Creating Animated Diagrams with Flash

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Abstract

Photographs, illustrations and diagrams have long been used as a way to support and enhance textual material. The emergence of the Web as a teaching platform has focused the attention of educators on the use of multimedia as an instructional medium. Sound, video and animation are the primary components of multimedia. Animation can be a powerful tool for introducing concepts and processes. An animated diagram can support the text or go beyond the written explanation. Adding motion to a process diagram or an illustration, which shows how something works, can help to explain difficult concepts. Although most educators avoid multimedia packages due to their expense and complexity, Flash is a great tool for the beginner. Flash offers a quick way to create simple animations to be used on the Web.

Introduction

Merging text and graphics has always proven to be effective in fostering learning. Multimedia instruction strives to further enhance the learning process by adding other media elements. Multimedia is defined as applications that bring together multiple types of media such as text, illustrations, photos, sounds, animations and video with some measure of interactivity (Apple, 1994). One of the main characteristics of multimedia is that it is interactive; it makes the viewer an active part of the presentation instead of a passive observer (Apple, 1994). Since multimedia employs a variety of media, it stimulates multiple senses. The value of multimedia learning materials is that they can accommodate many learning styles. Horton states "The more channels used to process the information, the more areas of the brain are activated and the more locations the information is stored in" (1991). Dale's Cone of Learning points out that the more involvement the learner has with the subject matter, the higher the retention rate (Dale, 1969).

As educators, we strive to present course materials in a variety of ways to emphasize and re-emphasize concepts. Most educators realize that different students respond to certain teaching techniques more than others. Some students only need to hear and/or read an explanation, whereas others need hands-on experimentation. For those in the latter group, a static illustration might not be enough, whereas an animated sequence that the student can stop and start might solidify the process. Animated sequences are engaging to the viewer and can be used to represent information that is difficult to explain with static images (Brinck et al., 2002).

Animated Diagrams

Animation is a subset of instructional visuals (Rieber, 1990). Just as static illustrations support textual and verbal explanations, animation adds another element of focus. Gonzales (1996) defined animation as "a series of varying images presented dynamically according to user action in ways that help the user to perceive a continuous change over time and develop a more appropriate
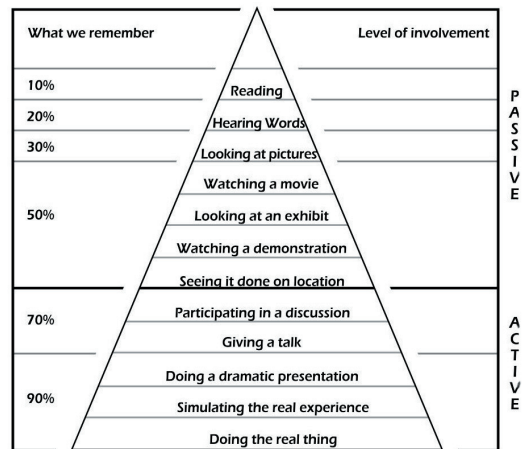

Figure 1 Dale's Cone of Learning

mental model of the task." While diagrams are used to show how various components work as a whole (Horton, 1991), animated diagrams are useful for showing sequences. An ordered sequence of images answers the questions when? why? and how? (Meyer, 1997). For example, consider an animation that shows how a car's brake system works. The viewer could learn that the brake shoes are activated as the driver pushes down on the brake pedal (when) and the fluid pressure increases (why) and activates a set of pistons (how) (Mayer, 2001). Animated sequences are best used to explain a process or casual relationships or illustrate a chronological order of events (Meyer, 1997). There are a variety of reasons to use animated sequences: 1) To enrich graphical representation, 2) To illustrate change over time 3) To illustrate how a mechanical device works and 4) to show a process or procedure (Horton, 1991; Nielsen, 1999).

Enriching Representation

Typically, graphics are used to illustrate things that are difficult to describe with words alone. A simple illustration of how to install a video card clarifies the location of and relationship between the parts more than words alone.

In the same way, using motion to depict changes over time or the interactions of moving parts should enhance the visualization of the sequence. Instead of examining a series of static images to convey how a pump works, the viewer can start and stop an animation or run it in slow motion to see how the pump functions.

Showing Change Over Time

Often, the process being illustrated happens over a period of time. For example, the way an oil field is formed over a period of many years or the second by second changes in a bullet from firing through impact are both time-based events. These types of processes can be better communicated through animation. The changes can be shown subtly with transitions, that gradually fade from one stage to the next, or precisely with step-by-step or on-going sequences that the viewer can control.

Illustrating a Mechanical Device

The most common use for animated diagrams

is showing how something works. Whether it's a pump, an engine or an electrical device, an animated diagram can illustrate how the parts interact and in what sequence. As with most graphic devices, diagrams offer a simplified version of the device to focus on the process being illustrated. Vector line images, such as those from Flash, using minimal color and shading, are well suited to this task because of their clarity and precision.

Showing a Process or Procedure

Animated diagrams are also appropriate for demonstrating processes or procedures. For example, an animated diagram can show how a virus invades a cell or how a casting is made. These time-dependent actions are difficult for observers to explore repeatedly in real life and in real time. With an animated diagram, however, the steps of these processes can be repeated indefinitely and dissected by curious minds until they reveal themselves more fully—allowing for a better understanding of the process. The power of visual thinking is combined with that of repetition in the use of animated diagrams.

Flash Animations

Flash is an animation tool that can be used to create effective animations that are efficient for use on the Web. It uses vector imaging that delivers resolution independent graphics with minimal file sizes. This makes them ideal for Internet transfer or insertion into multimedia presentation packages.

Flash also innovated the technique of anti-aliasing vector graphics for a more attractive look. Anti-aliasing softens the traditional sharp edges associated with vector imaging by using blending algorithms typically used in raster environments. This gives Flash graphics a more appealing look while retaining the precision and reproducibility of vector animation, making Flash a good choice for animated diagrams.

Flash animations are frame-based and often utilize scripting. This assures consistency of temporal elements and allows the developer to create levels of interactivity that range from limited to complex (Kaye, 2003).

Research On Animation

Research related to animated diagrams has

shown varied results. Bétrancourt and Tversky, in their review of animation studies, found that the primary problem was the methodology of the studies (Bétrancourt & Tversky, 2000). Some of the studies compared static and animated graphics, some compared text passages with animated displays, some compared computer- assisted-learning to classroom learning and others focused on how viewing the animation affected learning performance.

Further, when comparing static graphics to animated graphics, it was found that often the animated sequences included finer steps or provided information not available in the static image. The authors conclude, "... most of the successes of animation seem to be due to the extra information they convey, rather than the animation of that information." (Bétrancourt & Tversky, 2000) In other words, studies have not shown positive results that can support the effectiveness of animation per se. The research has shown, however, some of the problems associated with using educational animations, as well as, things to consider when designing animations.

Considerations When Using Animated Diagrams

Goals

As with any use of graphics, the effectiveness of an animation is determined by the goals, the implementation and viewer interaction (Bétrancourt & Tversky, 2000). Typically, graphics are included to help readers by 1) making the textual information more aesthetically pleasing (decoration); 2) making information easier to visualize (representation); 3) making information

easier to remember (transformation); 4) organizing the information (organization); and 5) increasing understanding (interpretation) (Levin, Anglin & Carney, 1987). Since animated diagrams are a subset of graphics they can serve all of the same goals.

What is the goal of the animation? Is it to engage the viewer by offering an alternative learning method? Is the goal to aid comprehension? Studies have shown that computer animation "holds motivation" (Reiber, 1991); that suggests that computer animation can serve as an effective teaching tool.

Implementation

Jones & Scaife (2000) point out several features of animation, that can affect perception and readability. They are design dimensions, representation and temporal aspects.

First, consider the design dimensions, which refer to the amount and complexity of the information being illustrated. Things to consider include the complexity of the image, the amount of information presented at one time and the clarity of the process being illustrated. For example, schematic representations were found to be more conducive to learning than pictorials (Hegarty
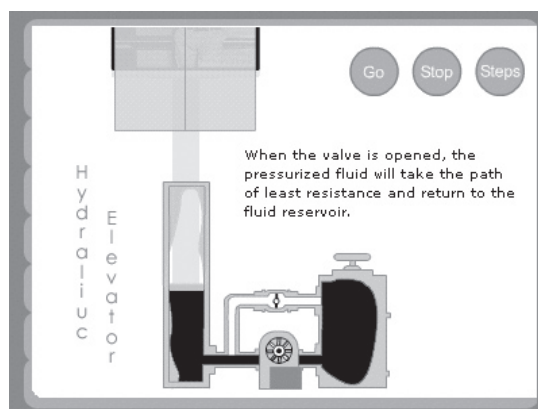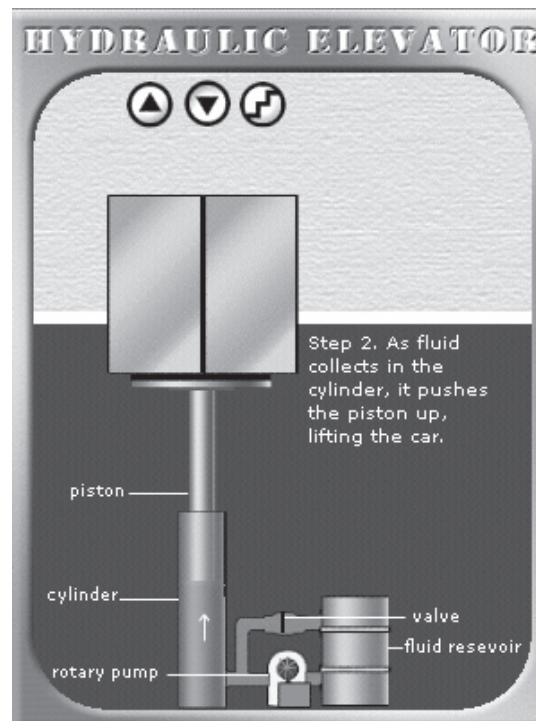
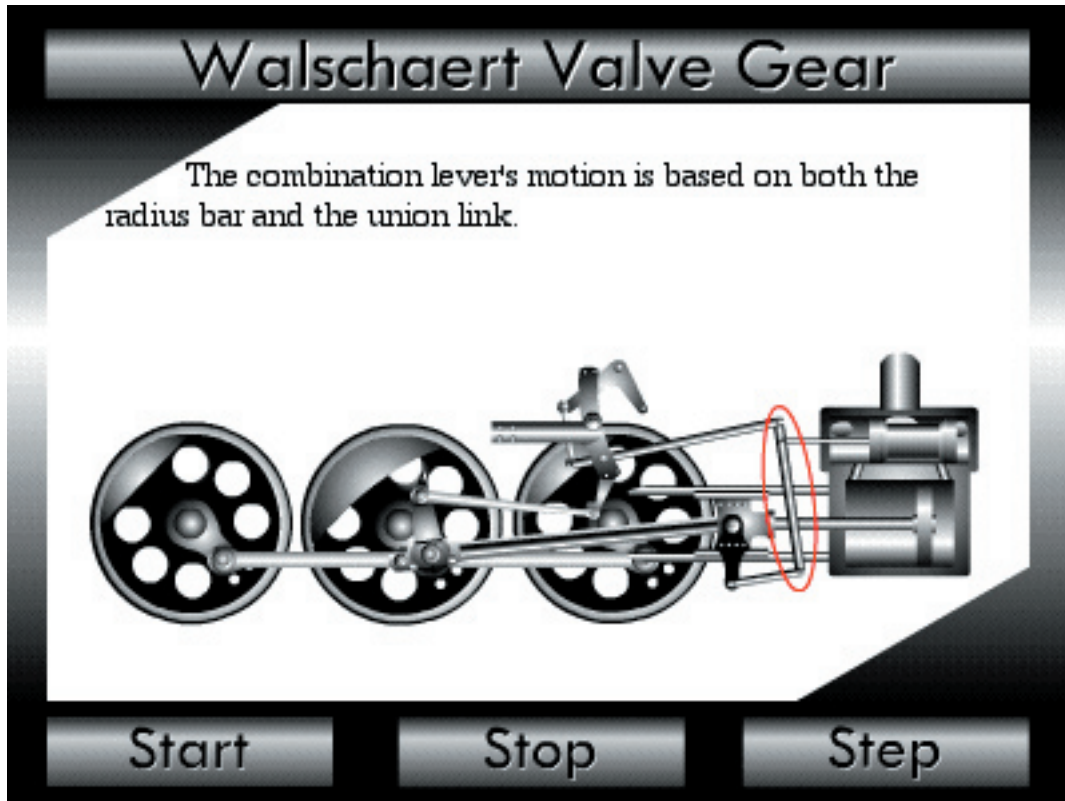**Figure 2** Elevator 1

Figure 3 Elevator 2

Figure 4 Gear animation with highlighted area

& Kozhevnikov, 1999). We can conclude that straightforward images, that eliminate excessive detail, help the viewer to focus on the process. Also, the complexity of the animation should be suitable for the user. The more inexperienced user requires simpler and better-documented animations whereas a more experienced user can comprehend something more abstract and complex (Scaife & Rogers, 1996).

Second, consider the representation of the process being animated or how the motion is depicted. For example, the order and number of steps and the amount of detail can vary. In the examples shown in figures 2 and 3, although both show the operation of a hydraulic elevator, they vary in several ways. The first example (Figure 2) uses color shapes to indicate the hydraulic fluid; the second example simply uses an arrow to show the direction of flow. When viewing the animations side by side, the first one is more effective because it conveys both direction and fluidity. The second example (Figure 3) labels the parts; the first one rotates the pump when the liquid moves. Both illustrate the same process in slightly different ways, each having features that, if combined,

would offer the best sequence.

Third, consider temporal aspects such as speed, direction and the relationship between parts over time. Although a process might be clearer when shown over time, if the sequence happens too quickly it might be difficult to understand. If too many parts are moving at the same time, pop-up labels with an explanation might help. Highlights can also be used to help the viewer focus on a particular part at a particular time. In the example shown in Figure 4, the pertinent step is circled on the diagram to direct the reader's attention to the correct location on the diagram.

Jones & Scaife (2000) state "Focusing and sequencing relieves learners from deciding which aspects are important and in what order to 'read' information, which may reduce confusion and enable focus of attention on relevant aspects."

Countering The Drawbacks Of Animation

There are several drawbacks associated with animated diagrams. First, animations are fleeting (Morrison et al., 2000). Typically, the user has little control over the animation and must retain
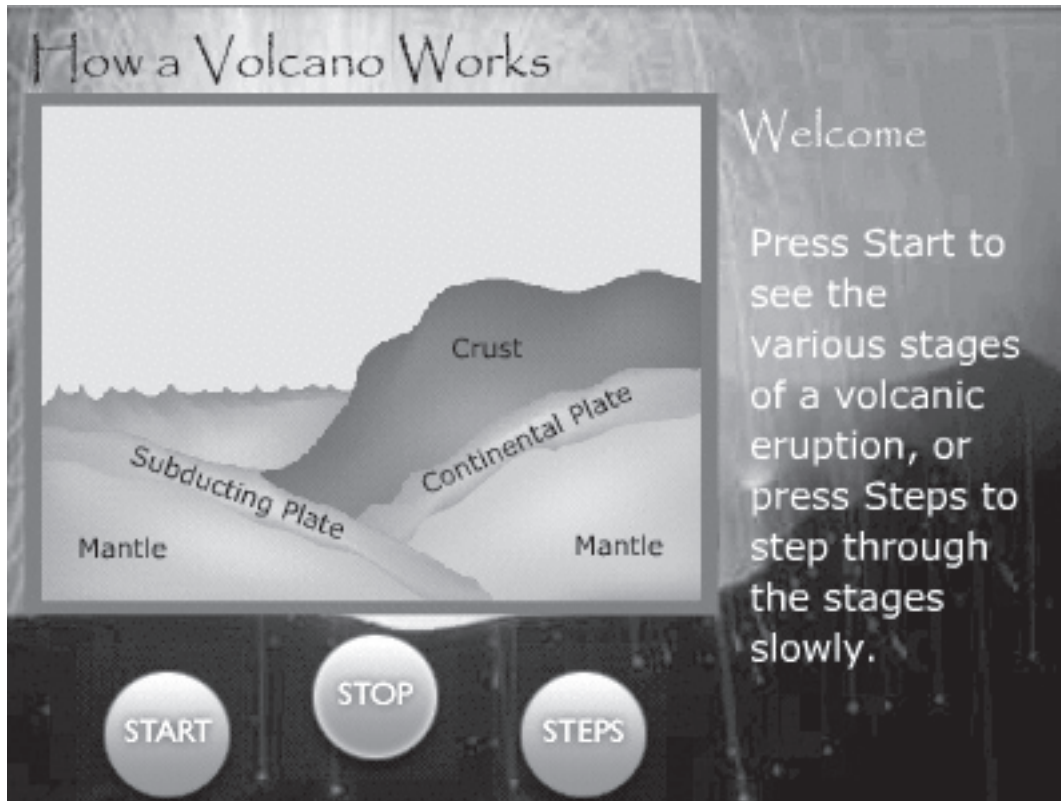
Figure 5 Volcano animation with controls

and integrate information over the course of the animation. To overcome this problem, give the user some control by adding a slow option or a static step-by-step playback with some instructions as show in Figures 5 and 6. This allows the user to replay both the motion and the explanation at will.

Second, animations can result in cognitive/ memory overload if too much information is presented at the same time or in a complex illustration (Kaiser et al, 1992). Jones & Scaife (2000) state that parsing motion sequences can lead to better understanding of the dynamics of the sequence. When the animation shows the interaction of multiple parts at a representational speed, the complexity might overwhelm the viewer. To compensate, the process can be broken into multiple stages that focus on different aspects of the overall process as shown in Figure 6. Likewise, allowing the user some level of interactivity gives them more control of the animation.

Third, as with any form of graphical communication, the information or message must be clear. Since the words and images are minimized,
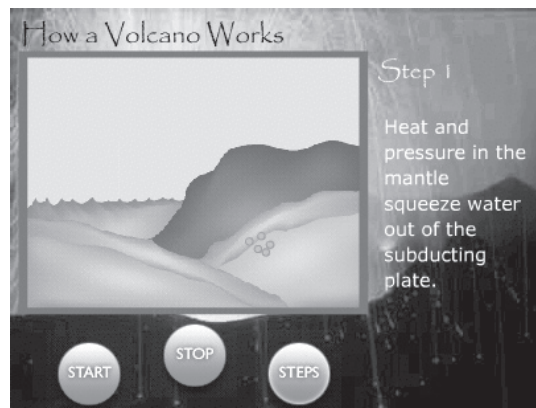

Figure 6 Step 1 in volcano sequence

they must be appropriately focused on the learning task. Mayer (2001) states that for multimedia learning to be successful, the learner must coordinate five cognitive processes. As information is presented, the multimedia user will actively monitor and process the presented information, using the five cognitive processes: 1) selecting relevant words, 2) selecting relevant images, 3) organizing words into a "verbal model," 4) organizing images into a "pictorial model," 5) integrating the two models.

When designing an animation, consideration needs to be given to things that will aid the learner in processing the information. Words can be presented as text and speech to encourage dual-channel learning and images can be simplified to remove extraneous elements and highlight important areas. Since images, text and spoken words are processed differently, the process of absorbing and sorting the data is complex and care must be taken to facilitate this process in a multimedia environment.

Mayer provides another set of guidelines that lead to successful multimedia, which can be incorporated into the design of animated learning sequences. He has identified five conditions that facilitate learning in a multimedia environment: 1) spatial contiguity, 2) temporal contiguity, 3) coherence, 4) modality, and 5) redundancy (Mayer, 2001).

To achieve spatial contiguity, place related text and images near to each other in the layout. For temporal contiguity, present the words and images at the same time rather than in a sequence. Coherence can be achieved by minimizing extraneous sounds, words and images, which may distract from the relevant material. The principle of modality states that a multimedia user learns better if words are spoken rather than written. Finally, learners do better when words are spoken rather than both spoken and written.

Levels Of Interaction

As Dale's cone of learning shows, learners tend to absorb more as their interaction increases (Dale, 1969). The complexity of an animation can vary based on the subject, the user, the goal and the skill of the developer. Many educators are capable of creating simple animations with Flash. Although more advance sequences might require expert assistance, the educator can still control the design and the effectiveness by following some of the guidelines presented earlier in this paper. Following are descriptions of the different levels of interactivity that can be achieved.

Start/Stop Control

At its basic level, interactivity entails controlling the timeline of an animated diagram. This means the user is able to start and stop an animation as desired. Often times this can also mean the animation plays through without halting, but the user can play it over and over to better understand the process being shown. At this level of interaction, audio components and special effects are usually left out

For the programmer, this level of interactivity is the simplest to devise. There is a major reduction in scripting. There may also be a reduction in communication. Start/stop control is most useful for short and simple repetitive animations-such as the turning of an electric motor-otherwise the nuances of more complex tasks may be glossed over in the animation and lost on the user.

Step-by-Step

At this level of interactivity the user would view the animation in a progression of steps. The viewer could pause in between each step for comprehension or repeat the material in the previous step. If part of the process is confusing, the user could focus on a specific step-repeating it until they were ready to proceed further.

At this level, the introduction of written and/or audio components can be added to the animation. Animated lessons alone are powerful tools, but additional dimensions of audio or written explanations increase the level of communication.

Most PCs today have some sort of simple audio recording software. If not, there is a variety of shareware and freeware available to aid in the recording of low to mid-grade audio files. These can easily be added to a Flash timeline and set to play along with defined steps in the process. The main drawback to the addition of audio files to an animation is that it increases the file size. Often times two or three minutes of sound can greatly increase the file size of a Flash document. Since Flash files are typically small, it may not be a problem. However, if web delivery is a primary concern, written instructions may be preferred to keep download times short.

Whether written or verbal, supplemental instructions in a step-by-step animation can make a big difference in broadening the communicative value of a piece and can make it more effective.

User Input

Some processes are best understood through the manipulation of variables. For example,

Pascal's law of pressurized fluids may be better interpreted visually if an interactive Flash animation is used, which allows the user to input data and see how it affects the process.

This type of animation will certainly involve some scripting in order to retrieve an inputted variable and modify the animation, but the benefits are great. By allowing the user to manipulate a process in such a way, the user can observe the changes, as data is input. The user can observe how different variables change the process and its importance to the overall sequence. In addition to written or audio instructions, questions about cause and effect can be a part of the animated lesson to encourage experimentation.

Full Interactivity

The highest level of interactivity is one in which the user can input at least one moderating variable in the process and also manipulate the graphics using a mouse or keyboard. This ability to handle and control elements of an animation depends upon the scripting abilities of the developer.

With the additional dimension of object manipulation, a user is often more likely to become interested and engaged with a process animation. It is the closest thing to being able to touch the objects in the animation, adding another level of control. This interactivity may not be necessary for basic processes, or even particularly complex ones. The need for user control is case dependant and to be determined by the developer.

It is important to remember control over interactivity is in the hands of the developer and designer of a Flash process animation. There is a limitless combination of interactive elements possible. It is always important to consider the process being shown when determining which of these levels is appropriate and beneficial when weighed against the development time.

Summary

In summary, animated diagrams can serve as an effective teaching tool. Animations can be used in a teaching situation as support to lecture material or as additional study materials for out-of-class assignments.

They can also serve as a problem-solving device, that students can use to independently draw conclusions by changing variables and seeing the effects. Although they are sometimes time-consuming to create they offer another tool to facilitate learning in a way that holds a student's interest.

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