DELAYED COGNITIVE EFFECTS OF COMPUTER GENERATED ANIMATION VERSUS REALIA UPON UNDERGRADUATES ENROLLED IN AN AGRICULTURAL POWER TECHNOLOGY CLASS

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Abstract

The utilization of visual aids is typically a major part of the educational climate. Traditionally, in an agricultural power technology course, still illustration and representatives of real equipment (realia) have been utilized to teach the hidden concepts that comprise the most basic operational process of the internal combustion engine and its accompanying systems. New advances in technology have provided teachers with the ability to have a new form of visual aid. These visual aids are high-quality computer-generated animation that provide the students with the ability to see the engine move as it was actually operating. This study, which is one part of a larger study, investigated the effects of computer-generated animation on delayed low-level and high-level cognition in undergraduates. The dual-coding theory was utilized as the investigation’s theoretical framework. Computer-generated animations are most effective when used with topics that are abstract, vague, hidden, or too fast or slow to view. When combined with internal combustion engines, animation fits in perfectly with the teaching process. The study utilized an experimental pretest-posttest control group design. Participants were undergraduate students (n=51) enrolled in “Agricultural Power Units,” an undergraduate agricultural power technology course at a university in Texas. The study involved a pretest and then a delayed posttest to determine if the students had lost any knowledge gained through the course presentation. For this investigation, the dependent measure (multiple choice test) consisted of delayed low-level and high-level questions. Three hypotheses were developed. Results indicate that no significant differences existed between the traditional and animated groups. This indicated that animation and realia can be interchanged with the expectancy of similar learning effects. The authors call for replication and an indepth study of the utilization of animation in various teaching fields.
Introduction/Theoretical Framework

The utilization of visual aids is typically a major part of the educational climate. Traditionally, in an agricultural power technology course, still illustration and representatives of real equipment (realia) have been utilized to teach the hidden concepts that comprise the most basic operational process of the internal combustion engine and its accompanying systems. New advances in technology have provided teachers with the ability to have a new form of visual aid. Theses visual aids are high-quality computer-generated animation that provide the students with the ability to see the engine move as it was actually operating. A common problem that occurs in technology based teaching fields relates to students having difficulty learning concepts that are not seen by the human eye. An example of a type of class that provides challenges to students is an agricultural power technology course. This type of course includes concepts or content that may be abstract, vague, hard to visualize, too fast or slow to see, or hidden from view, hence, they are abstract concepts in the student’s mind (Gagne’ 1985). This study will compare the use of expensive and time-consuming equipment to the advancing age of computer-generated animation.

New advances in the area of computer-generated animation may be one of the tools that aids student learning in such topics as agricultural power, while relieving some of the monetary and time constraints that are consistent with traditional methods of visual lesson reinforcement. Although much of the research conducted on the benefits of animation in a learning environment is not consistent (Park & Hopkins, 1993; Rieber, 1990a), many students favor and enjoy learning with animation (Rieber, 1990b, 1991; Rieber, Boyce, & Assad, 1990; Dooley, Stuessy, Magill, & Vasudevan, 2000).

A computer-generated animation is a series of still computer-generated pictures that are presented in succession in order that the illusion of motion is developed, much like a picture flip-book (Burke, Greenbow, & Windschitl, 1998). Animations differ in that they offer two unique attributes that still pictures do not, trajectory and motion (Rieber, 1991). Therefore, animations represent a subset of instructional visuals (Rieber, 1990a) and receive general theoretical support from information processing learning theories proposed by individuals such as Gagné (1985) and Paivio (1971, 1983, 1986, 1990).

Animations tend to aid in high-level cognition situations such as problem solving, incidental learning, critical thinking, etc., rather than aiding students in low-level recall (Baek & Layne, 1988; Agnew & Shinn, 1990; Rieber, 1990a; Rieber, Boyce, & Assad, 1990; Mayer & Anderson, 1991, 1992; Park & Hopkins, 1993; Williamson & Abraham, 1995; Nicholls, Merkel, & Cordts, 1996). According to Park and Hopkins (1993), if a lesson is limited to low-level learning tasks, animations have the same effect as still illustrations. We also know from the literature that animations are specialized and must be used in the correct context, situation, and the appropriate philosophical perspective, (Rieber & Hannafin, 1988; Rieber, 1990a; 1990b; 1991; LoPresti & Garafalo, 1992; Park & Hopkins, 1993; Williamson & Abraham, 1995; Nicholls, Merkel, & Cordts, 1996; Dooley, Stuessy, Magill, & Vasudevan, 2000) as well as with the appropriate learner (expert vs. non-expert learners, experienced vs. non-experienced learners, low-spatial vs. high-spatial ability learners, younger vs. older learners, etc.) or their effects are negated (Mayer, 1989; Rieber, 1990a; 1990b; Rieber, Boyce, & Assad, 1990; Park & Hopkins, 1993; Mayer & Sims, 1994; Williamson & Abraham, 1995; Mayer, 1997; Dooley, Stuessy,
Next, through the work of Richard Mayer and others, we know that animations need narration to be most effective; preferably the narration and animation are delivered simultaneously (Rieber, 1991; Mayer & Anderson, 1991; 1992; Park & Hopkins, 1993; Burke, Greenbow, & Windschitl, 1998). It has also been found that animations can reduce the time it takes to complete a defined task such as model construction or test taking (Rieber, Boyce, & Assad, 1990; Park & Hopkins, 1993). Although there are not vast amounts of empirical evidence, animations have also been found to be excellent attention-gaining devices in the classroom (Baek & Layne, 1988; Park & Hopkins, 1993). Finally, we know that students view animation favorably, that animation helps to motivate students, and that practice can affect how students learn with animation (Peters & Daiker, 1982; Rieber, 1990a, 1990b, 1991; Nicholls, Merkel, & Cordts, 1996; Rieber, Noah, & Nolan, 1998; Rueter & Perrin, 1999; Dooley et al., 2000).

Primary theoretical support for the use of animations, as well as still illustration, and their effects on learning comes from the dual-coding theory (Pavio, 1971, 1983, 1986, & 1990). According to this theory, information is processed and represented by two separate codes known as verbal codes and non-verbal codes. The theory argues that humans understand the world around them through language and non-verbal objects and occurrences. Language is categorized as incoming and outgoing and shares a symbolic relationship to the non-verbal, which can be representative of such things as objects, events, and behaviors. The non-verbal code includes all information that can be processed from the senses, which includes non-verbal sounds. These verbal and non-verbal codes can be encoded information from a human’s environment individually or simultaneously.

Verbal and non-verbal coding systems work as a sort of two-lane road in which information travels. As information travels along this roadway, many connections are developed during the process of cognition. As information is acquired, representational connections are made to verbal or non-verbal information received by the learner. These connections are exactly as their name implies, they are representative schema that activate prior knowledge or experiences that the learner may have in relation to what is being learned. For example, if a student views a brightly colored rubber orb, the structure is representative of a ball used for play, representation is developed between what is experienced by the senses and the individual’s sense representation for what is experienced. Associative connections are made within the verbal and non-verbal “lanes,” respectively, that is, actual words and an individual’s verbal representations of the words are developed and connected. Also, words that may be associated to one another tend to make connections as well (i.e., the word tabby may also activate the word feline). Non-verbal are also connected associatively. Just as with words, smells may conjure visual memories or the sight of certain objects may cause flashbacks to scenes experienced by an individual. Put simply, associations are made, and words are related to other words and images to other images of the same or different sense perception mode (Pavio, 1971, 1986; Clark & Pavio, 1991). The third type of links are referential connections, which are connections that cross over “lanes” in order to create links between the verbal and non-verbal information. These types of connections are championed by supporters of multimedia instruction for the argument that if information is coded verbally, as well as through another sense such as sight (visually), the information is more likely to be remembered because one representation or reference can activate another. “When information is dually coded, the probability of retrieval is increased because if one memory trace
is lost, another is still available” (Rieber, 1991, p. 319). Figure 1.1 is a visual representation of the dual-coding theory.

Figure 1: A dual-coding model for processing animation and speech. Adapted from *Mental Representations: A Dual-Coding Approach*, Pavio, 1990.

Current research indicates that animation tends to have a cognitive skew; therefore, a low/high level cognitive orientation was implemented in this study (Baek & Layne, 1988; Agnew & Shinn, 1990; Rieber, Boyce, & Assad, 1990; Mayer & Anderson, 1991 & 1992; Park & Hopkins, 1993; Williamson & Abraham, 1995; Nicholls, Merkel, & Cordts, 1996). The investigation of the delayed effects of animation on testing in this area is limited, therefore, the study also researched the delayed cognitive effects of animation as prescribed by prior research (McGregor, Fraze, Baker, Drueckhammer, Lawver, 2003; McGregor, Fraze, Baker, Haygood, Kieth, 2003).

**Purpose and Hypotheses**

The purpose of the study was to determine if there were any measurable learning effects, which would result from the use of computer-generated animations as a replacement for realia on a delayed posttest with a combination of low and high-level cognitive questions. Undergraduate students enrolled in an Agricultural Power Technology course were studied in order to determine if there were significant differences between students who view computer-generated animations compared to the student that view static illustrations and realia. Consequently, the following hypotheses were formulated:

H₀₁: There are no significant differences between the illustration/realia (traditional) groups and the illustration/animation (animation) group on the delayed low-level cognitive test scores.
\( H_02: \) There are no significant difference between the illustration/realia (traditional) group and the illustration/animation (animation) group on the delayed high-level cognitive test scores.

\( H_03: \) There are no significant difference between the illustration/realia (traditional) group and the illustration/animation (animation) group on the delayed total-cognitive test scores.

**Methodology**

The research design for this study was an experimental, randomized subjects, pretest-posttest control group design (Ary, Jacobs, & Razavieh, 1996). Even though the subjects were self-selected into a particular course through registration for the course, rationale for selection of this design does exist because of random assignment of subjects to experimental treatment was possible (Kirk, 1995; Ary et al., 1996; Gay & Airasian, 2000). The population consisted of undergraduate students in Colleges of Agriculture whose major course of study requires an agricultural power course and/or students that may have a particular interest in an agricultural power course.

Data was collected during the fall semester of 2003. The actual experiment took place during one instructional week. The pretest was administered two weeks prior, and the delayed posttest one week following the instructional unit. Pretest and Posttest questions were identical. The groups participated at 9:25 a.m., the regularly scheduled class time. Subjects were asked to participate in the class as they normally would, attending to the content in the lesson and take notes as they wanted. Subjects were informed of the delayed posttest that would follow. Both of the lessons lasted approximately one hour and thirty minutes; included in this time frame were the instructional and testing time.

A lecture style presentation was presented to participants in the traditional (control) and animation (treatment) groups. The content of the lecture focused on the operational theory of the spark ignition internal combustion engine. Students in the animation group viewed a PowerPoint® presentation, which included illustrations and animations that were inserted into the presentation. The traditional group also viewed a PowerPoint® presentation, which covered the same material, only differing in that there were realia utilized in place of the animations that were utilized for the treatment group.

Following the lesson's content, a 45 question multiple-choice test was administered to each participant. This administration served as the delayed posttest. Students were given as much time as needed to complete the posttest. The instrument was a researcher-developed test that coordinated with the lesson’s content and material. The overall instrument’s item content varied according to high and low cognitive levels, according to the levels of cognition developed by Newcomb and Trefz (1987), which were adapted from Bloom’s Taxonomy. Newcomb and Trefz consolidated Bloom’s Taxonomy into four levels of cognition, which are remembering, processing, creating, and evaluating. Test items classified as low-level cognitive questions were directly taught during the instructional setting, and therefore students needed only to recall
information in order to be successful on each low-level question. Test items classified as high-level challenged students to combine, create, or evaluate the information given in the lesson in order to arrive at the appropriate answer.

The instrument was tested for face and content validity by a national panel of experts in agricultural education, agricultural mechanization, and agricultural engineering whose research areas have focused on agricultural mechanization/engineering, cognitive levels for testing, and educational objectives. The overall reliability of the test was measured by the Kuder-Richardson-20 (KR-20) formula upon completion of the delayed posttest. Initial reliability coefficients for the overall pretest (.68) and overall delayed posttest (.70) were more than acceptable when compared to similar research in this area.

After completing the testing periods, data was entered into and analyzed using SPSS for Windows. Data that was collected include low and high level cognitive test scores from each test: pre-test and delayed posttest, also total scores from each of the test, gender, GPA, and classification.

Mean comparisons were made utilizing an analysis of variance for all hypotheses. The final number of scores available for analysis was $n = 51$; therefore, the control (traditional) group ($n = 28$) and the treatment (animation) group ($n = 23$) were un-equated when considering frequency. According to Green, Salkind, and Akey (2000), if cell sizes are not equal, it is suggested that un-weighted means (estimated marginal means) be reported in the results. All hypotheses were tested at the $p < .05$ level.

**Results/Findings**

Following analysis of all valid cases, it was found that 31 participants were male (60.7%) and 20 (39.3%) were female. The average age of the participants was 20.76 years (SD= 3.39) and the average cumulative GPA for all participants was 2.51 (SD=.57) on a 4.0 scale. Of the students who participated in the study, 16.9% were freshmen, 42.4% were sophomores, 28.8% of the participants were juniors, 10.2% were seniors and 1.7% were graduate students.

Table 1 reports the estimated marginal mean scores, standard error, and confidence intervals for each testing administration during the course of the experiment for the traditional (control) and the animation (treatment) groups.
## Table 1
Summary of Pretest and Delayed Posttest Administrations to Participants

<table>
<thead>
<tr>
<th>Test Administration</th>
<th>Traditional Group</th>
<th>Animation Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EMM</td>
<td>SE</td>
</tr>
<tr>
<td>Low-Level Pretest</td>
<td>40.2</td>
<td>2.88</td>
</tr>
<tr>
<td>High-Level Pretest</td>
<td>37.7</td>
<td>2.56</td>
</tr>
<tr>
<td>Total Pretest</td>
<td>38.5</td>
<td>2.42</td>
</tr>
<tr>
<td>Low-Level Delayed Posttest</td>
<td>73.3</td>
<td>2.25</td>
</tr>
<tr>
<td>High-Level Delayed Posttest</td>
<td>59.0</td>
<td>2.39</td>
</tr>
<tr>
<td>Total Delayed Posttest</td>
<td>65.2</td>
<td>2.15</td>
</tr>
</tbody>
</table>

EMM – Estimated Marginal Mean
SE – Standard Error

### Hypothesis One
Hypothesis one tests the hypothesis of no differences between traditional and animation groups for the delayed low-level posttest. Table 2 summarizes the results of an analysis of variance utilized to test the hypothesis of no differences.

### Table 2
Analysis of Variance Comparing Traditional and Animation Groups on Delayed Low-Level Cognitive Posttest Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>Df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>52.650</td>
<td>1</td>
<td>52.650</td>
<td>.371</td>
<td>.545</td>
</tr>
<tr>
<td>Within</td>
<td>6948.331</td>
<td>49</td>
<td>141.803</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7000.980</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although the traditional group (M=73.3) did score lower on the delayed low-level posttest in comparison to the animation group (M=75.4), no significant differences were detected. According to the non-significant F-ratio, the finding indicates that the use of animation develops equivalent learning effects when compared to realia on a delayed low-level cognitive test.

### Hypothesis Two
Hypothesis two tests the hypothesis of no differences between traditional and animation groups for the delayed high-level posttest. Table 3 summarizes the results of an analysis of variance utilized to test the hypothesis of no differences.
Table 3
Analysis of Variance Comparing Traditional and Animation Groups on Delayed High-Level Cognitive Posttest Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>Df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>8.617</td>
<td>1</td>
<td>8.617</td>
<td>.371</td>
<td>.545</td>
</tr>
<tr>
<td>Within</td>
<td>7875.304</td>
<td>49</td>
<td>160.720</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>7883.922</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although the traditional group (M=59.0) did score lower on the high-level posttest in comparison to the animation group (M=59.8), no significant differences were evident. This finding was consistent with the delayed low-level cognitive examination. According to the non-significant $F$-ratio, the finding indicates that the use of animation develops equivalent learning when compared to realia on a delayed high-level cognitive test.

Hypothesis Three

Hypothesis three tests the hypothesis of no differences between traditional and animation groups for the delayed total posttest. Table 4 summarizes the results of an analysis of variance utilized to test the hypothesis of no differences.

Table 4
Analysis of Variance Comparing Traditional and Animation Groups on Total Delayed Cognitive Posttest Scores

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>Df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>22.102</td>
<td>1</td>
<td>22.102</td>
<td>.170</td>
<td>.682</td>
</tr>
<tr>
<td>Within</td>
<td>6357.193</td>
<td>49</td>
<td>129.739</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6379.294</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As described in table 4 the traditional group (M=65.2) did score lower on the total delayed posttest in comparison to the animation group (M=66.6), but no significant differences were evident. This finding was consistent with the delayed low-level and high-level cognitive examinations. According to the non-significant $F$-ratio, the finding indicates that the use of animation develops equivalent learning effects when compared to realia on the total cognitive test.

Conclusions/Recommendations

Hypothesis One

The results from this study indicate the addition of animation to an agricultural power lesson can be successfully interchanged with realia without concern for a loss in learning on a delayed low-level posttest. This finding is consistent with prior research that has found that, typically, no differences exist between animation and illustration/realia when considering low-level recall information (Mayer, 1989; Rieber, 1990a, 1990b, 1991; Rieber, Boyce, & Assad, 1990; Rieber & Kini, 1990; Mayer & Anderson, 1991, 1992; Park & Hopkins, 1993). If asking students to perform simple tasks related to remembering and processing (Newcomb & Trefz, 1987), still illustrations and computer-generated animation are just as effective as realia coupled with still illustrations.
Hypothesis Two

The results from this study indicate the addition of animation to an agricultural power lesson can be successfully interchanged with realia without concern for a loss in learning on a delayed high-level posttest. This finding contradicts prior research relating to animation’s beneficial effects on high-level cognition (Baek & Layne, 1988; Agnew & Shinn, 1990; Rieber, 1990a; Rieber, Boyce, & Assad, 1990; Mayer & Anderson, 1991, 1992; Park & Hopkins, 1993; Williamson & Abraham, 1995; Nicholls, Merkel, & Cordts, 1996).

Hypothesis Three

Considering that hypothesis three was simply a culmination of hypotheses one and two, one would expect no difference between groups. Once again, results indicate that there were no differences between students who viewed animated visual aids rather than realia based models based on the total delayed cognitive posttest.

Discussion

The authors would like to advise the readers to approach the findings of this study with caution. Findings were based upon a subset of students from a limited geographical location in the United States. Also, generalizability could also be limited due to the study’s small sample size and limited available population.

Study of the pre-test and delayed posttest reveals that there were no significant differences. The results seemed to express that the treatment perform slightly higher than the control group, however there were no significant differences. Therefore, no inference can be made to that effect.

In this study it was shown how animation could assist a teacher in an agricultural power course. Using what has been learned from this study, educators can utilize the benefits of animation to replace realia in appropriate situations. For example, providing illustration on how a sewing machine works or how a chain saw cuts wood. Through this understanding of how technology works and how technology is being used in the classroom provides the basis of why it should be used in a classroom. Technology surrounds us and is more and more available to educators for less compared to buying the displays that would be needed to teach the various classes. Animation, in turn, poses the question, “if you can receive the information from the resources you have at a cheaper cost then why not use that source?” Another problem related to realia is finding the space to store items when not in use. With animation storage is provided in an area that is used everyday, your computer!

The authors would like to call for additional research in the areas of different age groups, ethnic groups, social economic groups, and groups from different nations. This would provide a better understanding of how each of these groups learn and how well animation plays a role in their learning.
References


