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ABSTRACT

According to Keller's Model of Motivation, one technique for increasing learners' motivation, and thus their mental effort, involves increasing the personal relevance of the material. When instruction is perceived as relevant, learners perceive that important personal needs are being met by the learning situation. The purpose of this study was to manipulate the degree of relevance present in both a videotaped and print version of a lesson to determine whether increasing the relevance of a lesson increases the amount of material effort invested. Students enrolled in a sophomore level education course at a large Midwestern university were invited to participate in a two-hour lesson on desktop publishing. Instructional materials consisted of four lessons: (1) a "standard" video on desktop publishing; (2) a motivationally enhanced videotape; (3) a text version of the standard lesson; and (4) a text version of the motivationally enhanced lesson. Assessment measures consisted of a self-report questionnaire, a computer program that measured response rates, and a posttest. Findings were consistent with the results of previous studies conducted with elementary and middle school students. Participants reported in the questionnaire that they invested more mental effort in learning from print versions of the lessons than in video-based versions. The students who received the video-based lesson had significantly longer reaction times to the secondary task measure. (Contains 26 references.) (AEF)

Title:

The Effects of Relevance on Mental Effort

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The Effects of Relevance on Mental Effort

It is a commonly accepted that learners view video as an easy, passive medium, and thus invest little mental effort in processing the information (the "couch potato"). This assumption is primarily based on a series of studies that Salomon (Salomon, 1983; Salomon, 1984; Salomon & Leigh, 1984) conducted in the early eighties. In these studies, Salomon found that learners perceived it to be "easier" to learn from television than books, reported spending less mental effort in learning from videotape than from books, and recalled less from a video-based version of a story than from a print-based version. Salomon assumed that learners perceptions of video or television as "easy" resulted in the investment of less mental effort, and consequently less learning achievement, when compared to reading books.

We could assume from these conclusions that it is preferable to provide instruction in a printed form; however, video remains a popular means of conveying instruction, particularly in the training environment. In fact, a recent survey conducted by Training magazine reported that the use of videotape for conducting corporate training was exceeded only by stand-up instruction (Froiland, 1993).

The majority of research investigating the mental effort invested in instructional videotapes has been conducted with elementary and middle school children (Beentjes & van deer Voort, 1993; Sherman, Salomon, 1983; Salomon, 1984; Salomon & Leigh, 1984). Although several researchers have investigated the amount of effort that college students invest in processing print lessons (Britton, Muth, & Glynn, 1986; Britton, Piha, Davis, & Wehausen, 1978; and others) and television commercials (Lang, Geiger, Strickwerda, & Sumner, 1993; Reeves & Thorson, 1986; and others), there has been very little research that has systematically investigated the mental effort older learners expend in learning from video-based instructional materials. As older learners may have more well developed strategies for learning from videotape that elementary and middle school students, it is important to investigate the extent to which Salomon's conclusions apply to the adult population.

Salomon (1983a) defines the construct of "mental effort" as the "number of non-automatic elaborations applied to a unit of material" (p. 42). In contrast to automatic processing that is fast and effortless, non-automatic processing is deliberate, conscious, and very much under the control of the individual. As new information is received, the new information cues the retrieval of related prior knowledge (E. Gagne, 1985) stored in the learner's schemata. The learner is then able to make connections between the new information and information retrieved from prior knowledge; this process is referred to as elaboration (E. Gagne, 1985). The increased contact with the learner's mental schemata that results from the conscious, non-automatic generation of elaborations, or mental effort, is presumed to facilitate the retention and retrieval of the new material.

The search for techniques to increase the effort that learners invest in video-based instruction has been hindered by the limitations of the instruments used to assess the construct of mental effort. Early work (Salomon, 1983; Salomon, 1984; Salomon & Leigh, 1984) that investigated the amount of effort learners invested in print and video-based instruction used self-report questionnaires to document the learners' effort expenditures. However recently, researchers (Beentjes, 1989; Cennamo, Savenye, & Smith, 1991) have identified a need for more precise methods of assessing mental effort. Beentjes (1989) accurately states that "... validation studies in which mental effort is assessed by multiple methods are called for." (p. 56).

Secondary task techniques have been used to assess effort in a variety studies using print (Britton, Muth, & Glynn, 1986; Britton, Piha, Davis & Wehausen, 1978; and others) and television commercials (Lang, Geiger, Strickwerda, & Sumner, 1993; Reeves & Thorson, 1986; and others), and seem to offer a promising method of assessing the mental effort invested in video-based lessons. When using the secondary task technique, a participant completes a primary task (reading, watching a video, etc.) and at the same time is instructed to respond to a secondary task such as a beep or flash of light as quickly as possible. Researchers assume that as learners spend more cognitive resources on the primary task, they have less cognitive resources left to allocate to the secondary task. They assume that slower reaction times to the secondary task indicate that additional cognitive effort is being allocated to the primary task.

Although Salomon's questionnaire and the secondary task technique are assumed to both measure mental effort, the results of a recent study call that assumption into question. Beentjas and van der Voort (1993) assessed the effort that fourth and sixth grade students invested in two print-based stories and the "structurally equivalent" video-based versions. While students were reading or viewing the stories, they responded to a secondary task, an audible beep, by pressing a key as quickly as possible after hearing the beep. After they completed the stories, they responded to a self-report questionnaire of mental effort that was based on Salomon's instrument. Then they completed an achievement test. The researchers found very low correlations between students scores on the questionnaire and the secondary task measures of effort. In addition, the correlations between scores on both measures and achievement scores on a test of recall inferences were also very low. To further complicate the search for a valid means of assessing mental effort, students reported

spending significantly more effort in reading the text versions than in viewing the videotapes. However, when reaction times to the secondary task were used as a measure of mental effort. the opposite effects were found; reaction times were significantly longer, indicating more mental effort, for the videotaped versions than the text versions. Beentjas and van der Voort state that further research is needed on the validity of both methods of assessing mental effort. They suggest that one promising area of investigation may be to determine to what extent both measures are sensitive to manipulations that are intended to increase mental effort.

But what manipulation? No prior studies have manipulated variables designed to increase mental effort and assessed increases in effort using the secondary task technique and a questionnaire. To select a manipulation that has been shown to increase mental effort as measured by a self-report questionnaire (fun/learn for example) may be biased toward demonstrating effects on the questionnaire. To select a variable that has been shown to increase mental effort as measured by the secondary task technique (related or unrelated cuts, for example) may be biased toward demonstrating effects on the secondary task measure . To further complicate the selection of variables, the vast majority of research that has used reaction times to a secondary task as a dependent variable has manipulated features of either text or video, not both. To select a variable that is effective in print may bias the results toward print; conversely, to select a variable that is effective in videotape may bias the results toward that medium.

Mental effort refers to the choice on the part of the learner to allocate cognitive resources to elaborating on an idea, thus, it has motivational as well as cognitive components (Salomon, 1983). According to Keller (1983), motivation "refers to the choices people make as to what experiences or goals they will approach or avoid, and the *degree of effort* they will exert in that respect." (p. 389, italics in original). He further distinguishes between effort and performance: "*Performance* means actual accomplishment, whereas *effort* refers to whether the individual is engaged in actions aimed at accomplishing the task. Thus effort is a direct indicator of motivation" (p. 391). Based on the literature in motivational theory, Keller's ARCS Model of Motivation (1983) breaks the concept of motivation down into four parts (attention, relevance, confidence and satisfaction). Keller provides specific strategies that instructional designers can use to increase learner's motivation, or the effort expended in accomplishing an instructional task.

According to Keller's (1983) ARCS model, one promising technique for increasing learner's motivation, and thus their mental effort, involves increasing the personal relevance of the material. When instruction is perceived as relevant, learners perceive that *important personal needs* are being met by the learning situation" (p.406, italics in original)

Nwagbara (1993) presented learners with two versions of a videotape to examine the effects of relevance on learners motivation toward learning the steps involved in creating a document using a desktop publishing system. Half the learners received the "standard" videotape and half received a "motivationally enhanced" version of the program that included scenes to increase the relevance of the lesson for the learners. He found that learners reported a greater willingness to expend effort in watching the motivationally enhanced videotape than in watching the same program without the motivational enhancements. Although the actual effort expended in the lesson was not assessed, these results suggest that increasing the perceived relevance of a lesson may encourage learners to invest more mental effort in learning the material.

The purpose of this study was to manipulate the degree of "relevance" present in both a videotaped and print versions of a lesson to determine whether increasing the relevance of a lesson increases the amount of mental effort invested in the lesson. In addition, mental effort was assessed using both the secondary task technique and a self-report questionnaire to determine the more valid way of assessing mental effort. And finally, the study was conducted to determine the extent to which Salmon's conclusions apply to learners of college age. The following research questions were addressed:

a)Do learners invest more effort in print-based versions of the lessons than in video-based lessons?

b) Do learners invest more mental effort in motivationally enhanced lessons than in "standard" lessons which lack these characteristics?

c) Do learners' self-reports of effort correlate with their "on-line" measurements of effort collected using a secondary task technique?

d) Do learners mental effort scores (from secondary task or self-report measures) correlate with their post-test scores on recall measures

Methods

For this study, a 2 (text vs. video) X 2 (enhanced vs. standard versions) X 2 (secondary task vs. non-secondary task) design was used. Eight sessions were scheduled over a two week period with treatments randomly assigned to each of the eight sessions.

Participants

Students enrolled in a sophomore level education course at a large Midwestern University were invited to participate in a two hour lesson on desktop publishing. Of 225 students invited to participate, 130 students volunteered for the study. Thirteen cases were eliminated due to incomplete data (failed to complete the mental effort questionnaire, failure to respond to the secondary task, or to problems with the data collection equipment). After eliminating incomplete data sets, 117 participants remained in the study. Participants were both male (N= 35) and female (N=82).

Instructional Materials:

Instructional materials consisted of four lessons: a) a "standard" video on desktop publishing, b) a motivationally enhanced videotape , c) a text version of the "standard" lesson, and d) a text version of the motivationally enhanced lesson.

The two videotapes were used in Nwagbara's (1993) previous study. The "standard" video tape is a commercially available product. The motivationally enhanced videotape was created by editing segments designed to increase the personal relevance of the material into the commercial videotape.

Keller (1987) suggests that to increase the relevance of a lesson, instructional designers should provide goal orientation, motive matching, and familiarity. Goal orientation can be created by relating the benefits of instruction to getting a job, getting a promotion, or improved job performance, or other goals that may be of value to the learners. The goals of the lesson should be clearly presented or learners should have the opportunity to set their own goals. In addition, learners must understand how the concepts and skills are related to their present or future goals. For learners who are present oriented, the instructional content can be related to their current interests. For future oriented learners, the instruction must provide a rationale as to how the information will be helpful in the future. Motive matching can be enhanced by providing personal achievement opportunities, cooperative activities, and positive role models. Learners should be encouraged to assume responsibility for his or her own behavior and the materials should promote perceptions of self-improvement on the part of the learners (McClelland, 1965; Keller, 1983). Familiarity can be increased by using concrete examples from settings familiar to the learner; stories, pictures, or testimonials about specific people or things familiar to the learner; and through the use of analogies (Keller, 1984).

Following Keller's (1983; 1987) recommendations, motivational elements were added to a) illustrate concrete and provide practical examples, b) provide goals for the learners, c) provide positive role models through testimonials from product users, d) illustrate how the lesson might help the learner improve their present and future skills, e) encourage learners to assume responsibility for their learning, and e) illustrate how the skills are useful. For example, a section was added that stated:

> " Some of you may have used the computer at home or in school to do some assignments, write term papers, and other interesting things. You'll see that some of the things you already know about computers, like how to turn the power on, how to use the mouse, or your familiarity with the buttons on the key board will be handy and helpful to you in the process." (Familiarity)
>
> "Gaining the knowledge and skills in this presentation will open a variety of windows of opportunities for you in the world of work in terms of good jobs, good salaries, and of course, prospects for promotions whether you chose to work in the industry or as the owner of your won desktop publishing business." (goal orientation)

In addition, Nwagbara a) removed non-instructional graphic images, b) condensed time between the narrators and c) eliminated or reduced the time between illustrations of the computer screens to result in two versions of the lesson that were both approximately 35 minutes in length.

For this study, text versions were prepared from Nwagbara's tapes. The text of the print versions was prepared by transcribing the narration from the videotapes. Two undergraduate students viewed the videotapes and read the text versions to identify visual images that they believed to be important to the text. Based on their recommendations, 35 images were digitized from the videotape and added to the text to provide interest and illustrate key points. For example, the text booklet begins with a series of images created using desktop publishing packages. Visual images of the "speaker" accompany the testimonials. And finally, the text versions include numerous images of the computer screen. The verbatim transcription was modified slightly for the print version. When the narrator makes statements such as "now you see" , the text version makes reference to the appropriate figure (in Figure 1, you see..").

Text versions were analyzed to ensure that they were equivalent to the videotaped versions. One by one, four graduate students in instructional design independently reviewed the text and video materials. Each student reviewed the regular text and video versions together, then the motivationally enhanced materials were reviewed together. As differences were identified between text and video versions, revisions were made to the text version. After two rounds of revisions, two reviewers agreed that the text and video versions were equivalent.

Assessment measures

Self-report questionnaire: The self-report measure of effort was created by modifying questions used by other researchers (Salomon, 1983b; Salomon & Leigh; 1984; Sherman, 1993). When Salomon's questions were used in a previous study with college students, the instrument only had Chronbach's alpha of .55 (Cennamo, Savenye, & Smith, 1991). Beentjas and van der Voort (1993) reported alphas of .60 to .64 when using similar questions with children. Thus, the instrument was modified in an attempt to increase the reliability of the instrument. Four of the questions were modifications of questions used by Salomon (1983b, 1984) and five questions were modifications of questions used by Sherman (1993) who reported a Chronbach's alpha of .69 for his mental effort questionnaire. Participants were asked to respond to questions such as "While reading the booklet, I concentrated hard on what was shown in the pictures." "The lesson made me think very hard." "I tried hard to understand the information presented in this lesson." Participants responded on a 5-point Likert scale which rated responses from "Strongly Agree" (5) to "Strongly Disagree" (1). In this study, the questionnaire had a Chronbach's alpha of .78 , indicating an acceptable degree of internal consistency (Borg and Gall, 1983).

Additional questions on the self-report questionnaire gathered information regarding participants' gender, previous experience with Macintosh computers, experience using desktop publishing software, and other demographic information.

Secondary task measure. The secondary task measure consisted of a computer program that presented an audible beep at random intervals then measured and the time between the beep and the moment when the participant clicked the mouse button in "tics" (a tic is equivalent to 1/60 of a second). During the practice phase, participants received seven practice beeps randomly generated in 10 to 30 second intervals. By averaging the seven practice response times, a baseline response rate was established.

During the actual use with instructional materials, participants responded to a beep randomly generated over intervals ranging from 30 to 90 seconds. Secondary task reaction times were calculated for each student by averaging the response time for each participant engaged with a lesson. Consistent with a procedure used by another researcher (Grimes, 1990), responses that were more than three standard deviations from the individual's mean were ignored for analysis. For example, if a participant failed to respond to a beep or responded after a much longer interval than usual, that particular score was eliminated from the final average score.

Post-test. The post-test consisted of a cued recall test, where students wrote down all they could remember about topics presented in the lessons. Participants were first asked to recall the ideas that impressed them most. The next five questions corresponded to the five major topics of the videotape. Participants responded to questions such as: " In SuperPaint, what tools do you remember and what were their uses?" and "What steps would you follow to create a news letter with a page-layout program?" Finally students were provided with the opportunity to list other information they recalled from the lesson ("What else do you remember from the lesson?")

A scoring key was developed that categorized responses to the post-test. The primary researcher and two research assistants (a graduate student in instructional design and an undergraduate education student) each reviewed 15 recall post-tests and clustered responses that seemed to be of a similar type. Responses seemed to directly recall information presented in the lessons, make inferences based on the information presented in the lessons, summarize information that was presented in the lessons, or evaluate the lessons. Differences in coding responses among the three individuals were discussed and coding categories were finalized. The final coding categories consisted of recall responses (this software leaves room to correct mistakes, I can design my own letterhead), inferences (it seemed easy, it seems convenient to use), and summary statements (there were different photos of parts of the computer, I remember the letters from people in the industry). Evaluative comments (the information was presented in good form; I was falling asleep) were not coded. The two research assistants then coded 15 other post-test using the coding scheme. After finding an acceptable inter-rater reliability of .97 between the two scorers, the tests were scored by one of the research assistants using the scoring key. Participants received a recall score, inference score, summary score, and total post-test score.

Procedures

All sessions were held in a computer lab which contained approximately 40 computers. Groups using the secondary task measure had a demonstration of the data collection program and practice with the program. During the practice session, a baseline measure of reaction time to the secondary task was collected.

All participants received either a motivationally enhanced videotape, "standard " videotape, motivationally enhanced print booklet, or "standard" print booklet. All learners were asked to read or view the lesson to learn as much as possible about the topic of the lesson. Participants in four of the eight sessions were asked to respond to a secondary task while attending to their lesson. They were informed that their primary task was to learn as much as possible from the lesson and also to press a key on a computer keyboard as soon as they heard a beep. Participants participating in the secondary task sessions wore earplugs to avoid sound carrying throughout the room.

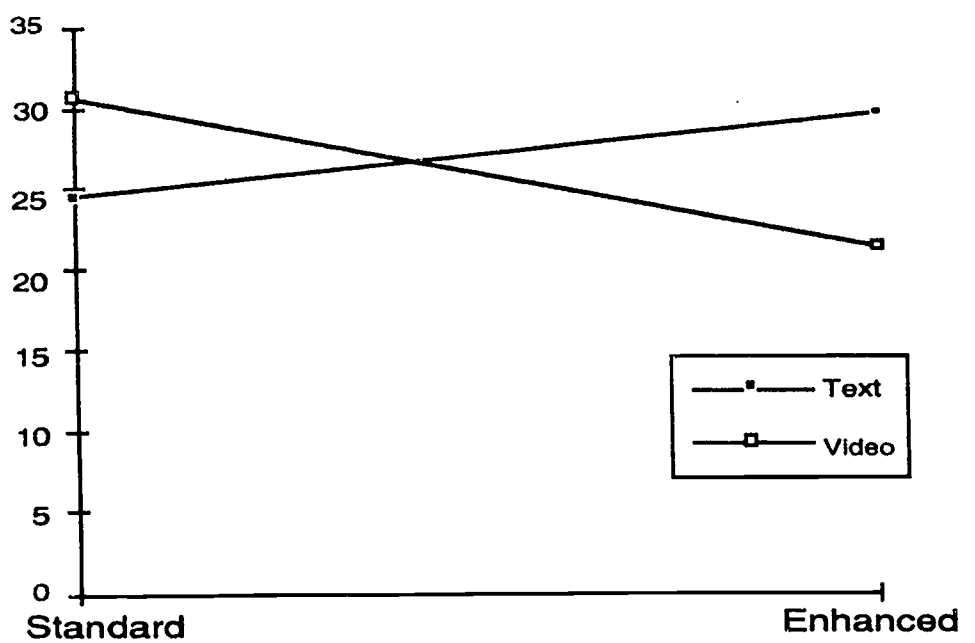
Participants receiving one of the videotaped versions viewed the lesson as a group from a large video monitor placed in the front of the room. Participants receiving the text versions read the lesson at their own pace from individual booklets. Following completion of one the four versions of the lesson, all participants completed the mental effort questionnaire. Finally, all participants completed the post-test, then created a logo and letterhead using the software demonstrated in the lessons. The participants were provided an opportunity to apply the skills demonstrated in the lesson to create a logo and letterhead; however, these products were not analyzed.

Results

Multivariate Analysis of Variance (MANOVA) was used to determine if there were significant differences among the eight groups for post-test and self-report mental effort scores. The analysis indicated several significant effects.

Interaction between media and version for post-test scores. The interaction between media (text or video) and lesson version (standard or motivationally enhanced) was significant, $F(2, 107) = 4.37$, $p=.01$. Univariate analysis indicated that the interaction effects were caused by significant differences among groups on the post-test scores, $F(1, 108)= 8.38$, $p=.005$. An examination of the means (see Table 1) revealed that post-test scores were higher for the standard version of video ($M= 30.58$) than the motivationally enhanced version ($M= 21.23$) , and higher for the motivationally enhanced version of text ($M=29.64$) than for the standard version ($M= 24.49$). (See Figure 1.)

Figure 1: Mean Post-test Scores



Mental effort assessment condition and recall scores. There were also significant differences in the post-test scores between groups who responded to the secondary task measure of effort and those who only responded to the mental effort questionnaire , $F(2, 107)= 4.10$, $p=.02$. Univariate analysis revealed that the significant difference was due to significant differences in achievement test scores, $F(1,108) = 6.71$, $p=.01$. Participants who responded to the secondary

task while reading or viewing the lesson received significantly lower scores (M= 23.33) on the post-test of cued recall than those participants who only responded to the mental effort questionnaire after the lesson (M= 28.70). (See Table 1.)

Table 1: Post-test means

	standard text	enhanced text	standard video	enhanced video	TOTAL
Secondary task	**23.94**	**27.67**	**23.11**	**15.75**	**23.33**
	10.80	9.53	8.77	11.60	10.66
	17	12	9	8	46
Questionnaire	**25.00**	**30.76**	**34.53**	**24.36**	**28.70**
	13.24	12.17	12.98	13.36	13.29
	18	21	17	14	31
Totals	**24.49**	**29.64**	**30.58**	**21.23**	
	11.95	11.23	12.77	13.16	
	35	33	26	22	

Effect of media on mental effort scores. MANOVA indicated a significant effect for media, F(2, 107)= 6.83, p=.002. Univariate analysis revealed that the significant effect was due to differences among groups on their responses to the mental effort questionnaire, F(1, 108)= 11.78, p=.001. Students who received the text version of the lesson reported spending significantly more effort (M=29.53) in the lesson than those who received the videotaped version (M=26.23). (See Table 2.)

Table 2: Means on Mental Effort Questionnaire

	Text	Video
Means	29.53	26.23
SD	5.59	4.52
N	68	48

Note: Possible scores ranged from 9 to 45

Secondary task data. Initially, Analysis of Variance was used to analyze differences among group means for baseline reaction times collected during the practice session. There were no significant differences in the baseline reaction times among groups for media, F(1, 42) = 1.43. p=.24, lesson version F(1, 42)= .08. p=.78, or the interaction between media and lesson version, F(1, 42)= .31, p=.58. Since there were no significant differences among groups for the baseline reaction times (see Table 3 for mean scores on practice task), Analysis of Variance was used to determine differences among group means for reaction times to the secondary task. The interaction between media and lesson version was significant, F(1,42)= 4.17, p=.047. There also were significant differences among groups for media, F (1,42)= 7.28, p=.01, and lesson version, F(1,42)= 11.39, p =.002. An examination of the group means revealed that reaction times for those who received the video versions were significantly longer (M= 78.13) than those who received the text versions (M=55.38). In addition, the reaction time means for those who received the motivationally enhanced versions of the lesson (M=78.33) were significantly longer than those who received the standard versions of the lesson (M=52.59). (See Table 4 for means for secondary task.) Although the analysis revealed a significant interaction between media and lesson version (see Figure 2), an examination of the means indicates that the effects of media and lesson version was much stronger than the interaction. The significant interaction effect appears to be caused by the larger difference in reaction time scores between the standard video group (M=56.27) and the enhanced video group (M=102.71) than between the standard text group (M= 50.(5) and the enhanced text group (M= 62.08).

Table 3: Mean baseline reaction scores

	Text	Video
Standard	43.62	47.76
SD	14.24	18.05
n	17	9
Enhanced	41.84	53.24
SD	27.50	25.45
n	12	8

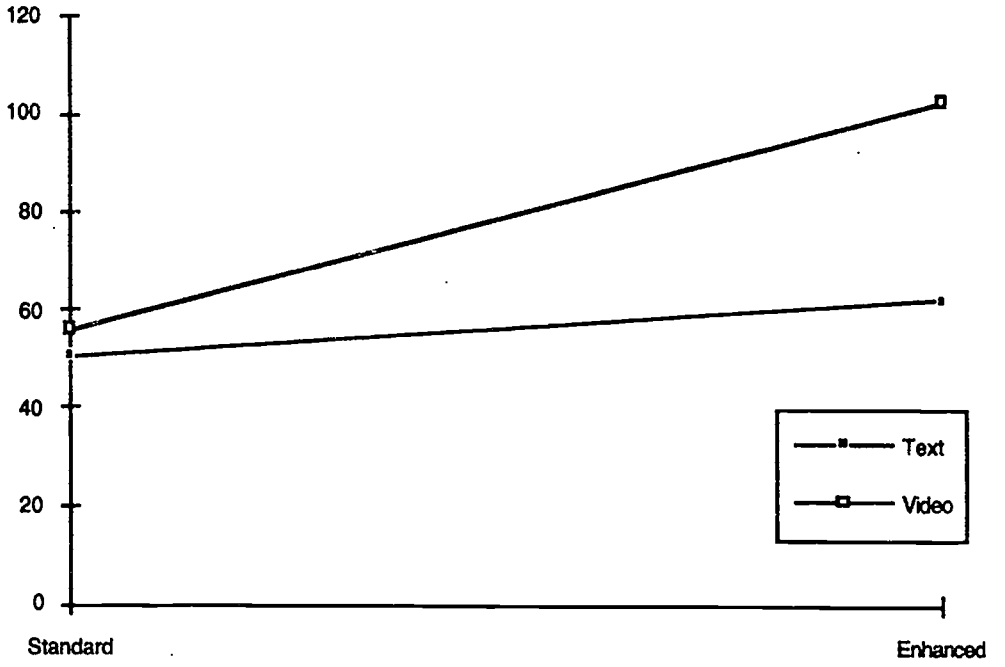
Note: reaction time measured in "tics", equivalent to 1/60 of a second

Table 4: Mean reaction times to secondary task

	Text	Video	Total
Standard	50.65	56.27	52.59
sd	18.68	23.83	20.31
n=	17	9	26
Enhanced	62.08	102.71 78.33	
sd	34.42	36.79	40.02
n=	12	8	20
Totals	55.38	78.13	
	26.41	38.04	
	29	17	

Note: reaction time measured in "tics", equivalent to 1/60 of a second

Figure 2: Mean Reaction Times to Secondary Task



Correlations. Correlations among scores on the three dependent measures (post-test, mental effort questionnaire, and secondary task reaction measure) were tested using a Pearson's r test of correlation. The correlation between reaction time means on the secondary task measure and the scores on the self-report of mental effort were very low, r=-.05, p=.61 (N=46). Likewise, the correlations were low between post-test scores and responses to the self-report measure of effort r=-.069, p= .46 (n=117). The correlation between post-test scores and the secondary task response times was somewhat higher, r=-.28, p= .056 (n= 46) but in a negative direction. Correlations between the number of inferences generated on the post-test and scores on the mental effort questionnaire and secondary task measure were also low, with values of r=-.06, p=.79 (questionnaire) and r= .22, p= .52 (secondary task) respectively.

Post hoc analysis

Several analysis were conducted to determine whether participants' prior experience with desktop publishing or Macintosh computers may have influenced participants scores on the post-test and mental effort questionnaire. When prior experience with desktop publishing (experienced/ no experience) and Macintosh computers (experienced/ no experience) were used as independent variables in a MANOVA with mental effort and post-test scores as the dependent variables, there were no significant interactions, F(2, 103)= 1.20, p=.31, differences due to prior experience with Macintosh computers, F(2, 103)= 2.17, p=.12, or desktop publishing software (F(2,103) = .32, p=.73).

Discussion

The purpose of this study was to investigate a) whether college-age learners invest more effort in print-based lessons designed to teach the skills involved in desktop publishing than in video-based versions of the lessons, b)whether learners invest more mental effort in motivationally enhanced lessons than in "standard" lessons which lack motivational enhancements, c) the extent to which learners' self-reports correlate with their "on line" measurements of effort collected using a secondary task technique and d) the correlation between mental effort scores (from secondary task or self-report measures) and post-test scores on a recall measure.

As in Beentjas and van der Voort's (1993) study, the two measures of mental effort appeared to assess different things. Correlations between the mental effort questionnaire and the secondary task measure of effort were very low.

Despite the lack of correlation between scores on the mental effort questionnaire and the secondary task measure of effort, the findings of this study, conducted with college age students, are consistent with the results of studies conducted with elementary and middle school students. Like the younger learners who participated in Salomon (1983; 1984; Salomon & Leigh, 1984) and Beentjas and van der Voort's (1993) studies, college students who participated in this study reported that they invested more mental effort in learning from print versions of the lessons than in video-based versions on a self-report questionnaire. And like the younger learners who responded to a secondary task measure of effort in Beentjas and van der Voort's (1993) study, the college students who received the video-based lesson had significantly longer reaction times to the secondary task measure.

But the question remains: Which is a more valid way of assessing mental effort? If sensitivity to manipulations designed to increase the effort expended in the lesson is used as an indictor of the most valid measure of mental effort, then the secondary task measure may be superior. Using this means of assessing mental effort, participants spent more mental effort in reading and viewing the motivationally enhanced versions of the lesson than in the standard versions.

However, the results of this study indicate that the secondary task measure of effort interferes with student learning. For students who responded to the secondary task while reading or viewing the lesson, overall achievement was lower than for the other groups. Constant response to the secondary task may have interrupted their concentration just enough to disrupt the learning process.

In addition, there appears to be very little relationship between learner's achievement test scores, as measured by a test of cued recall, and the extent to which learners are cognitively engaged in the lesson, as measured by a secondary task technique. Likewise, there appeared to be very little relationship between learners' achievement scores and their perceptions of the mental effort they expended in processing the lesson as reported on a self-report questionnaire. However, these results are consistent with the low correlations between achievement scores and mental effort found in Beentjas and van der Voort's (1993) research with younger learners.

Of course recall depends not only on the extent to which learners concentrate on, process, or elaborate on the materials but also on their ability and willingness to retrieve the information (Driscoll, 1994). Participants may have lacked motivation to succeed on the achievement test, as course credit was awarded for participation in the study regardless of scores on the achievement test.

Keller (1983) also reminds us that achievement scores reflect a variety of factors other than the extent to which learners' expend effort in processing a lesson. He (1983) suggests that effort, rather than performance, is an indicator of motivation. Although participants who received the motivationally enhanced videotape expended more effort in the lesson, as measured by a secondary task technique, than those who received any other version, recall scores were lowest for those who received the motivationally enhanced videotape.

The overall intent in adding "motivational enhancements" was to increase the personal relevance of the materials (Nwagbara 1993), theoretically increasing the mental effort expended on the materials and achievement scores. However, the addition of motivational aspects may have "backfired". With the addition of motivational enhancements, learners may have had a difficult time distinguishing relevant information from irrelevant information. For example, learners who received the motivationally enhanced videotape may have been thinking about how desktop publishing could enhance their lives and missed information necessary for success on the recall test. Perhaps increased cognitive engagement, especially in response to video, resulted in lower achievement scores. As learners took the time to elaborate on the information presented in the motivationally enhanced videotape, they ran the risk of missing critical information due to the constant stream of visual and auditory information presented via video. Although learners who received the standard version of the videotaped lesson recalled more information than those who received the motivationally enhanced video version, learners who received the motivationally enhanced version in print form recalled more information than those who received the standard version of the print lesson. In addition, learners who received the motivationally enhanced print version had longer reaction times to the secondary task, suggesting greater mental effort, than those who received the standard print version. When learning from print, readers may take time to elaborate on the content of a lesson without "missing" critical information, due to the individual's control over the pace of their reading. This study provided no information on the nature of thoughts that may have occurred during the lesson. Future research using a "think-aloud" protocol may provide additional insight as to the cognitive processing that occurs while reading or viewing a lessons.

At minimum, there is a complex relationship between effort and achievement. In some studies, longer reaction times to a secondary task have paralleled less achievement (Lang, et. al., 1993; Reeves, et. al., 1985, and others); however, in other situations, increased effort paralleled increased achievement (Grimes, 1990; Britton, Glynn, Muth, & Penland, 1985, and others). Other times, more or less effort made no difference in achievement (Britton, Glynn, Meyer,

& Penland, 1982; Reeves, et. al., 1985). Does the secondary task technique and achievement tests the simply measure different things? The low correlations between learners' post-test scores and their reaction times to the secondary task appear to support this idea.

Future researchers may need to decide which is important to them: Effort or achievement? Does effort matter without achievement? Does achievement matter if learners are cognitively engaged and expending effort in learning? It may not be useful to use the secondary task technique to determine if manipulations increase the amount of effort invested in learning from materials in situations where the major goal is achievement.

Additional problems in using the secondary task measure of effort remain. Large standard deviations in scores are common when using a secondary task measure of effort. Due to the small number of students in this study, and the large standard deviations, the results of this study should be replicated with a larger number of students to increase confidence in the findings. In this study, it was possible to hold the class in a computer lab to avoid the appearance of a laboratory setting because the subject matter of the lessons was computer skills; however, researchers must consider that the use of the secondary task measure requires a laboratory like setting, where participants have access to the data collection equipment. In addition, there is a great deal of variability in the way researchers score and analyze data from the secondary task. If investigations of ways to increase the effort invested in video-based materials are to continue, the search for techniques to accurately assess the effort expended in the lessons continues to be an important area for further study.

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