June 2009

THE USE AND DEVELOPMENT OF ANIMATION IN LABORATORY EDUCATION: part of The Connected Laboratory Project

Brant Christian Carter
Worcester Polytechnic Institute

Subaiou Zhang
Worcester Polytechnic Institute

Follow this and additional works at: https://digitalcommons.wpi.edu/iqp-all

THE USE AND DEVELOPMENT OF ANIMATION IN LABORATORY EDUCATION:

part of The Connected Laboratory Project

BY:

Brant Carter

Subaiou Zhang

The Use and Development of Animation in Laboratory Education:

part of the Connected Laboratory Project

An Interactive Qualifying Project
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
degree of Bachelor of Science

by
Brant Carter
Subaiou Zhang

Date:
May 21, 2009

Report Submitted to:

Professor Jill Rulfs and Professor Michael Buckholt
Worcester Polytechnic Institute

This report represents work of WPI undergraduate students submitted to the faculty as evidence of a degree requirement. WPI routinely publishes these reports on its web site without editorial or peer review. For more information about the projects program at WPI, see http://www.wpi.edu/Academics/Projects.

ABSTRACT

This project examines the use of computer animation in tutorial videos as an educational tool within the biology laboratory curriculum and explores the methodology for the development of computer animation. Student reception of the tutorials was assessed by survey (BB2903 C09 lab) with both multiple choice and open ended questions and the number of "hits" on the media server. Tutorials were found to be well received and instructionally beneficial. Animations were not preferred over live action of procedures, thus was recommended for supplementing live action.

Table Of Contents

INTRODUCTION

This Interactive Qualifying Project (IQP) examines the use of computer animation in tutorial videos as an educational tool within the laboratory curriculum in the Department of Biology & Biotechnology (BB) and explores the methodology of the development and use of such computer generated animation which future teams may use, as part of The Connected Laboratory Project currently under development at Worcester Polytechnic Institute (WPI). The goals of the project were to determine the best structure for animated content that would facilitate efficient learning, develop a method for creating or integrating computer animated content (graphics, movement, narration, and music), determine the pitfalls and workarounds future teams would need to avoid and follow, to asses the reception of the tutorials in general by students and analyze student feedback, and present direction for the future use of animation within the Connected Laboratory Project. The reception of these tutorials, both in general as an educational tool and specifically for computer animated content, was assessed by a survey of BB2903 C09 students with both multiple choice and open ended questions and the recording of access request numbers (hits) for the tutorials on the media server. It was found that the tutorials were well accepted by students and were instructionally effective. Students required less assistance from faculty and staff and reported feeling more comfortable and confident performing in the lab after watching tutorials and having access to them during the session. Animations were found not to be preferred over live action demonstrations of procedure and it was therefore recommended that their use be restricted to supplementing live action or in cases where live action is inappropriate or impossible (such as demonstrations of molecular interaction). The team found that the development of animations is best accomplished with true animation software such as Adobe Flash or the open source Synfig Studio.

About the Connected Laboratory Project

The Connected Lab Project will provide an opportunity to design a laboratory experience that will engage current students to take advantage of novel technologies,

including blogs, wikis and podcasts, to gather information. The program will eventually be adapted for use with other courses at WPI. Some of the benefits from incorporating multimedia and other digital resources and technology include instant access to information and instant exchange of data in the teaching labs. Instant access to information will bring new efficiency to the current teaching lab, allowing students to control the pace at which they work and learn. The main products of this project will include digital media to support independent procedural learning in the lab, a process that makes it easy for both faculty and students to create and share digital media that supports the laboratory experience.

Background: Animation & Learning

Animation, as defined by Rieber & Kini (1991), is a rapid presentation of an image series, say, on a computer screen, so as to depict change over time (Hoffler & Leutner, 2007). Animation, therefore, could be very useful when presenting information to and audience as a change over time which simulates the "real world" and potentially lends itself to better understanding by the audience relative to static images (Arguel and Jamet, 2009).

Potential Advantages of Animation

Animation has a host of potential advantages, as it can be made to closely simulate the space and time of reality. The **congruence principle**, proposed by Tversky et al., (2002), states that when the subject an animation presents is very similar to the actual content to be learnt, closely simulating reality, it allows learners to better internalize it (Arguel & Jamet, 2009; Schnotz & Bannert, 2003). The fact that animation can operate with a dimension of time, information involving changes over time can be more accurately represented with animation as opposed to static figures (Arguel & Jamet, 2009; Tversky et al., 2002). Additionally, animation conveys more information to viewers than a simple series of static images would by showing changes that would take place between each of the static images and would not require viewers to infer them (Arguel & Jamet, 2009). Research has found that animation can be especially effective when depicting

human-motor skills, for example, learning to tie knots or complete puzzle rings by Ayres et al., (2009) and teaching paper-folding tasks by Wong et al., (2009). Learning human-motor skills in this way is so effective due to a human's ability to learn actions by observing them with the system of mirror-neurons (Ayres et al., 2009).

Yet, despite these potential advantages, research has often found animation to be no more effective than the use of static images (see review by Tversky et al., 2002). In fact, in certain cases, static images were found to be more effective than animation. Such was the finding of research by Mayer et al., (2005), where static diagrams were educationally superior to animation when learning about mechanical systems. In order to understand how and when animation may or may not be a more effective learning medium, Cognitive Load Theory can help to shed some light on how cognitive processes may handle such information.

Animation & Cognitive Load Theory

Cognitive load theory (CLT) is centered on the idea that long term memory (LTM), working memory (WM), and the interaction between the two is very important for the learning process. WM is highly limited, both in capacity of information and the duration information remains (Miller, 1956; Peterson & Peterson, 1959), and behaves something like a temporary buffer for momentary information that the brain is using. So, if instructions of any kind ignores the limitations of WM, such as when more new information is presented than WM can effectively handle, effectively learning that information may not be possible (Ayres & Paas, 2007).

CLT describes three types of load that can affect WM intrinsic, extraneous, and germane (see Paas et al., 2003; Sweller et al., 1998). Intrinsic load is caused by the inherent complexity of the information input itself (Ayres & Paas, 2007). The greater the complexity of the information presented, the greater the intrinsic load on WM. Extraneous load is caused by unclear, poorly designed instructions which require extra cognitive effort to sort out in an attempt to understand them (Ayres & Paas, 2007). Germane load is the "good" load caused by the active cognitive tasks in place to learn and process the novel material (Ayres & Paas, 2007). Learning is impeded when either

the intrinsic or extraneous loads are too high and not enough WM resources are available to support the necessary germane load.

With this in mind, the design of animation becomes very important in order to facilitate good learning. A given animation can not be overly complex, with numerous elements and excessive motion at any given time, in order to reduce intrinsic load. The instruction it self must be clear and easily understood in order to reduce the extraneous load. According to Sweller & Chandler (1994) and Sweller et al. (1998), an animation as such would have two essential functions:

- If an animation reduces such loads so as to permit processing tasks, then the animation has an enabling function.

- If an animation reduces loads of tasks that, without the animation, would require more effort, then the animation has a facilitating function.

By minimizing these two loads imposed my an animation (or any educational material, more WM resources may be allocated to the germane load and thus facilitate better learning of the material.

Further Explanation for the Relative Ineffectiveness of Animation

Further explanation as for why animations are sometimes relatively ineffective compared to static images stems largely from how animations may be used. The **congruence principle** (Tversky et al., 2002), as described above, indicates that an animation depicting content that is not inherently dynamic, or if constructing a dynamic internalization of the content is not relevant for learning it, would be no more effective that displaying static information and images (Arguel & Jamet, 2009). In fact, having an animation of such material could be detrimental, as it may be more complex or present more information than is necessary and raise cognitive load (Arguel & Jamet, 2009; Sweller & Chandler, 1994). The dynamic nature of animation can be just as detrimental as it is beneficial if non essential elements or material distract viewers from the relevant material, forcing viewers to filter out unimportant information themselves and raising cognitive load (Ayres & Paas, 2007).

The transient nature of animation can also lend it self to insufficient learning of material, most especially when important information is on screen for a short amount of time before disappearing and new information is presented (see Ainsworth & VanLabeke, 2004; Ayres & Paas, 2007). Rapid succession of material can also put unnecessarily heavy loads on WM, especially when trying to remember and integrate already past material with present and upcoming material (Arguel & Jamet, 2009).

The evolved mirror-neuron system in the brain may also explain how animations not related to human-motor action may not be better suited than static images. Ayres et al. (2009) note:

> "If ... humans have evolved to observe movement and copy it (through mirror-neurons), then asking learners to observe an animation in order to learn a motor skill may not place an excessive burden on WM resources, as we have biologically evolved to cope with it. In contrast, learning about secondary knowledge (see Geary, 2007), such as mechanical systems, or using static diagrams to represent human movement, may require more WM resources, because we do not have the same biological (neural networks) advantages" (Ayres et al., 2009).

Fortunately, taking care in the animation design process can combat some of the educational ineffectiveness.

Design Practices to Optimize Learning

First and foremost, designing animations with CLT theory in mind, reducing intrinsic and extraneous cognitive load to maximize germane load, should be the primary focus in animation designing to facilitate better learning (Chandler, 2004). Taking care to reduce unnecessary visual complexity and developing streamlined instruction are the first steps optimizing WM resources.

Maintaining certain key elements on screen for as long as possible without cluttering the presentation can help to reduce the negative impact transience can have on learning

(Arguel & Jamet, 2009). Additionally the negative effects of transience can be reduced with the use of static images to supplement material in motion (Arguel & Jamet, 2009)

Adding interactivity can also aid in reducing cognitive load caused by transience. Access to playback controls allows for users to pause and go back to review information that was perhaps missed by the viewer or if the viewer wants to review a section again for reinforcement (Betrancourt, 2005; Hasler et al., 2007). Additionally, dividing the presentation into sections, where the presentation may pause at the end of each before proceeding, allows viewers to better organize related information which would let WM resources "catch up" before proceeding (Arguel & Jamet, 2009). Interestingly, a study by Hasler et al. (2007) found that the group of learners with access to playback control learnt better than the group without it, though the group rarely used the controls.

Forms of guidance integrated with animated visuals can reduce load by helping viewers focus on the most important points. The use of textual annotations on screen can help to highlight essential information (Harp & Mayer, 1998). Narration provides guidance and explanation similarly to text, but does not require the viewer's visual diversion from the primary presentation.

METHODS

The animated tutorials produced for the Connected Laboratory Project at WPI were created using Apple iWork '09 Keynote. Figure 1 below illustrates the overall process for creating any one of the tutorials. The detailed methodology is described in the following subsections.
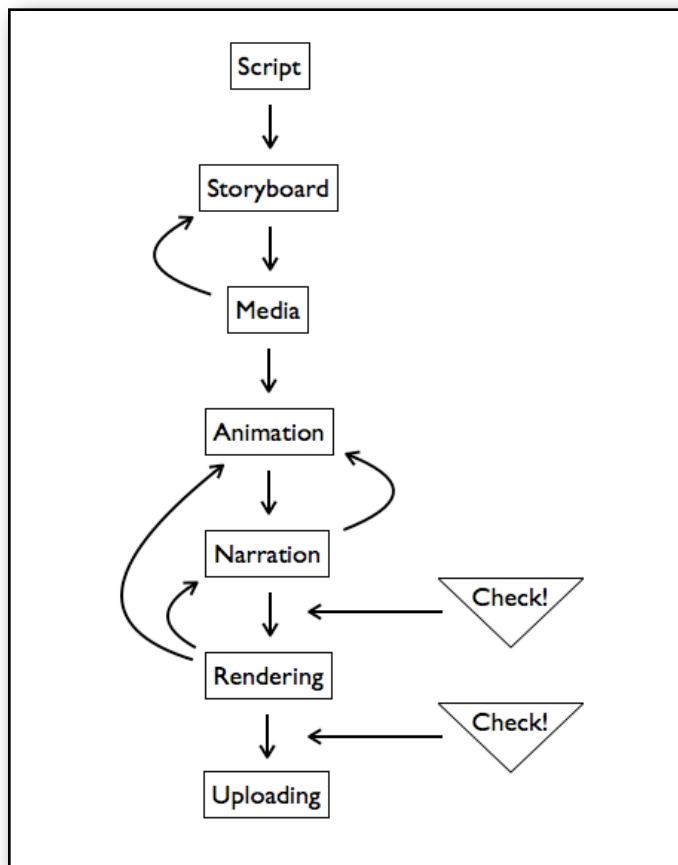
Figure 1. Animated Tutorial Development Flow Chart

Script Writing

Step one in the entire process of tutorial development, after a topic had been selected, was to begin researching that topic and write the first draft of the script to be used. Research primarily involved reviewing laboratory protocol and documentation already written by lab faculty. However, sources on the web, such as encyclopedias, online tutorials, and published papers, were also consulted. The script primarily consisted of

content to be spoken as narration and was written with the rich text editing application for Mac OS X named "TextEdit" (Windows homolog: "Wordpad"). Use of a rich text editor was chosen for its basic word processing whilst retaining rich text capabilities and universality of file format (Rich Text Format, .rtf).

Storyboard Development

Once the script was written the next step was to develop the visual accompaniment that would serve as a template for the animated tutorial's key frames. The film & television industries refer to this process as story-boarding.   The "storyboard" developed for these tutorials never involved the creation of an authentic storyboard and instead consisted of discussion, brainstorming, and crude sketches. The first step was to develop the overall visual theme used in the tutorial to maintain consistency. The series of animated tutorials made all possess a similar overall visual scheme with little deviation. The second step in this process was to pick out the illustratable parts of the script and determine how to best portray it, a step which included initial drafting of motion and animation schemes.

Media

After the "storyboard" was determined desirable it was time to begin collecting and creating the various forms of media. Vector graphics, graphics drawn by the computer from a mathematic model (as apposed to raster graphics like a photograph), were most often created from within Keynote using the "Insert->Shape" dialog in the menu bar. Similarly, vector graphs and charts were used in one case using the "Insert->Chart->3D Line" dialog. Shapes, which include a variety of primitive geometries as well as lines and free form bezier curves, were combined together and formatted to produce more complex shapes and forms. General parameters for shapes include Fill (none, color, gradient, advanced gradient, image, and tinted image), Stroke (none, line, and picture frame), Shadow, Reflection, and Opacity, all of which can be controlled using the "View->Show Inspector" interface window under the "Graphic" tab, as well as Size, Position,

and Rotate, all of which can be controlled using the "View->Show Inspector" interface window under the "Metrics" tab (see Figure 2).
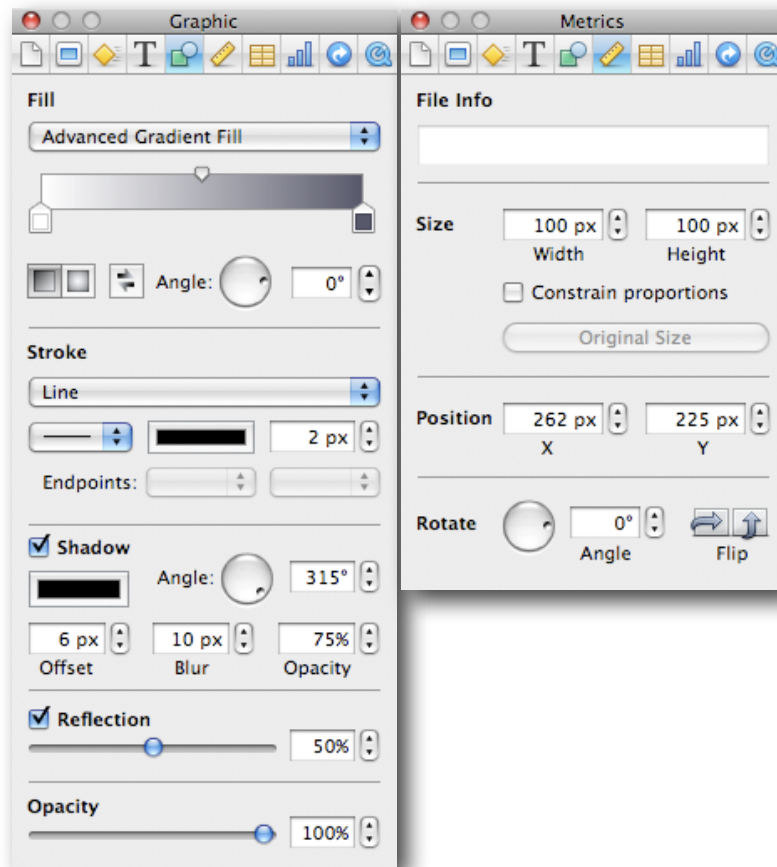
Figure 2. Keynote Inspector: Graphic & Metrics Tabs

High resolution photographs used were taken with a Canon PowerShot S3 IS camera at 6 mega pixels. Any enhancement of images was conducted using a free photo management, editing, and sharing software, "Google Picasa" (available for MacOS 10.4.9+ (Intel Only), Windows XP/Vista, and Linux at http://www.google.com/picasa) or using Keynote's built in "View->Show Adjust Image" interface window. Most parameters for vector graphics in keynote are available for photographs. Photographs of the various waste disposal units in Salisbury Labs 223 were prominently featured in the Waste Management animation.

In some cases where the use of highly conserved graphics was desired, such as with the

collection of hazard symbols and signs used in the Laboratory Safety animation, searches for high resolution vector and raster graphics were conducted online using search tools provided by google at http://www.google.com, http://images.google.com, and http://www.wikipedia.org. Wikipedia and the Wikimedia Commons were consulted most frequently, as many of the graphics available are in a vector graphics format (Scalable Vector Graphic, .svg) and are provided under public license by their contributers. It should be noted that, though vector graphics are most desirable as they can be resized without a loss in quality, Keynote does not understand the most common format, Scalable Vector Graphic. As a result, all SVGs were converted to high resolution Portable Network Graphic (.png) images using the open source vector graphics application, Inkscape (available for MacOS 10.3+ (Universal), Windows XP/Vista, and Linux at http://www.inkscape.org).

Video used was filmed in Salisbury Labs 223 in Digital Video format (DV) using a Canon 3CCD GL 2 Video Camcorder and tripod. Footage was then transferred from miniDV tape to first generation Apple MacBook 1,1 via FireWire 400 interface using iMovie '09. iMovie '09 was used to trim and enhance the video picture, and add stabilization where necessary when a tripod wasn't used. Video footage of the bubble blowing procedure was featured in the animated tutorial, "Bubble Blowing".

Music was used in one animation, "Laboratory Safety," for background. The piece, "Let's go Shopping," by Jerry Martin, was chosen for its lack of lyrics, subtle background quality, and humorous retro informercial sound. The music was written and performed by Jerry Martin, and permission from him to use the piece in the animation was necessary. Permission was requested and granted via email.

Animation Development

With media "in hand", the elements could be put together in a time based structure that would ultimately form the final animated tutorial. In Keynote, the key frames from the story board were recreated as presentation slides. After putting the storyboard into a

working series of slides, they could begin to be animated. Depending on the complexity of the animation produced, some slides were broken up into sub slides with different groups of animation actions on each slide, while other slides were combined into a single slide if the animation desired required the elements to be on the same slide. This sort of decision could only be made on a case by case basis depending on the desired actions of slide elements. Music and sound also play a role in how slides were organized, as music and sound cannot cross between slides *except* for an single background track which will play for the entire length of the animation and repeats itself until the animation ends.

In general, there are three different types of animation: slide transitions, entrance and exit animations, and actions. Transitions, as they are so rightly named, are the animated effects applied between slides as one transitions to the next. The transitions can be as simple as a cross dissolve or fade (referred to as "Dissolve" by Keynote) or as complex as 3D movement of objects on both slides or of whole slides. Consistency in any single tutorial was maintained, using only a select few transitions throughout any single presentation to give an overall consistency, using a certain transition specifically for moving from one section to the next with another specifically for the initial opening of the tutorial, and more professional look. Ergo, the use of "Random" as a transition option was always avoided. Transition effects are accessible in the Inspector under the Slide tab (see Figure 3).
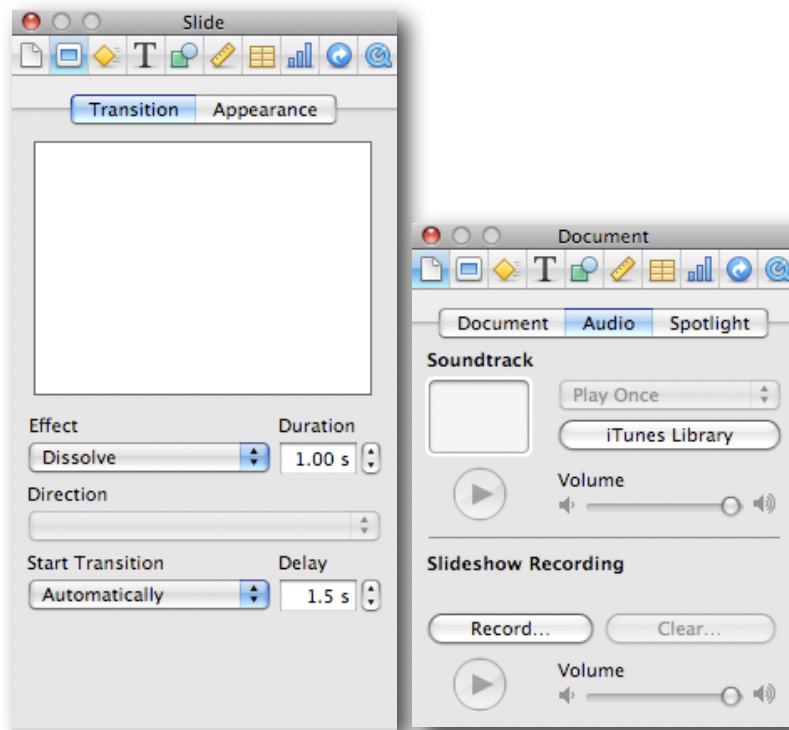
Figure 3. Keynote Inspector: Slide & Document Tabs

Entrance and exit object transitions, referred to as "Build In" and "Build Out" by Keynote, were used to bring or remove objects to and from the field of view (i.e. the slide). Many of these effects are similar to transitions, such as the "Dissolve" effect, but instead of applying to a slide or all the objects on a slide they apply to a single object, such as a text box or an image, or a group of objects. As with the transitions, conservative use of these effects was important for giving a professional presentation. Any object, or group of single objects forming a larger more complex object, can be given any number of these animation schemes over time. While the specific options vary between these builds, they all have a given "Duration" and "Order". Each build can be set to occur after the previous build has completed or while the previous build is executing, and each can be delayed by a specified time in seconds. These "Build In" and "Build Out" effects are accessible in the Inspector under the Build tab (see Figure 4).
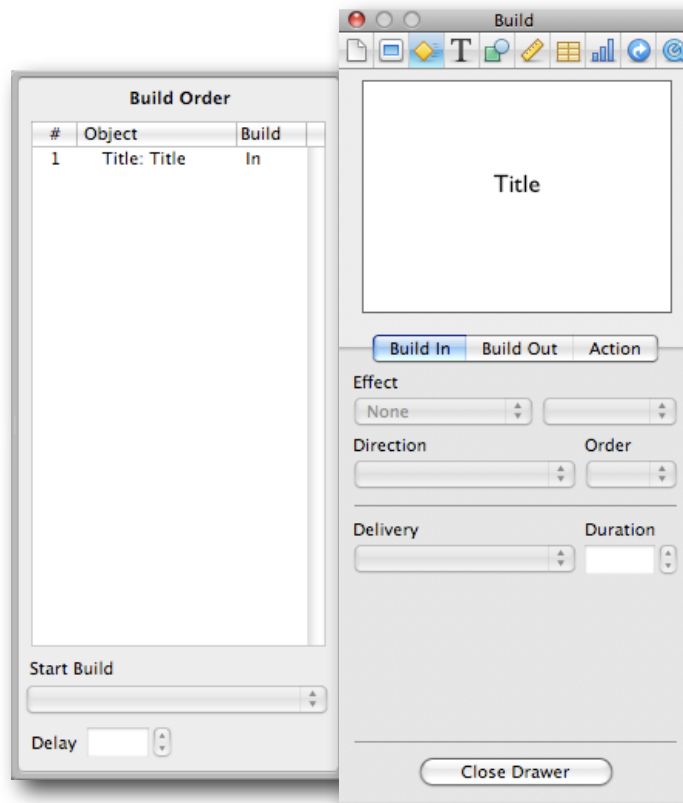
Figure 4. Keynote Inspector: Build Tab with Build Order Drawer Opened

The movement and alteration of objects on a slide over time (the closest thing to true animation controlled by the artist), using what Keynote refers to as "Actions", was necessary in certain cases where the animation of objects could not be achieved by "Build In"/"Build Out" transitions alone. "Actions" can be applied to any object or group of objects and include "Movement", "Scale", and "Opacity". Like the builds, actions have a specified duration and delay. Staring with Keynote '09, the "Magic Move" slide transition was implemented. This transition detects objects that repeat from one slide to the next and automatically calculates the movement to transition those objects from their position on the first slide to their position on the second slide. This new transition was used instead of the "Movement" action where it could be, as it is faster and simpler to use. The "Actions" are accessible with "Build In" and "Build Out" in the Inspector under the Build tab (see Figure 4 above).

Sound was used in the tutorials for narration and, in one instance, music. Music intended to play continuously in the background was not applied to any single slide but to the document as a whole in Audio under the Document tab in the Inspector dialog (see Figure 3 above). Other sounds, including narration, was imported (or dragged) directly to a given slide. An audio object is controlled using the "Build In" and "Build Out" and is a part of the same build order as the animation builds and actions. Because background audio is the only audio capable of spanning multiple slides, audio desired to cross from one slide to the next was split into multiple files (see more in Narration Synthesis section below).

Narration Synthesis

Narration for these animations was synthesized using a computer voice introduced by Apple, Inc. with Mac OS 10.5 Leopard named Alex. Alex was chosen as a voice for its advanced and relatively realistic speech compared to its predecessors. The voice even takes breaths. As advanced as it is, it nonetheless does not always speak in a manner that is natural. This can be humorous, but for certain scientific names and words it was important that the voice speak them correctly. This was achieved by altering the spelling of words in the narration text to trick the voice into speaking words correctly. For example, "pipetting" became "pi-petting" and "Vibrio fischeri" became "Vibbrio Fisher-ay". Any text desired to be heard spoken by Alex could be previewed in TextEdit by selecting "TextEdit->Services->Speech->Start Speaking Text". The voice "Alex" must be selected as the computer speech voice in System Preferences under the "Speech" preference pane. A sample script is available in Appendix B.

Once the narration bugs were worked out and Alex spoke in a manner desired, the speech needed to be saved as an audio file on the computer before it could be added to the animation. This was accomplished by creating a small applet that took some text and saved it as audio using the desired voice. The applet, dubbed "Speak it & Save it" was created as an Automator Workflow and runs through Automator to allow for maximum control and customization.

Because Keynote operates in a slide-to-slide manner, audio cannot easily be made to play while transitioning from one slide to another. Therefore, the narration was broken down into pros or smaller segments and converted to separate audio files as such. In this way, the timing for the narration could be more precisely controlled and the narration as a whole could span from slide to slide. After adding the audio clips into the animation scheme, timing often had to be slightly adjusted to allow for more or less time in order to synchronize the animation with the newly added speech. In some cases where it was necessary to have speech span a slide transition, the audio file was added the rendering of the tutorial by injecting it into the raw video file at the desired time. The technique for this used Apple Quicktime Pro, which allows for addition and subtraction of as many video or audio tracks as desired at any time in the timeline without the need to re-render the original data, resulting in no loss of quality and no addition render time.

Video Rendering

Video rendering was initiated only after a final play through of the animation to verify that all timing was correct. Once verified, settings were selected in the Export interface at File->Export for Manual Advance, Full Quality, Include Audio, and Include Transparency (see Figure 5). Parameters for rendering could be customized further, but Full Quality was found to be sufficient. After rendering the video it was opened using Apple Quicktime Pro to remove the Sprite track (so the video would advance on its own), enable the playback controls, and to play through once again in order to check for improper timing with narration (it was found that the timing isn't always the same after rendering). If any discrepancies appeared, then adjustments were made in the original project data and the animation was rendered and checked again.
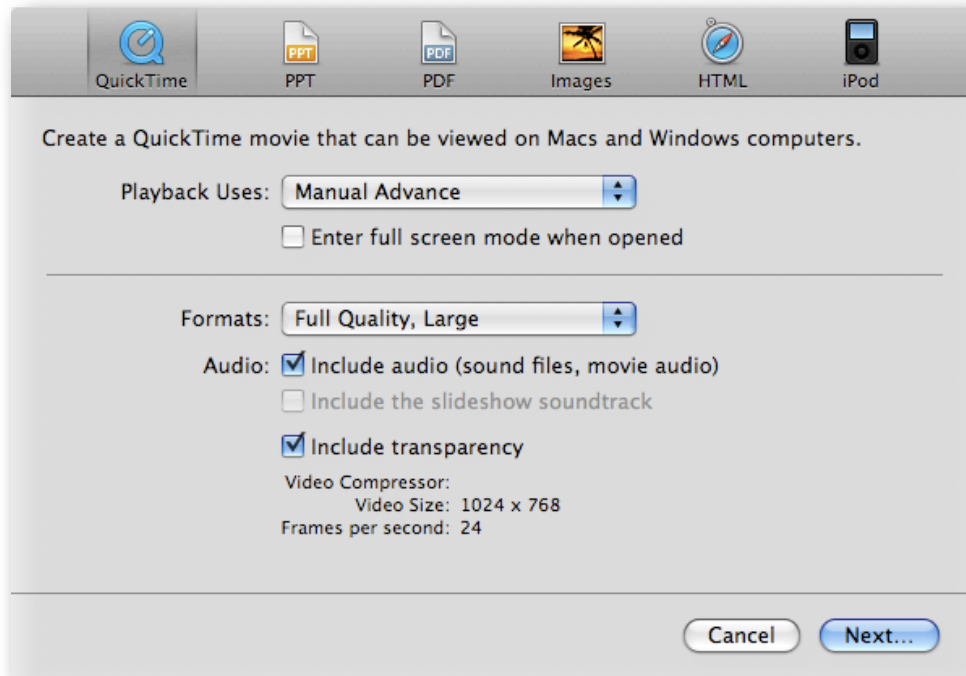
Figure 5. Keynote Export Interface.

Once the animation was fully finalized, a version needed to be exported to Windows Media Video format, though less desirable as it lacks in quality per bitrate, in order to be played back using WPI's Windows Media Streaming Server. Conversion was carried out using Flip4Mac plugin for Apple Quicktime Pro. The parameters given by WPI's Academic Technology Center are as follows:

Codec: Windows Media Video 9, Windows Media Audio 9.2

Size: 640x480, Square Pixels (Progressive)

FPS: 29.97

One Pass, Constant Bit-rate

Max Bit-rate: 600kbps

Keyframe Interval: 20

Audio Format: 32kbps, 44kHz, Stereo (A/V) CBR

Uploading to Intranet

Finished animated tutorials were uploaded to WPI's Windows Media Streaming Server at media.wpi.edu via server message block network protocol (smb://media.wpi.edu)

using Finder's "Go -> Connect to Server..." function in Mac OS X. Files followed the proper naming convention: all lowercase characters, no spaces, underscores.

Survey of Students

Students of the BB903 C09 lab course were surveyed with 15 Likert-Scale, closed-ended questions and 7 open-ended questions designed to gather students feedback on the educational value and quality of the tutorials, the use of animation versus live action, and recommendations for future tutorials. The survey was administered on paper during Monday lecture on paper. Candy was offered to students in exchange for filling out the survey as incentive. See Appendix A for survey questions.

RESULTS

The following results were compiled from a survey administered to BB2903 C09 by Connected Lab IQP teams.

Quality of Videos

In assessment of the tutorials' quality, 83 students (95%) agreed or strongly agreed that spoken word in the tutorials was spoken clearly, 63 students (72%) disagreed or strongly disagreed that featured background music was distracting, and 80 students (92%) felt the computer synthesized voice, Alex, was audible and clear (see Figure 6).
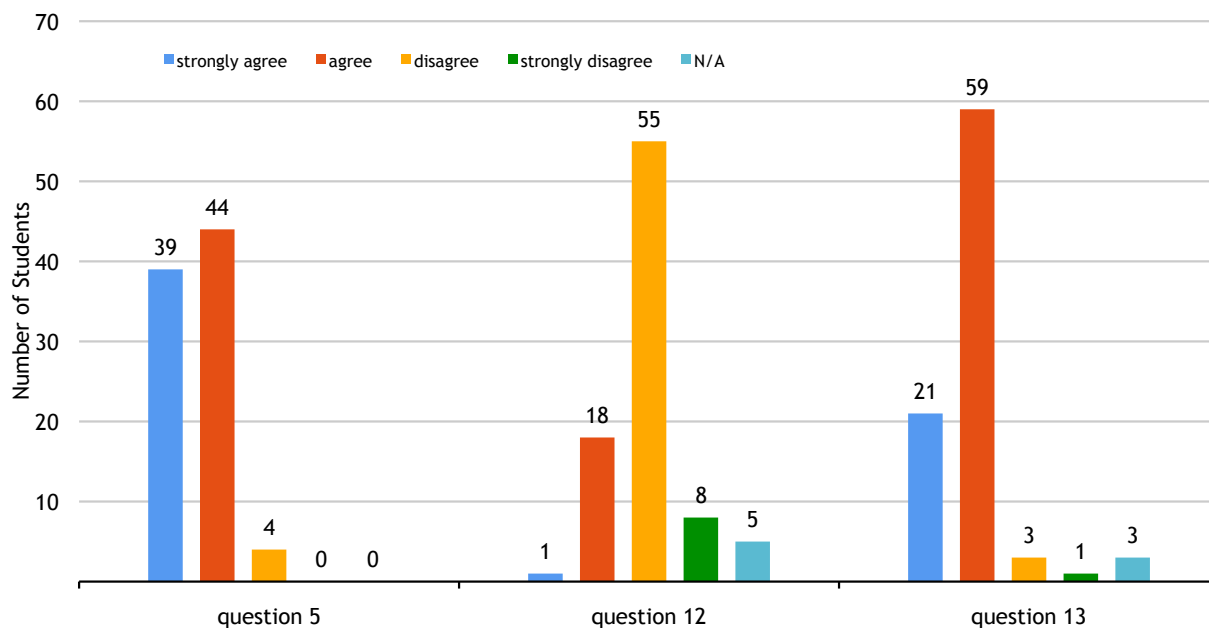
Figure 6. Questions Pertaining to Tutorial Quality from IQP Team Survey of Students: question 5, "the audio associated with the videos were clear/audible"; question 12, "the background music in the animated video is distracting"; question 13, "the computer voice, Alex, is audible/clear."

Helpfulness of Videos

In assessment of the tutorials' value or helpfulness, 75 students (86%) agreed or strongly agreed that the tutorials aided in their completion of the lab course, 71 students (82%) agreed or strongly agreed that they learned and retained more information about the lab procedures by watching the tutorials, 71 students (82%) agreed or strongly agreed that they where more comfortable performing in lab after viewing the tutorials, and 80 students (92%) agreed or strongly agreed that these tutorials were a helpful supplement (see Figure 7).
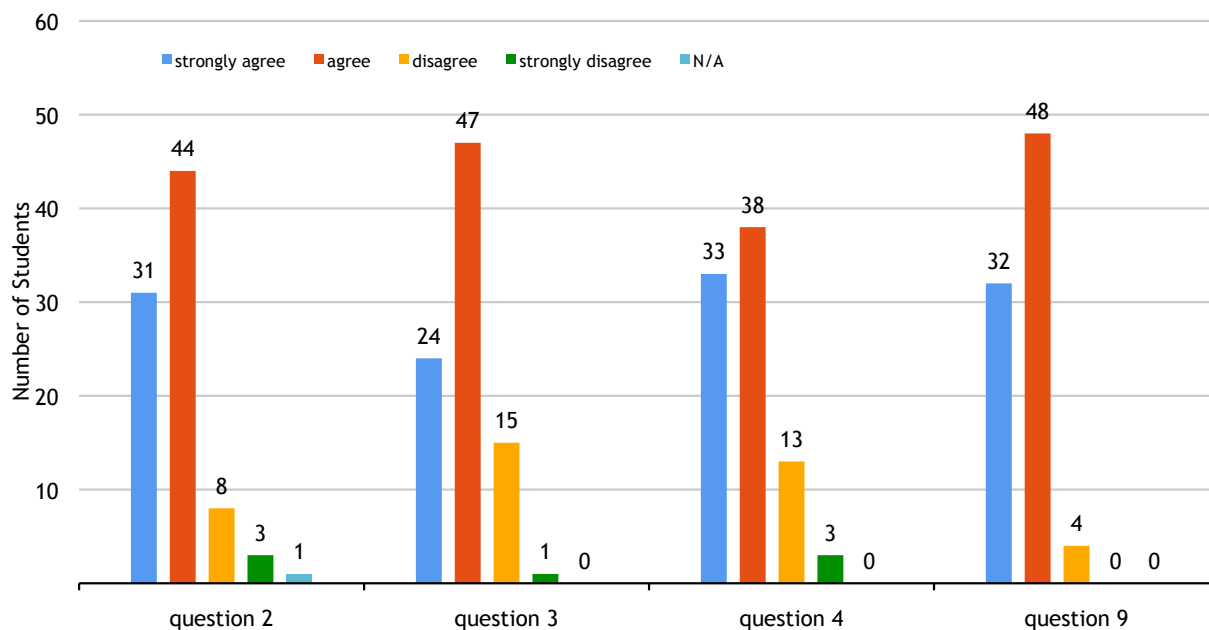
Figure 7. Questions Pertaining to Tutorial Helpfulness from IQP Team Survey of Students: question 2, "I believe the videos aided me in effectively completing the current lab"; question 3, "I learned and retained more information about the lab procedures by watching the videos"; question 4, "I was more comfortable performing in lab after watching the associated videos"; question 9, "the videos were helpful as a supplement."

Student Stats

In assessment of student stats, comparing final grades earned to whether or not students viewed the tutorials prior to lab, the results indicate that students who made use of the tutorials prior to lab sessions performed better academically: of students who felt they would receive an A (17, 37% of students answering), 12 (80%) agreed or strongly agreed that they viewed the tutorials prior to the lab section; of students who felt they would receive an B (17, 37% of students answering), 11 (65%) agreed or strongly agreed that they viewed the tutorials prior to the lab section; of students who felt they would receive an C (4, 9% of students answering), 2 (50%) agreed or strongly agreed that they viewed the tutorials prior to the lab section; of students who felt they would receive between and A and B (2, 4% of students answering), 1 (50%) agreed or strongly agreed that they viewed the tutorials prior to the lab section. 1 student reported expecting to receive an NR (F equivalent) and 5 choose not to respond (see Figure 8). Of students who indicated they had taken a BB2900 lab course prior to BB2903 C09, 73% felt that they required less help from the lab TAs for this course compared to previous courses (see Figure 9). 69% of students agreed or strongly agreed that they attended lecture (see Figure 10).
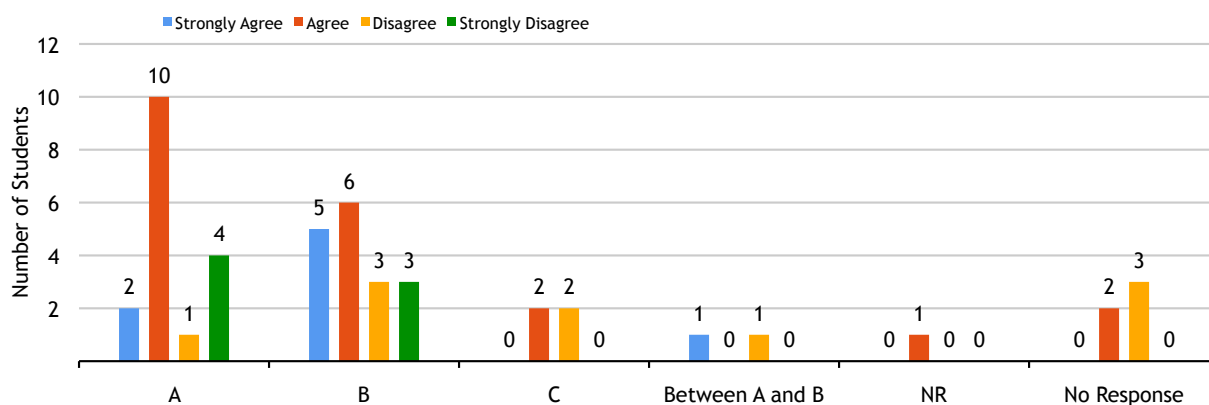
Figure 8. Questions Pertaining to Student Statistics from IQP Team Survey of Students: (A) Student Grades Against Responses to Survey Question 1 (top), if students watched tutorials prior to going to the lab.
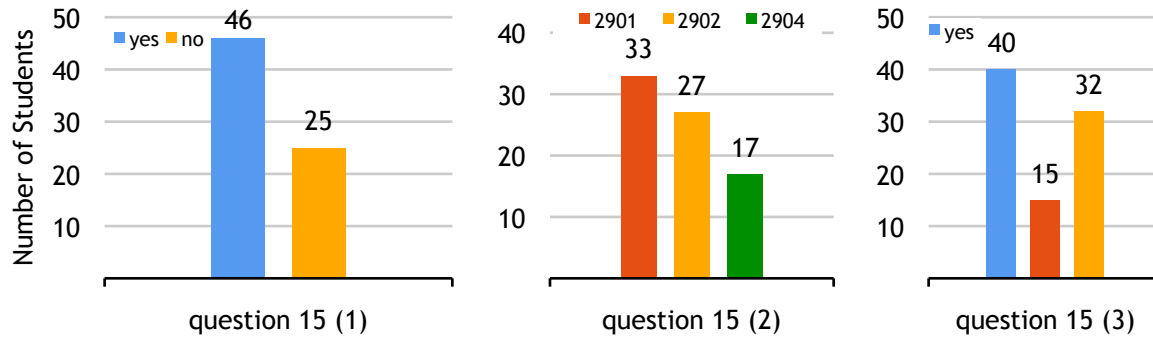
Figure 9. Responses to Survey Question 15, with part 1 (left) asking if students had taken a BB2900 lab before, part 2 (center) asking which BB2900 lab if yes to part 1, and part 3 (right) asking if students felt they asked for aid less from TAs than in prior BB2900 labs.
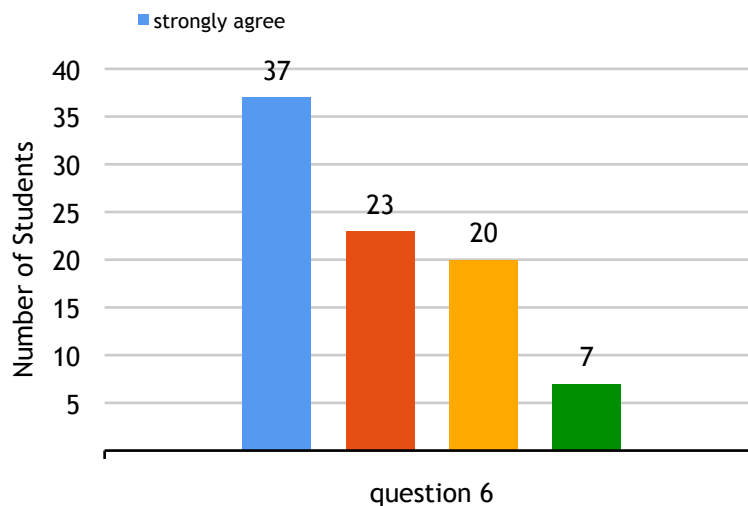
Figure 10. Responses to Survey Question 6 (bottom), if students attended lecture.

Additional Feedback

93% of students agreed or strongly agreed that video technology used for BB2903 C09 should be implemented in other biology labs at WPI, 84% of students disagreed or strongly disagreed that the tutorials where unnecessary, and when asked if animated tutorials where easier to watch, 51% disagreed or strongly disagreed while 40% agreed or strongly agreed (see Figure 11).
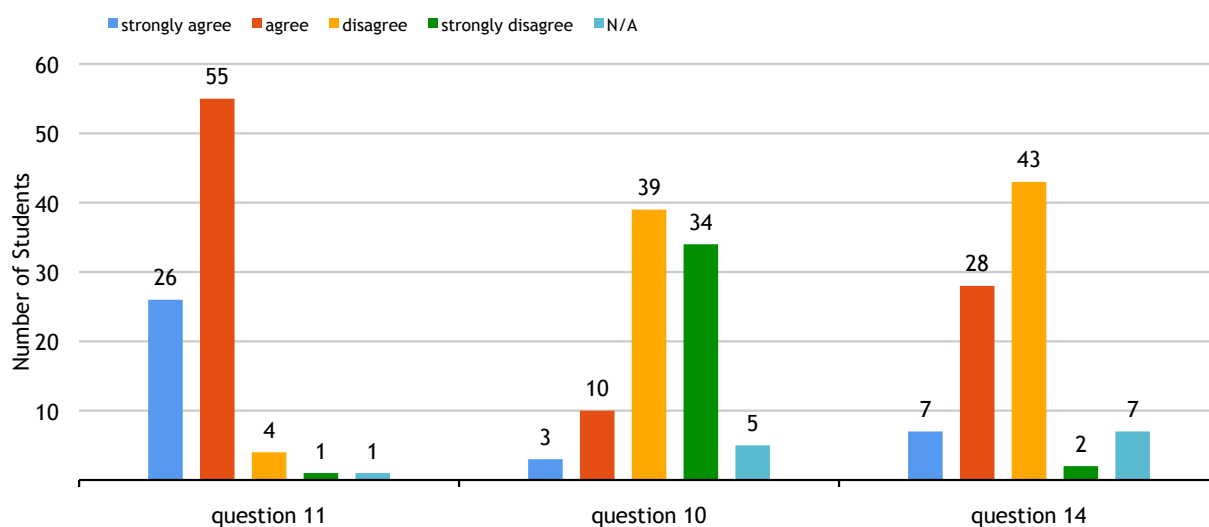
Figure 11. Questions Pertaining to Student Feedback: question 11, "this video technology should be implemented in other biology labs at WPI"; question 10, "the videos were unnecessary"; question 14, "the animated videos were easier to watch than just video demonstrations."

Open Response

The Connected Lab IQP team survey also featured an open response section with a series of questions, the most pertinent of which described here. In the short answer section of the survey when asked what was most liked about the video tutorials, 49% of students answered that it was the step by step nature of the tutorials and only 5% answering that they never watched the videos. When asked what was particularly disliked about the videos, 30% of students who answered (22% total) indicated the videos were too long. When asked whether or not there were videos/animations they felt would be better as one or the other, 45% of students didn't answer but 37% of students indicated they preferred an actual demonstration as apposed to an animated one, 11% felt they were good as they were, and 3% indicated "yes" but did not specify anything further. When asked how the tutorials were most beneficial, for quizzes, laboratory reports, or understanding and retaining material, 47% of students who answered indicated understanding and retaining the material, with 22% indicating lab reports and 24% indicated that they were most useful while in lab. For the full set of questions and their tallied answers, see Appendix A.

Additional data, including final student grades and hit counts (the number of times each of the tutorials were accessed), is also available in <u>Appendix A</u>.

DISCUSSION

The educational value of these tutorials in teaching laboratory assays and techniques is rather certain, and the cessation of their development and use is not recommended. Responses to the administered survey show that 82%+ of students agreed that the tutorials aided in their completion of the lab course, that they learned and retained more information about the lab procedures, and that they where more comfortable performing in lab after viewing the tutorials; 92% of students agreed or strongly agreed that these tutorials were a helpful supplement (see Figure 7 in Results). Hit count records show that students accessed some of the videos over hundreds, sometimes thousands, of times, especially for the more complicated dissection procedures (see Appendix A). Students who watched the tutorials performed better in the course overall, feeling they would receive higher grades than those students who did not watch the tutorials (see Figure 8 in Results).

Additionally, the majority of students (92%+) were relatively pleased with the quality of the tutorials, having no difficulty in understanding the spoken word, both recorded and synthesized, used for narration. Most students (93%) also agreed that the use of these tutorials should be expanded to other biology labs. In the search to enhance laboratory education, the Connected Laboratory Project has certainly found a medium, these video tutorials, to assist instruction of students both outside of the laboratory and within it.

Specifically regarding the use of animated tutorials, preference to watching an animated instruction over live action was split near fifty-fifty with the slight minority preferring animation. In the open response section, when asked whether or not certain tutorials would be better animated or live action, 45% of students didn't answer but 37% indicated that they preferred a live action demonstration of procedure and protocol. While 37% is not the majority of students, it is a large enough percentage that, coupled with the fact that no students indicated that they preferred animation over live action, this input should be considered. The **congruence principle** by Tversky et al. (2002), as described in the introduction) says that the more realistic presentation facilitates better learning, and since little is more real than live action, this preference makes sense.

Therefore it is suggested that the use of animated tutorials be kept to non procedural demonstrations, as featured in "Lab Safety" and "Waste Management", to topics where live action would be inappropriate, such as microscopic or molecular settings as featured in "Quorum Sensing", or to be used in conjunction with live action as an instructional supplement as featured in "Bubble Blowing". This third and final model, hybrid tutorials where live action is supported with computer animation, may be the most powerful option, providing students with a systematic breakdown of procedure and action where it may be visually confusing with live action while still providing real examples. This would, in turn, create the most complete model tutorial which caters to the greatest breadth of students with diverse learning styes and preferences, and would comply with the congruence principle to facilitate optimal learning. This model is therefore recommended for future tutorial development.

Though the reason for choosing Apple's Keynote software stems from the following facts, (1) Keynote provides good control over actions and animations and has a wide range of presets and (2) Keynote can export directly to a host of video file formats, it is the experience of the developers/authors that Keynote, while powerful, it falls short more than anticipated. Developing certain animated tutorials using Keynote proved especially tedious and difficult, the best example of this being "Quorum Sensing," which features especially dynamic characters and interactions. "Quorum Sensing" could not be properly completed with Keynote alone. Therefore it is recommended by this team that further computer animation development be done with software actually designed for this purpose. Keynote does have a relatively short learning curve and certainly if professors or students wanted to contribute material, Keynote or other presentation softwares are still decent options. To "do it right", however, it is better long term and will be more flexible for core development teams if such true animation software is used. WPI provides access to Adobe Flash on select campus computers and, now, the proper training is available from WPI's Academic Technology Center. A noteworthy alternative to Adobe Flash is the free open source software packaged, Synfig Studio, available at www.synfigstudio.com. While not as powerful or fully

featured as Adobe Flash, it provides a free option for institutions other than WPI without Flash and the funding to acquire it.

As a final note, the use of Adobe Flash or Synfig Studio lends themselves to the development of interactivity within the tutorials, live action or animated. Though students already have access to playback controls with all the video tutorials, additional interactivity would allow for devision of material into relevant segments, giving students a more organized presentation and additional control of pace and reducing the effects of unwanted cognitive load (Arguel & Jamet, 2009). Additionally, further exploration of interactivity may facilitate further learning options, such as requesting student input or action in the virtual "laboratory" such a tutorial would provide. Interactivity within these video tutorials provides the next dimension in laboratory education as a part of the Connected Laboratory Project.

REFERENCES

Ainsworth, S., & VanLabeke, N. (2004). Multiple forms of dynamic representation. *Learning and Instruction*, 14(3), 241-255. doi:DOI: 10.1016/j.learninstruc.2004.06.002

Arguel, A., & Jamet, E. (2009). Using video and static pictures to improve learning of procedural contents. *Computers in Human Behavior*, 25(2), 354-359. doi:DOI: 10.1016/j.chb.2008.12.014

Ayres, P., Marcus, N., Chan, C., & Qian, N. (2009). Learning hand manipulative tasks: When instructional animations are superior to equivalent static representations. *Computers in Human Behavior*, 25(2), 348-353. doi:DOI: 10.1016/j.chb.2008.12.013

Ayres, P., & Paas, F. (2007). Making instructional animations more effective: A cognitive load approach. *Applied Cognitive Psychology*, 21(6), 695-700. doi:10.1002/acp.1343

Betrancourt, M. (2005). The animation and interactivity principles in multimedia learning. In R. E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 287–296). New York: Cambridge University Press.

Chandler, P. (2004). The crucial role of cognitive processes in the design of dynamic visualizations. *Learning and Instruction*, 14(3), 353-357. doi:DOI: 10.1016/j.learninstruc.2004.06.009

Cierniak, G., Scheiter, K., & Gerjets, P. (2009). Explaining the split-attention effect: Is the reduction of extraneous cognitive load accompanied by an increase in germane cognitive load? *Comput.Hum.Behav.*, 25(2), 315-324. Retrieved from http://dx.doi.org/10.1016/j.chb.2008.12.020

Geary, D. C. (2007). Educating the evolved mind: Conceptual foundations for an evolutionary educational psychology. In Carlson J. S., Levin J. R. (Eds.), *Psychological perspectives on contemporary educational issues* (pp. 1–99).Greenwich, CT: Information Age Publishing.

Harp, S. F., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology*, 90(3), 414-434. doi:10.1037/0022-0663.90.3.414

Hasler, B. S., Kersten, B., & Sweller, J. (2007). Learner control, cognitive load and instructional animation. *Applied Cognitive Psychology*, 21(6), 713-729. doi:10.1002/acp.1345

Hegarty, M. (2004). Dynamic visualizations and learning: Getting to the difficult questions. *Learning and Instruction*, 14(3), 343-351. doi:DOI: 10.1016/j.learninstruc.2004.06.007

Hegarty, M., Kriz, S., & Cate, C. (2003). The roles of mental animations and external animations in understanding mechanical systems. *Cognition and Instruction*, 21(4), 325-360. Retrieved from http://www.jstor.org/stable/3233804

Höffler, T. N., & Leutner, D. (2007). Instructional animation versus static pictures: A meta-analysis. *Learning and Instruction*, 17(6), 722-738. doi:DOI: 10.1016/j.learninstruc.2007.09.013

Kablan, Z., & Erden, M. (2008). Instructional efficiency of integrated and separated text with animated presentations in computer-based science instruction. *Computers & Education*, 51(2), 660-668. doi:DOI: 10.1016/j.compedu.2007.07.002

Kirschner, P. A. (2002). Cognitive load theory: Implications of cognitive load theory on the design of learning. *Learning and Instruction*, 12(1), 1-10. doi:DOI: 10.1016/S0959-4752(01)00014-7

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(4), 256-265. doi:10.1037/1076-898X.11.4.256

Mayer, R. E., & Chandler, P. (2001). When learning is just a click away: Does simple user interaction foster deeper understanding of multimedia messages? *Journal of Educational Psychology*, 93(2), 390-397. doi:10.1037/0022-0663.93.2.390

Mayer, R., & Moreno, R. (2002). Animation as an aid to multimedia learning. *Educational Psychology Review*, 14(1), 87-99. Retrieved from http://dx.doi.org/10.1023/A:1013184611077

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*, 63(2), 81-97. doi:10.1037/h0043158

Moreno, R. (2004). Decreasing cognitive load for novice students: Effects of explanatory versus corrective feedback in discovery-based multimedia. *Instructional Science*, 32(1), 99-113. Retrieved from http://dx.doi.org/10.1023/B:TRUC.0000021811.66966.1d

Moreno, R. (2007). Optimising learning from animations by minimising cognitive load: Cognitive and affective consequences of signalling and segmentation methods. *Applied Cognitive Psychology*, 21(6), 765-781. doi:10.1002/acp.1348

O'Day, D. H. (2007). The value of animations in biology teaching: A study of long-term memory retention. *CBE Life Sciences Education*, 6(3), 217-223. doi:10.1187/cbe.07-01-0002

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. *Educational Psychologist*, 38(1), 1-4.

Paas, F., Renkl, A., & Sweller, J. (2004). Cognitive load theory: Instructional implications of the interaction between information structures and cognitive architecture. *Instructional Science*, 32(1), 1-8. Retrieved from http://dx.doi.org/10.1023/B:TRUC.0000021806.17516.d0

Paas, F., Van Gerven, P. W. M., & Wouters, P. (2007). Instructional efficiency of animation: Effects of interactivity through mental reconstruction of static key frames. *Applied Cognitive Psychology*, 21(6), 783-793. doi:10.1002/acp.1349

Peterson, L., & Peterson, M. J. (1959). Short-term retention of individual verbal items. *Journal of Experimental Psychology*, 58(3), 193-198. doi:10.1037/h0049234

Rebetez, C., Betrancourt, M., Sangin, M., & Dillenbourg, P. (2005). Collaborer pour mieux apprendre d'une animation. Paper presented at the *IHM 2005: Proceedings of the 17th International Conference on Francophone Sur l'Interaction Homme-Machine*, Toulouse, France. 171-176. Retrieved from http://doi.acm.org/10.1145/1148550.1148572

Rieber, L. P., & Kini, A. S. (1991). Theoretical foundations of instructional applications of computer-generated animated visuals.(1991). *Journal of Computer-Based Instruction*, 18(3), 83.

Schnotz, W., & Bannert, M. (2003). Construction and interference in learning from multiple representation. *Learning and Instruction*, 13(2), 141-156. doi:DOI: 10.1016/S0959-4752(02)00017-8

Schwan, S., & Riempp, R. (2004). The cognitive benefits of interactive videos: Learning to tie nautical knots. *Learning and Instruction*, 14(3), 293-305. doi:DOI: 10.1016/j.learninstruc.2004.06.005

Sweller, J. (2004). Instructional design consequences of an analogy between evolution by natural selection and human cognitive architecture. *Instructional Science*, 32(1), 9-31. Retrieved from http://dx.doi.org/10.1023/B:TRUC.0000021808.72598.4d

Sweller, J., & Chandler, P. (1994). Why some material is difficult to learn. *Cognition and Instruction*, 12(3), 185-233. Retrieved from http://www.jstor.org/stable/3233760

Sweller, J., van Merrienboer, J., & Paas, F. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, 10(3), 251-296. Retrieved from http://dx.doi.org/10.1023/A:1022193728205

Tversky, B., morrison, J. B., & betrancourt, M. (2002). Animation: Can it facilitate? *International Journal of Human-Computer Studies*, 57(4), 247-262. doi:DOI: 10.1006/ijhc.2002.1017

van MerriÃ«nboer, J., & Ayres, P. (2005). Research on cognitive load theory and its design implications for e-learning. *Educational Technology Research and Development*, 53(3), 5-13. Retrieved from http://dx.doi.org/10.1007/BF02504793

Weiss, R. E., Knowlton, D. S., & Morrison, G. R. (2002). Principles for using animation in computer-based instruction: Theoretical heuristics for effective design. *Computers in Human Behavior*, 18(4), 465-477. doi:DOI: 10.1016/S0747-5632(01)00049-8

Wong, A., Marcus, N., Ayres, P., Smith, L., Cooper, G. A., Paas, F., et al. (2009). Instructional animations can be superior to statics when learning human motor skills. *Computers in Human Behavior*, 25(2), 339-347. doi:DOI: 10.1016/j.chb.2008.12.012

APPENDIX A: EXTENDED DATA

Survey Data

		strongly agree	agree	disagree	strongly disagree	N/A	Total
question 1		13	45	18	10	1	87
question 2		31	44	8	3	1	87
question 3		24	47	15	1	0	87
question 4		33	38	13	3	0	87
question 5		39	44	4	0	0	87
question 6		37	23	20	7	0	87
question 7		10	20	34	20	3	87
question 8		6	13	43	22	3	87
question 9		32	48	4	0	3	87
question 10		3	10	39	34	1	87
question 11		26	55	4	1	1	87
question 12*		1	18	55	8	5	87
question 13		21	59	3	1	3	87
question 14		7	28	43	2	7	87
question 15**			yes	no	Total:		
			46	25	71		
			2901	2902	2904		

		33	27	17		
		yes	no	no response (answered no to first part)		
		40	15	32		

*question 12: one student marked an x between agree and disagree - this was tallied into the disagree column.

**question 15: two students had not taken other labs but marked that they required less assistance than in other labs. Tally was placed instead under "no response"

IQP Team Survey Closed-Ended Questions

1. I watched the videos prior to coming to lab.

2. I felt that the videos aided me effectively in completing the current lab.

3. I learned and retained more information about lab procedures by watching the videos.

4. I was more comfortable performing in lab after watching the associated video.

5. The audio associated with the videos were spoken clearly.

6. I always attended the lecture.

7. The appearance of Gompei enhanced my interest in the videos.

8. The presence of Gompei helped me remember the lab protocol more.

9. The videos were a helpful supplement.

10. The videos were unnecessary.

11. This video technology should be implemented in other biology labs at WPI.

12. The background music in the animated video is distracting.

13. The computer voice, Alex, is audible and clear.

14. The animated videos were easier to watch than just the video demonstrations.

15. Have you taken other BB290X labs? (Yes, No)

    If yes, which ones have you taken? Circle all that apply. (BB2901, BB2902, BB2904)

    Did you feel you required less assistance from the TAs after watching the videos than in previous 2900 labs? (Yes, No)

*Questions 1-14 are likert-scale: Strongly Agree, Agree, Disagree, Strongly Disagree. Question 15 is multiple choice with specific answers in parenthesis.

IQP Team Survey Open Response Questions and Tallied Answers

1. What did you particularly like about the videos?
   - No answer
     i. 11
   - Thorough and clear
     i. 13
   - Visual demonstration/ Helpful with dissection
     i. 15
   - Step by step instructions(specific)/procedure/protocol
     i. 26
   - Well paced
     i. 1
   - Well constructed
     i. 2
   - Animation
     i. 1
   - Follow while doing lab
     i. 4
   - Needed TA less
     i. 1
   - Easy to Follow
     i. 1

- Ahead of time help/availability
    i. 5
- Narration
    i. 2
- Summary at end
    i. 1
- Showed what to do and what tools looked like
    i. 2
- Didn't watch any, no opinion
    i. 4
- They Exist
    i. 1
- Easy to Access
    i. 1
- Nothing
    i. 1
- Good Supplement to other materials
    - 1
- Alternative to reading
    - 2

2. What did you particularly dislike about the videos?
   - No answer
       i. 23
   - Nothing
       i. 14
   - Slow
       i. 11
   - Fast
       i. 1
   - No location of materials
       i. 1
   - Awkward timing
       i. 1
   - Quality
       i. 6
   - Length (long)
       i. 19
   - Wish could skip around easier
       i. 1
   - Naming materials took too long
       i. 5
   - More detail

- i. 1
- Gompei (Stupid Goat)
  - i. 2
- Talked too slow
  - i. 2
- Some videos had poor sound quality
  - i. 1
- Didn't watch, no opinion
  - i. 2
- Trouble Loading/Playing the video
  - i. 1
- Couldn't follow dissection with book
  - i. 1
- They were in 2D
  - i. 1

3. Any suggestions for future videos? Something you would have liked to see?
   - No Answer
     - i. 36
   - Nothing
     - i. 19
   - Don't list all the materials/procedure or keep it shorter
     - i. 4
   - Better volume control
     - i. 2
   - Separate into sections
     - i. 3
   - Keep concise and similar to lab (no deviations)
     - i. 3
   - Speed up dissections
     - i. 3
   - More text to point out key step
     - i. 2
   - Lines for incisions drawn
     - i. 1
   - Mike cameo (humorous) w/ helpful hints
     - i. 1
   - Label organs better
     - i. 1
   - Podcast
     - i. 1
   - Explanation of expected results
     - i. 1

- Close-up shots of more things (i.e. well plate vs. strip for ELISA)
    i. 1
- Spend more time on how to make initial cuts
    i. 1
- More animations
    i. 1
- Less monotonous voices
    i. 1
- Overview at beginning and recap at end
    i. 1
- Better editing
    i. 1
- Faster
    i. 1
- More discussion while dissection
    - 1
- Film in smell-o-vision
    - 1
- Use a standardized format for the videos
    i. 1
- Have several file formats available to open
    - 1

4. Are there any videos you feel would be better understood as an animated video? (or vice versa)
    - No Answer
        i. 39
    - No – Good as they were
        i. 10
    - No (prefer actual demonstration)
        i. 32
    - Yes (No indication to which)
        i. 3
    - See what's happening at molecular level (?)
        i. 1
    - Animated images of wells
        i. 1
    - Fetal Pig Dissection
        i. 1
    - Background information on related topics
        i. 1
    - Show what you should see under microscope / label and point things out
        i. 1

- Any that involve small instruments
  - i. 1
- ?
  - i. 1

5. What do you think the video helped more; quizzes, laboratory reports, or understanding and retaining material?
    - No answer
      - i. 16
    - Understanding and retaining material
      - i. 37
    - All the above
      - i. 3
    - Quizzes
      - i. 2
    - Laboratory reports (procedures)
      - i. 17
    - Quizzes and Lab Reports
      - i. 1
    - Help while doing lab
      - i. 19

6. What grade do you expect to receive?
    - A
      - i. 42
    - Between A and B
      - i. 2
    - B
      - i. 29
    - C
      - i. 8
    - NR
      - i. 1
    - No Answer
      - i. 7
    - Don't know
      - i. 1

7. Other Comments?
    - No Answer
      - i. 66
    - No
      - i. 5
    - God help me

- - i. 1
- Good Job
  - i. 6
- Didn't work on a MAC (didn't watch until lab)
  - i. 1
- Didn't watch Labs 5 & 6 because of time management problems
  - i. 1
- More videos in Bio classes, good way to teach and learn
  - i. 1
- "The videos are great, and I felt so much more comfortable using them in lab. Please make them for the D-term BB2000 level labs!!"
  - i. 1
- Did not watch the videos
  - i. 1
- Candy is a big motivator
  - i. 1
- Interesting supplement to lab
  - i. 1

Grades

Grades are displayed as points (left) and letter grade (right).

Total|100160	Grade
240.5	NR
479.75	A
497	A
440.75	B
439.75	B
485.15	A
490.25	A
0	NR
490	A
397.25	C
495.75	A
470.25	A
473.5	A
405.75	C

488.25	A
415	B
492.25	A
321.25	NR
462.25	B
381.5	C
342.5	NR
469.75	A
468.25	A
489	A
411.25	C
506	A
404.5	C
407.25	C
379.5	C
436.75	B
448.8	B
484.25	A
511.65	A
498.5	A
447.75	B
462.25	B
476	A
165.15	NR
462.45	B
476.5	A
408.75	B
473.75	A
485.5	A
432	B
479.5	A
430.25	B
403.75	C
375	C

482.25	A
497.5	A
459.5	B
239.75	NR
468.75	A
495.4	A
222.75	NR
311.75	NR
481.5	A
469.75	A
432.75	B
488.75	A
18	NR
395.25	C
486	A
485.5	A
375.25	C
484.8	A
382	C
456.5	B
481.5	A
331.5	NR
429.5	B
208.5	NR
210	NR
395.35	C
460.5	B
495.25	A
462.05	B
418	B
354.6	NR
466.75	A
455.95	B
469.95	A

350.75	C
488.5	A
485.9	A
108	NR
465.5	A
482.4	A
413	C
491.5	A
451.95	B
428.75	B
417.75	B
425.75	B
481	A
477.25	A
421.5	B
463.75	B

Number of Requests Sent for Online Tutorials (Hit Counts)

Tutorial Directories on Media Server	Total	Peak*
/Academics/Depts/Bio/ConnectedLab/BB2903/amoeba_slides.wmv	457	244
/Academics/Depts/Bio/ConnectedLab/BB2903/dialysis_tubing.wmv	298	177
/Academics/Depts/Bio/ConnectedLab/BB2903/diffusion_plates.wmv	326	152
/Academics/Depts/Bio/ConnectedLab/BB2903/elisa.wmv	223	125
/Academics/Depts/Bio/ConnectedLab/BB2903/euglena_slide.wmv	286	184
/Academics/Depts/Bio/ConnectedLab/BB2903/lime+water_breath.wmv	35	21
/Academics/Depts/Bio/ConnectedLab/BB2903/micropipettors.wmv	221	137
/Academics/Depts/Bio/ConnectedLab/BB2903/onion_plasmolysis.wmv	191	114
/Academics/Depts/Bio/ConnectedLab/BB2903/phalanges_measurement.wmv	1	1
/Academics/Depts/Bio/ConnectedLab/BB2903/phenothalein_breath.wmv	36	20
/Academics/Depts/Bio/ConnectedLab/BB2903/pig_disection.wmv	2632	233
/Academics/Depts/Bio/ConnectedLab/BB2903/Pig_dissection_Chapter1.wmv	164	100
/Academics/Depts/Bio/ConnectedLab/BB2903/Pig_dissection_Chapter2.wmv	207	90
/Academics/Depts/Bio/ConnectedLab/BB2903/Pig_dissection_Chapter3.wmv	922	105
/Academics/Depts/Bio/ConnectedLab/BB2903/Pig_dissection_Chapter4.wmv	310	85
/Academics/Depts/Bio/ConnectedLab/BB2903/Pig_dissection_Chapter5.wmv	59	29
/Academics/Depts/Bio/ConnectedLab/BB2903/Pig_dissection_Chapter6.wmv	27	17

Tutorial Directories on Media Server	Total	Peak*
/Academics/Depts/Bio/ConnectedLab/BB2903/Pig_dissection_Chapter7.wmv	105	65
/Academics/Depts/Bio/ConnectedLab/BB2903/Pig_dissection_Chapter8.wmv	66	25
/Academics/Depts/Bio/ConnectedLab/BB2903/potato_staining.wmv	277	163
/Academics/Depts/Bio/ConnectedLab/BB2903/safety_corner.wmv	261	149
/Academics/Depts/Bio/ConnectedLab/BB2903/Sequence+01.wmv	3	2
/Academics/Depts/Bio/ConnectedLab/BB2903/sequence_amoeba.wmv	1	1
/Academics/Depts/Bio/ConnectedLab/BB2903/sequence_squamous_cell.wmv	10	8
/Academics/Depts/Bio/ConnectedLab/BB2903/serial_dilutions.wmv	1	1
/Academics/Depts/Bio/ConnectedLab/BB2903/squamous_cell_stianing.wmv	267	160
/Academics/Depts/Bio/ConnectedLab/BB2903/using_spirometer.wmv	53	29
/Academics/Depts/Bio/ConnectedLab/BB2903/yeast_budding.wmv	250	158
/Academics/Depts/Bio/ConnectedLab/general/lab/lab-trash.wmv	4	3
/Academics/Depts/Bio/ConnectedLab/general/lab/lab_safety.wmv	4	2
/Academics/Depts/Bio/ConnectedLab/general/LabSafety/lab_safety.wmv	4	2
/Academics/Depts/Bio/ConnectedLab/general/Microscopy/using-a-microscope.wmv	371	200

*peak refers to the highest number of hits per single day.

APPENDIX B: SAMPLE SCRIPT

- sample script of "Survivorship Curve" animated tutorial:

   Welcome to "Connected Lab at W.P.I." video tutorial on "Survivorship."

   Section 1: Types of Survivorship

   Survivorship Curves visually depict age-specific mortality through survivorship. Any such curve is obtained by plotting the number of individuals of a particular age group against time. Conventional graphing methods plot the logarithms of survivor number against age. Any such survivorship curve can be classified into at least 3 types.

   Type 1 Survivorship curves are convex and illustrate species with high survivorship whose members most often liv out the majority of their lifespan. Certain plants and mammals tend to follow this trend, most notably Human Beings.

   Type 2 Survivorship curves are linear and illustrate species with relatively constant mortality rates. Many reptilian species, corals, and the honey bee follow this trend.

   Type 3 Survivorship curves are concave and illustrate species with high mortality rates in early life. Most species with large numbers of offspring, such as invertebrates and fish, follow this trend.

   Now we have learned the 3 primary survivorship curves. Isn't this fascinating?

   Thank you.