

Apps and Animations: Choosing Web-based Demonstrations to Support Student Learning

Mark Holden

The University of Western Ontario, mholde3@uwo.ca

Alexandra Twyman

The University of Western Ontario, atwyman3@uwo.ca

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Summary

Over the past decade, the prevalence of mobile devices (e.g., smartphones, tablets, laptops) on university campuses has skyrocketed. A 2015 survey shows these technologies are quickly becoming ubiquitous in the classroom, with 87% of university students using laptops and 64% of students using smartphones on a weekly basis to complete their schoolwork (Pearson, Harris Polls, 2015). These same students also agree that tablets will transform university learning in the future (83%), that mobile technology makes learning more fun (79%), and helps students perform better in class (68%); in addition, 40% of university students would like to use mobile technologies in classes more often than they do now, while only 13% would like to use mobile devices less often (Pearson, Harris Polls, 2015).

Mobile devices seem to tantalize both students and educators alike with the promise of enhanced student learning including tailored content, instructional methods based on the needs of individuals, interactive engagement with the material, exploration beyond the classroom, and connections to the material unrestricted by time or location. The goals of teaching-related apps and animations are obvious: to generate student interest in a topic, promote student engagement, concretize abstract principles, and to enhance student learning. However, the small-but-growing body of research on the use of apps and animations has suggested that all are not created equal, particularly with respect to the ultimate goal of enhancing student learning (e.g., Tversky, Morrison, & Betrancourt, 2002). Several reviews have reported mixed findings with respect to the effects of mobile technology on student learning, with some suggesting that it enhances learning (Hwang & Wu, 2014) and others finding few significant benefits in learning outcomes (Cheung & Hew, 2009). Some studies have even shown that objective measures of student learning of critical concepts are actually *impaired* by the use of animations or computer-based demonstrations of these concepts (Copeland, Scott, & Houska, 2010; Mayer, Hegarty, Mayer, & Campbell, 2005).

The purpose of this workshop is to introduce participants to some of the research exploring the use of apps, animations, and demonstrations (e.g., participation in a classical experiment on visual perception) in university-level courses, with a focus on identifying the characteristics that separate the good from the bad in terms of student learning measures. The ultimate goal is to provide guidelines that will help educators better identify those apps, animations, or other instructional technologies that will be most beneficial in terms of encouraging deep student understanding of course material. Much of the material in this workshop is drawn from research in education and psychology, but the principles that we discuss would apply to almost any domain.

Keywords

mobile technology; computer animations; apps; multimedia; student learning

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Apps and Animations: Choosing Web-based Demonstrations to Support Student Learning

Mark Holden and Alexandra Twyman, The University of Western Ontario

SUMMARY

Over the past decade, the prevalence of mobile devices (e.g., smartphones, tablets, laptops) on university campuses has skyrocketed. A 2015 survey shows these technologies are quickly becoming ubiquitous in the classroom, with 87% of university students using laptops and 64% of students using smartphones on a weekly basis to complete their schoolwork (Pearson, Harris Polls, 2015). These same students also agree that tablets will transform university learning in the future (83%), that mobile technology makes learning more fun (79%), and helps students perform better in class (68%); in addition, 40% of university students would like to use mobile technologies in classes more often than they do now, while only 13% would like to use mobile devices less often (Pearson, Harris Polls, 2015).

Mobile devices seem to tantalize both students and educators alike with the promise of enhanced student learning including tailored content, instructional methods based on the needs of individuals, interactive engagement with the material, exploration beyond the classroom, and connections to the material unrestricted by time or location. The goals of teaching-related apps and animations are obvious: to generate student interest in a topic, promote student engagement, concretize abstract principles, and to enhance student learning. However, the small-but-growing body of research on the use of apps and animations has suggested that all are not created equal, particularly with respect to the ultimate goal of enhancing student learning (e.g., Tversky, Morrison, & Betrancourt, 2002). Several reviews have reported mixed findings with respect to the effects of mobile technology on student learning, with some suggesting that it enhances learning (Hwang & Wu, 2014) and others finding few significant benefits in learning outcomes (Cheung & Hew, 2009). Some studies have even shown that objective measures of student learning of critical concepts are actually *impaired* by the use of animations or computer-based demonstrations of these concepts (Copeland, Scott, & Houska, 2010; Mayer, Hegarty, Mayer, & Campbell, 2005).

The purpose of this workshop is to introduce participants to some of the research exploring the use of apps, animations, and demonstrations (e.g., participation in a classical experiment on visual perception) in university-level courses, with a focus on identifying the characteristics that separate the good from the bad in terms of student learning measures. The ultimate goal is to provide guidelines that will help educators better identify those apps, animations, or other instructional technologies that will be most beneficial in terms of encouraging deep student understanding of course material. Much of the material in this workshop is drawn from research in education and psychology, but the principles that we discuss would apply to almost any domain.

KEYWORDS: mobile technology; computer animations; apps; multimedia; student learning

LEARNING OUTCOMES

By the end of this workshop, participants will be able to:

- Identify the potential promises and pitfalls of mobile learning, compared to more traditional teaching methods.
- Critically evaluate computer- and web-based animations, apps, and other technologies for their value in terms of student learning outcomes. (For example, cognitive psychology instructors might use web-based demonstrations of well-known experiments or effects).

- Avoid demonstrations that introduce extraneous processing demands that detract from student learning, and identify demonstrations that promote generative processing and support deep understanding among students.
- Incorporate active learning strategies when using these apps, animations, or demonstrations in the classroom, so as to maximize the value of these technologies for student learning.

REFERENCE SUMMARIES

Diliberto-Macaluso, K., & Hughes, A. (2016). The use of mobile apps to enhance student learning in Introduction to Psychology. *Teaching of Psychology, 43*, 48-52.

Students from two different sections of Introduction to Psychology were required to complete a worksheet on the topic of the human brain and central nervous system. The worksheet included diagrams to label and multiple choice questions covering topics such as the functions of different regions of the brain or disorders associated with these areas. Students in one section of the course completed the worksheet while using an interactive 3D brain app, while students in the second section completed the worksheet using their online course textbook. A pre-test was administered to each group prior to the worksheet activity to ensure that they were well-matched in terms of prior knowledge, and a post-test was administered at the beginning of the class following the worksheet activity. Student learning was assessed by comparing the difference in pre- versus post-test scores. In addition, students were asked to rate their enjoyment of the worksheet activity (using either the online textbook or the 3D brain app).

The results demonstrated that the students using the app scored significantly higher on their post-test than the pre-test. Furthermore, this improvement occurred for both labelling and multiple choice questions. In contrast, students using the online textbook did not show an overall improvement from pre- to post-test. There was a significant improvement on the labeling measure, but this was offset by a minor deficit for the multiple choice questions. Comparing the two groups, there was a significant difference in the increase in performance (favoring the App group) for both the multiple choice and overall score measures. There was no difference between the groups in terms of overall enjoyment though the authors suggest that this may be due to the fact that online platforms were used for both groups.

This article will serve as the introduction to the session because it provides an excellent introduction to the use of apps as a pedagogical aid to enhance student learning and functions as a “good” example of using apps in the classroom. It is also important to emphasize that, as the authors note, they used a learner-centered approach which sought to integrate technology into the classroom, and designed their worksheet activity around specific learning objectives. That is, in incorporating technology, the researchers did not simply ask students to “mindlessly” take notes to a lecture using laptops, but rather students were encouraged to use their mobile devices to label, summarize, and discover new knowledge. This study incorporates many of the themes that will be discussed during the workshop (e.g., careful selection of apps, active student engagement, etc.).

Copeland, D.E., Scott, J.R., & Houska, J.A. (2010). Computer-based demonstrations in cognitive psychology: Benefits and costs. *Teaching of Psychology, 37*, 141-145.

Students from an upper-level cognitive psychology course participated in online demonstrations of six lecture topics. On topic, for example, is a famous effect in cognitive psychology whereby an individual has difficulty naming the ink color of a word, if that word spells out a different (incongruent) color;

essentially, reading interferes with the desired response for the task (the Stroop Effect). The online demonstrations involved students participating in versions of the original experiments so that they would have first-hand experiences with the effects and be able to compare their performance with the results of the original study.

For a given concept, the whole class read a book chapter, while half of the class also participated in an online demonstration of that concept. All students participated in the reading-only condition for three topics and in the reading/demonstration condition for another three topics. Student learning was assessed through one-page essays handed in at the end of each topic, through short-answer quizzes at the end of each topic, and through multiple choice exam questions. In addition, students were asked to rate their enjoyment, perceived degree of learning, and time spent on readings for each of the conditions.

The results show that students enjoyed participating in the demonstrations and believed that they learned more from the demonstrations than from reading alone. However, the objective measures of learning showed that students did *not* benefit from participating in demonstrations. For two of the three measures, participating in the computer-based demonstrations led to significantly *worse* performance compared to the reading-only conditions. The authors suggest that this may be due to students' mistaken belief that sufficient learning occurs simply by participating in the demonstrations, leading them to expend less effort toward the readings.

Based on these results, the authors make several suggestions for improving the use of computer-based demonstrations to facilitate student learning. These include a) using demonstrations that can be performed at home at the convenience of the student, b) better integrating text within the context of the demonstration, c) making the demonstrations optional, and d) emphasizing to students that completing the demonstration is *not* a substitute for reading, but rather is a supplement to the reading. Given the surprising results with respect to student learning when using this form of online participation/demonstrations, this article will be used as an example to demonstrate not all apps, animations, or demonstrations are beneficial to student learning. Furthermore, it is not immediately obvious which will be a benefit and which will be a hindrance to student learning. This will lead into discussion of how we can differentiate good from bad, particularly focusing on the suggestions from the following two references. Later in the workshop, when discussing active learning strategies and other methods to improve learning when using similar demonstrations (or apps or animations), we will return to this paper to discuss the authors' suggestions outlined above.

Mayer, R.E., Hegarty, M., Mayer, S., & Campbell, J. (2005). When static media promote active learning: Annotated illustrations versus narrated animations in multimedia instruction. *Journal of Experimental Psychology: Applied*, *11*, 256-265.

Although several studies have examined the use of animations versus static figures, many of these comparisons have not used information-equivalent displays (see Tversky, Morrison, & Betrancourt, 2002 for a review). Here, the authors address this weakness by comparing narrated animations with annotated illustrations that contain the same information (i.e., both conditions contained the same words, and the static images were multiple, key frames from the animation). Four experiments are presented, covering four different content areas (lightning and ocean wave formation, toilet tank operation, and brake systems). Learning outcomes were measured both with a retention test (recall) as well as a transfer test (applying similar principles to a new problem). In all four experiments, and in all tests, participants in the computer animation condition never scored higher than the static figures

group. However, participants who viewed static figures scored significantly higher on four of the eight tests. The authors argue that these results arise from several factors that may favor well-chosen static figures. First, the series of static images were presented simultaneously, allowing participants to look back-and-forth and note key differences from one frame to the next; in contrast, animations are, by their very nature, fleeting and may require one to hold previously-viewed images in memory for similar comparison. Secondly, well-chosen static figures present only those frames that distinguish major changes in state; this may act as a signal cue to the reader to attend selectively to these more pertinent changes, relative to animations which rarely highlight critical changes from less pertinent ones. Thirdly, the authors suggest that static figures require generative (i.e., active or deep) processing of information, because readers are encouraged to explain the changes from one frame to the next, as opposed to passively viewing these changes.

The authors interpret these results with respect to Mayer's (2011) Cognitive Theory of Multimedia Learning (described below). This paper will serve as an introduction to the differences between good and poor animations, and some of the key differences will be discussed in the workshop before moving on to discussing Mayer's Cognitive Theory. Facilitators should first emphasize the authors' suggestions for animations, with the goal of developing and/or selecting animations that will retain their positive features, but also tap into the positive features of static illustrations. For example, learners might be given control over the pace and order of animations through the use of a slider bar or they might be guided through key steps by segmenting the animation into meaningful chunks, separated by a key-press. The authors also offer suggestions to manage the cognitive overload caused by introducing extraneous detail to many animations (e.g., minimize eye-catching graphics that may distract learners from the critical points).

Based on these results, a major theme of this workshop will focus on how to select apps or animations that reduce extraneous processing demands, as these demands necessarily pull student attention away from course-relevant content and therefore detract from learning. An example of these extraneous processing demands might be flashy and unnecessary components in an animation (e.g., explosions that accompany ion movement across a cell membrane during an action potential) which draw attention away from the critical processes. This theme will also be highlighted in one of the group workstations during the workshop. Participants will compare and contrast a flashy animation of an action potential with a more subdued version in which they have control over the timing (a slider bar), and with static images taken from the second animation. After experiencing these animations for themselves, participants will briefly discuss their observations before the facilitator reviews the results and conclusions of this study.

Mayer, R.E. (2011). Applying the science of learning to multimedia instruction. *Psychology of Learning and Motivation*, 55, 77-108.

This is an excellent review article in which Mayer outlines his Cognitive Theory of Multimedia Learning (see also Clark & Mayer, 2016). This theory is largely based on three well-established principles of cognitive psychology: 1) the *dual channel principle* states that individuals have separate channels for processing words and pictures; 2) the *limited capacity principle* notes that individuals can only engage in a limited amount of processing in each channel at one time; and 3) the *active processing principle* is that meaningful learning outcomes depend on learner engagement and active cognitive processing. The theory also describes three types of cognitive processing that individuals typically engage in when learning from multimedia sources. *Extraneous processing* is that which does not serve the instructional objective (e.g., irrelevant graphics that draw attention away from the objective), *essential processing* is

that which is required to mentally represent the material and is caused by the complexity of the material, and *generative processing* is required to make sense of the material (e.g., relating it to pre-existing knowledge, or mentally re-organizing material). In order to facilitate deeper learning, the goal of multimedia demonstrations and visualizations, therefore, should be to reduce extraneous processing, manage essential processing, and to foster generative processing.

The majority of the article delves into the 12 principles of multimedia design that Mayer and his colleagues have identified through experimentation over the past 20 years. Each of these principles addresses at least one of the goals mentioned above. For example, the *Coherence Principle* essentially states that people learn better when extraneous words, images, or sounds are excluded and, as such, directly addresses the goal of minimizing extraneous processing.

The applicability of Mayer's Cognitive Theory of Multimedia Learning to this workshop is self-evident. Many of the ideas addressed in the other key references of this workshop (e.g., promoting active learning during classroom demonstrations; Crouch et al., 2004) dovetail perfectly with the principles identified by Mayer. As such, his theory will form the backbone for the workshop's didactic component. A handful of the 12 principles will be demonstrated (at least one from each of his three goals for effective multimedia demonstrations) at different workstations (see Presentation Strategies section). Participants will also be provided a link to a website that briefly summarizes Mayer's 12 principles, their effect on student learning, and conditions under which they may be especially important.

Balch, W. (2012). A free-recall demonstration versus a lecture-only control: Learning benefits. *Teaching of Psychology, 39*, 34-37.

While the above papers present strong evidence that not all classroom demonstrations lead to increased learning, it is also important to recognize that it is equally true that not all demonstrations are poorly-conceived. Here, Balch presents a well-designed classroom demonstration of well-known effects in memory (i.e., the primacy and recency effects). Students were randomly assigned to come to class at two different times. One group of students participated in a memory demonstration with debriefing in which they attempted to learn a word list; their pattern of recall demonstrated the primacy effect. The second group of students received the same information as was in the debriefing, but did not participate in the demonstration. Instead, in the lecture condition, the instructor simply described the typical pattern of results. The time spent on learning the effect was approximately equal between the two groups.

Both groups were tested on their knowledge of relevant information in a 14-item multiple choice pre-test (taken during the previous class), as well as the identical test as a post-test (taken during the subsequent class). The results clearly show that, while the two groups did not differ in terms of their pre-test scores, those students that participated in the demonstration scored significantly higher on the post-test than those that received the lecture alone.

Balch suggests that this demonstration is particularly effective because it provides a social learning environment, which may increase student engagement (e.g., through friendly competition to see who will remember more). Furthermore, he argues that this type of demonstration allows for direct interaction between the instructor and students, and that the immediacy of the instructional content (i.e., it is temporally paired with the demonstration) may serve to facilitate student learning.

This study serves to demonstrate the power of effective classroom demonstrations on student learning outcomes. Furthermore, it identifies specific characteristics that contribute to its efficacy. Because this activity is easily administered in any size of class, this workshop will include a modified version of this activity (constrained slightly for time) as well as a brief group discussion about what made the demonstration effective. This will serve as segue to discussing the final theme of the workshop: how to incorporate active learning strategies when using demonstrations, apps, or animations in the classroom, so as to maximize the value of these technologies for student learning.

Crouch, C.H., Fagen, A.P., Callan, J.P., & Mazur, E. (2004). Classroom demonstrations: Learning tools or entertainment? *American Journal of Physics*, 72, 835-838.

The final paper outlined here details the importance of active learning strategies when using classroom-based demonstrations. In this study, students in an introductory physics class observed several demonstrations of physics principles during a lab component. Students either a) viewed the demonstration and received the instructor's explanation (traditional demonstration condition), b) made predictions first (prediction condition), or c) made predictions, observed the demonstration, discussed it with other students, and then heard the instructor's explanation (discussion condition). Student learning in each condition was compared to a control condition in which students did not see the demonstration at all. All students participated in each condition (including control) approximately equally. On their final exam, students were asked to predict the outcome of situations very similar to those demonstrated in class, and follow-up questions probed student understanding of the underlying physics.

The results indicated that students in the traditional demonstration condition displayed no greater understanding of the underlying concepts than students who did not observe the demonstration at all (control group). In contrast, both the prediction and the discussion groups showed significant gains in student learning and comprehension compared to both the control and the traditional demonstration conditions. There was also a slight difference in student learning between the prediction and discussion groups, although the authors suggest that the time cost for including group discussion may outweigh the modest gains for that group over the prediction condition.

Although this paper deals with subject matter outside of psychology, the results and conclusions may be more widely applicable. Specifically, the authors argue that asking students to make predictions *before* viewing a demonstration encourages student engagement and promotes active learning. This, in turn, they argue, is what leads to increased conceptual understanding. Critically, the time taken to add the prediction component (using clickers, in this study) was only 2 minutes compared to the traditional demonstration condition, yet it quadrupled the degree of improvement relative to the controls.

As with the preceding paper, the results of this work will help to provide examples for the final theme of the workshop: incorporating active learning strategies when using demonstrations, apps, or animations in order to maximize their effectiveness in terms of student learning. This theme will also be highlighted in one of the group workstations during the workshop, as participants compare and contrast two demonstrations, derived from this study, either with or without an active learning component. Following these demonstrations, we will discuss observations and briefly review the results and conclusions of this study.

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CONTENT AND ORGANIZATION TABLE

Duration (MIN)	Subject	Activity	Purpose
10	Introduction to the Costs and Benefits of Using Demonstrations	<p>Draw on the work of Diliberto-Macaluso & Hughes (2016), Copeland et al. (2010), and Mayer et al. (2005) to convey that apps, animations, and web-based demonstrations may be beneficial in some instances, but that they are not always effective in enhancing student learning.</p> <ul style="list-style-type: none"> Emphasize Copeland et al.'s (2010) results showing that student learning was significantly worse for those who both read the text and participated in an online demonstration, compared to those who only completed the reading. Stress that student perceptions of learning or enjoyment may not reflect true learning. 	Challenge the idea that all demonstrations promote learning, and to introduce the central question of the workshop: <i>“What makes an effective demonstration?”</i>
15	Group Discussion: What Makes an Effective Demonstration? (Part I)	<p>Ask participants to think about their best and most challenging experiences with apps, animations, or other forms of computer-based demonstrations, from either the instructor or student perspective.</p> <ul style="list-style-type: none"> Have participants share the characteristics that made the best demonstrations memorable and the poor demonstrations frustrating. Record participant contributions. Try to phrase characteristics in terms that relate to Mayer's (2011) principles (see Presentation Strategies). 	Identify characteristics of effective demonstrations through self-reflection.
30	Workstation Activity: Comparing Demonstrations	<p>Break participants into small groups of 4-5 individuals and assign each group to a specific workstation.</p> <ul style="list-style-type: none"> At each workstation, groups will read a short description that introduces a specific topic (e.g., resting and action potential) and review two apps, animations, or web-based demonstrations, each of which depicts the phenomenon. One animation should follow 	<p>Identify additional characteristics of effective demonstrations by modelling the student learning experience for participants.</p> <p>Provide a resource (the handout) that can be used as a guide when evaluating future apps, animations, or web-based demonstrations</p>

		<p>several (if not all) of Mayer's (2011) principles, while the other will not.</p> <ul style="list-style-type: none"> Instruct groups to critically evaluate the paired demonstrations, identifying the positive and negative characteristics of each. Provide discussion questions (Appendix A) to facilitate the group conversation. Encourage participants use these guidelines in any future course plans. 	<p>for use in a class.</p>
15	<p>Group Discussion: What Makes an Effective Demonstration? (Part II)</p>	<p>Ask each group to report on the demonstrations they viewed. Have them focus on characteristics that distinguished the effective demonstration from the ineffective demonstration.</p> <ul style="list-style-type: none"> Record the summary contributions from groups, adding characteristics to the list that was started in the previous discussion. Again, contributions should be phrased in a way that connects to Mayer's (2011) principles. 	<p>Identify additional principles of effective multimedia design and add to the list from the previous activity.</p> <p>Emphasize that identifying effective demonstrations involves more than simple common-sense or brief introspection.</p>
25	<p>Mayer's Cognitive Theory of Multimedia Learning</p>	<p>Outline Mayer's (2011) Cognitive Theory of Multimedia Learning.</p> <ul style="list-style-type: none"> Cover key concepts like the <i>dual channel principle</i>, the <i>limited capacity principle</i>, and the <i>active processing principle</i>. Describe the concepts of <i>extraneous</i>, <i>essential</i>, and <i>generative processing</i>, including the pedagogical goals reducing extraneous processing, managing essential processing, and fostering generative processing. Define the 12 principles of multimedia design, relating each to one of the goals above (see Tables 3-5 in Mayer (2011) and the Presentation Strategies section). <p>As part of a large group discussion, ask participants to identify which principles may have been present (or absent) in their</p>	<p>Provide a framework that organizes the principles identified through class discussion, and identify additional principles that have not yet been discussed.</p>

		personal experiences with computer-based demonstrations. Then use the think-pair-share method to encourage participants to identify which principles were most relevant to the demonstrations viewed during the workstation activity.	
20	Making Demonstrations Effective for Student Learning through Active Learning	<p>Emphasize that apps, animations, and web-based demonstrations are most effective for student learning when students engage with them through planned/structured active learning activities.</p> <ul style="list-style-type: none"> • Describe suggestions for active learning proposed by Copeland et al. (2010), Mayer et al. (2005), Balch (2012), and Crouch et al. (2004). E.g., asking students to make predications or provide explanations when interacting with a demonstration. • Ask participants to brainstorm and discuss how active learning strategies and principles of multimedia design could be combined to facilitate student learning. 	Provide a model (active learning) for effectively incorporating apps, animations and web-based demonstrations into university-level classrooms.
5	Conclusion	Remind participants that they now have the skills to choose the best versions of the available apps, animations, or web-based demonstrations regardless of how the technology changes or their field of study.	Wrap up the workshop and motivate participants to incorporate effective demonstrations into their future teaching.
Total Time: 120 minutes			

PRESENTATION STRATEGIES

Pre-Workshop Preparation

Because the topic of this workshop would apply well to many disciplines, we recommend that apps, animations, and web-based demonstrations are chosen with respect to the discipline or subject matter of interest to the workshop participants. Examples that apply or omit principles of multimedia design should be relatively easy to find. Note, these principles are summarized in Mayer (2011), and can also be found online (e.g., <http://www.renewlearning.com/mayers-multimedia-learning-principles/>). Ideally, the workshop facilitator will choose paired examples (one great and one not as great) that cover the same topic or phenomenon. Ensure that the workshop is held in a room with a good wireless internet connection. Encourage participants to bring their own mobile devices to the workshop so that they are

able to interact with the apps, animations, or other demonstrations. Remind participants to download relevant apps before coming to the workshop.

Workshop Strategies

This workshop primarily relies on group discussions and activities in order to encourage student engagement. The workstation activities are specifically designed so that participants can “discover” the principles of effective multimedia demonstrations on their own, which fosters deeper understanding. While some didactic lecture is necessary, it is only used to introduce the topic and to provide a framework for the results of our class discussions. The facilitator should provide participants with clear time allowances for each activity and steer wayward discussions back on topic. If presentation slides are used, make them available following the workshop so that participants are not distracted by note-taking during the session.

Class Discussion: What Makes an Effective Demonstration? (Part I)

This portion of the workshop asks participants to brainstorm and share their best and most challenging experiences with apps, animations, or other forms of computer-based demonstrations. To encourage participation, the facilitator may wish to share a personal experience (ideally a slightly humorous, less successful example). Participant contributions should be recorded in some way as the group will re-visit the examples later on. Take care to re-word participant explanations (as necessary) in order to make the relationship to Mayer’s (2011) principles obvious. At this point, it is unlikely that all of the principles will be identified but the group will continue to add to the list as the workshop progresses.

Workstation Activity: Comparing Demonstrations

Small groups will interact with the chosen paired apps, animations, or web-based demonstrations. Again, each pair should be selected to depict the same phenomenon but one should follow Mayer’s (2011) principles better than the other. Groups will identify both the positive and negative characteristics of each demonstration, and consider questions that will help them discover the principle that distinguishes the given pair (see handout in Appendix A). During this time, the workshop facilitator should walk through the room, checking on each group and asking questions as needed to assist their progress. Ideally, each group will be able to interact with more than one pair of demonstrations, switching at regular time intervals.

Class Discussion: What Makes an Effective Demonstration? (Part II)

The whole group reconvenes to discuss observations. Each group will briefly report on the characteristics that distinguished effective from ineffective demonstrations. The facilitator should add observations to the list of characteristics started earlier in the workshop, again rephrasing them in a way that links to the principles of effective multimedia design.

Mayer’s Cognitive Theory of Multimedia Learning

Outline Mayer’s (2011) Cognitive Theory of Multimedia Learning, with special emphasis on the 12 Principles of Multimedia Design. Participants should be encouraged to identify which principles were most relevant to the pairs of demonstrations that they interacted with. Refer back to the list of characteristics that was created earlier in the workshop, noting the relationship between the

characteristics and the principles. Note the contributions from participants' previous experiences and make explicit the relationship between their successes (or failures) and the principles.

Making Demonstrations Effective for Student Learning through Active Learning

Note that additional strategies, beyond simply selecting good demonstrations, are necessary to enhancing student learning. Emphasize the idea that observing a demonstration does not necessarily result in student learning. Active learning strategies that incorporate the use of apps, animations, or web-based demonstrations, however, can be used to engage students with the material and their peers, and lead to enhanced student learning. For example, students could engage by generating short answers, drawing concepts, or by providing predictions/explanations about the material. The facilitator can draw on suggestions made by Copeland et al. (2010), Mayer et al. (2005), Balch (2012), and Crouch et al. (2004) for examples.

APPENDIX A

Guiding Questions for Apps, Animations, and Computer Demonstrations - Handout

When considering a demonstration for use in one of your classes, use the following questions to evaluate its value for student learning. The following questions are based on the work of Mayer's (2011)¹ and Clark & Mayer's (2016)².

01. Are there extraneous words, images, or sounds included which may distract students by drawing attention away from the content material? This issue is particularly important in the context of teaching low-knowledge learners (e.g., first-year students).
02. Are there cues that highlight the organization of the content material? Again, this issue is important in the context of teaching low-knowledge learners or when teaching complex material.
03. For animations, is there on-screen text (as well as audible narration)? How far away from the animation was the text? Did you find it easy to both watch the animation and read the text?
04. For apps, animations, interactive diagrams, or demonstrations, are words and corresponding pictures presented near one another? Did you find it easy to switch attention from diagram to text and back?
05. For narrated animations, were the words spoken at the same time as the animation, or were the animation and narration presented successively? If the latter, was it easy to remember the animation when presented with the narration?
06. Is the multimedia lesson presented continuously, or is it presented in segments (i.e., with the user in control of pacing)? If continuously, did you feel that you would have had enough time to take notes and understand the material, or did it proceed too quickly?
07. Do your students already know the characteristics of the main concepts, or is the multimedia lesson their first interaction with the topic? If it is the first interaction with a topic, then did the lesson proceed at a good pace for first-time learners?
08. Was accompanying narration delivered audibly (spoken narration) or visually (on-screen text)?
09. Are there visualizations that accompany the text, or is the demonstration purely text-based?
10. Does the multimedia include an active learning component, in which the students must generate words, drawings, explanations, or predictions?
11. Is the text (or narration) presented in a conversational style, or a more formal style? Did you find one style to be more engaging?
12. For audible narrations, was the voice a human or machine voice? Was one voice type more/less engaging? Did the human voice have a reasonably pleasing quality to it (i.e., in terms of timbre, accent, etc.)?

¹ Mayer, R.E. (2011). Applying the science of learning to multimedia instruction. *Psychology of Learning and Motivation*, 55, 77-108.

² Clark, R.C., & Mayer, R.E. (2016). *e-Learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning* (4th ed.). Hoboken, NJ: Wiley.