ASSESSING STRATEGIES FOR DEVELOPING EFFECTIVE AND EFFICIENT TEXT FOR DISTANCE EDUCATION: TRADITIONAL AND ELECTRONIC

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ABSTRACT

One dimension of the Program of Systematic Evaluation was to examine the instructional effectiveness with which different types of independent variables employed (singly and in combination) in text based learning environments facilitated the achievement of different types of learning objectives. Fifteen thousand college students participated in 45 research studies conducted from 1968-2000. The results of this evaluation provide a number of insights; (a). research studies that focus generally on achievement rather than specifying precisely what constitutes the achievement (facts, concepts, rules, principles, comprehension, etc.) contribute very little to the practitioner who is interested in designing effective textual learning environments, and (b) research studies which conclude generally that independent variables such as visuals, questions, advance organizers, metaphors, feedback etc., can be embedded in text to improve achievement offer little useful guidance to the designer unless they describe these quantitative variables precisely in terms of type of visuals, types of question, types of advance organizers etc. employed and describe the achievement facilitated by these variables to specific types of learning outcomes.

INTRODUCTION

Text continues to be the fundamental communication medium. Its presence is apparent in both traditional (paper based) and the new electronic distance education formats (multi-media, web-based, etc). Text, properly designed is structured to instigate and sustain the learner-content interaction necessary to facilitate optimum achievement. Its structure can help the learner process the information and affects learning by increasing the probability that learners will attend, interact, understand, remember, retrieve and utilize the information presented. However, text design does not exist in isolation but is intimately related to the knowledge structures of the learners, their learning styles, reading comprehension and the types of learning objectives to be achieved. Although inherently possessing the potential to improve learner achievement text has been found to
be consistently unreliable for optimum communication between and among individuals who have had limited opportunities for shared concrete experiences or possess different learning styles (Dwyer, 1978, 1987). Acknowledging the limitations of the use of text alone, considerable research has explored the use of various types and formats of embedded tactics and strategies (independent variables such as visuals, questions, feedback, metaphors, analogies, advance organizers, etc) used singly and in combinations to improve the instructional outcomes of text based instruction (Ragan & Smith, 1996; Duffy & Cunningham, 1996; Park, 1996; Morey, 1996, Rothkopp, 1996, Hartly, 1996 Braden, 1996). Despite the extensive research that has been conducted in these areas, generic guidelines for the effective and efficient integration of independent variables into text has not been realized. Despite the unpredictability of the learner outcomes when these types of variables are embedded into text based instruction, the prevailing literature continues to endorse the “arbitrary” use of these types of variables as if merely incorporating them into textual material will automatically improve learner achievement of all types of learning objectives without any sustained evidence as to whether or not the varied types of independent variables are equally effective for all types of learning objectives or whether they might be differentially effective for different types of objectives.

STATEMENT OF THE PROBLEM

Many types of independent variable (visuals, questions, feedback, metaphors, advance organizers, etc.) are routinely being suggested for inclusion in text based instruction to improve its effectiveness in promoting learning. However, at the present time text designers have no way of knowing whether one type of variable embedded in text is any more or less effective than another in facilitating achievement of different learning objectives. Examinations of results of relevant research studies to answer this question typically yields inconclusive results because of the wide variety of “uncontrolled” variables in many of the studies:

- achievement not defined in specific types of learning outcomes
- control groups were not utilized
- numbers of participants in the individual studies were low
- positioning of the independent variables was not discussed (e.g., item analysis)
- specifications of the independent variables were not precise or quantified
- test reliabilities were not reported
- content across studies was not held constant
- variables were not defined adequately in terms of type and frequency of utilization
- appropriate experimental designs were not utilized

The purpose of this analysis was to examine the findings of a comprehensive series of research studies conducted in the Program of Systematic Evaluation which were designed to resolve many of the inherent limitations of prior
research related to text design. Specifically, the purpose of this analysis was to examine the validity of the inference currently prevalent in practice and in the literature that one type of independent variable used to complement text bases instruction is as effective an another in facilitating learner achievement of all types of learning objectives.

**METHODOLOGY**

Instructional content and criterion measures were held constant throughout all studies. Learners were randomly assigned to treatments and each study has a control treatment. Positioning of the varied enhancement variables in each study was implemented via item analyses. Appropriate statistical analyses were implemented; alpha was held at the 0.05 level. Appropriate follow-up analyses were conducted when significant F-ratios were realized. The instructional content employed in all studies was an 1800 word module focusing of the parts of the human heart, their locations, functions and processes during the systolic and diastolic phases. Student receiving the self paced text based formats were allowed to interact with their respective instructional treatments for as long as they felt necessary to comprehend the information being presented. Achievement was measured in terms of facts, concepts, rule/procedures and comprehension. A 20-item test was developed for each of these criterion measures. Items in each individual were combined into an 80-item total criterion test. Average Kuder-Richardson Reliability Formula 20 Reliability coefficients from a random sampling of studies (Dwyer, 1978 are .83 Terminology Test, .81 Identification Test, .83 Drawing Test, .77 Comprehension Test, and .92 Total Test.

**CRITERION MEASURES**

Following is a description of each of the criterion measures (Dwyer 1978, pp. 45-47).

**Drawing Test**

The objective of the drawing test was to evaluate student ability to construct and/or reproduce items in their appropriate context. The drawing test provided the students with a numbered list of terms corresponding to the parts of the heart discussed in the instructional presentation. The students were required to draw a representative diagram of the heart and place the numbers of the listed parts in their respective positions. For this test the emphasis was on the correct positioning of the verbal symbols with respect to one another and in respect to their concrete referents.

**Identification Test**

The objective of the identification test was to evaluate student ability to identify parts or positions of an object. This multiple-choice test required students to
identify the numbered parts on a detailed drawing of a heart. Each part of the heart, which had been discussed in the presentation, was numbered on a drawing. The objective of this test was to measure the ability of the student to use visual cues to discriminate one structure of the heart from another and to associate specific parts of the heart with their proper names.

**Terminology Test**

This test consisted of items designed to measure knowledge of specific facts, terms, and definitions. The objectives measured by this type of test are appropriate to all content areas which have an understanding of the basic elements as a prerequisite to the learning of concepts, rules, and principles.

**Comprehension Test**

Given the location of certain parts of the heart at a particular moment of its functioning, the student was asked to determine the position of other specified parts or positions of other specified parts of the heart at the same time. This test required that the students have a thorough understanding of the heart, its parts, its internal functioning, and the simultaneous processes occurring during the systolic and diastolic phases. The comprehension test was designed to measure a type of understanding in which the individual can use the information being received to explain some other phenomenon.

**Total Test Score**

The items contained in the individual criterion tests were combined into a composite test score. The purpose was to measure total achievement of the objectives presented in the instructional unit.

**RESULTS**

In examining the instructional effect of visualization and type of visualization used to complement text based instruction on different types of learning objectives, a meta-analytic study was conducted (Baker & Dwyer, 2000). Hedges (1982) weighted mean formula was employed to systematically analyze the effect of embedded visualization and the effect of different types of embedded visualization in Facilitating student achievement of different educational objectives. Eight visualized treatments were developed each containing 37 (redundant) illustrations and designed to visually complement the printed information that students experienced difficulty in acquiring. The control treatment received no visuals, but did contain printed word symbols designating facts and concepts referred to in the text: Treatment 1. Simple line Drawings (b&w), Treatment 2. Simple Line Drawings (color), Treatment 3. Detailed Shaded Drawings (b&w), Treatment 4. Detailed Shaded Drawings (color), Treatment S. Heart Model Photographs (b&w), Treatment 6. Heart Model Photographs (color), Treatment 7. Realistic Heart Photographs (b&w), Treatment 8. Realistic Heart Photographs
(color). Placement of the visualization was guided by item analysis. Nine hundred sixty-four college level subjects participated in four different studies (Dwyer, 1968a, 1968b, 1971a, 1972). Two hundred twenty effect-sizes were obtained. Table 1 presents the effect sizes and type of visualization found to be most effective in facilitating achievement on each criterion measure.

**TABLE 1. TREATMENTS AND EFFECT-SIZES FOUND TO BE MOST EFFECTIVE ON EACH CRITERION MEASURE FOR EACH CRITERION MEASURE ACROSS THE FOUR STUDIES**

<table>
<thead>
<tr>
<th></th>
<th>Terminology</th>
<th>Identification</th>
<th>Drawing</th>
<th>Comprehension</th>
<th>Total Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text Based Instruction</td>
<td>Line Drawing (Color) 0.64</td>
<td>Line Drawing (Color) 0.99</td>
<td>Line Drawing (Color) 0.82</td>
<td>Line Drawing (Color) 0.87</td>
<td>Line Drawing (Color) 1.08</td>
</tr>
</tbody>
</table>

The coding process in this assessment was greatly simplified by virtue of the similarities through all studies in terms of treatment content, criterion measures, and illustration type. The large number of effect size from the four studies was a result of the method of computation and the fact that the four studies were analyzed separately. The initial effect-size measure was a comparison of a control group receiving verbal information versus the eight experimental groups receiving the same verbal information complemented by different types of illustrations. Subsequent effect-size measures were calculated using the treatment containing the lesser amount of visual stimuli as the control treatment. This procedure was followed in calculating effect-sizes on each of the five criterion measures. Since each measure was computed while holding all other variables at a particular level, studies incorporating multiple illustration types yielded multiple effect-size measures. Effect-sizes of 0.5 were considered to be significant. Table 2 illustrates the specific type of visualization found to be most effective in facilitating achievement of each criterion test when ANOVA procedures were conducted on data from each of the individual studies.

**TABLE 2 TREATMENTS FOUND TO BE MOST EFFECTIVE IN FACILITATING ACHIEVEMENT ON EACH CRITERION MEASURE FOR EACH STUDY.**

<table>
<thead>
<tr>
<th></th>
<th>Dwyer 1968a</th>
<th>Dwyer 1971a</th>
<th>Dwyer 1972</th>
<th>Dwyer 1968b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terminology</td>
<td>Control (No Visuals)</td>
<td>Control (No Visuals)</td>
<td>Control (No Visuals)</td>
<td>Control (No Visuals)</td>
</tr>
<tr>
<td>Identifications</td>
<td>Control (No Visuals)</td>
<td>Detailed Shaded Simple Line (Color)</td>
<td>Heart Model Simple Line (B&amp;W)</td>
<td>Detailed Shaded Simple Line (B&amp;W)</td>
</tr>
<tr>
<td>Drawing</td>
<td>Control (No Visuals)</td>
<td>Control (No Visuals)</td>
<td>Control (No Visuals)</td>
<td>Control (No Visuals)</td>
</tr>
<tr>
<td>Comprehension</td>
<td>Control (No Visuals)</td>
<td>Control (No Visuals)</td>
<td>Heart Model (Color)</td>
<td>Simple Line (Color)</td>
</tr>
<tr>
<td>Total Test</td>
<td>Simple line (Color)</td>
<td>Control (No Visuals)</td>
<td>Heart Model (Color)</td>
<td>Simple Line (Color)</td>
</tr>
</tbody>
</table>

Following is a listing of studies and the types of variables which were examined in terms of the effectiveness in facilitating achievement of different types of
educational objectives in text based instruction. Forty five independent studies involving more than 15,000 high school and college level students participated in these studies examining the instructional effectiveness of the varied types of independent variables used to complement text design. ANOVA procedures were implemented in analyzing the data generated in each of the cited studies. Following is a sampling of the categories of variables examined and their associated references.

<table>
<thead>
<tr>
<th>Category</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visualization</td>
<td>Dwyer, 1968a,b; 1971a;1972; Arnold &amp; Dwyer, 1975;Dwyer, C, 1978; Wu &amp; Dwyer, 1990</td>
</tr>
<tr>
<td>Elaboration</td>
<td>Dwyer, 1970; 1971a,b,c,; Vance &amp; Dwyer, 1968; Lee &amp; Dwyer, 1992; Myung &amp; Dwyer, 1992; Slater &amp; Dwyer, 1999</td>
</tr>
<tr>
<td>Advance Organizers</td>
<td>Parkhurst &amp; Dwyer, 1983; Joseph &amp; Dwyer, 1984; Akambi &amp; Dwyer, 1989; Alemar &amp; Dwyer, 1993; Moore &amp; Dwyer, 1997</td>
</tr>
<tr>
<td>Job Aids</td>
<td>Jennings &amp; Dwyer, 1985, Jackson &amp; Dwyer, 1985; Williams &amp; Dwyer, 1996)</td>
</tr>
<tr>
<td>Rehearsal Strategies</td>
<td>Arnold &amp; Dwyer, 1975a,b</td>
</tr>
<tr>
<td>Realistic Detail</td>
<td>Dwyer, 1970, Wood &amp; Dwyer, 1971</td>
</tr>
<tr>
<td>Questions</td>
<td>Dwyer, 1970; 1971a,b,c,; Vance &amp; Dwyer, 1968; Lee &amp; Dwyer, 1992; Myung &amp; Dwyer, 1992; Slater &amp; Dwyer, 1999</td>
</tr>
<tr>
<td>Feedback</td>
<td>Dwyer, 19171, Wood &amp; Dwyer, 1971</td>
</tr>
<tr>
<td>Learning Style</td>
<td>Parkhurst &amp; Dwyer, 1983; Joseph &amp; Dwyer, 1984; Akambi &amp; Dwyer, 1989; Alemar &amp; Dwyer, 1993; Moore &amp; Dwyer, 1997</td>
</tr>
<tr>
<td>Elaboration</td>
<td>Jennings &amp; Dwyer, 1985, Jackson &amp; Dwyer, 1985; Williams &amp; Dwyer, 1996)</td>
</tr>
<tr>
<td>Objectives</td>
<td>Arnold &amp; Dwyer, 1975a,b</td>
</tr>
<tr>
<td>Image Size</td>
<td>Dwyer, 1970</td>
</tr>
<tr>
<td>Visual Interactive</td>
<td>Bennett &amp; Dwyer, 1994</td>
</tr>
<tr>
<td>Strategies</td>
<td>Dwyer, Dwyer &amp; Moore, 1993; Cha &amp; Dwyer, 1991</td>
</tr>
<tr>
<td>Concept Mapping</td>
<td>Smith &amp; Dwyer, 1995; Roshan &amp; Dwyer, 1998</td>
</tr>
<tr>
<td>Advance Organizers</td>
<td>Dwyer, 1971a; Ruthkosky &amp; Dwyer, 1996</td>
</tr>
<tr>
<td>Chunking</td>
<td>McBride &amp; Dwyer, 1985</td>
</tr>
<tr>
<td>Student Perceptions</td>
<td>Dwyer, 1969,1971a</td>
</tr>
<tr>
<td>Overt/Covert</td>
<td>Dwyer &amp; Dwyer, 1993; Dwyer, Dwyer, &amp; Moore, 1993; Dwyer, 1989</td>
</tr>
<tr>
<td>Rehearsal</td>
<td>Walko &amp; Dwyer, 1990</td>
</tr>
<tr>
<td>Note-taking</td>
<td>Williams &amp; Dwyer, 1999</td>
</tr>
<tr>
<td>Metaphors</td>
<td>Spaulding &amp; Dwyer, 1999</td>
</tr>
<tr>
<td>Job Aids</td>
<td>Spaulding &amp; Dwyer, 1999</td>
</tr>
</tbody>
</table>


DISCUSSION

In the meta-analysis examining the global effect of visualization across all studies significant effect sizes were found for each criterion measure (Table 1) indicating that in general visualization is an important instructional variable for facilitating student achievement. However, follow-up analyses within each study (Table 2) revealed that for some educational objectives text instruction without visualization was as effective as the visually complemented instruction and that identical types of visualization were not equally effective for all types of criterion measures. One interpretation might be that on the terminology criterion, where fact acquisition was achieved by association, visualization was not needed by college level students. On the comprehension test where students were required to acquire an understanding of the internal processing associated with the internal functioning of the heart static visuals alone, regardless of the amount of information they contained, were unable to instigate the level of information processing necessary to achieve the intended learning outcomes. These findings indicate that global recommendations for using visualization to facilitate achievement is not a valid recommendation unless it is for a specific type of visual and learning objective. Additionally, of the two hundred twenty effect sizes calculated ninety nine were negative indicating that there instances stances where text alone was more effective than the visualized presentation and when visual by visual comparisons were examined some visuals were significantly more effective than others in facilitating achievement of specific learning objectives. Visualization, like the other variables cited (questions, feedback, advance organizers etc.) are quantitative in that there are many types of questions, feedback strategies, advance organizers etc. Visualization examined in the meta-analysis was dichotomized into eight types of visuals and many more are possible. The process of generally suggesting that varied independent variables: e.g., visuals, questions, advance organizers, job aids, etc., be embedded in text to improve achievement is questionable.

ANOVA procedures conducted in the above cited studies examining the effect of embedding visuals, questions, feedback strategies, elaborations, objectives, chunking, metaphors, job aids, etc. yielded conclusive results. Generic suggestions that these types of quantitative variables embedded in text will automatically improve all types of achievement at the knowledge acquisition level (facts, concepts, rule, procedures, comprehension understanding) is misleading. Like in the visual meta-analysis study, many of the control treatments were found to be as effective and in some cases more effective than varied embedded treatments.

In comparing the effects of many of the varied qualitative dimensions within the individual generic independent variables if was found that for specific learning outcomes treatment effects were differentially effective in facilitating achievement of different types of educational objectives. In many instances the control group achievement was similar to the enhanced treatments. In terms of facilitating achievement it was also found that many of the quantitative levels within a variables (eg, visualization ... eight types) although structurally different were found to be functionally identical in facilitating achievement of certain types of
learning objectives. ANOVA conducted on the above cited studies reveal a similar pattern of results. The following examples related to visualization, questions and feedback illustrate the pattern of findings.

**Visualization**

All types of visualization are not equally effective in facilitating achievement of different types of learning objectives.

* Some types of visualization are significantly more effective than others in facilitating achievement of specific learning objectives.
* Certain types of visualization are equally effective in facilitating achievement of specific learning objectives.
* For certain types of learning objectives visualization is ineffective in complementing text-based instruction.
* Specifically designed static visuals are equally effective as animated visualization in complementing text-based instruction.

**Questions**

All types of questions are not equally effective in facilitating achievement of different types of learning objectives.

* Some types of questions are significantly more effective than others in facilitating achievement of specific learning objectives.
* Certain types of questions are equally effective in facilitating achievement of specific learning objectives.
* For certain types of learning objectives the use of questions are ineffective in complementing printed instruction.
* Question placement is a critical variable in the use of questions to facilitate achievement of specific learning objectives

**Feedback**

All types of feedback are not equally effective in facilitating achievement of different types of learning objectives.

* Some types of feedback are significantly more effective than others in facilitating achievement of specific learning objectives.
* Certain types of feedback are equally effective in facilitating achievement of specific learning objectives.
* For certain types of learning objectives the use of feedback is ineffective in complementing text-based instruction.

A number of possible explanations may be offered to explain the general-global in-effectiveness of the various types of independent variables reported in this examination (although there were many instances where specific levels of variables embedded in text were significantly effective in facilitating learner achievement of specific types of educational objectives. It may be that the level of learner interaction (level of information processing) with the content stimu-
lated by the type and level of the independent variable was not sufficient to collapse information into knowledge and move it from short term into long term memory. It was also found that for certain audiences (high prior knowledge, high I.Q., internals, field independents) that the text-based instruction without enhancements was as effective as the enhanced text formats. It is also possible that the structure imposed by the unfamiliar independent variables (concept maps, chunking, elaborations etc. may have had the tendency to interfere with learners' conventional style of learning (text based only) and thereby impeded rather than facilitated learning. For example, verbal elaboration treatments significantly increased the time learners took in interacting with the content but achievement did not exceed that achieved by the control. However, rearranging content (utilizing chunking strategies) was found to significantly reduce the time needed to interact with the instruction, but the level achievement was not influenced. The "novelty" of the varied embedded variables may also have a negative effect on learning. For many students this may have been the first time they had experienced the opportunity to interact with these specific types of variables. Since they had no prior experience with these kinds of variables they were unprepared to profit from inherent benefits they possessed. It may be that achievement would have been facilitated had training sessions been conducted familiarizing the student with the purpose of the variables and how to take advantage of their inherent benefits.

The results of this evaluation provide a number of insights; (a). research studies that focus generally on achievement rather than specifying precisely what constitutes the achievement (facts, concepts, rules, principles, comprehension, etc.) contribute very little to the practitioner who is interested in designing effective textual learning environments, and (b) research studies which conclude generally that independent variables such as visuals, questions, advance organizers, metaphors, feedback etc., can be embedded in text to improve achievement offer little useful guidance to the designer or practitioner unless they describe these quantitative variables precisely in terms of type of visuals, types of question, types of advance organizers etc. employed and describe the achievement facilitated by these variables to specific types of learning outcomes.

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