DOCUMENT RESUME

ED 387 529 TM 024 082

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TITLE The Effect of Animation on the Instruction of the Principles of ANOVA.
PUB DATE Nov 94
NOTE 11p.; Paper presented at the Annual Meeting of the Mid-South Educational Research Association (Nashville, TN, November 9-11, 1994).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Analysis of Variance; *Animation; *College Students; Feedback; Graphs; Higher Education; Instructional Effectiveness; Pilot Projects; *Statistics; *Teaching Methods; Test Results
IDENTIFIERS *Graphic Representation

ABSTRACT

This study examined the effects of using static graphics and animated graphics to introduce statistical concepts associated with analysis of variance (ANOVA) to a group of college students. The demonstrations led the learner from the concrete to the abstract by use of dynamically adjustable variables paired with immediate feedback. Participants in this pilot study were inexperienced in statistical methods. Those in one group were exposed to static graphics, a program in which they could view before and after conditions. Those in the second group were exposed to animated graphics dynamically displaying the movement of a piston corresponding to increases in pressure or temperature. Graphs depicting the relationships were dynamically constructed on the screen. The goal of the pilot study was not to establish statistical significance, but to observe the effects of graphic presentation. Those receiving content with static graphics scored better than those receiving animated graphics, but these graphic presentations alone were not enough to add to the participants' knowledge of statistical concepts. (Contains 21 references.) (SLD)

"THE EFFECT OF ANIMATION ON THE INSTRUCTION OF THE PRINCIPLES OF ANOVA."

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Paper presented at the Annual Meeting of the

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Nashville, TN November 8-11, 1994

Often statistical concepts are introduced visually by means of graphs and drawings with the intention of clarity. And the resulting concepts can be effective while they are being presented. Unfortunately this success is short lived as students who receive excellent grades in advanced research classes often fail to answer the simplest questions when they are quizzed outside the context of the class. In oral examinations and casual conversations these outstanding students fail to verbalize their understanding of key research concepts. Accordingly, these concepts never enter into their thinking about real problems and how they might be investigated. One such concept, often touted as the most popular statistic used in research, is Analysis of Variance (ANOVA).

In the field of education, several variables are often used and analyzed during an experimental design investigating educational practices and methods. One of the most frequently used analysis is a two-way (factorial) ANOVA. This procedure allows the effects of the individual independent variables and/or a combination of those variables on the dependent variable to be analyzed. The effect of each level of one independent variable on the dependent variable is referred to as the main effect. Interaction occurs when the effect of one independent variable changes the effect of another variable. Simple effect is the level of one independent combined at a level of another independent variable on the dependent variable.

In classes where statistics are taught computers have been suggested as a solution to interact with students: they serve as patient tutors and unbiased examiners, allowing students freedom of pace and time (Kulik, 1981). The development of computer-assisted instruction modules requires simple and logical consideration to the screen design as it is the window through which the learner must look . The consistency in screen design enables the learner to automate software manipulation while reducing cognitive load (Norman & Draper, 1986; Shneiderman, 1987). The use of color, backgrounds, type styles, navigation modes and type of presentation are all part of the screen design effecting the learner.

The introduction of graphic display and its importance to CAI have been studied by many educational researchers (Kobayashi, 1986; Alesandrini, 1987; Rieber & Kini, 1991). In Kobayashi (1986) used several theorists to document a study which addressed the superiority of pictures in the encoding of information into memory -- Paivio (Dual-coding); Craik and Lockhart (Levels of processing); Nelson (Sensory-Sematic Model); and Pylyshyn and Anderson (Propositional Theories). Graphics were suggested by others as having several advantages to computer-assisted instruction: aiding visualization of spatial relationships (Cooper & Shepard, 1973); acting as positive mnemonics for verbal and concrete information (Paivio & Csapo, 1973); bringing attention and appeal to instructional material (Surber & Leeder, 1988); and enhancing performance Alesandrini (1987). Rieber & Kini's research (1991) suggested that CAI is enhanced when graphics are included. The question of adding graphics into each computer-assisted instructional piece must be understood in terms of motivation and learning (Levie, 1987). Yang (1992) demonstrated a "superiority" for the CAI in a study which compared print-based material and computer-assisted instruction.

Some guidelines for the development of graphic material used as teaching tools have been researched. Dwyer's studies (1978, 1987) with adults on visual presentations suggested that too much information leads learners to ignore appropriate, or to study inappropriate, information. Mayer (1989) suggested that static graphics when used with instructional text improved problem solving abilities of students . Later Mayer and Anderson (1992) applied the name "contiguity principle" for this dual presentation of graphics and textual material. Their study found that college students were better able to solve transfer problems when graphics and texts were presented together. Their task of studying a mechanical operation was presented in several different methods: concurrent graphic and oral narration; successive graphic and narration; graphics only; narration only; and no instruction (control group). Because of the limited capacity of working memory, students were able to construct better referencing connections when textual and graphics material were presented together.

Another design choice available to computer assisted instruction is animation. This design form is defined as a series of rapidly changing computer screen displays which appear to human perception as if they are moving (Caraballo, 1985). Four practical reasons were described by Rieber (1990) for application of animation in computer-assisted instruction: visual stimulation, practice, presentation, and cosmetic. Animated visuals stimulate the learner and are practical and effective attention-gaining devices. When used properly attention is gained. Gagne (1985) suggests that this is an important initial event for learning. Animations also offer a contrast to textual information or static backgrounds, bringing attention to important lesson information (Hannafin & Peck, 1988).

Research has yet to make clear any differences between static and animated graphics for educational concepts. One exception is in the area of changing concepts where animation communicates better because it reduces the level of abstraction required. To visualize ideas which change in time or involve motion, animation conveys a more concrete image to the learner (Rieber & Kini, 1991). Animation is also more effective than static graphics when presented as a series of verbal and visual chunks. A study by Rieber, Boyce and Assah (1988) found no performance differences between the types of visual presentation. However, the measured response time showed a significant difference for the animation condition. This suggests that the process of encoding the information was aided by the animation, reducing the retrieval time. Quicker response time suggests that the animated presentation aided the students in the reconstruction process during recall (Rieber, 1989). The attention of the learner was easily directed to animated information and less easily distracted from the animation when the frame was broken down into textual and visual "chunks" (Rieber, 1989).

Just as problem solving was improved when static illustrations were used concurrently with instructional text (Mayer, 1989), improvement was also found with animation (Mayer and Anderson , 1991). Mayer and Anderson (1992) found that animation, when presented with concurrent narration, performed better on transfer problems. As with

Rieber's study in 1989. the presentation of the attributes of motion by animation reduces the processing demands of short term memory. Therefore, animation is expected to increase encoding information into long term memory.

There are inherent dangers in the random addition of animation to computer assisted instructional units. Too much "glitter" added to educational software can be detrimental when the educational value has not been considered first (Rieber, 1989). Rieber (1991) later restated that animation is an effective attention device, but it must be informative. The learner, in order to gain knowledge, must be able to see the relevance of the animation to the instruction. This supports earlier studies by Dwyer (1978, 1987) which stated too much information creates confusion in the focusing the student's attention to the proper material.

This investigation examined the effects of using static graphics and animated graphics to introduce statistical concepts associated with ANOVA to a group of college students. The demonstrations were used to lead the learner from concrete to abstract by use of dynamically adjustable variables paired with immediate feedback. Principles of Boyle's and Charles' laws governing the behavior of ideal gases were used to illustrate main effects and interactions.

The main effect of an ANOVA are typically illustrated via static graphs and have proven to be quite successful. However, interactions are displayed by connecting points which represent a mean of the interaction. This technique often confuses students, leading them to believe the data is continuous rather than categorical. The true comparison has to deal with the differences found between graphic points. regardless of whether they are representative of main effect or interactions.

Method

Participants. All participants were enrolled in educational classes at Virginia Tech and were inexperienced in statistical methods. Students were offered the opportunity to participate in an experiment related to learning statistics using graphic display on the computer as a remediation tool.

Post Test measure. Questions related to the areas which commonly are confusing to novice students of ANOVA were adapted from a proficiency exam given by the Research and Evaluation department of the College of Education. These questions are normally used to test the knowledge of statistical concepts for those graduate students who seek advancement through their degree. Six of the questions were word problems and the remaining eight questions were graphic.

Cognitive measure. The Hidden Patterns Test was developed by the Educational Testing Service. The test measures participant's ability to search a complex field in order to disseminate a hidden pattern.

Computer software. Software was created using *Multimedia Toolbook 3.0* (Asymetric) and *Authorware* (Macromedia, Inc.). The program was implemented in a *Windows 3.1* (Microsoft, Inc.) environment while running on Intel 486, 8 Mb RAM platform.

Procedure

Assessment. The Hidden Figures test was administered by pen and pencil immediately before the presentation. It was administered in two parts and timed with 3 minutes allotted for each section. Students were assessed for knowledge gained via a computer-mediated, on-line multiple-choice instrument immediately following the intervention.

Treatments. The presentation of ANOVA concentrated on main and interactive effects (pressure and temperature) and their resulting graphs. The effects of pressure and temperature on a volume of gas were introduced to participants using two different computer-mediated visuals: static graphics and animated graphics. Text was removed as much as possible. As a result, participants were expected to infer the knowledge from the graphic presentation to which they were assigned.

Participants were assigned to each condition by a random number printed on the Hidden Patterns test. Participants in group one were exposed to static graphics. At designated locations, they were given the opportunity to further interact with the program by using "clickable" buttons to view *before* and *after* conditions resulting from changes in temperature and pressure. The static graphics immediately appeared as they would appear in a textbook or a presentation on the board in the classroom.

Participants in the second group were exposed to animated graphics. The interactions which helped deliver instruction were also different because they resulted in the generation of animated components which visually reinforced the concepts associated with ANOVA. That is, animations dynamically displayed the movement of the piston which corresponded proportionately to increases in either pressure or temperature. Simultaneously, graphs depicting the relationship between the variables were dynamically constructed on screen.

Results/Discussion

The purpose of this pilot study was to gather evidence which might support further investigation regarding the differences between using static and animated graphics in instructional settings. The goal of the study was not to establish any statistical significance; rather, to observe the effects of graphic presentation and the inference gained by participants. One question (question #12) demonstrated significant differences ($p > .035$, two-tail) between animated and static graphics. This graphic question illustrated a dramatic interaction by the two line crossing in the shape of a "X". The participants who received the instructional content with static graphics scored significantly better then those receiving animated graphics instruction.

Although no definitive results were found from this study, it is generally understood that graphics combined with text enables better encoding of information and may lead to better learning. While no significant conclusion may be drawn from the presentation of concepts using graphics (static or animation) alone, we can state that graphics aid the learning process. It is quite clear that these presentations were not enough to add to the participants knowledge of statistical concepts.

The relationship suggested between field dependence/independence and mathematical concepts was not supported by the Hidden Figure Test results. There was no suggestion of any correlation between this cognitive test and any results of the experiment.

This study strongly suggests that graphics, alone, do not provide enough instructional cues to influence learning of this type. From the studies of others who used a combination of both textual and graphics to present new material, we can draw the assumption that both are better. These studies (Cooper & Shepard, 1973; Surber & Leeder, 1988 and Rieber & Kini, 1991) have stated the advantage of both but have left questions about the amount of text and/or graphics.

Future trials should gradually add textual material to look at the question of "How much is enough?" to aid learning.

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