storyboards were developed. These included: atmospheric pressure, centre of gravity, conservation of energy, convection, density, energy conversions, friction, pressure, sink or float and sound. The videos were then filmed by a professional camera man and directed by team members over two days in a laboratory setting. The model of camera used was a Canon 7D. The videos were edited using Adobe Premier Pro CC.4.

In terms of the development and design of the COG hook specifically, the aim was to take objects that don’t intuitively balance and put them together. The ideas and visuals were identified from internet searches and again, testing in a laboratory setting. The ideology behind the COG hook was to trigger pupil’s interest and to get them thinking about the COG of different everyday objects. The hook attempts to use the ‘wow factor’ to draw pupils’ attention. None of the balancing items look like they should balance and the experiments keep getting bigger and better as the video continues. This is the simple explanation of why the video acts as a hook, however, the complex design strategy behind the COG video is illustrated in the following sections.

Design Principles

Facilitation of cognitive processing with multimedia is a function of how media is designed (Gilbert 2005). Facilitation of cognitive processing refers to the quality of presentation. Lack of quality in place of excess quantity leads to the student being bombarded with too much information. This in turn leads to a lack of comprehension (Gilbert 2005). One needs to be strategic in the design of instructional presentations so as to achieve a particular learning outcome (Gilbert 2005). Cognitive load theory suggests that the capacity of working memory or the amount of information the mind can process at any time is limited (Mayer and Moreno 2003). This situation is known as cognitive overload (Mayer and Moreno 2003). Hence, if a learning activity requires too much of this capacity, learning will be hampered. It is suggested
the design of instruction should be optimised to avoid cognitive overload (De Jong 2010). This is described by Mayer and Moreno (2003, p. 45) as a “central challenge for instructors”. To reduce cognitive load, the hook design was aligned with the principles of cognitive load theory and multimedia learning. The following delineates how the principles were embedded into the COG hook.

The most efficient way an instructional designer can reduce cognitive load is by streamlining the video content. In accordance with recommendations from Mayer and Moreno (2003) and Berk (2009), the hooks had any extraneous material removed allowing for a clear logical sequence of events. This is known as the redundancy effect where redundant information can interfere with learning as it augments working memory load (Kalyuga et al. 1999). The COG takes a minimalist approach with the removal of irrelevant information. Within the COG hook, (Figure 1) streamlining was achieved through a slow and deliberate build up from a small scale experiment with the fork, spoon and toothpick to the larger scale experiment with the sledgehammer and metre stick. The three experiments featured operate on the same principle, however, the visual simply becomes more impressive as the video progresses.

**Figure 1: Build up in the video from small scale experiments to larger ones (0:11 s, 0:41 s, 1:12 s).**

Streamlining was also achieved by limiting words and narratives within the hook. When words or narratives were used, they helped direct the learner’s attention to the relevant content (Spanjers et al. 2011). Throughout the hook, the narration is brief. Three questions are posed in the video before each experiment.
Narrative cues orient the student through the video and facilitate the extraction of essential information. Such design techniques reduce cognitive load as the learner does not have to try to figure out the most vital aspects intended for comprehension (Mayer and Moreno 2003). Moreover, as suggested by Berk (2009) and Mayer (2008) the narrative was written in everyday and non-scientific language.

To further reduce cognitive load, the hooks were also aligned (where appropriate) with the principles of multimedia learning. The COG hook was specifically aligned with the split-attention principal of multimedia learning. This principle states that words should be delivered in an auditory manner rather than visually. Narration and visual information are processed in different systems of the brain reducing reliance on a singular information delivery method (Mayer and Moreno 1998). It is argued that narration is beneficial to students as the human eye cannot be subject to concurrent information (Mayer and Moreno 2003). For example if the abundant narration was on screen, the student’s visual channel would be overloaded. If the video shows a sequence and the student has to read on screen text, this would create a split-attention effect. The learner’s eye is searching for where to look and is processing too much visual information. Humans can only attend to so much information at one time. Poorly designed media combinations result in poor comprehension as they compete for the same cognitive resources creating a ‘bottleneck’ effect on cognitive function (Sutcliffe 2012). The solution for the COG hook was to off load visual information using narration. Thus, the processing demands of the visual channel are reduced and moved to the audatory channel (Mayer and Moreno 2003, Sutcliffe 2012). This allows learners to focus on the relationship between the auditory working memory and the visual working memory (Mayer and Moreno 1998). Hence, narration was used during the majority of videos and on screen text was only used for labelling purposes when appropriate. Thus, narration formed an integral part of the COG hook design.

<table>
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<th>Time</th>
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<td>0:11 s</td>
<td>“How do you find the centre of gravity between a spoon a fork and a toothpick?”</td>
</tr>
<tr>
<td>0:40 s</td>
<td>“Now, let’s see if we can find the centre of gravity between a hammer, a ruler and a piece of twine.”</td>
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<tr>
<td>1:14 s</td>
<td>“Do you think this experiment would still work with a metre stick and a sledgehammer?”</td>
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Table 1: Narration used throughout the hook.
Design Elements

The hook design involved the examination of instructional techniques used to stimulate attention, interest and engagement. This produced a list of specific elements used in instruction to generate the aforementioned constructs. The goal was to find the techniques that could be embedded into the hook videos. This list had to be broken down into design elements that would translate effectively onto a visual medium. The design elements embedded into the COG hook are a) Relevance, b) Questioning and c) Discrepancy.

Relevance strategy

Osborne et al. (2003) state that without relevance, sustaining interest is difficult, if not impossible. Perceived usefulness in content, creates an inherent interest (Rotgans and Schmidt 2011) leading to motivation (Edelson and Joseph 2004). Relevance can be grounded in reality or based on fiction. In this way, it can be highly varied and it is difficult for a teacher or designer to know what will work most effectively for students (White 2010, Zahorik 1996). The relevance strategy employed within the COG hook was to use everyday objects. This is a recognition strategy that demonstrates how physical phenomena can be created at home. It can also be recreated by the teacher in class. Figure 1 exhibits the equipment within the hook. The three images can be found at 0:11 s, 0:41 s and 1:12 s respectively. The equipment was laid out and placed on screen for at least five seconds. This was to give students time to recognise the materials and potentially formulate a mental image of the equipment as the video is played.

Questioning Strategy

Questioning facilitates attention (Bergin 1999). Questions allow students to make their own inferences and connect concepts (Jewett Jr 2013). Within models of interest development, the first phase usually involves triggering interest. Questions provide a perfect basis for the triggering phase. The questions posed within the video are the same as the narration described in the previous section (Table 1). The questioning strategy was used to trigger attention and to direct students’ thinking processes towards the content of the video. It was also used to aid pedagogy, as teachers can pause the video and ask the students to formulate their own answers to the questions.
Discrepancy strategy

Discrepancy is a pedagogical methodology noted by a number of authors to stimulate interest and attention among learners (Thornton and Sokoloff 1998, Cakir 2008, Edelson and Joseph 2004, Bergin 1999). When employing this method, an educator presents an issue or topic that has associated misconceptions. Students often hold misconceptions that are at odds with scientific explanations (Broughton et al. 2010) which has been coined ‘children’s science’ (Duit and Treagust 2003). As the video presents discrepant events, it reveals a gap in a learners’ knowledge that may spark a flame of curiosity, inspiring interest (Bergin 1999, Edelson and Joseph 2004, Rotgans and Schmidt 2011). This is why it was built into the COG video (Figure 3). Reindeau (2013) is an advocate of discrepancy strategies. The author states “you are not looking for answers… you are trying to get the students so interested that they seek answers for themselves” (Reindeau 2013, p. 380). The three experiments within the video attempt to be novel and demonstrate an anomalous event that does not fit with the viewer’s cognitive structure. Since, the COG experiments should not make intuitive sense to the majority of viewers, it encourages interest in the scientific content.

Figure 3: Example of the discrepancy strategy (0:32 s, 1:10 s, 1:25 s).
Current Work and Concluding Remarks

The overall aim of the hooks project was to develop a resource for teachers that would gain student attention and interest while also being pedagogically friendly. This article demonstrates the application of various design principles and elements which informed the physics hook structure. By breaking down the design of the COG hook, it is hoped that readers will gain an insight into the planning and implementation behind the hook videos. It is endeavoured that other multimedia projects both on an individual and larger scale will benefit from, and advance the presented design theory.

The physics hooks are currently being tested by teachers in schools across Ireland as part of the primary author’s doctoral research.

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References


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