The effects of seductive details in an inflatable planetarium

Introduction
The planetarium has undergone an evolution in delivery (Yo, Chaplin, & Goldsworth, 2011). No longer do some planetariums use analog projectors to display the stars, but rather use digital projectors to create immersive cosmic environments on a grand scale using a multimedia format of images, video, sound, and narration (Rosenfield et al, 2010).

Does this new method of delivery provide a benefit to the audience? Are the strategies employed to instruct the audience effective? Which strategies, if any, deliver optimal learning conditions?

Cognitive theory of multimedia learning
Richard Mayer (2009) developed twelve principles of multimedia learning, known as the cognitive theory of multimedia learning or CTML, for dealing with learning based on the plethora of modern electronic delivery choices. CTML assumes that “people learn better from words and pictures than from words alone” (Mayer, 2009, p. 1). It was founded on the science of learning, which is a change in knowledge based on experience (Mayer, 2008).

Learning is comprised of three cognitive processes: (a) selecting relevant material, (b) organizing the material into understandable models, and (c) integrating the material with prior knowledge (Lusk, 2008).

CTML supposes three design elements. First, humans process material using dual-channels (Ozdemir, 2009); humans have one incoming channel for visual information and another for verbal information (Austin, 2009).

Secondly, humans have limited capacity for processing information while learning (Mayer et al., 2008). Think of each channel as a pipe. Each pipe has only a certain diameter through which material can pass through. If too much information is pushed through the pipe, the human mind rejects the extra material, and it is never learned.

According to CTML, material can be delivered through the auditory channel and through the visual channel without any limiting effect (Mayer et al., 2008). Looking at a diagram and reading accompanying text may overload the visual channel, while looking at the same diagram but listening to narration processes the material through dual channels resulting in effective learning (Mayer, 2009).

Finally, humans engage in active processing, which depends on the learner’s cognitive function (selecting, organizing, and integrating) at the time of learning (Harskamp et al., 2007). Learning can be a demanding experience. Cognitive load is the stress placed on the learner to acquire new knowledge and is limited by the available resources at hand (Lusk, 2008).

Fortunately, CTML has three major strategies to manage this stress (Harskamp et al., 2007). First, the instruction needs to reduce extra or unnecessary learning, known as extraneous processing (Mayer et al., 2008). Any extra processing within the human mind does not aid in the creation of mental models. Focusing on the relevant material provides less crowding of the dual channels involved in cognitive processing.

Second, instructors need to focus entirely on the main idea being taught and use successful learning strategies, referred to as essential processing (Park et al., 2011). The greater number of elements that need to be learned in a lesson, the higher the essential cognitive load.

Finally, the material needs to be presented in a manner that makes sense to the learner, often called generative or germane process-
ing. Generative processing is the mind’s ability to make sense, organize, integrate new material [schema acquisition], and is influenced by presentation design and focuses the learner to create mental models of the material (Lusk, 2008).

CTML forms the umbrella for twelve principles of designing instruction for multimedia education (Mayer, 2008). Excessive processing (unnecessary material) is reduced by (1) coherence, (2) signaling, (3) redundancy, (4) spatial contiguity, and (5) temporal contiguity principle (Mayer, 2009).

Essential processing (main idea) is managed by (6) segmenting, (7) pretraining, and the (8) modality principle (Mayer, 2010).

Generative processing (mental models) is fostered by the (9) multimedia, (10) personalization, (11) voice, and the (12) image principle (Mayer, 2009), see table 1.

Coherence principle/seductive details

Within the context of this study, the coherence principle was applied to student learning in an inflatable planetarium. The coherence principle states that people learn better when unnecessary information is omitted from instructional design (Austin, 2009). This needless material is referred to as seductive details (Lusk, 2008).

Seductive details may take the form of graphic narratives of people struck by lightning, while teaching a lesson about lightning formation (Mayer, 2009), or anecdotal stories involving sexual harassment (Towler, 2009).

According to CTML, the brain will use its limited cognitive resources and focus on the more interesting seductive details at the expense of the learning goal, commonly referred to as the seductive detail effect (Mayer et al., 2008).

The foremost theory for including seductive details in educational text is the arousal theory (Mayer, 2009). Arousal theory (Weiner, 1990, 1992) is the notion that students learn more effectively by being emotionally interested in the learning material.

This higher level of interest should translate into better attention and reward the learner with a better understanding of the material (McCrudden & Corkill, 2010).

Arousal theory is based on the model of knowledge transition—information is transferred from the teacher to the student, whereas CTML is based on the belief of knowledge construction—the students actively build the knowledge base in their own minds (Mayer, 2009).

It is believed that seductive details harm learning in three ways. First, seductive details divert the learner’s attention away from the learning goal and cause increased attention to be spent on the seductive details (Mayer, 2009). The learner focuses on the seductive details at the expense of the learning goal. Within a lesson, seductive details appear as interesting factoids designed to catch the attention of the student and possibly increase learning.

Second, seductive details disrupt the creation of mental models based on the learning goal (Ozdemir, 2009). Seductive details may insert themselves incorrectly into cause-and-effect chains (Mayer, 2009). This disruption in formation of a correct mental model is known as the coherence break hypothesis; seductive details break comprehension and interfere with the learner’s ability to construct accurate mental models of the learning goal (Lehman et al., 2007).

Third, the learner may incorrectly assume that the seductive details are the learning goals and construct their mental model around the seductive details, at the expense of the true learning goal (Mayer, 2009). This is referred to as the inappropriate schema hypothesis; the mental model is created around the seductive details and not the learning goal (Lehman et al., 2007).

In an attempt to increase retention of material learned in the planetarium, Fisher (1997) inserted humor related to pop culture every ninety seconds during a 15-minute planetarium lesson. The prediction was that humor would relax the participants and provide greater recall of the material.

Participants who did not experience the humor scored higher than those that did. In fact, the humor acted as a distraction and prevented the subjects from learning the material. The humor represented a seductive detail, interesting but irrelevant material that did indeed harm the learning goal (Bryant, 2010).

Research study

This study used an inflatable planetarium dome with digital projection to teach fifth grade elementary students astronomy concepts with and without seductive details. Lessons were constructed around National Science Education K-4 astronomy standards and California Fifth Grade Standards relating to astronomy (California Department of Education, 2009; National Academy of Sciences, 2012; Project 2061, 2012). The pre-test and the post-test, titled The Astronomy and Space Science Concept Inventory (ASCI), was designed by Project MOSART with funding from NASA’s Science Mission Directorate (#NCCS-706) and is specifically targeted for fifth grade students (see Appendix A) (MOSART, 2007).

Each question provided “distractor-driven” multiple-choice answers (DMC). DMC tests include popular misconceptions as provided answers, forcing the test taker to choose between a single correct answer and one or more research-identified misconceptions. In order for this project to be comparable to other CTML studies, reporting of problem-solving means and standard deviations are included along with an effect size (Mayer, 2009).

Lessons were created using Nightshade Astronomical Simulation, which is an open-source platform based on Stellarium Astronomical Simulation, but optimized for use in a planetarium (Nightshade, 2011).

Custom controls and instructions in the planetarium can be recorded and replayed using Nightshade's scripting language, known as Stratuscripts (Nightshade User Guide, 2010). Stratuscripts are an open-source set of computer commands used by the Nightshade Astronomy Simulator software to automate multiple routine directions, allowing the planetarium operator to focus on the audience and not on the equipment (Nightshade, 2011).

Two groups take part

Two groups participated in the planetarium lesson, with one group experiencing the experimental lesson embedded with seductive detail design elements and the other group participating in the controlled lesson without seductive details.

A total of fifty-six (n = 56) 5th grade students were selected based on: (a) attending the orientation, (b) taking the pre-test, (c) submitting a
had a harmful effect on learning. The mean score of the control group () was 55% and the mean score of the experimental group ) was 47%. By subtracting the experimental group () mean and dividing by the Pooled Standard Deviation (SDpooled) of 18 yields an Effect Size (d) of .4, see Equation 4. Effect Size is published as a value between 0 and 1, so the decimal equivalents were used in calculating.

Swaminathan, Horner, Rogers, and Sugai (2012) define effect size as measuring the magnitude of the opposing results using standardized units. A small effect would be less than .3, a medium effect would be greater than .3 but less than .8, and a large effect would be greater than .8 (Cohen, 1988; Mayer, 2009). If the effect size is large or medium then there is a relationship between seductive details and learning; conversely, if the effect size is small, then the relationship between seductive details and learning is quite small (Mayer, 2009).

When comparing the two post-test means, an effect size of .4 (d = 0.4) denotes that a medium effect was observed between the two post-test means. This suggests that the exclusion of seductive details had a medium-sized effect on learning. Student learning was harmed by the inclusion of seductive details. Placing this into perspective in regards to the post-test means, 20 students (71%) in the control group (n = 28) outscored the mean score for the experimental group. Only 10 students (36%) in the experimental group (n = 28) outscored the mean score for the control group, indicating that the control group performed significantly better with the exclusion of seductive details.

Table 1 - CTML Design Principles (Mayer, 2009)

The data also provided an answer to the research questions by demonstrating that CTML, when applied to planetarium instruction, does cause an increase in learning and that seductive details do have a negative effect on learning.

These results are in line with the predictions of CTML (Mayer, 2009), that the control group (no seductive details) will outperform the experimental group (seductive details included) on assessment performance tests and that the inclusion of seductive details may have increased student attention, but this increase in attention did not translate into higher test scores.

The evidence for this conclusion is the increase in the post-test mean scores between the experimental group ( = 47%, sd = 22) and the control group ( = 55%, sd = .14). This increase can be summarized by the size of the effect (d = 0.4) between the two groups.

With these results in mind, it is reasonable to conclude that planetarium instruc-

was designed without any distracting seductive details.

The lesson presented to the experimental group contained the exact same design elements with the inclusion of seductive details. These seductive details were represented by 53 images and approximately 27 deviations from the control lesson script. These extra seductive details translated to an additional three minutes of instruction, for a total run time of approximately 37 minutes (see Appendix C).

On average, a seductive detail image interrupted the lesson every 40 seconds and script deviations were experienced every 78 seconds.
The effect of seductive details do have a negative effect on instruction.

References


