DOCUMENT RESUME

ED 196 405 IR 008 920

AUTHOR	Clark, Francis E.; Angert, Jay F.
TITLE	A Meta-Analytic Study of Pictorial Stimulus Complexity.
PUB DATE	Apr 80
NOTE	43p.: Paper presented at the Annual Convention of the Association for Educational Communications and Technology (Denver, CO, April 21-24, 1980). For the complete proceedings of the Research and Theory Division, see IR 008 914.
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Bibliographies; Codification; *Evaluation Methods; *Media Research; Nonverbal Communication; Pacing; *Pictorial Stimuli; *Visual Aids

ABSTRACT

The purpose of this paper is to integrate the findings of studies undertaken by Dwyer (1978) and colleagues which represent the only extended and concerted investigation of pictorial stimulus complexity as it relates to static instructional visuals. After scrutinizing all available published and unpublished reports of research in this series for appropriate data, 23 sets of complete data were found to be available. Those studies which contained data sufficient for the application of meta-analysis techniques developed by Glass (1977) comprise the sample for this investigation. Effect size measures were computed, and regression analysis was performed to examine the relationships of effect size with presentation pace, grade level, type of learning, and type of illustration. Results of the analysis are reported, and it is concluded that, although it is likely that more thorough aggregation will modify these findings, the data do provide indications of possible trends which may ultimately be sustained by more complete analyses, and which may help to generate experimental investigation in the interim. A 92-item bibliography, tables and figures referred to in the text, and a list of the publications which comprised the sample are attached. (Author/CHC)

title • A Meta-Analytic Study of
Pictorial Stimulus Complexity

presenters • Francis E. Clark, Director
Educational Technology
College of Education
Texas A&M University
College Station, TX 77843

• Jay F. Angert
Educational Technology
College of Education
Texas A&M University
College Station, TX 77843

A META-ANALYTIC STUDY OF PICTORIAL STIMULUS COMPLEXITY

As an applied field of communication, educational technology has concerned itself with the practical utilization of communications technology in the instructional process. This focus has created a large body of media research studies with discouraging appraisals of the value of these media research efforts (Bracht, 1970; Cronbach & Snow, 1977; Dwyer, 1978; Fleming, 1970; Hawkridge, 1973; Heidt, 1977; Parkhurst, 1975). It has been suggested, as one solution to these difficulties, that the pertinent variables in media research be reconceptualized.

In 1965, Lumsdaine and May stated that educational media research was a field frequently defined in terms of presentation modes rather than on a more fundamental basis. Both Conway (1967) and Knowlton (1964) observed that media researchers have made no consistent distinction between the sensory modalities involved in communication and the coding systems incorporated in the message. Knowlton noted the regrettable mix of pictorial and verbal elements in audiovisual presentations and the lack of a carefully described unit of analysis, specifically the pictorial iconic sign. This description, he continued, was essential to the development of a science of audiovisual communication. In 1966, Norberg lamented that considerable audiovisual research dealt only with media presentations; iconic signs had rarely been an experimental variable. In 1978, Levie clearly specified that one area of media research emphasis should be the symbolic codes of pictorial media. Levie was referring to the iconic coding system which uses referent symbols (e.g., pictures) to communicate, as opposed to the digital coding system (e.g., words and numbers) which communicates by non-referent symbols (Littlejohn, 1978; Schramm, 1977).

Salomon (1974) argued that media need not be represented only in terms of presentation techniques or technology systems (e.g., television, computer-assisted instruction), but could also be represented as consisting of messages (subject-matter content) or symbolic systems. This last method of representation has received the least emphasis. In delineating the potential elements in a taxonomy of media attributes, Salomon described a tentative hierarchy of symbol systems (e.g., digital, iconic), coding elements (e.g., dimensionality, iconicity), secondary coding systems (e.g., editing, sequencing), and such additional features as complexity, redundancy, or ambiguity. In a review of Salomon's analysis, Schramm (1977) acknowledged the desirability of such a taxonomy, regretted that it was not close at hand, and admitted that media researchers have "only the foggiest of ideas about the area that Salomon is opening up" (p. 87).

Many of the conceptual difficulties in media research may be related to a decreasing link, described by Hill (1978), between communication theory and instructional media research. Mielke (1972) also has noted that "the current trends and emphases in instructional media research . . . has evolved increased association [illegible] educational psychology and decreased association with general communication theory and research" (p. 358). Similarly, Allen (1971) concluded that the "broad field of communication research never became integrated with the mainstream of instructional media research, and to this day these related disciplines are taking different routes" (pp. 6-7).

Dance (1970) observed that the diverse fields involved in the study of communication have created considerable looseness in the definition of the concept of communication. Westley and MacLean (1974) found this looseness counter productive, noting that there exists a "jungle of unrelated concepts and systems of concepts . . . and a mass of undigested . . . sterile empirical data" (p. 336). Consequently, Mortensen (1972) considered the prospects unlikely for a synthesized communication theory. Despite this deficiency, many communication models possess certain essential commonalities which can be directly related to instructional media research. Deutschmann, Barrow, and McMillan (1961) considered the Shannon-Weaver (1949) model as directly applicable to the classroom. Berlo (1960), moreover, observed that a comparison of the process models generally indicated a great deal of similarity.

One basic area of agreement among the various descriptive and graphic models of the communication process lies in the recognition of the importance of codification and sign usage. Littlejohn (1978), for example, described coding as a fundamental concern in the study of communication and concluded that "essentially every theoretical approach to communication takes place through the use of signs" (p. 80). Salomon (1974) stated that one of the key steps in designing instructional media is the selection of a symbolic coding system which is "isomorphic . . . to the learner's symbolic mode of thinking" (p. 401). According to Conway (1967), the translation of information from one mode to another (coding) is a significant empirical problem. The conceptualization of media research variables in terms of codes and symbol systems, as suggested by Conway (1967), Knowlton (1964), Lumsdaine and May (1965), Norberg (1966), and Salomon (1974) would be consistent with the calls for increased association of media research with communication theory.

The conceptual difficulties and conflicting results in media research have had ramifications on the guidelines for the design of instructional materials. Levie (1973) concluded that "the lack of . . . well-defined variables in pictorial stimuli has . . . hindered progress in understanding what kinds of pictures may have what kinds of effects" (p. 40). Two diametrically opposed orientations to visual design have arisen from the concept of pictorial stimulus complexity, one element in Salomon's (1974) proposed taxonomy.

Hoban, Hoban, and Zisman (1937) proposed that the instructional effectiveness of visual resources depended in part upon the degree to which they approached the reality of experience. According to Norberg (1966), this notion helped set a pattern followed in the audiovisual literature for thirty years. Travers (1964) noted that this proposition had almost the status of a cornerstone in the audiovisual field. Dwyer (1978) collectively entitled this set of theoretical positions as the "realism" theories. Basically, these orientations contend that the more nearly a visual representation resembles its referent (i.e., the higher its "iconicity"--Morris, 1946), the more effective it will be for most instructional purposes. The realism theories encompass Carpenter's (1953) sign-similarity hypothesis and Dale's (1946) Cone of Experiences. Miller (1957) tied a basic principle of stimulus-response theory, stimulus generalization, to the realism position.

The relevant cue hypotheses represent the opposite principle. These hypotheses contend that a reduction of stimulus complexity is beneficial for most learning (Hartmann, 1961; Levie, 1973; Miller, 1957; Rudnick, Porter, & Suydam, 1973; Travers, 1964). Travers (1964) has suggested that "the emphasis on realism . . . is the worship of a false God" (p. 380). The relevant cue position has its origins in information theory and the concept of a limited channel capacity in humans for processing sensory stimulation. The relevant cue idea is congruent with Broadbent's (1958) conclusion that the perceptual system functions as a single channel system accessible to only one source of information at a time. According to Travers (1964), the nervous system handles a wealth of detail by simplifying it.

Miller (1957) described the essential dilemma involved in the two opposing positions. He noted that methods of directing attention to the relevant cues will invariably involve a departure from strict realism and come into conflict with the principle of stimulus generalization. Thus far, neither position has been fully supported by the research (Hedberg & Clark, 1976). Moreover, as Travers (1964) pointed out, "The position of the research scientists and the designers of audiovisual materials are at such opposite poles that it hardly seems possible that both can be correct" (p. 375).

RELATED RESEARCH

The predominant definition of pictorial complexity within the perception research literature has been expressed in terms of the physical parameters of the stimulus. Efforts to quantify the complexity of visual forms have produced a sizable number of studies describing precise methodologies for the generation of random shapes (Attneave, 1957; Dember & Earl, 1957; Den Heyer, 1974; Den Heyer, Ryan, & MacDonald, 1975; Hall, 1969; Stenson, 1966; Terwilliger, 1963; Vitz, 1966). However, it is more difficult to quantify the physical dimensions of the pictorial content common to instructional materials with this same degree of precision. Bergum & Flamm (1979) suggested that bidimensional complexity measures, of the type employed in the evaluation of random figures, may be inadequate for judging the complexity of pictures with tridimensional characteristics: "A complicating factor in the quantification of figural complexity is the matter of how to evaluate depictions of animate objects" (p. 194). Moreover, the thematic complexity, the learner's subjective impressions, or the illustration's function may be more important considerations than the physical parameters in judging instructional effectiveness (Duchastel & Waller, 1979). Nonetheless, variations in the amount of realistic detail, including color, have been the most frequently used method for defining pictorial stimulus complexity in still visuals of an instructional nature (Dwyer, 1978).

Many studies have documented the effects of pictorial complexity on subject preferences in both the research literature on perception (Berlyne, 1958; Dember & Earl, 1957; Hershenon, Munsinger & Keesen, 1965; Vitz, 1966; Wright & Gardner, 1960), and instructional media (Bloomer, 1960; Ibison, 1952; MacLean, 1930; Rudisill, 1952). However, there is a fallacy in basing visual design decisions on subject preferences. Bloomer, 1960; Dwyer, 1971, 1978; Lumsdaine, 1963; Otto and Askov, 1968; and Travers and Alvarado, 1970 have documented that desired instructional outcomes have not been consistent with the expressed preferences for a particular level of pictorial complexity. The research results do suggest that at least two variables (subject age or grade level, and amount of exposure time) interact with the complexity of visual displays to produce differential learning effects.

Subject Age

Studies have shown that rapid increases in pictorial learning skills occur from pre-school through the elementary years. The difficulties of young children with pictorial materials have been demonstrated through inadequate eye movement patterns (Mackworth & Bruner, 1970), and through problems in interpreting dimensional cues and spatial relations (Asso & Wyke, 1970; Brown, 1969).

Elkind, Koegler, and Go (1964) have shown that parts of a picture are perceived at an earlier age than wholes. This result is consonant with Piaget and Inhelder's (1956) finding that young children will reproduce outlines accurately but will improperly locate details within a drawing.

Travers (1969) used subjects varying in age from four to twelve years and discovered a tendency for young children to latch onto one particular object in a picture when presented with repeated short exposures, and to fail to observe other details. Travers also observed a marked improvement across age groups in the ability to report dynamic features of an illustration. Moore and Sasse (1971) used subjects at the third, seventh, and eleventh grade levels and observed a statistically significant difference across grade levels in the amount of immediate recall of picture content.

Presentation Pacing

Levie (1973) has said that "whether it is advisable to reduce the cues to only those which are crucial to the primary learning task . . . or to provide additional cues . . . is largely a function of the amount of time allowed to study the display" (p. 41). Dwyer (1978) and his associates have conducted over one hundred studies on the effectiveness of different types of illustrations. These studies indicated that with fixed exposure times (e.g., experimenter-controlled slide presentations), line drawings have been most effective, while with non-fixed exposure time (e.g., programed instruction), realistic photographs were more effective (Hedberg & Clark, 1976). Corroborating evidence is provided by Hunter (1943), who found that the time required to learn information in a visual display is, in part, dependent upon the complexity or quantity of information it contains, and by Grover (1974), whose data revealed that the recall of complex stimuli improved significantly as the duration of exposure time increased.

INTERPRETING THE FINDINGS

Several authors have attempted to draw conclusions from the many studies dealing with pictorial complexity. Dwyer (1978) summarized his own systematic series of studies on color and realistic detail in still visuals and concluded that these variables are differentially effective, depending on the type of learning outcome.

Other researchers have formed conclusions on the basis of only partial examination of nonrandom and perhaps unrepresentative samples of studies on the topic. Levie (1973) noted that research comparing pictures varying in gross respects (e.g., photographs versus line drawings) usually provide no evidence of differences in learning. The value of realism has been questioned by Boguslavsky (1967), Attneave (1954), Devor and Stern (1970), Gorman (1973), and Rudnick, Porter, and Suydam (1973). On the other hand, support for high iconicity has been provided by Bevan and Steger (1971), Koen (1969), Nelson (1971), Smith (1964), and Spaulding (1955, 1956). Still others have provided evidence which is not so clearcut (Vandermeer, 1954; Fonesca & Bryant, 1960). In reviewing the research findings, Huggins and Entwisle (1974) declared that "more knowledge about the principles of iconic communication is needed" (p. xi).

With respect to graphics in instructional materials, MacDonald-Ross and Smith (1977) concluded that research results have been sufficiently confusing and contradictory and furthermore, that "some kind of preliminary sorting-out is necessary before we can proceed to a 'science of visual instruction'" (p. 5). Burton (1979) proposed a decreased emphasis on *confirmatory* research which tests hypotheses, and has suggested that this "sorting-out" could be accomplished through *exploratory* research which generates hypotheses through an examination of existing research data.

Through the years there have been frequent calls for research syntheses or integrations (Broudy, 1970, 1972; Clark & Angert, 1980; Kuhn, 1962; Petrie, 1976; Randhawa, 1978). Meta-analysis techniques (Glass, 1977) are the most recently developed methodology for accomplishing research integration. Glass has suggested that these techniques are particularly well-suited for resolving controversies arising from conflicting research results. A more conservative approach, however, would be to consider research integration as a form of exploratory rather than confirmatory research.

STATEMENT OF THE PROBLEM

Two distinct but related problems have caused concern within the applied field of educational technology. First, disappointment with much instructional media research has created a sizable literature dealing with media research difficulties and with suggested improvements. Inadequate conceptualization of experimental variables has been frequently blamed for conflicting media research results. Second, concern has been expressed about the decreasing interrelationship between communication theory and educational technology research. Many educational technology researchers have failed to focus on the commonalities that exist among communication models. As a result, some conceptual problems in instructional media research can be traced to a failure to define variables in terms peculiar to communication theory.

One consequence of the above shortcomings is that guidelines for the selection and/or design of instructional materials are often inprecise or contradictory. The conflicting positions of the research scientists and the designers of audiovisual materials have been pointed out.

One proposal has been to increase the emphasis on research which generates hypotheses. Research synthesis, or integration, has been suggested as a methodology for implementing this solution. In addition, researchers have proposed integration as a necessary first step in establishing new media directions. Research integration studies which proceed with variables defined in terms commensurate with communication models could help reaffirm the linkage between communication theory and educational technology.

PURPOSE

The series of studies undertaken by Dwyer (1978) and colleagues represents the only extended and concerted investigation of pictorial stimulus complexity as it relates to static instructional visuals.

Since any conclusions on this topic invariably have leaned heavily on the results of these investigations, an integrative review was deemed to be a useful adjunct in guiding future empirical efforts. Further, although narrative style literature reviews have been quite detailed, thorough, and informative (Dwyer, 1978), it was presumed that a statistical integration as described by Glass (1977) would add a degree of specificity to the numerous conclusions which have already been drawn regarding this research. Finally, the basic similarities among all the studies in the series provided an excellent data base for testing the feasibility of applying certain meta-analysis techniques (Glass, 1977) to the entire body of research in the topic area.

METHODOLOGY

Sample

According to Glass (1977), the spirit of meta-analysis is that statistical methods aid perception, and the question therefore of how large a sample size is adequate for a meta-analysis ought properly to be rephrased to: "How many studies can be read and integrated without resorting to statistical methods to reveal aggregate findings and relationships?" (p. 362). The number, he concluded, is probably quite small. As proposed by Glass, the initial step in a meta-analysis is the computation of a common measure of treatment effectiveness, known as the *effect-size*. An effect-size is calculated most directly by taking the difference between a treatment and control group mean and then dividing this difference by the control group standard deviation. Although Glass described methods for recovering data and for computing estimates of effect-sizes and "pseudo" effect-size values in the absence of some data, this preliminary investigation is limited to those studies containing data necessary for the direct computation of effect-size measures.

All available published and unpublished reports of research in this series were scrutinized for appropriate data and an attempt made to recover original data where necessary. As a result of this delimitation, complete data were available from twenty-three publications, several of which were found to contain duplicate results (see Appendix A). Although Dwyer (1978) indicated that over 100 such studies have been conducted, the age of the bulk of these studies thwarted further efforts at recovery.

Procedure

All studies were coded for subject grade level, type of treatment illustration, color, type of criterion measure, time of testing (immediate post or delayed post), and method of presentation (i.e., internally paced as in programed instruction, or externally paced as in researcher-controlled slide/audiotape presentations). In addition, other variables peculiar to particular studies (e.g., image size, student preferences, I.Q., effects of prior knowledge) were coded. This coding process was greatly simplified by virtue of the similarities through all studies in terms of treatment content, criterion measures, and illustration types. (For a more detailed description of these variables and procedures, see Dwyer, 1978). The coding system was not significantly affected either by modifications to treatment content, illustrations, or criteria; or by the omission of certain illustrations and criteria from some studies.

All told, 1,329 effect-size measures were generated from the available data, and the effect-size values, rather than individual studies, served as the units of analysis. The large number of effect-size measures from a relatively small number of studies was a result of the method of computation. Each effect-size measure was a comparison of a treated control group receiving verbal information versus an experimental group receiving the same verbal information with the addition of an illustration. Since each measure was computed while holding all other variables at a particular level, studies incorporating multiple illustration types and several levels of numerous additional variables yielded multiple effect-size measures. The 1,329 effect-size measures represent about 4,800 treated and untreated subjects across five grade levels (grades 9-12, and college level).

The relationships between the effect-size values and the coded variables were examined by aggregating mean effect-sizes across various crosscuts of the data. In addition, in accordance with procedures recommended by Glass (1977), multiple regression techniques were also utilized for their descriptive force in revealing potential relationships among the coded variables.

RESULTS

By averaging the effect-size values across all studies and including all types of illustrations, criteria, and grade levels, we can generalize a mean effect-size of 0.65, i.e., the average subject receiving some form of illustrated treatment was about two-thirds standard deviation more improved in terms of learning outcome than the average control group member receiving only the verbal treatment. This relationship is depicted in Figure 1.

- - - - - - - - - - - - - - - - -

Insert Figure 1 about here

- - - - - - - - - - - - - - - - -

When the mean effect-size values and the coded variables were examined separately by type of illustration, grade level, type of criterion measure, type of pacing, and color, the results depicted in Table 1 were obtained. The regression analysis revealed the possibility of interactions of grade level with the type of criterion measure, as well as grade level with the type of illustration. Two examples of these potential relationships for externally paced presentations utilizing black and white illustrations are presented in Figures 2 and 3. These data are consistent with the information revealed in Table 1, and additionally describe fluctuations in mean effect-size rankings for criteria and illustrations by grade level changes.

effect-size values give initial indications of crude interval distances between the scaled entries. These findings are consistent with Dwyer's (1978) conclusion that the realism continuum for visual illustrations does not successfully predict learning efficiency for all educational objectives with all types of learners. Moreover, the data also suggest that it may be possible to impart a degree of specificity to the scale positioning, thus providing a basis for more specific and probing hypotheses regarding the extent of superiority of one illustration type over another. Such quantitative positioning may also afford the opportunity for comparisons across continuums.

- - - - - - - - - - - - - - - - - - - -

Insert Figure 4 about here

- - - - - - - - - - - - - - - - - - - -

Dwyer (1978) has also concluded that in many instances the control group was found to be superior to the treatment groups in achievement on particular tasks, and for specific students. Without disputing the validity of this conclusion, our analysis revealed that at least one illustrated treatment (and usually more) in every grade level by criterion comparison proved superior to the verbal control group. Thus, while there were several instances where negative effect-size values were obtained, indicating a negative effect for some illustrated treatments, there was at least one type of illustrated treatment that always ranked superior to verbal treatment alone. Table 2 presents the results of this analysis for externally paced presentations. The absence of

- -

Insert Table 1 and Figures 2 and 3 about here

- -

The potential utility of the meta-analytic style of research integration may perhaps be assessed by brief comparisons of the present data with a few previous conclusions drawn by Dwyer (1978) and others. A variety of realism or abstract/concrete continuums have been developed to represent a proposed scale of effectiveness for instructional materials. These scales extend from oral symbols (digital signs) at the highly abstract level to three-dimensional objects (iconic signs) at the most concrete level. The implication is that the most realistic representation (i.e., the most concrete) will be most beneficial for most instructional purposes.

Two points regarding these scales merit further analysis. First, the suggestion has been made by Wheelbarger (1970), Dwyer (1978) and others, that a variety of visual continuums may exist depending upon specific variables and conditions. Second, Haynie (1978) pointed out that existing continuums attempt to relate the scaled entries on an ordinal basis only, and not on an interval scale. Thus, inferences as to the extent of separation between entries heretofore have not been possible. Figure 4 presents findings from our analysis which speak directly to these points. By comparing the three continuums based upon mean effect-size values to Dwyer's visual continuum (also Figure 4), we can illustrate that a variety of continuums may indeed exist, depending upon the level of analysis. Additionally, the mean negative effect-size values illustrates the superiority of an illustrated treatment in every instance. Moreover, when we draw a hypothetical division in Dwyer's visual continuum (see Figure 4) such that illustrations 1-4 represent the least complex conditions and illustrations 5-8 the most complex conditions, our comparison of mean effect-size values indicates that:

(a) for externally paced presentations, the *most* effective illustration was one of the least complex in every grade level by criterion comparison (see Table 2), and

- - - - - - - - - - - - - - - - -

Insert Table 2 about here

- - - - - - - - - - - - - - - - -

(b) for externally paced presentations, the *least* effective illustration was one of the most complex in all but two grade levels by criterion comparisons (see Table 3).

- - - - - - - - - - - - - - - - -

Insert Table 3 about here

- - - - - - - - - - - - - - - - -

Table 2 also provides statistical support for Dwyer's (1978) conclusion that "for students in different grade levels, the same visuals are not equally effective in increasing achievement of identical educational objectives" (p. 95). As demonstrated by this table, the most effective illustration for every criterion had the lowest mean effect-size value at the college level.

Invariably, any comparative analysis of illustration effectiveness will lead to the persistent question of the value of color as a cueing technique. With our limited data, a further analysis of Tables 2 and 3 with regard to this question hints at the potential strength of the color cue. Color illustrations predominated as both the most and the least effective treatment presentation, providing the highest mean effect-size values on 13 of 20 occasions and the lowest mean effect-size values on 12 of 20 comparisons. Plausibly, color may be either highly facilitative or highly interferent for accomplishing given educational tasks. As yet, no discernible pattern of influence for either task or grade level is evident in Tables 2 and 3 with respect to this variable. Dwyer's (1978) conclusions regarding this issue are alternately bold and cautious. Consider these two quotations:

(a) "There is an increasing amount of empirical evidence which tends to support the contention that the addition of color in visual illustrations does improve student achievement of specific educational objectives" (p. 150);

(b) "For specific students and for specific educational objectives, the use of color in certain types of visuals presented via the slide/audiotape format appears to be an important instructional variable in improving student achievement. For other educational objectives, however, the added cost of color may not be justified from the instructional effectiveness standpoint" (p. 96).

Although Figure 5 suggests consistent supremacy of color illustrations over their black and white counterparts when results are generalized across grade levels and criteria for externally paced presentations, the danger of overgeneralization at the macro level of analysis becomes apparent when Figure 5 is compared with Figure 6. In the latter figure, mean effect-size comparisons are again presented for identical black and white versus color illustrations, but within an internally paced presentation format. Additionally, for Figure 6, the focus has narrowed to a single criterion (the comprehension test), and to one specific grade (the college level). As shown by the data, the use of color in this situation serves to increase the *ineffectiveness* of three types of illustrations and to increase the *effectiveness* of a fourth type.

Insert Figures 5 and 6 about here

CONCLUSION

The data reported herein should be regarded as only a preliminary and partial investigation of the topic of pictorial stimulus complexity, and as such, our results are not conclusion oriented. Although it is likely that more thorough aggregation will modify these findings, the data do provide indications of possible trends which may ultimately be sustained by more complete analyses, and which may help to generate experimental investigation in the interim.

Since our analysis was limited to variables common to all studies, more finite analyses of specific student attributes or treatment variations is not always feasible at the macro level of research integration. However, this condition is not always restrictive, since a molar level of analysis has genuine value for certain levels of educational decision making. While important individual differences undoubtedly are obscured to some extent in this type of analysis, there are nevertheless instances where the specificity of information is sufficient for generating hypotheses for further research.

REFERENCES

Allen, W. H. Instructional media research: Past, present, and future. AV Communication Review, 1971, 19, 5-18.

Asso, D., & Wyke, M. Visual discrimination and verbal comprehension of spatial relations by young children. British Journal of Psychology, 1970, 61, 99-107.

Attneave, F. Some informational aspects of visual perception. Psychological Review, 1954, 61, 183-193.

Attneave, F. Physical determinants of the judged complexity of shapes. Journal of Experimental Psychology, 1957, 53, 221-227.

Barr, A., Goodknight, J., Sall, J., & Helwig, J. SAS user's guide. Raleigh, North Carolina: SAS Institute, Inc., 1979.

Bergum, B. O., & Flamm, L. E. Reversibility and apparent tridimensionality. Bulletin of the Psychonomic Society, 1979, 14, 193-196.

Berlo, D. K. The process of communication. New York: Holt, Rinehart, and Winston, 1960.

Berlyne, D. E. The influence of complexity and novelty in visual figures on orienting responses. Journal of Experimental Psychology, 1958, 55, 289-296.

Bevan, W., & Steger, J. A. Free recall and abstractness of stimuli. Science, 1971, 172, 597-599.

Bloomer, R. H. Children's preferences and responses as related to styles and themes of illustration. Elementary School Journal, 1960, 60, 334-340.

Boguslavsky, G. W. Study of characteristics contributing to the effectiveness of visual demonstrations. (Final Report Project No. 5-0458, Grant No. 7-42-1070-178). Troy, New York: Renssaeler Polytechnic Institute, April, 1967.

Bracht, G. H. Experimental factors related to aptitude-treatment interactions. Review of Educational Research, 1970, 40, 627-645.

Broudy, H. S. On knowing with. In H. S. Broudy (Ed.), Proceedings of the philosophy of education society: Studies in philosophy and education. Edwardsville, Illinois: Southern Illinois Univ., 1970. pp 89-103.

Broudy, H. S. *The real world of the public schools*. New York: Harcourt, 1972.

Brown, L. The 3-D reconstruction of a 2-D visual display. *Journal of Genetic Psychology*, 1969, *115*, 257-262.

Burton, N. W. Assessment as exploratory research: A theoretical overview. *Educational Technology*, 1979, *19*(2), 5-11.

Carpenter, C. R. Psychological concepts and audiovisual instruction. *AV Communication Review*, 1957, *5*, 361-369.

Clark, F. E. & Angert, J. F. Inadequacies in media research. *Instructional Innovator*, 1980, *25*(1), 36-37.

Conway, J. K. Multiple-sensory modality communications and the problem of sign types. *AV Communication Review*, 1967, *15*, 371-383.

Cronbach, L. J., & Snow, R. E. *Aptitudes and instructional methods*. New York: Irvington, 1977.

Dale, E. *Audio-visual methods in teaching*. New York: Dryden Press, 1946.

Dance, F. E. X. The "concept" of communication. *The Journal of Communication*, 1970, *20*, 201-210.

Dember, W. H., & Earl, R. W. Analysis of exploratory, manipulatory, and curiosity behaviors. *Psychological Review*, 1957, *64*, 91-96.

Den Heyer, K. Structural stimulus complexity: One factor influencing the clarity of iconic storage. *Acta Psychologica*, 1974, *38*(1), 21-31.

Den Heyer, K., Ryan, B., & MacDonald, J. The relationship between structural stimulus complexity and clarity of iconic storage under a backward masking paradigm. *Acta Psychologica*, 1976, *40*(3), 189-198.

Deutschmann, P. J., Barrow, L. C., Jr., & McMillan, A. The efficiency of different modes of communication. *AV Communication Review*, 1961, *9*, 263-270.

Devor, G. M., & Stern, C. Objects versus pictures in the instruction of young children. *Journal of School Psychology*, 1970, *8*, 77-81.

Duchastel, P., & Waller, R. Pictorial illustration in instructional texts. *Educational Technology*, 1979, *19*(11), 20-25.

Dwyer, F. M. Student perceptions of the instructional effectiveness of black & white and colored illustrations. The Journal of Experimental Education, 1971, 40, 28-34.

Dwyer, F. M. Strategies for improving visual learning. State College, Pa.: Learning Services, 1978.

Elkind, D., Koegler, R., & Go, E. Studies in perceptual development: II part-whole perception. Child Development, 1964, 35, 81-90.

Fleming, M. L. Media research prospects: Considerations from a perceptual point of view. In G. Salomon and R. E. Snow (Eds.), Viewpoints, (Bulletin of the School of Education, Indiana University), 1970, 46, 119-136.

Fonesca, L., & Bryant, K. Comparison of pictorial symbols -- an experiment in rural Brazil. Bulletin 30. Madison, Wisconsin: College of Agriculture, University of Wisconsin, 1960.

Gibson, J. J. A theory of pictorial perception. AV Communication Review, 1954, 2, 3-23.

Glass, G. V. Primary, secondary and meta-analysis of research. Educational Researcher, 1976, 5, 3-8.

Glass, G. V. Integrating findings: The meta-analysis of research. Review of Research in Education, 1977, 5, 351-379.

Gorman, D. A. Effects of varying pictorial detail and presentation strategy on concept formation. AV Communication Review, 1973, 21, 337-350.

Grover, P. L. Effect of varied stimulus complexity and duration upon immediate recall of visual material in a serial learning task. AV Communication Review, 1974, 22, 439-452.

Hall, A. C. Measures of the complexity of random black and white and coloured stimuli. Perceptual and Motor Skills, 1969, 29, 773-774.

Hartmann, F. R. Single and multiple channel communication: A review of research and a proposed model. AV Communication Review, 1961, 9, 235-261.

Hawkridge, D. G. Media taxonomies and media selection. Paper prepared for the Institute of Educational Technology. The Open University, Milton Keynes, England, 1973.

Haynie, W. J., III. The instructional effectiveness of realism and enhancement of illustrations as related to visual continuum theories (Doctoral dissertation, The Pennsylvania State University, 1978). Dissertation Abstracts International, 1979, 39, 4666A-4667A. (University Microfilms No. 7902608)

Hedberg, J. G., & Clark, R. E. Realism in pictorial instruction: What the research says. *Educational Technology*, 1976, *16*, 46-47.

Heidt, E. U. Media and learner operations: The problem of a media taxonomy revisited. *British Journal of Educational Technology*, 1977, *8*, 11-26.

Hershenon, M., Munsinger, H., & Keesen, W. Preference for shapes of intermediate variability in the newborn human. *Science*, 1965, *147*, 630-631.

Hill, H. E. Communication research and instructional technology. *Educational Communication and Technology Journal*, 1978, *26*, 47-54.

Hoban, C. F., Hoban, C. F. Jr., & Zisman, S. B. *Visualizing the curriculum*. New York: The Dryden Press, Inc., 1937.

Huggins, W. H., & Entwisle, D. R. *Iconic communication: An annotated bibliography*. Baltimore: The Johns Hopkins University Press, 1974.

Hunter, W. S. Visually controlled learning as a function of time and intensity of stimulation. *Journal of Experimental Psychology*, 1943, *31*, 423-429.

Ibison, R. A. *Differential effects on the recall of textual materials associated with the inclusion of colored and uncolored illustrations*. Unpublished doctoral dissertation, Indiana University, 1952.

Isaac, S., & Michael, W. B. *Handbook in research and evaluation*. San Diego, CA: Edits Publishers, 1971.

Jackson, G. B. *Methods for reviewing and integrating research in the social sciences*. Final report, National Science Foundation Grant # DIS 76-20398. Washington, D.C.: Social Research Group, George Washington University, April 1978.

Knowlton, J. Q. A conceptual scheme for the audiovisual field. In *Viewpoints*, (Bulletin of the School of Education, Indiana University), 1964, *40*, 1-42.

Koen, F. Verbal and nonverbal mediators in recognition memory for complex visual stimuli. USOE Bureau of Research, Grant BR-6-1784, February, 1969. Contract OEC-3-6-061784-0508. (ERIC Document Reproduction Service No. ED 029 349)

Kuhn, T. S. Structure of scientific revolutions. Chicago: Univ. of Chicago Press, 1962.

Levie, W. H. Pictorial research: An overview. In W. H. Levie (Ed.), Viewpoints, (Bulletin of the School of Education, Indiana University), 1973, 49, 37-45.

Levie, W. H. A prospectus for instructional research on visual literacy. Educational Communications and Technology Journal, 1978, 26, 25-36.

Littlejohn, S. W. Theories of human communication. Columbus, Ohio: Charles E. Merrill, 1978.

Lumsdaine, A. A. Instruments and media of instruction. In N. L. Gage (Ed.), Handbook of Research on Teaching. Chicago: Rand McNally, 1963, pp. 583-682.

Lumsdaine, A. A., & May, M. A. Mass communication and educational media. In P. R. Fransworth (Ed.), Annual Review of Psychology, 1965, 16, Palo Alto, California.

MacDonald-Ross, M., & Smith, E. Graphics in text: A bibliography. (IET Monograph No. 6). Institute of Educational Technology, The Open University, Milton Keynes, England, 1977.

MacLean, W. P. A comparison of colored and uncolored pictures. Educational Screen, 1930, 9, 196-199.

Mackworth, N. H., & Bruner, J. S. How adults and children search and recognize pictures. Human Development, 1970, 13, 149-177.

Mielke, K. W. Renewing the link between communications and educational technology. AV Communication Review, 1972, 20, 357-399.

Miller, N. E. (Ed.) Graphic communication and the crisis in education. By N. E. Miller in collaboration with W. A. Allen, et al., AV Communication Review, 1957, 5, 1-120.

Moore, D. M., & Sasse, E. B. Effect of size and type of still projected pictures on immediate recall of content. AV Communication Review, 1971, 19, 437-450.

Morris, C. E. Signs, language and behavior. New York: Prentice-Hall, Inc., 1946.

Mortensen, C. D. Communication: The study of human interaction. New York: McGraw-Hill, 1972.

Nelson, K. E. Memory development in children: Evidence from nonverbal tasks. Psychonomic Science, 1971, 25, 346-348.

Norberg, K. D. Iconic signs and symbols in audio-visual communication. Sacramento, Calif.: Sacramento State College, 1966. (ERIC Document Reproduction Service No. ED 013 371)

Otto, W., & Askov, E. The role of color in learning and instruction. Journal of Special Education, 1968, 2, 155-165.

Parkhurst, P. E. Generating meaningful hypotheses with aptitude-treatment interactions. AV Communication Review, 1975, 23, 171-196.

Petrie, H. C. Do you see what I see? The epistemology of interdisciplinary inquiry. Educational Researcher, 1976, 5(2), 9-15.

Piaget, J., & Inhelder, B. The child's conception of space. London: Routlege and Kegan Paul, 1956.

Randhawa, B. S. Visual trinity: An overview. In B. S. Randhawa & W. E. Coffman (Eds.), Visual learning, thinking, and communication. New York: Academic Press, 1978, 191-211.

Rudisill, M. Children's preferences for color versus other qualities in illustrations. The Elementary School Journal, 1952, 52, 444-451.

Rudnick, M. F., Porter, M. C., & Suydam, E. L. Pictorial stimulus variables. In W. H. Levie (Ed.), Viewpoints, (Bulletin of the School of Education, Indiana University), 1973, 49.

Salomon, G. What is learned and how it is taught: The interaction between media, message, task, and learner. Seventy-third yearbook of the National Society for the Study of Education. Chicago: NSSE, 1974, 383-406.

Schramm, W. Big media, little media. Beverly Hills, Ca.: Sage Publications, Inc., 1977.

Shannon, E. E., & Weaver, W. The mathematical theory of communication. Urbana, Ill.: The University of Illinois Press, 1949.

Smith, W. H. Visual analogy in nonverbal communications (Doctoral dissertation, Indiana University, 1965). Dissertation Abstracts, 1965, 25, 2595A. (University Microfilms No. 65-10891)

Spaulding, S. Research on pictorial illustration. AV Communication Review, 1955, 3(1), 35-45.

Spaulding, S. Communication potential of pictorial illustrations. *AV Communication Review*, 1956, *4*(1), 31-46.

Stenson, H. H. The physical factor structure of random forms and their judged complexity. *Perception and Psychophysics*, 1966, *1*, 303-310.

Terwilliger, R. F. Pattern complexity and affective arousal. *Perceptual and Motor Skills*, 1963, *17*, 387-395.

Travers, R. M. W. The transmission of information to human receivers. *AV Communication Review*, 1964, *12*, 373-385.

Travers, R. M. W. *A study of the advantages and disadvantages of using simplified visual presentations in instructional materials.* (Final Report, Dept. of HEW, USOE), 1969. (ERIC Document Reproduction Service No. ED 031 951)

Travers, R. M. W., & Alvarado, V. The design of pictures for teaching children in elementary school. *AV Communication Review*, 1970, *18*, 47-64.

Vandermeer, A. W. Color vs. black and white in instructional films. *AV Communication Review*, 1954, *2*, 121-134.

Westley, B. H., & MacLean, M. S., Jr. Conceptual model for communications research. In N. L. Harper (Ed.), *Human communication.* New York: MSS Information Corporation, 1974.

Wheelbarger, J. J. An investigation of the role of pictorial complexity in visual perception (Doctoral dissertation, University of Virginia, 1970). *Dissertation Abstracts International*, 1971, *31*, 5864A. (University Microfilms No. 71-6636)

Wright, B., & Gardner, B. Effect of color on black and white pictures. *Perceptual and Motor Skills*, 1960, *11*, 301-304.

Table 1

Mean Effect-Size Values By Coded Variable

(In Standard Deviation Units)

Variable	n	Mean Effect-Size[a]
Illustrations		
Simple Line Drawing (B&W)	235	.71 ± .06
Simple Line Drawing (color)	112	1.04 ± .07
Shaded Detailed Drawing (B&W)	173	.76 ± .05
Shaded Detailed Drawing (color)	112	1.19 ± .10
Model Photograph (B&W)	135	.46 ± .06
Model Photograph (color)	112	.68 ± .08
Realistic Photograph (B&W)	178	.39 ± .05
Realistic Photograph (color)	152	.39 ± .06
Grade Levels		
Ninth	190	1.00 ± .06
Tenth	406	.64 ± .04
Eleventh	160	1.00 ± .06
Twelfth	140	.80 ± .06
College	433	.33 ± .03
Criteria		
Drawing Test	273	.91 ± .05
Identification Test	273	.63 ± .04
Terminology Test	261	.54 ± .05
Comprehension Test	253	.27 ± .05
Presentation Pace		
External	942	.77 ± .03
Internal	387	.36 ± .04
Color		
Black and White	721	.59 ± .03
Color	608	.72 ± .04

[a] With an indication of the approximate standard error of the mean. Thus, the interval indicated for each mean effect-size value has a confidence coefficient of about two-thirds.

Table 2

Most Effective Illustration for Externally

Paced Presentations

Criterion	Grade Level 9	10	11	12[a]	College[b]
Drawing Test	Simple Line Drawing (B&W) ES = 2.60	Shaded Detailed Drawing (color) ES = 2.07	Shaded Detailed Drawing (color) ES = 1.39	Shaded Detailed Drawing (color) ES = .92	Simple Line Drawing (B&W) ES = .83
Identification Test	Shaded Detailed Drawing (color) ES = 1.38	Shaded Detailed Drawing (color) ES = 1.66	Shaded Detailed Drawing (color) ES = 1.63	Shaded Detailed Drawing (color) ES = 1.31	Simple Line Drawing (color) ES = 1.08
Terminology Test	Shaded Detailed Drawing (color) ES = 1.07	Shaded Detailed Drawing (B&W) ES = 1.37	Shaded Detailed Drawing (B&W) ES = 1.37	Shaded Detailed Drawing (color) ES = 2.88	Simple Line Drawing (B&W) ES = .30
Comprehension Test	Simple Line Drawing (B&W) ES = .73	Simple Line Drawing (color) ES = 1.19	Shaded Detailed Drawing (B&W) ES = 1.21	Shaded Detailed Drawing (color) ES = 1.19	Simple Line Drawing (color) ES = .56

Note. ES = mean effect-size value.

[a] No treatment group in this grade level utilized realistic color photographs.

[b] Several treatments in this grade level with only one effect-size value.

Table 3

Least Effective Illustration for Externally Paced Presentations

Criterion	Grade Level				
	9	10	11	12[a]	College[b]
Drawing Test	Model Photograph (B&W) ES = 1.26	Realistic Photograph (color) ES = .55	Realistic Photograph (color) ES = .60	Model Photograph (color) ES = .30	Realistic Photograph (color) ES = .08
Identification Test	Realistic Photograph (B&W) ES = .32	Realistic Photograph (color) ES = .50	Model Photograph (color) ES = .63	Simple Line Drawing (B&W) ES = .41	Realistic Photograph (B&W) ES = -.09
Terminology Test	Realistic Photograph (B&W) ES = .15	Realistic Photograph (color) ES = .11	Realistic Photograph (color) ES = .24	Model Photograph (color) ES = .86	Realistic Photograph (color) ES = -.35
Comprehension Test	Shaded Detailed Drawing (B&W) ES = -.24	Model Photograph (B&W) ES = .76	Realistic Photograph (color) ES = -.67	Realistic Photograph (B&W) ES = .18	Realistic Photograph (color) ES = -.40

Note. ES = mean effect-size value.

[a] No treatment group in this grade level utilized realistic color photographs

[b] Several treatments in this grade level with only one effect-size value.

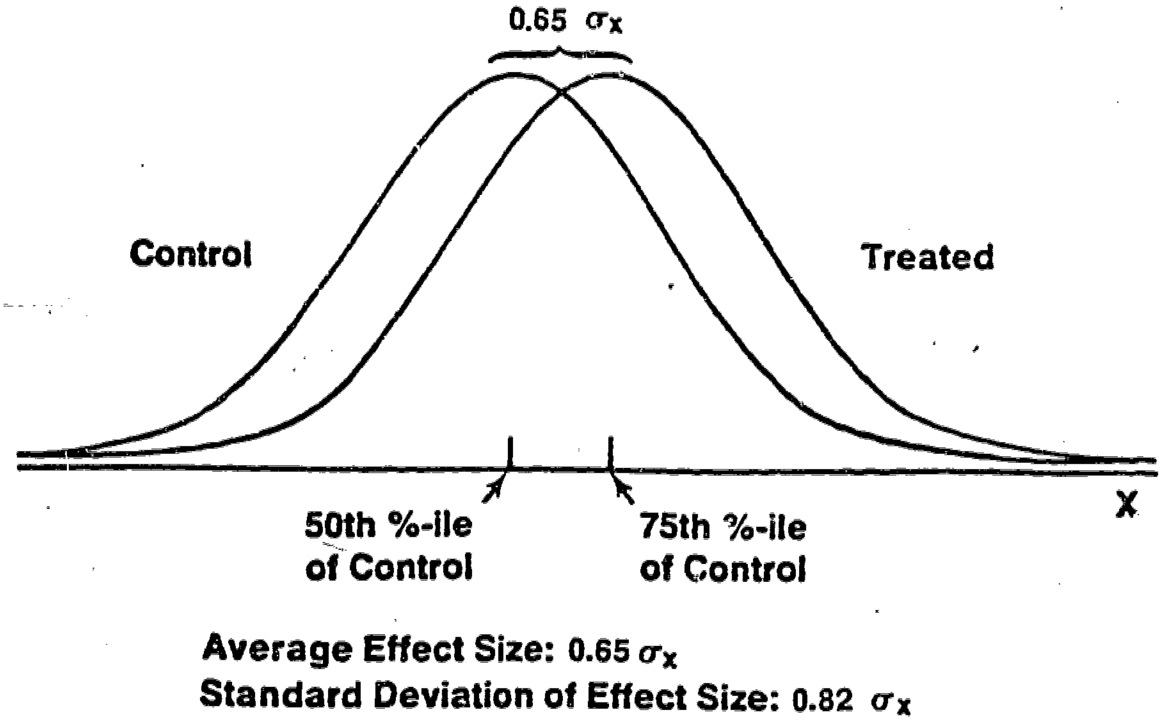

Figure 1. Normal curves showing the aggregate effect of illustrated treatments in relation to treated control groups.

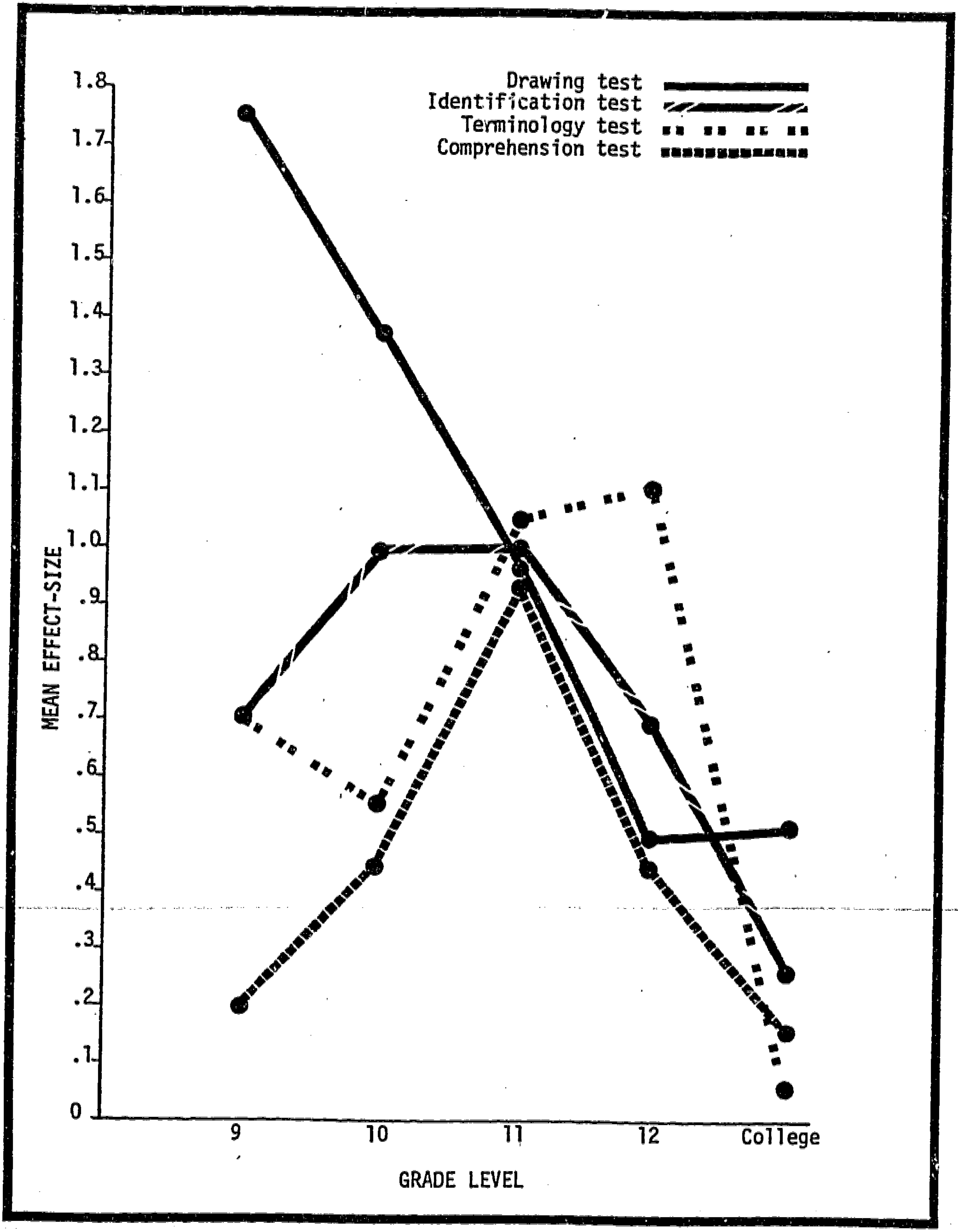

Figure 2. Mean effect-size values for black and white illustrations by criterion and grade level. (For externally paced presentations.)

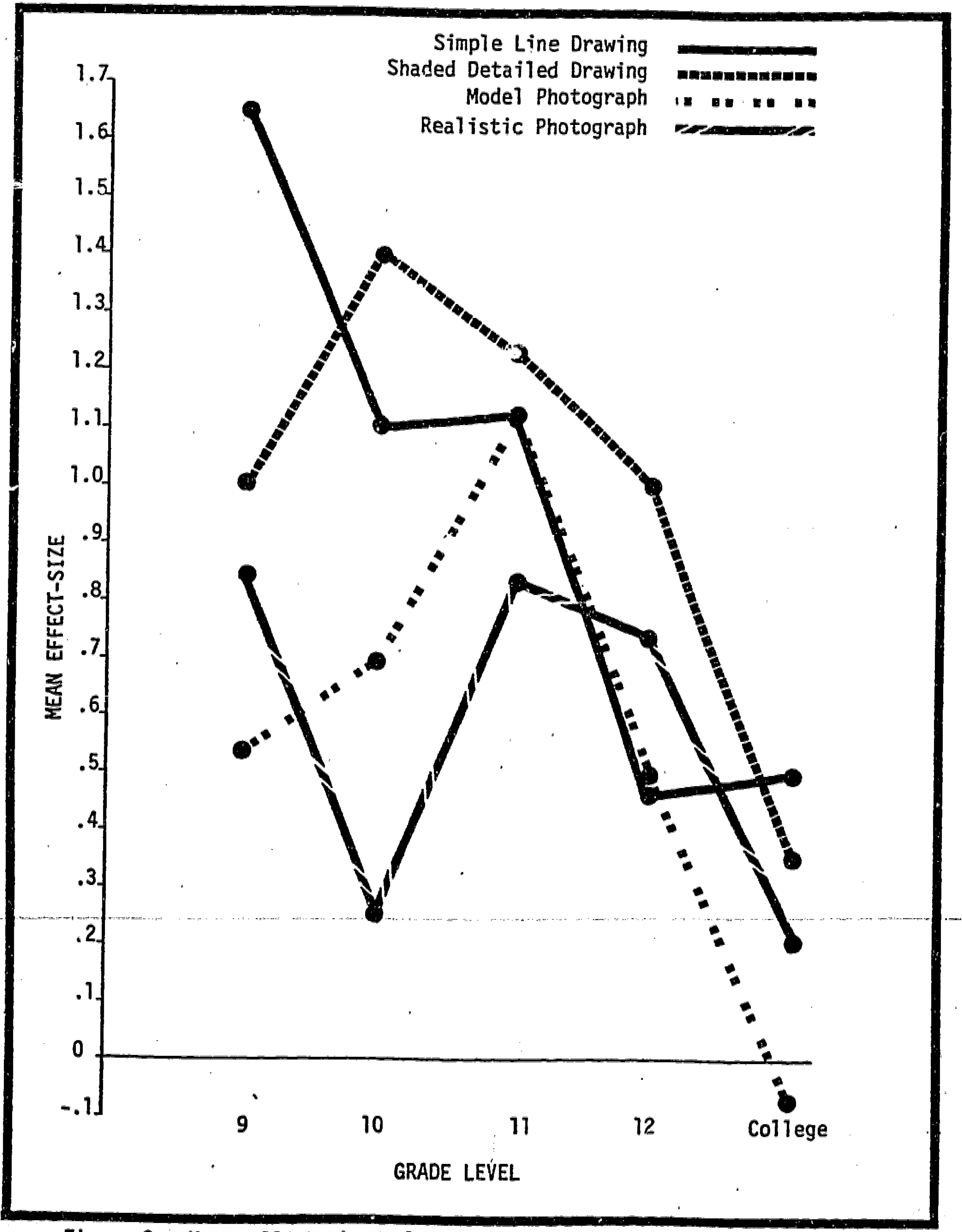

Figure 3. Mean effect-size values for all criteria by black and white illustration and grade level. (For externally paced presentations.)

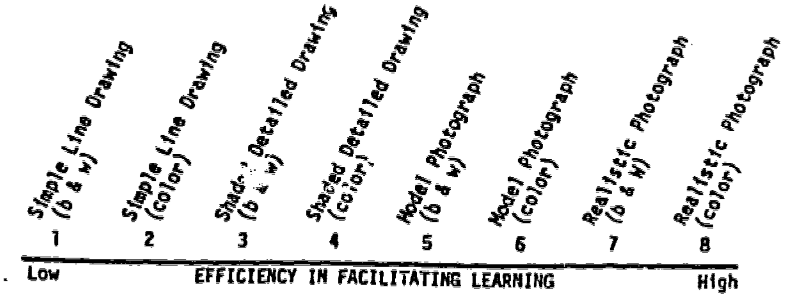

Plate 1. Realism continuum for illustrations in accordance with the "realism theories" (Dwyer, 1978).

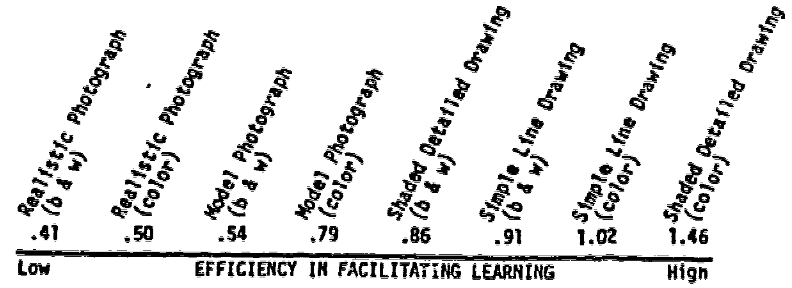

Plate 2. Realism continuum for illustrations generalized across four criteria and five grade levels.

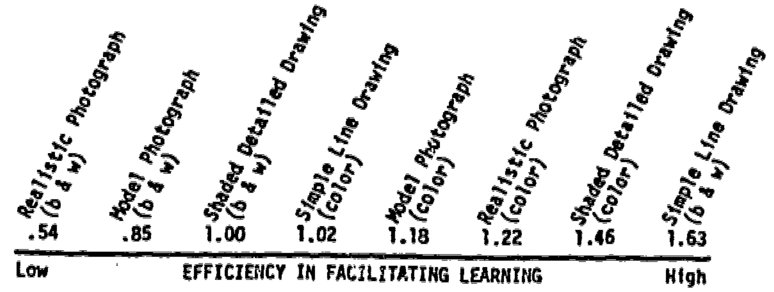

Plate 3. Realism continuum for illustrations generalized across four criteria for the ninth grade.

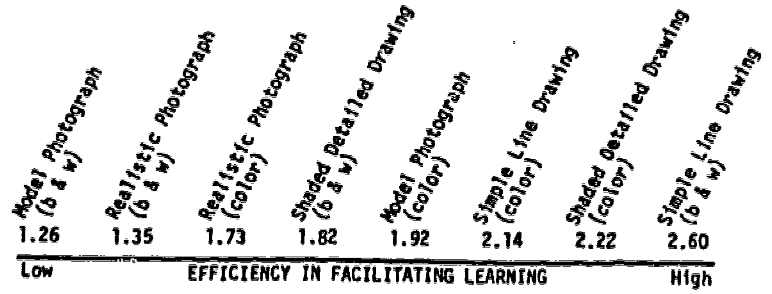

Plate 4. Realism continuum for illustrations specific to the drawing test criterion for the ninth grade.

Figure 4. Comparison of Dwyer's (1978) visual continuum with three visual continuums derived from mean effect-size values.

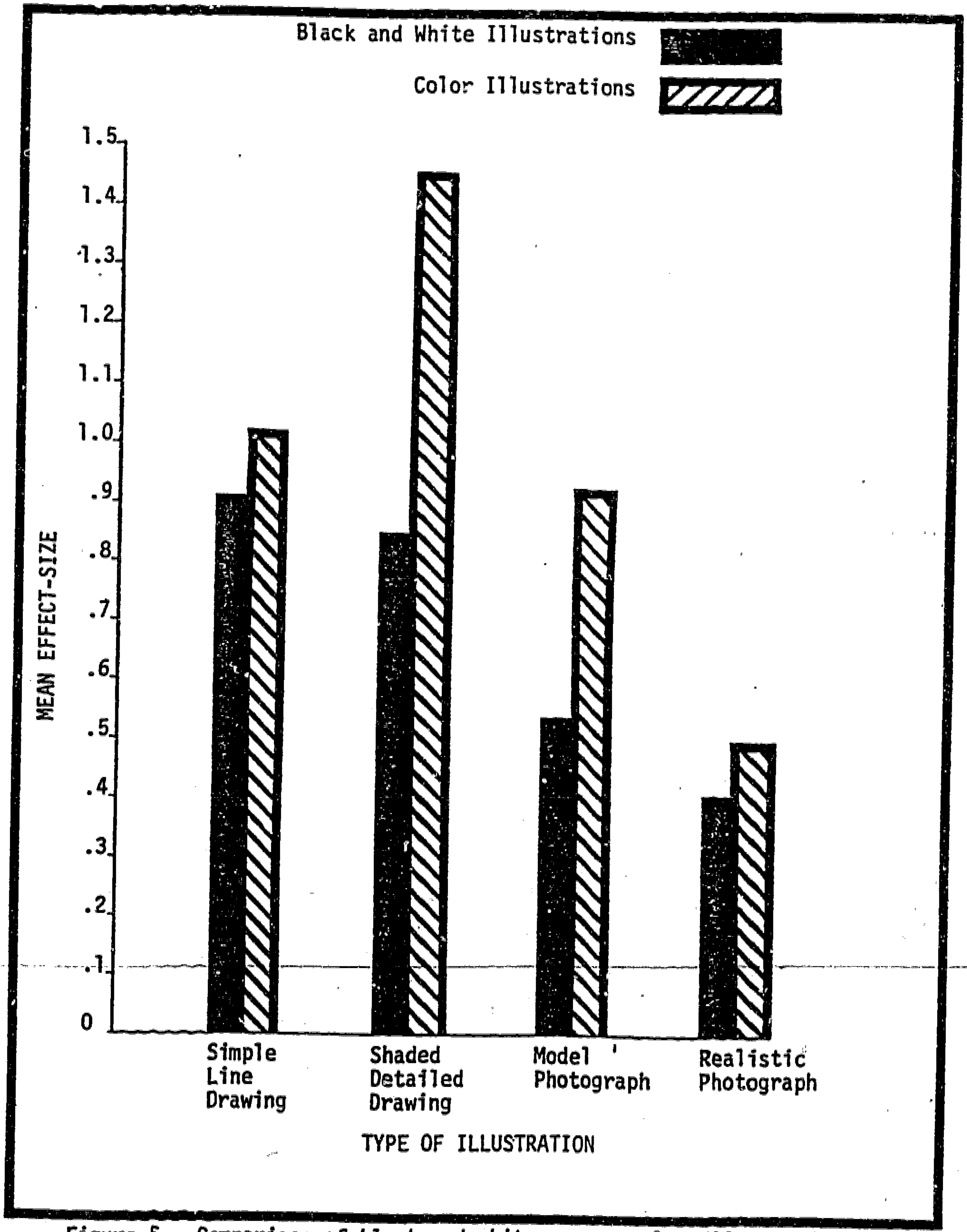

Figure 5. Comparison of black and white versus color illustration mean effect-size values for all criteria and grade levels. (For externally paced presentations.)

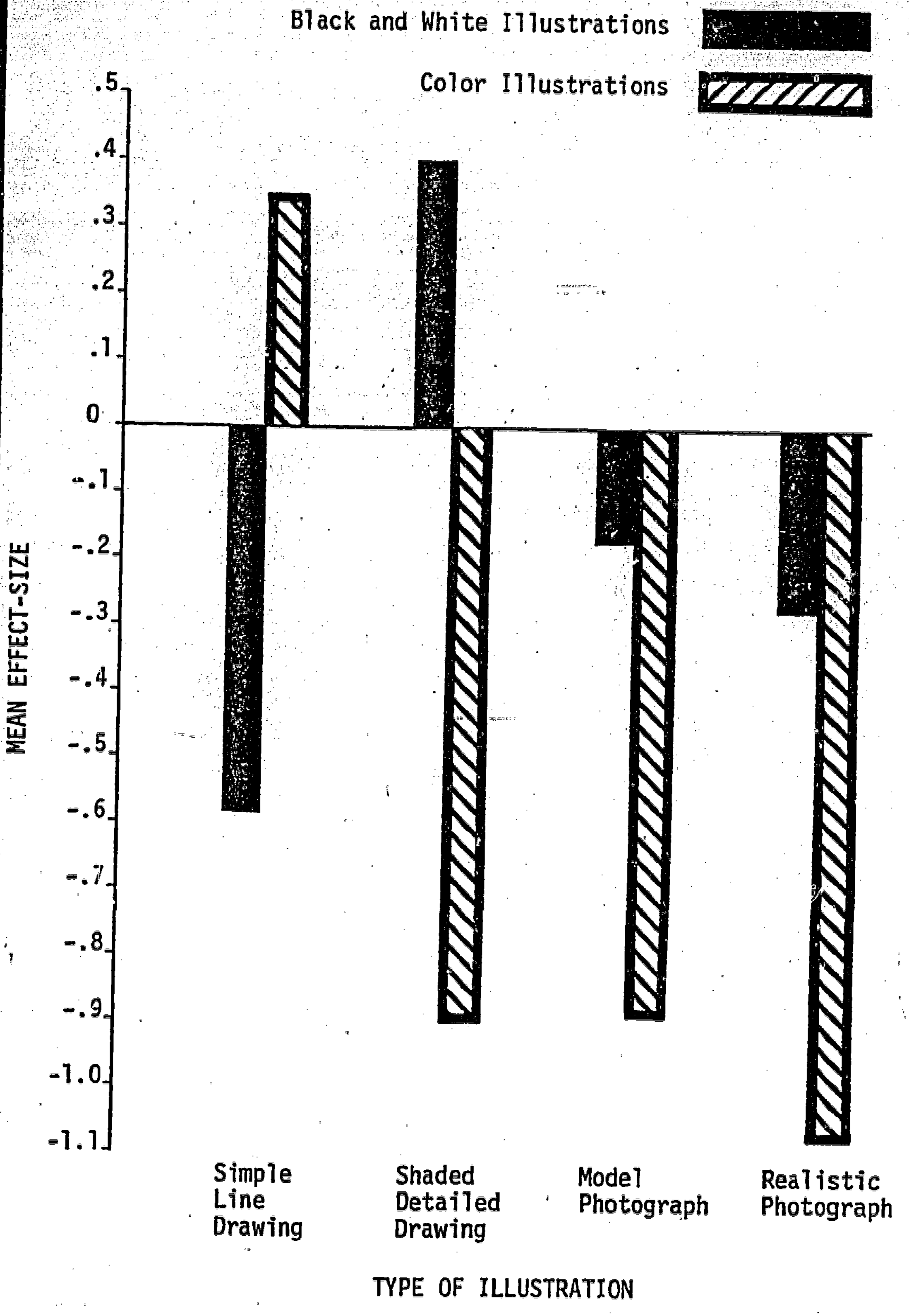

Figure 6. Comparison of black and white and color illustration mean effect-size values for the comprehension criterion for college level students. (For internally paced presentations.)

Appendix A: Publications Comprising the Sample

Arnold, T. C., & Dwyer, F. M. Realism in visualized instruction. Perceptual and Motor Skills, 1975, 40, 369-370.

Dwyer, F. M. Adapting visual illustrations for effective learning. Harvard Educational Review, 1967, 37, 250-263.

Dwyer, F. M. An experimental evaluation of visual illustrations used to complement programed instruction. University Park, The Pennsylvania State University, University Division of Instructional Services, 1967. (ERIC Document Reproduction Service No. ED 019 871)

- Contains data found in:

  Dwyer, F. M. The effectiveness of visual illustrations used to complement programed instruction. The Journal of Psychology, 1968, 70, 157-162.

Dwyer, F. M. The relative effectiveness of varied visual illustrations in complementing programed instruction. The Journal of Experimental Education, 1967, 36, 34-42.

Dwyer, F. M. The effectiveness of selected visual illustrations in teaching science concepts to college freshmen. The Journal of Educational Research, 1968, 61, 343-347.

Dwyer, F. M. When visuals are not the message. Educational Broadcasting Review, 1968, 2, 38-43.

Dwyer, F. M. The effect of varying the amount of realistic detail in visual illustrations designed to complement programed instruction. Programed Learning and Educational Technology, 1969, 6, 147-153.

Dwyer, F. M. Effect of questions on visual learning. Perceptual and Motor Skills, 1970, 30, 51-54.

Dwyer, F. M. The effect of image size on visual learning. The Journal of Experimental Education, 1970, 39, 36-41.

- Contains data found in:

  Dwyer, F. M. An evaluation of image size as an instructional variable on television. Unpublished Research Report, University Park, The Pennsylvania State University, University Division of Instructional Services, 1969.

Dwyer, F. M. *Visual learning: An analysis by sex and grade level.* University Park, The Pennsylvania State University, University Division of Instructional Services, 1970. (ERIC Document Reproduction Service No. ED 041 478)

- Contains data found in:

    Dwyer, F. M. *A study of the relative effectiveness of varied visual illustrations.* USOE Final Report, Project No. 6-8840, Grant No. OEG-1-7--68840-0290. University Park, The Pennsylvania State University, University Division of Instructional Services, 1967. (ERIC Document Reproduction Service No. ED 020 658)

    Dwyer, F. M. An experiment in visual learning at the eleventh-grade level. *The Journal of Experimental Education*, 1968, *37*, 1-5.

    Dwyer, F. M. Effect of visual stimuli on varied learning objectives. *Perceptual and Motor Skills*, 1968, *27*, 1067-1070.

    Dwyer, F. M. An experiment in visual communication. *Journal of Research in Science Teaching*, 1969, *6*, 185-195.

    Dwyer, F. M. The effect of stimulus variability on immediate and delayed retention. *The Journal of Experimental Education*, 1969, *38*, 30-37.

Dwyer, F. M. An experimental evaluation of the instructional effectiveness of black and white and colored illustrations. *Didakta Medica*, 1971, *3&4*, 96-101.

Dwyer, F. M. Color as an instructional variable. *AV Communication Review*, 1971, *19*, 399-416.

Dwyer, F. M. The effect of overt responses in improving visually programed science instruction. *Journal of Research in Science Teaching*, 1972, *9*, 47-55.

Dwyer, F. M. On visualized instruction effect of students' entering behavior. *The Journal of Experimental Education*, 1975, *43*, 78-83.

- Correctly entitled:

    Effect of students' entering behavior on visualized instruction.

Haynie, W. J., III. The instructional effectiveness of realism and enhancement of illustrations as related to visual continuum theories (Doctoral dissertation, The Pennsylvania State University, 1978). *Dissertation Abstracts International*, 1979, *39*, 4666A-4667A. (University Microfilms No. 7902608)

Joseph, J. H. The instructional effectiveness of integrating abstract and realistic visualizations. The Pennsylvania State University, 1978. *Dissertation Abstracts International*, 1979, *39*, 5907A. (University Microfilms No. 7909090)