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ABSTRACT

This study investigated the effects of computer and print text density on learning, and the nature and effects of learner preference for different density levels in both print and computer presentation modes. Subjects were 48 undergraduate teacher education majors, who were assigned at random to six treatment groups in which a statistics lesson was presented in either of two modes (computer or print) crossed with one of three text density-level conditions (high, low, or learner control). Dependent variables were different types of learning achievement, lesson completion time, attitudes, and learning efficiency. Overall, the experimental findings were not supportive of computer based instruction relative to print as a delivery medium for the current statistics lesson. This lesson's dependency on mostly narrative descriptions of rules and operations and allowance of self-pacing remained constant regardless of mode, but print offered the possible advantage of representing the text in a more readable and accessible form. Furthermore, the newness of the computer mode may have caused students to perceive it as more difficult or challenging. In the attitude survey, subjects were generally favorable to computer based instruction (CBI). In learner control selections, high density material was favored for CBI 75% of the time, as opposed to 25% for print. The overall impression is of a less confident and more conservative computer based instruction group, which generally worked as a disadvantage for achievement and learning efficiency. The text is supplemented by one figure and one table. (39 references) (EW)

Text Density and Learner-Control as Design Variables with CBI and Print Media

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Text Density and Learner Control as Design Variables
With CBI and Print Media

Instructional designers frequently ignore the unique properties of computer-based instruction (CBI) by creating materials using the same design formats and teaching strategies traditionally incorporated in print lessons (Bork, 1985; Burke, 1982). One important difference between the two media lies in the constraints that CBI imposes on the display of instructional text (Grabinger, 1983; Hartley, 1985; 1987; Lancaster & Warner, 1985; Richardson, 1980). Specifically, computer text offers considerably less flexibility than print by: (a) limiting the visible display to one page at a time, (b) making backward paging for review purposes more difficult, (c) limiting the size of the page layout to about 24 lines and 40-80 characters, and (d) offering limited cues regarding lesson length.

Recognizing these properties, instructional designers generally advocate formats that minimize clutter and maximize "white space" in the display area (Allessi & Trollip, 1985; Bork, 1985; Burke, 1982; Caldwell, 1980; Heines, 1984; Tullis, 1981). One popular system for spacing text is "chunking" (Bassett, 1985; Grabinger, 1983), which involves separating sentences into meaningful thought units with blank spaces surrounding each. Chunking and similar methods, however, have failed to show clear advantages under either print or CBI presentations (cf, Bassett, 1985; Carver, 1970; Feibel, 1984; Gerrell & Mason, 1983; Hartley, 1987; O'Shea & Sindelar, 1983). A possible limitation is that they leave lesson content unaltered while presenting it in an unfamiliar format.

The main interest in the present research was varying lesson content in accord with attributes of the presentation media employed. Of specific concern was the level of "richness" or detail provided in instructional text, an attribute we will label text "density level." In earlier research with print material, Reder and Anderson (1980; 1982) compared complete chapters from college textbooks with summaries of main points on both direct and indirect questions. In 10 separate studies, summaries were found to be comparable or superior for learning to the original text. The authors concluded that summaries may help students to isolate central ideas without the distraction of having to attend to unimportant details. Similar to the Reder and Anderson (1980) study, the present conception of text density level concerned such attributes as length of materials (number of words used), redundancy of explanations, and depth of contextual support for important concepts. This construct resembles what reading researchers have labeled the "microstructure" of text (Davison & Kantor, 1982), as contrasted with "macrostructure" which concerns how information is organized and elaborated through comparison of examples, nonexamples, and concept categories (Di Vesta & Finke, 1985; Frayer, Fredrich, & Klausmier, 1969; Moes et al., 1984; Reder, Charney, & Morgan, 1986). An example of a low-density frame and a parallel high-density frame from the present instructionl materials is presented in Figure 1. Note that the low-density version contains the same information as the conventional version but eliminates details and nonessential words. The result is approximately a 50% reduction in both number of words and screen area required. One hypothesis in the present study was that such low-density narrative would promote better learning and more favorable attitudes on CBI lessons by reduiig reading and cognitive processing demands of screen displays.

Insert Figure 1 about here

A second research interest was the nature and effects of learner preferences for different density levels in print and CBI modes. Although "learner-control" strategies that allow students to self-determine instructional conditions have shown positive results in some studies (Judd, Bunderson, & Bessent, 1970), recent findings have more often been negative (Carrier, Davidson, & Williams, 1985; Carrier & Sales, 1985; Fisher, Blackwell, Garcia, & Greene, 1975; Lahey & Crawford, 1976; Ross & Rakow, 1981; Tennyson, 1980). Studies of aptitude-treatment interaction (ATI) effects further suggest that the less the student's prior knowledge, the less effective learner-control tends to be (Carrier & Sales, 1985; Fisher et al., 1975; Gay, 1986; Hannafin, 1984; Ross & Rakow, 1981; 1982; Tennyson, 1980). To extend this research, we explored the viability of allowing learners to make selections of text density level, which unlike the variables of task length, quantity, and difficulty emphasized in previous studies, represents a contextual rather than primary lesson property. Low-density computer text was expected to be a more popular choice than the high-density versions due to the relative difficulty of reading text from CRT screens. These questions were examined by crossing two presentation modes (computer vs. print) with three text density conditions (high, low, and learner control). Dependent variables were different types of learning achievement, lesson completion time, attitudes, and learning efficiency.

Method

Subjects and Design

Subjects were 48 undergraduate teacher education majors enrolled in a beginning instructional technology course. They were assigned at random to six treatment groups in which learning materials were presented in either of two modes (computer or print) under one of three text density-level conditions (high, low, learner control).

Materials

Profile data form. A brief questionnaire was used to determine subjects' attitudes toward mathematics and CBI. Ratings were recorded on five-point Likert-type scales, with "5" representing the most positive reaction.

Instructional Unit. The learning material was an introductory unit on central tendency. The unit, which was organized into five

Instructional Unit. The learning material was an introductory unit on central tendency. The unit, which was organized into five sections, emphasized the teaching of facts and conceptual information that students would need to recall to solve and interpret problems. A conventional (high-density) print version of the lesson was initially prepared. Total length was 18 pages and 2,123 words. Within each section the basic instructional orientation involved defining the concept or main idea and then illustrating its application with several context-based numerical examples.

Following Reder and Anderson's procedure, low-density text was systematically generated from the conventional text by (a) first defining a set of general rules for shortening the material, (b) having at least two people discuss the rules and rewrite the materials accordingly, and (c) reviewing the material and making changes until consensus was achieved that all criteria were satisfied. Specific rules employed were:

1. Reduce sentences to their main ideas.

   a. Remove any unnecessary modifiers, articles, or phrases.
   b. Split complex sentences into single phrases.

2. Use outline form instead of paragraph form where appropriate.

3. Delete sentences that summarize or amplify without presenting new information.

4. Present information in "frames" containing limited amounts of new information, as in programmed instruction.

The completed low-density lesson consisted of 1,189 words, a 56% savings relative to the high-density version, and 15 pages, a 17% savings (see samples in Figure 1). CBI versions of the high- and low-density lessons were prepared directly from the print materials. Word counts for corresponding low- and high-density versions were identical across print and computer modes. Due to the much smaller display area of the computer screen, it was not possible or (considered desirable) to duplicate the print page formats. Computer frames were thus designed independently, using what were subjectively decided to be the most appropriate screen layouts for presenting the material. Each screen provided both back- and forward-paging options. The final versions of the low- and high-density CBI lessons consisted of 49 and 66 frames, respectively.

Attitude survey. Attitude items consisted of statements about the learning experience to which subjects indicated levels of agreement or disagreement on a 5-point Likert-type scale (e.g., 1 = "strongly disagree," 5 = "strongly agree"). Abbreviated descriptions of the six statements comprising the survey are: "Lesson moved quickly," "Material was interesting," "Was easy to learn," "Explanation was sufficient," "Text layout was easy to read," and "Prefer this method over lecture." Internal consistency reliability for the survey, computed by Cronbach's alpha formula, was r =.63 (n = 48).

Achievement posttest. The achievement posttest (print format) consisted of four sections designed to assess different types of learning outcomes. The first two sections were considered knowledge subtests, since each assessed recognition or recall of information exactly as it appeared in the text. The knowledge-1 subtest ("definitions") contained 17 multiple-choice items, each consisting of a statement describing one, all, or none of the three central tendency measures (mean, mode, or median). Those that described central tendency measures included the exact key words contained in both low- and high-density narratives. The knowledge-2 subtest ("distributions") contained eight questions concerning the effects of symmetrical and skewed distributions on the placement and interpretation of the mean and the median. On four of the items subjects were asked to write a brief rationale for their answers. The distributions shown on all items were exact replications of examples that appeared in the lesson.

The calculation subtest contained five problems requiring computation of different central tendency measures from new data not used in lesson examples. The transfer subtest consisted of 13 items that involved interpreting how central tendency would vary with changes in distributions or individual scores. Items of this type were not included in the lesson, nor were the underlying principles needed to answer those items explicitly stated. They were thus considered measures of transfer (or conceptual) learning.

Scoring rules on objective items and calculation problems awarded one point for a correct answer. On interpretative items one point was awarded for a correct answer and an additional point for a correct explanation. Internal consistency reliabilities were computed by means of the KR-20 formula for subtests with dichotomous item scores and by Cronbach's alpha formula for the remainder. A summary of resultant reliability values along with subtest lengths and maximum points is as follows: knowledge-1 (17 items, 17 points, $\underline{r}$ =.60), knowledge-2 (8 items, 12 points, $\underline{r}$ =.57), calculation (5 items, 5 points, $\underline{r}$ =.67) and transfer (13 items, 20 points, $\underline{r}$ =.84).

Procedure

Subjects completed the profile data form during a regular class meeting, at which time they signed up to receive the learning task the following week. Typically from 3-15 subjects attended an individual session. Two similar classrooms were used, one for the print condition and the other for the CBI condition. The latter classroom contained 12 Apple IIe computers with monochrome screens, either single or double disk drives, and from 64K to 128K of memory. Proctors began the session with instructions for completing the task. Instructions for all treatments indicated that (a) the five units were to be studied at one's own pace, (b) turning back to reread preceding pages (frames) was permitted if desired, and (c) a posttest would be given following the learning task. Subjects in the learner-control treatment received additional instructions indicating that depending on how much explanation they desired, they could choose between "long" and "short" presentations on each section. To help the subject make a decision for the first section, actual samples of parallel low- and high-density pages were shown. In the computer condition, subjects pressed a key to indicate their preferences, following which the appropriate high- or low-density version of the unit was presented. In the print condition, preferences were indicated orally to the proctor who then distributed appropriate materials. The same density selection procedures were repeated at the beginning of each of the remaining four sections. After subjects completed the last section, their finish times were recorded and the attitude survey was administered followed by the posttest.

Results

The basic statistical design was a 2(presentation mode) x 3(density condition) factorial. An alpha level of .05 was used to judge significance. Treatment means and standard deviations on major dependent variables are summarized in Table 1.

Insert Table 1 about here

Initial 2 x 3 ANOVAs were conducted on responses to the profile data survey to judge the equivalence of treatment groups prior to the administration of experimental tasks. No significant main effects or interactions were found on any of the items.

Learner-Control Selections

Preliminary analyses were made of density-level selections by learner-control subjects. Results for CBI and print groups combined (n = 16) showed that low-density and high-density materials were selected with equal frequency (both M's = 2.5) across the five sections. Low-density material, however, was selected an average of 3.75 times (and high-density 1.25 times) by print subjects, whereas the exact opposite pattern occurred for the CBI group (low-density M = 1.25; high-density M = 3.75). The differential showing greater low-density preferences by the print group was significant, $t(14) = 2.57$, $p < .05$.

Achievement Results

Analysis of scores on the knowledge-1 subtest ("definitions") showed a significant main effect of presentation mode, F (1, 42) = 4.48, $p < .05$. Subjects in the print condition (M = 13.1; 77% correct) scored higher than those in the CBI condition (M = 11.6; 68% correct). Neither the density level effect nor the interaction was significant.

The ANOVA performed on calculation subtest scores, showed the main effect of presentation mode, F (1, 47) = 10.08, $p < .02$, to be the only significant outcome. As on the knowledge-1 test, the print group (M = 4.0; 80% correct) surpassed the computer group (M = 3.1; 62% correct). No significant main or interaction effects were found on either the knowledge-2 or transfer subtests.

Lesson Completion Time and Learning Efficiency

The analysis of lesson completion time yielded a highly significant presentation mode main effect, F (1, 42) = 26.65, $p < .001$; and a marginally significant density-level main effect, F (2, 42) = 2.53, $p < .10$. The presentation mode effect was due to print subjects' taking significantly less time (M = 18.0 min.) to complete the lesson than did CBI subjects (M = 32.3 min.). The ordering of density-level groups was as expected, with low-density lowest (M = 20.8 min.), learner-control next (M = 26.9 min.), and high-density highest (M = 27.8 min.). The specific comparison between high- and low-density levels is attentuated, however, by the inclusion of the learner-control treatment which represented a mixture of the two variations. When the learner-control treatment was excluded from the analysis, the time savings for the low-density groups reached significance, F (1, 427) = 4.30, $p < .05$.

A desired outcome of adaptive instructional strategies is to improve learning efficiency, as measured by the level of achievement attained per instructional time allocated. Accordingly, as in several previous studies on adaptive instruction (Ross & Rakow, 1981; Tennyson & Rothen, 1977), treatments were compared on efficiency scores, computed as the ratio of posttest total score divided by lesson completion time. The ANOVA results showed the instructional mode main effect to be the only significant source of variance. Efficiency means for these comparisons were 2.15 for print versus 1.21 for CBI.

Attitude Results

Given that each attitude item dealt with a different property of the lesson, analyses were conducted to examine separate outcomes on each. No effects were obtained on Items 2 ("interesting"), 3 ("easy to learn"), or 5 ("readable layout"). On Item 1 ("lesson moved quickly"), the presentation mode x density level interaction was significant, F (1, 42) = 5.15, $p < .05$; and the presentation mode main effect approached significance ($p < .10$). In follow-up analyses, using the Tukey HSD procedure, the only difference was found within the high-density condition: print subjects (M = 4.25) gave significantly higher ratings ($p < .05$) than CBI subjects (M = 2.50). On Item 4 ("amount of explanation was sufficient") the two-way interaction was again significant, $F(2, 42) = 4.22$, $p < .05$. Comparisons between presentation modes showed significant variation only within the low-density condition: CBI subjects (M = 4.50) rated the materials higher ($p < .05$) in sufficiency than did print subjects (M = 3.23). The only other significant finding was the presentation mode main effect on Item 6 ("prefer method over lecture"), $F(1, 42)$ = 5.28, $p < .05$. CBI subjects (M = 3.75) were more positive about the teaching method received than were print subjects (M = 2.96).

Discussion

In contrast to Reder and Anderson's (1980; 1982) subjects who were tested exclusively on factual recognition (via treefalse questions), the present sample was administered a variety of achievement measures designed to assess factual knowledge, problem solving, and transfer. The absence of any evidence favoring the high-density text is consistent with the view, as theorized in hierarchical models of text structure (Meyer, 1975), that retrieval of main ideas is not necesszrily facilitated by providing additional details (or elaborations) in the text. However, if students are to develop good reading and writing skills, frequent exposure to elaborated and structurally sophisticated text styles seems essential. With this qualification in mind, instructional designers might consider selective uses of low-density narrative to reduce lesson length and completion time, in situations (such as CBI) where it is costly or difficult to display long segments of text.

Overall, the experimental findings were not supportive of CBI relative to print as a delivery medium for the present statistics lesson. In attempting to interpret this result one might consider Clark's (1983) suggestion that it is not media per se that affect learning, but the instructional strategies that the given media employ (also see Clark, 1984; 1985; Solomon & Gardner, 1985). Clark (1983) reinforces this point through the analogy that, "media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (p. 45). From this perspective, the consistency of outcomes across media studies would seem more validly interpreted on the basis of the instructional strategies used and the content taught rather than on how the lesson was delivered. It thus becomes important to recognize the present lesson's dependency on mostly narrative descriptions of rules and operations and allowance of self-pacing. These instructional features remained constant regardless of mode, but print offered the possible advantage of representing the text in a more readable and accessible form. Further, most subjects in the present study were unfamiliar with and probably somewhat threatened by both the statistical subject matter and learning from CBI. Given the newness of CBI for the present sample and its reputation as a "smart" medium (see Clark, 1984; Salomon & Gardner, 1986), it would seem likely that many subjects would naturally perceive it as more difficult or challenging than print. Such perceptions, if they occurred, would be consistent with the high degree of task persistence demonstrated by CBI subjects in their very deliberate pacing rates and preferences for high-density over low-density material under learner control.

Attitude results also suggested differences in how the two media were perceived. Subjects' generally favorable reactions to CBI were conveyed in their giving it higher ratings than print as a desired alternative to lecture. Interestingly, neither mode was favored on "clarity" or "readability" dimensions, but CBI subjects rated the lesson as slower moving than did print subjects, especially when high density material was used. CBI subjects also rated low-density material higher in sufficiency than did print subjects, even though both groups received the exact same content. Despite these perceptions, learner-control selections by the CBI group favored high density materials 75% of the time, compared to oly a 25% selection rate under print. The overall impression is of a less confident and more conservative attitude of the CBI group, which generally worked as a disadvantage for achievement and learning efficiency.

Seemingly, with students more experienced with CBI, little difference would have occurred between media. Further, potential bias was introduced by the decision to design realistic rather than parallel CBI and print displays to increase the external validity of density comparisons within each medium. In both applications use of low-density text was supported as a design strategy for expository lessons. The spatial limitations of electronic displays obviously makes low-density formats especially appealing for CBI.

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Table 1

Treatment Means and Standard Deviations on Major Dependent Measures

Measure	Print				Computer			
	L-Density	H-Density	L-Control	All	L-Density	H-Density	L-Control	All
Knowledge-1 (17)[a]								
M	12.6	13.1	13.6	13.1	12.1	11.0	11.6	11.6
SD	1.8	1.5	2.0	1.8	3.4	3.0	2.8	3.0
Knowledge-2 (4)								
M	7.4	7.3	9.0	7.9	8.1	7.1	7.5	7.6
SD	2.7	4.5	2.9	3.4	3.2	3.3	3.2	3.1
Calculation (5)								
M	3.8	3.8	4.5	4.0	3.6	2.4	3.3	3.1
SD	0.9	1.5	0.8	1.1	1.5	1.7	1.3	1.5
Transfer (20)								
M	10.6	10.9	14.3	11.9	10.5	9.1	9.8	9.8
SD	5.7	4.3	3.9	4.8	6.4	7.3	5.1	6.1
Attitude Total (30)								
M	20.0	21.7	21.5	21.1	21.6	20.6	21.9	21.4
SD	4.9	4.3	3.0	4.0	2.9	2.8	2.7	2.8
Study Time (Min.)								
M	17.4	18.4	18.4	18.0	24.3	37.3	35.5	32.3
SD	3.7	3.1	3.8	3.4	8.4	16.4	13.1	13.8

[a]Numbers in parentheses following measures indicate maximum scores.

Figure Caption

Figure 1. Sample low-density and high-density frames from CBI lesson.

Low-density sample

CENTRAL TENDENCY

A summary of group achievement is the score most typical or representative of all scores in a frequency distribution

These scores are measures of central tendency

Three common central tendency measures:

Mode--most frequently occurring

Median--middle score

Mean--the "average"

B< Press any key to continue >F

High-density sample

CENTRAL TENDENCY

A good way to precisely summarize group achievement would be to determine the score that is most typical or representative of all scores in a frequency distribution. We call these typical or representative scores measures of central tendency.

A measure of central tendency is a score that is typical or representative of a group of scores. Three of the most commonly employed central tendency measures are the mode (most frequently occurring score), the median (the middle score), and the mean (the "average" score). Most importantly though--any measure of central tendency is supposed to indicate a "representative" score value for the group being evaluated.

B< Press any key to continue >F