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ABSTRACT

The attribute-function relationships of visual illustrations used in educational textbooks were tested in a study of the effectiveness of illustrations providing either analogical or literal representation in serving two specific instructional functions. Subjects were 180 randomly selected undergraduate college students, who read two passages, one with an illustration providing analogical representation of nonphenomenal information discussed in the passage, the other with an illustration providing literal representation of phenomenal information discussed in the passage. Results showed that in a textbook passage concerning plant photosynthesis, more questions of a nonphenomenal nature were answered correctly by subjects who read the passage using an illustration providing analogical representation than by subjects who read the same passage using an illustration providing literal representation. Inversely, those students reading the passage using the illustration providing literal representation answered more questions of a phenomenal nature correctly than did those reading the passage using the illustration providing analogical representation. Eleven references are listed. (LMM)

A Function-Based Comparison of Illustrations Providing Literal and Analogical Representations on Comprehension of Expository Prose

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Introduction to the Study

The inclusion of visual illustrations in educational textbooks is a longstanding, practically universal practice. It can be determined from even the most rudimentary examination of currently used texts in both public schools and higher education that, regardless of subject or level, both publishers and educators seek texts which include a variety of visual representations. In light of the heavy reliance upon visuals in textbooks it seems appropriate that there would be empirical data to support this practice. Accordingly, several studies have been conducted which attempt to establish the relationship between pictures and accompanying text. However, to date research in this area has been non-conclusive. There are as many studies that indicate a lack of effect or a detrimental effect from illustrations in text as there are that indicate a positive effect (Duchastel, 1980).

It appears that the most valuable information gained from the majority of studies heretofore conducted concerning the relationship of illustrations and text is that there can be no generalizations made. One reason for this lack of conclusive evidence seems to be the inability to consider illustrations as complex, multivariate media. The type of illustration, its relationship to the text, its physical characteristics, its placement in the text, and the purpose

of its existence in the learning situation are among the variables that will have a profound bearing on its effectiveness. As noted by Schramm (1977), the differences within a medium are not smaller than those between media.

That there are differences found within various illustrations is well known (Goodman, 1976; Salomon, 1979; Schramm, 1977). It appears that these differences are manifested in an interrelationship of message, media attributes and environment. The problem of identifying those attributes of illustrations that help increase learning from textual matter in various situations is one of the unanswered questions in this realm of research. Yet, to date research has touched only lightly on an examination of specific attributes of illustrations as they relate to text (Brody, 1982).

Salomon (1978) asserts that because they are composed of a complex, flexible variety of attributes, different media can be used for a variety of instructional endeavors on a variety of levels. Following Schramm's (1977) statement concerning differences within a medium, Salomon's principle could also apply to the same medium used under different circumstances. In other words, the same medium could be used for a variety of instructional tasks and result in a variety of learning outcomes, based upon the circumstances of its use. Nevertheless, most research tends to examine the illustration as a whole rather than as a

complex combination of attributes. In order to assess the value of an illustration as an instructional tool when it is used in conjunction with textual matter, each of the attributes found in the illustration and its relationships with other attributes must be examined.

In order that an accurate assessment of effectiveness be placed on an illustration used in conjunction with text, it is first necessary to determine the instructional function that illustration is perfoming. Only after this determination is made can a comparison of effectiveness between pictorial formats occur. An illustration used in conjunction with text with no consideration as to what instructional role it is intended to serve might very well prove no more effective than no illustration; in fact, it might prove detrimental to pedagogical qualities of the text. But the fact that much research shows a positive effect from illustrations suggests that if an illustration serves an instructional function appropriate to the intended instructional outcome, it has value as a textual supplement.

The ability of an illustration to serve an appropriate function is dependent upon, among other things, the attributes present in the illustration and the relationship between the illustration and the text. Empirical studies have established that certain attributes of illustrations influence their instructional effectiveness (Levie and Lentz, 1982). Matching attributes to instructional

functions can therefore be considered one essential step in establishing a data base for decisions about illustration-text relationships.

Recently, studies have been conducted to begin the task of matching attributes of illustrations to specified instructional functions. Much more information is needed before effective utilization of illustrations in textbooks can be assured. The present study is a further test of the attribute-function relationship of visual illustrations used with text. It examines the effectivenesss of illustrations providing analogical representation and illustrations providing literal representation in serving two specific instructional functions.

The primary hypotheses of the study are that illustrations providing analogical representation better serve the instructional function of visually clarifying abstract or nonphenomenal information, and that illustrations providing literal representation better serve the function of identifying physical properties of phenomenal information. The distinction between phenomenal and nonphenomenal information is the difference between information that does or does not have a tangible existence that can be recorded. Nonphenomenal information has no tangible existence or is too large, too small, too distant or too transient to be recorded (Knowlton, 1966). For example, voltage, which is defined as electromagnetic force

and is derived by multiplying current by resistance, has no tangible existence and is therefore nonphenomenal. Phenomenal information has a tangible existence that can be recorded. A resistor, which alters voltage in a circuit, is composed of tangible substances such as metal wire and plastic, and therefore is phenomenal.

In terms of textbook utilization, the hypotheses of the study are that if an intended instructional function is to clarify nonphenomenal information, an illustration that provides an analogical representation is more likely to be effective. If the intended instructional function is to identify properties of phenomenal information, an illustration that provides a literal representation is more likely to be effective. Analogical illustrations are defined for this study as being functionally as well as physically different from literal, or realistic, illustrations. An illustration providing analogical representation is one in which a visual is used as a reference to information that is not literally identified by, but rather conceptually represented by, the visual. Its features usually do not resemble the features of the information it represents. This type of illustration is effectively used when the information it illustrates is nonphenomenal. For example, an illustration providing analogical representation could depict the effect of resistors on voltage in a circuit, even though voltage is

nonphenomenal.

An illustration providing a literal representation, on the other hand, is a more salient representation of real phenomena, usually because it pictorially resembles such. Although all illustrations depart in some degree from real objects, for example in aspects such as dimensionality or size, an illustration possessing a physical resemblance to an object establishes a relatively more literal representation of the object than does an illustration not possessing a physical resemblance. In other words, if the object in an illustration can be identified by the viewer as that object, the illustration is providing a literal representation. An illustration physically resembling a resistor would provide literal representation. This type of illustration, often referred to as realistic, has traditionally been considered instructionally effective. Recently, resemblance and realism have been questioned as proper criteria for judging the appropriateness of visual materials. Salomon (1979) asserts that resemblance to a real object in visuals is at best superficial, and that the real meaning behind any communication is what is attributed to it by way of mental processes rather than a property of the message itself. Thus, for increasing comprehension, the illustration providing analogical representation might better illustrate information that would be difficult or impossible to illustrate literally, while the illustration

providing literal representation might more effectively supplement an expository description of phenomenal information.

Experimental Procedures

Following a pilot study to determine validity and establish parameters of the experiment, the hypotheses were tested by assigning the reading of college level textual excerpts to two groups of college students. The groups each read two passages, one utilizing an illustration providing analogical representation of nonphenomenal information discussed in the passage, the other utilizing an illustration providing literal representation of phenomenal information discussed in the passage. While group one read a passage utilizing an illustration depicting an analogical representation, group two read the same passage utilizing an illustration depicting a literal representation. This procedure was reversed for the second passage. Thus, both groups read two passages, each one utilizing an illustration with a different depiction. Results of subsequent comprehension tests were analyzed to determine the relative effects of the illustrations on comprehension of phenomenal and nonphenomenal information within the passages.

The hypotheses were tested on 90 randomly selected male and 90 randomly selected female college undergraduates students. Then each of the two 90 subject groups was

equally divided into two treatment groups. Thus, equal numbers of subjects were represented in each of the four groups.

Since the study is a test of comparative comprehension effects, it is necessary to remove as many other variables as possible from the population. Thus, a group of college students, who can be assumed to be skilled readers, will allow a more accurate assessment of the variables tested, since inability to perform well on a comprehension test could not be attributed to the subject's inability to read.

Two expository prose passages taken from college level texts were used in the study, one concerning photosynthesis in plants and one concerning the structure and function of human muscles. Both passages were selected from monographs currently or recently used as college level supplemental texts, to insure that the passages qualified as college level expository pieces.

When testing with higher level subjects and curriculum-based material, it is many times difficult to distinguish what is learned from what is already known. It was therefore decided to use passages that would contain information commonly attainable, but probably not overly familiar to college undergraduates, as determined by a pretest survey. The passages were also selected because of the high level of technicality and density of information contained in a short space as well as the presence of both

performed on the gathered data, one acting as a replication study to the other. The passage variable was not incorporated into a single ANOVA so that it would be possible to isolate and emphasize predicted interactions between other variables, and because this experiment is not a comparison of comprehension of the two passages per se. Any possible loss of information occasioned by not testing this interaction is offset by the increase in power and ability to generalize brought about by the replication aspect of the study.

The analysis of variance tests devide the groups by task and treatment for each passage. A third division, gender of subjects, was used to test for any possible interaction between task and gender or treatment and gender. Thus, the three-way design incorporates type of illustration, type of question and gender variables into a factorial analysis.

Results

Comprehension performance tests for each of the passages were statistically analyzed separately. The passage concerning photosynthesis in plants was assessed first. Results were obtained concerning the differences between and within the blocked groups of subjects. The analysis of variance, shown in Table 1, identifies the interaction between treatments and tests as significant,

$F(1,176) = 83.34$, $p<.01$.

Table 1

Photosynthesis in Plants Passage
Analysis of Variance
N = 180

Source	SS	df	MS	F
Between Groups	264	179		
Treatments	1.61	1	1.61	1.08
Gender	0.41	1	0.41	.28
Treatment X Gender	0.17	1	0.17	.11
Groups w/Treat,Gen	261.81	176	1.49	
Within Groups	190.50	180		
Tests	0.41	1	0.41	.56
Treatments X Tests	60.84	1	60.84	83.34*
Tests X Gender	0.70	1	0.70	.96
Treat X Test X Gender	0.41	1	0.41	.56
Tests X Groups w Treatments X Gender	129.14	176	0.73	
Total	454.50	359		

* $p<.01$

As illustrated in Table 1, there were no significant differences for the main effects of treatment, gender and tests. There was a significant difference for the treatment x test interaction, which reflects the ability of subjects to respond correctly to different types of questions depending the type of illustration provided in the passage. All other interactions were analyzed as

nonsignificant.

The data supports the rejection of both the null hypotheses of this study. It indicates that there is a significant difference in ability of subjects to respond correctly to questions of a nonphenomenal and a phenomenal nature depending upon the type of visual illustration utilized in an expository passage. Specifically, in a textbook passage concerning photosynthesis of plants, more questions of a nonphenomenal nature were answered correctly by subjects who read the passage utilizing an illustration providing analogical representation than by subjects who the same passage utilizing an illustration providing literal representation. Inversely, those students reading the passage utilizing the illustration providing literal representation answered more questions of a phenomenal nature correctly than did those reading the passage utilizing the illustration providing analogical representation.

The data derived from the replication test performed on the passage concerning the parts and functions of human muscles supports the results of the photosynthesis passage. Again, results were obtained concerning the differences between and within groups of subjects. The analysis of variance, shown in Table 2, again identifies the interaction between treatments and tests as significant, $F(1,176) = 77.80$, $p>.01$.

Table 2

Parts and Functions of the Human Muscle
Analysis of Variance
N = 180

Source	SS	df	MS	F
Between Groups	308.87	179		
Treatments	0.62	1	0.62	.35
Gender	0.62	1	0.62	.35
Treatments X Gender	0.23	1	0.23	.13
Groups w/Treat,Gen.	307.40	176	1.75	
Within Groups	175.50	180		
Tests	0.02	1	0.02	.03
Treatments X Tests	53.68	1	53.68	77.80*
Tests X Gender	0.01	1	0.01	.01
Treat X Test X Gender	0.22	1	0.22	.32
Tests X Groups w/ Treatments X Gender	121.57	176	0.69	
Total	484.37	359		

* p<.01

Again the analysis of variance indicates a lack of significant difference for main effects of treatment, gender and tests, and for all interactions with the exception of the treatment x test interaction. The results of the replication test support the rejection of the null hypothesis reported from the first test. Again, there is a

significant difference in ability of subjects to respond correctly to questions of a nonphenomenal and a phenomenal nature, depending upon the type of visual illustration utilized in conjunction with the text.

Lack of any significant difference within groups or of any interaction other than that between treatment and test in either analysis of variance indicates that in each situation the illustration was performing a specific instructional function that was not being served by the other type of visual representation.

Discussion and Recommendations

The data generated in this study support one of the basic premises of the functional approach to research on illustrations; functions served by illustrations must be viewed in terms of specific and precise instructional roles rather than more general instructional goals or outcome statements (Brody, 1983). In this study, illustrations were selected to serve two specific functions, with the intent of the selection and subsequent utilization being to aid in the achievement of an instructional outcome. Specifically, one illustration was selected to identify properties of phenomenal information introduced in an expository prose passage and one illustration was selected to clarify nonphenomenal information introduced in an expository prose

passage. These are two examples of instructional functions which can be served by illustrations, viewed in terms of precise and specific instructional roles. The expected instructional outcome to be aided by these functions was comprehension of the prose passages read in conjunction with the illustrations.

Results of comprehension tests from both passages indicate that overall comprehension scores on the tests were similar regardless of the type of illustration utilized. This indicates that the presence of an illustration has a similar effect on overall comprehension of the passage. It also supports the long established positive correlation between the effectiveness of an illustration and its relevancy to the text (Halbert, 1943).

More important for this study, however, is the indication that the illustrations served specific instructional functions. The group that read the passage with an illustration which served the function of identifying properties of phenomenal information did significantly better on comprehension of that type of information than did the group reading the passage with an illustration serving another function. Conversely, the group reading the passage with an illustration which served the function of clarifying nonphenomenal information did significantly better on comprehension of that information than did the other group. Thus, it can be concluded that,

while both illustrations were assisting in the overall comprehension of the passage, they served different functions to achieve this assistance, by addressing different types of information. Analysis of the data indicates that different types of information were more effectively comprehended, depending upon the illustration used with the passage.

Based upon the results of the empirical tests, it appears that there is not a significant difference between the ability of male and female students to utilize the illustrations for the specified instructional functions of this study. It could therefore be concluded that for college-aged students, no gender distinction is necessary when selecting illustrations to fulfill instructional functions.

Thus, the relationship between the instructional function served by an illustration and the instructional outcome aided by that function can be compared to the relationship between "means" and "end". Functions provide the means of achieving instructional ends. Further, the success or failure of an illustration to serve an instructional function depends, among other things, upon the appropriate selection of an illustration for that function. and the effective implementation of that function in the text.

Data derived from this study concerning selection of

illustrations to serve specified instructional functions indicates that there is an interaction between the type of representation provided by the illustration and the instructional function served by the illustration. Specifically, an illustration providing analogical representation, which, as defined in this study acts as an abstract representation of information, helps to clarify abstract or otherwise nonphenomenal information. Similarly, an illustration providing literal representation, which usually denotes a salient physical resemblance to phenomenal objects, helps to identify phenomenal information. Thus, it appears that achievement of different instructional functions may require the use of different types of illustrations in some cases.

Recommendations for Further Study

Several recommendations for further investigation concerning the functions that can be served by illustrations in text can be made. Initially, the results of this study support the need for more extensive investigation concerning illustrations serving instructional functions in relationship to textual matter. Tests similar to this one need to be conducted with students on various educational levels. Information as to what levels can effectively use illustrations providing analogical representation, for example, can add significantly to understanding of

functional services of illustrations as well as many related areas of concern. Another area of investigation concerns the academic subjects introduced in the textual passages. Illustrations providing analogical representation and those providing literal representation should be created for subject disciplines outside the pure sciences, to increase ability to generalize and extend understanding of circumstances under which these representational types of illustrations can effectively serve instructional functions. Assessments should be made as to which subject disciplines lend themselves to these types of illustrations serving these functions.

There is also a need to conduct studies concerning the use of different types of representations serving functions identical or similar to the ones served in this study. For example, it would be valuable to know whether representations other than those providing analogical representation will effectively clarify nonphenomenal information. This should, of course, be conducted with a wide variety of representational forms. Closely related studies using a variety of representational formats which serve other instructional functions than the ones utilized in this study are also needed.

Tests could be constructed to see whether two illustrations, each serving a different function within a passage, would contribute more toward the achievement of

instructional outcomes than one illustration serving one function. The basis of this hypothesis would be that instructional outcomes cannot necessarily be achieved in their entirety through achievement of one function. In many cases, a number of different functional operations, both pictorial and nonpictorial, may be needed to achieve an instructional outcome.

It would also be relevant to test whether a number of different functions could be served by the same illustration. For example, the illustration serving the function of identifying phenomenal information might also have served the function of emphasizing a point, providing examples, or directing attention.

Studies will also be necessary to assess the effectiveness of illustrations serving functions with literary forms other than expository prose. This will involve the application of various representational types to various functional operations for each of the literary forms investigated.

In short, this study is but one of many that will result in a better understanding of illustrations serving as instructional tools when used in conjunction with textual matter. The conclusiveness of the results of this study both necessitates and facilitates further investigation into this aspect of pictorial research.

Much of the recent literature concerning the use of

illustrations in text has stressed the need for an assessment of the instructional function being served by the illustration. When an illustration is incorporated into textual matter, it should be serving a specific, pedagogically sound instructional function. Otherwise, the reader will probably not benefit from the illustration's inclusion in the text; in fact, the reader might be distracted from the text by the illustration, with no cognitive gain being derived from this distraction. Therefore, to the traditional criteria for selection of illustrations used with text must be added perhaps the most important criterion, instructional function intended to be served.

To determine whether an illustration will effectively serve an intended instructional function, a close examination of both the illustration's attributes and its relationship to the text must be made. Research has shown that illustrations are composed of a variety of attributes, pertaining to physical, instructional and relational qualities of the illustrations, and that these attributes affect the way in which illustrations can be used as instructional tools. Therefore, the attributes present in an illustration will account in part for its effectiveness in serving an instructional function.

In light of this, a study was developed to demonstrate the relative effectiveness of two illustrations, which

possess differences concerning the type of representational format they provide in supplementing text, in serving two distinct instructional functions, both of which assist in the overall comprehension of a textual passage. The primary hypotheses of the study were that illustrations providing analogical representation better serve the instructional function of visually clarifying abstract or nonphenomenal information, and that illustrations providing literal representation better serve the function of identifying physical properties of phenomenal information.

The hypotheses were tested by assigning the reading of college level textual excerpts to two groups of college students. The groups each read two passages, one utilizing an illustration providing analogical representation of nonphenomenal information discussed in the passage, the other utilizing an illustration providing literal representation of phenomenal information discussed in the passage. While group one read a passage utilizing an illustration depicting an analogical representation, group two read the same passage utilizing an illustration depicting a literal representation. This procedure was reversed for the second passage. Thus, both groups read two passages, each one utilizing an illustration with a different depiction. Results of subsequent comprehension tests were analyzed to determine the relative effects of the illustrations on comprehension of phenomenal and

nonphenomenal information within the passage.

The analyses of variance that were performed support the stated hypotheses of the study. Specifically, an illustration which provides a literal representation of information introduced in the passage was shown to be more effective in serving the instructional function of identifying physical properties of phenomenal information introduced in the text. Conversely, an illustration which provides an analogical representation of information introduced in the passage was shown to be more effective in serving the instructional function of clarifying nonphenomenal information in the text. These findings suggest that, in instructional situations similar to the one in this study, illustrations possessing literal representation are more effective than illustrations possessing analogical representation when the instructional function to be served is identification of properties of phenomenal information, and illustrations possessing analogical representation are more effective than illustrations possessing literal representation when the instructional function to be served is clarification of nonphenomenal information.

Thus, this study is one of many needed to provide a comprehensive analysis of illustrations functioning as instructional supplements to text. Until a thorough understanding of the relationship between attributes and

functions of illustrations is achieved, textbooks will in all probability continue to include illustrations which do not fulfill their instructional potential.

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