A Proposed Model for the Systematic Design of Instructional Pictures

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Abstract: This paper describes a systematic method for producing pictures to accompany textual Instructional materials. The method integrates Gagne's classic approach to textual Instructional design with Goldsmith's approach to evaluating educational illustrations, that is based on empirically validated principles of visual perception and communication. The resulting instructional design model describes a procedure for creating the textual, and pictorial elements of printed, Instructional materials used in an ATI study to produce Instructional materials that appeared to differentially affect the learning outcomes of adult learners with different levels of visual learning skills.

Resume: Get article decrlt une methode systematique de production d'lmages utllisees dans les documents textuels didactiques. Cette m6thode permet ('Integration de la methode de conception de documents textuels didactiques classiques de Gagne au precede devaluation des Illustrations didactiques de Goldsmith qui est basesur des principes de validation externe de perception visuelle et de communication. Le modele didactique qui en decoule presente un proced6 de creation d'e!6ments textuels etd'imagesde documents didactiques utilises dans une «6tude ATI* pour produire du materiel didactique qui semblalt affecter, par action differentiate, les resultats obtenus par les etudlants adultes de differents nlveaux d'apprentissage visuel.

INTRODUCTION

Educational researchers have confirmed that, in some circumstances, adding pictures to represent verbal information in printed instruction has resulted in better learning outcomes (Dwyer, 1978, 1987; Fleming & Levie, 1978; Levie & Lentz, 1982). Many attribute treatment interaction studies have examined the interactive effects of making instruction less verbal by adding visuals to verbally-based instructional materials. Most researchers have concluded that, other

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things being equal, people having spatial and abstract abilities relatively stronger than their verbal abilities benefitted more from visual treatments than they did from exclusively verbal treatments (Cronback & Snow, 1977). An integrated system of creating instructionally effective pictures to supplement instructional text, however, has not yet emerged from the research literature.

The authors of this paper describe a method for integrating a highly regarded systematic approach to designing printed instructional materials with a little known method of analysing pictures for their educational effectiveness. The result is a system that educators can use to create pictures to supplement instruction and enhance concept acquisition. Research is reported in which guidelines derived from this approach were used to produce pictures, embedded in self-instructional print materials, that appeared to enhance the performance of adult learners with varying levels of visual learning skills.

The Need for Guidelines for Creating Educational Pictures

In their review of the research, Cronback and Snow (1977) concluded that well designed graphics (which included many different kinds of pictorial representations) can act as prostheses for learners with poor spatial ability. A number of studies on mental imagery and learning indicate that mental imagery appears to have a role in facilitating both higher, and lower level, concept learning (Kyllonen,Lohman&Snow, 1984;Levie&Lentz, 1982;Lohman, 1984; Sternberg & Weil, 1980; Taylor, Canelos, Belland, Dwyer & Baker, 1987). The use of analogical visuals (pictures that draw parallels between familiar and new concepts), either embedded or spontaneous, appears to be of particular importance in higher level cognitive processes (Kaufmann, 1980;Krueger, 1984;Miller, 1984). Research on the role of experimenter-provided visuals (pictures, diagrams and charts) in text-based and computer-based instructional materials supports the beneficial effects of adding visuals, especially for learners who are less proficient in manipulating verbal symbols, or low visual learners (Dwyer, 1978 and 1987; Fleming & Levie, 1978; Fleming, 1987; Levie and Lentz, 1982).

Over the past twenty-five years, Dwyer and his associates have consistently demonstrated that pictures supplementing text assist some individuals to learn from printed, programmed, instructional materials (Dwyer, 1978; Dwyer, 1987). From this large body of research, Dwyer concluded that "The use of visuals specifically designed to complement printed instruction can significantly improve student achievement of certain types of educational objectives" (Dwyer, 1987, p. 365).

Levie and Lentz (1982), in their examination of the relationship between pictorial and printed instructional materials, generated nine guidelines for the use of illustrations in text. These guidelines give educators good but very general advice, including such things as: a) the addition of pictures not related to the text will not enhance the learning of information in the text; b) illustrations can sometimes be used as substitutes for words or provide additional information; and c) learners may fail to make effective use of complex illustrations unless they are prompted to do so.

Fleming and Levie (Fleming & Levie, 1978; Fleming, 1987) have provided a promising beginning to the formulation of practical guidelines by summarizing into twenty broad principles what is known about key perception and memory variables that contribute to effective messages, including visual displays. These principles suggest recommendations that range from limiting the number of objects or groups of objects in a visual display to seven (the average number of items that people can perceive and store in short-term memory), to using visuals instead of words to illustrate concepts that are obviously spatial in nature. The most recent guidelines offered build on these principles (Fleming & Levie, 1993), giving greater attention to integrative theories and models than its predecessor (Alien, 1991).

Unfortunately, the numerous efforts that have been made to suggest guidelines for developing instructional visuals have generally not produced specific procedures for developing well designed pictures (Friedman, 1986; Alien, 1991). A number of researchers have, however, emphasized the importance of considering certain relevant variables, such as the learners' profiles of cognitive abilities, the nature of the learning tasks, and the overall context of instruction (Alexandrini, 1984, 1985; Stein, Brock, Ballard & Vye, 1987; Sternberg & WeU, 1980; Tversky, Kugelmass & Winter, 1991; Winn, 1982; Winn, Li & Schill, 1991) in the picture design process.

Merging Instructional Design and Picture Evaluation Principles

This section describes how widely accepted systematic instructional design principles for creating educational materials can be merged with picture evaluation principles to create pictures that act as "conceptual bridges" to effectively supplement text (Kozma & Bangert-Drowns, 1987). The procedure employs Gagne's model for designing instruction (Gagne, Briggs & Wagner, 1988), and Goldsmith's (1987) guidelines for analysing the comprehensibility of illustrations.

The resulting instructional design model that incorporates both Gagne and Goldsmith's models is illustrated in Figure 1. The model has four phases: (a) Analysis of Instructional Factors, (b) Development of Textual and Pictorial Outcomes, Instructional Techniques and Instructional Content, (c) Integration of Textual and Pictorial Elements, and (d) Validation of Instructional Materials. Each of these phases is described in the discussion that follows.

PHASE A: ANALYSIS OF INSTRUCTIONAL FACTORS

Phase A involves determining which learner, task and environmental factors should guide the development of the instructional materials. Learner factors (that is, the knowledge and capabilities that the learner brings to the instructional situation; referred to as pragmatic communication factors by Goldsmith) to be assessed include such things as reading ability, prior knowledge and

Figure 1.
Systematic Design of Instructional Pictures

Phase A: Analysis of Instructional Factors

1. Learner Attributes
   - Reading Ability
   - Prior Knowledge
   - Learning Style
   - Picture Literacy
2. Learning Task Analysis
   - Objectives
   - Target
   - Enabling
   - Textual/Pictorial
3. Learning Environment
   - Medium of Instruction
   - Instructional Setting

Phase B: Development of Textual/Pictorial Outcomes, Instructional Techniques & Content

1. Outcomes

Textual:	Pictorial:
Intellectual	Attentional
Verbal Info.	Affective
Cog. Strategy	Cognitive
Motor Skill	Compensatory
Attitude	

2. Instructional Techniques

Behavioral Objectives
Advance Organizers
Inserted Questions
Underlined keywords/phrases
Examples
Analogy

3. Instructional Content

Textual:	Pictorial:
Gagne's Events of Instruction	Goldsmith's Visual & Communication Factors

Phase C: Integration of Textual & Pictorial Elements
Goldsmith's Picture-Text Parallel Elements

Phase D: Validation of Instructional Materials
Subject Content Experts & Target Learners

learning style (cognitive strategies used to process new information) and picture literacy. Learning task factors are the target objectives (knowledge, attitudes and skills to be attained at the end of instruction) and enabling objectives (knowledge, attitudes and skills pre-requisite to attainment of the target objectives), which are derived from the task analysis of the overall instructional objective (Gagne, Briggs & Wagner, 1988).

Learning environment factors that need to be reviewed are issues like *how* (instructional medium) and *where* (instructional setting) the instruction will be delivered (Kozma & Bangert-Drowns, 1987).

PHASE B: DEVELOPMENT OF TEXTUAL & PICTORIAL OUTCOMES, INSTRUCTIONAL TECHNIQUES & CONTENT

The first step of Phase B involves translating each objective (derived from the task analysis) into one of Gagne's learning outcomes (i.e., intellectual skill, verbal information, cognitive strategy, motor skill and/or attitude), and then developing the particular textual instructional techniques to be used in the instructional materials. Gagne suggests a number of effective instructional techniques, such as, behavioural objectives, advance organizers, inserted questions, underlined keywords/phrases, good and poor examples, presented familiar information (e.g., use of analogy).

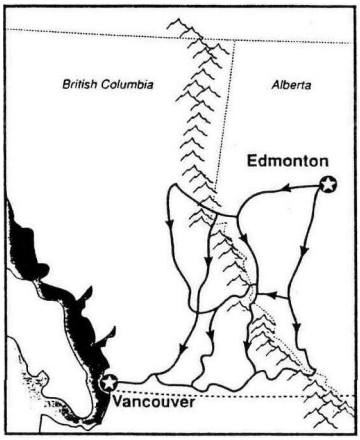
The techniques selected to assist the pictures to accomplish their outcomes are often determined by both the particular textual instructional techniques employed, and the function that the pictures serve. Levie and Lentz (1982) proposed that pictures serve four functions or outcomes: a) attentional: attracting and directing a learner's attention; b) affective: influencing emotions and attitudes; c) cognitive: facilitating learning by improving information acquisition, comprehension and retention; and d) compensatory: accommodating poor readers. One of the most effective pictorial techniques is the use of analogy, or the pictorial presentation of familiar images that are equivalent to less familiar textual information (Gentner, 1989; Gick & Holyoak, 1983; Holyoak, 1985). The use of analogical visuals to meet cognitive objectives is well supported in the research literature, possibly because analogy appears to lend itself well to visualization (Winn, 1982).

In the third step of phase B, the content and format that the instructional materials take is guided by Gagne's nine events of instruction (e.g., gaining learners' attention, presenting learning objectives, stimulating recall of prerequisite learning, presenting stimulus material, providing learning guidance, eliciting performance, providing corrective feedback, assessing performance, and enhancing retention and learning transfer).

Next, the picture design process involves first deciding on the subject matter of each picture, and then each picture's key visual features. Deciding on the subject matter of the pictures requires close consultation with individuals

Figure 2.
Example Application of Goldsmith's Model

Picture:



"Entering a new occupation is like taking a journey"

Element:

1. Syntactic unity - dark, thick border around picture; bold lines define alternate travel routes.
2. Semantic Unity - provincial borders indicated with broken line; British Columbia's coast and Vancouver Island indicated with shading; highways indicated with heavy lines; Edmonton and Vancouver indicated with large starred dots; mountains indicated with triangular symbols.
3. Pragmatic unity - clearly identifiable as a map of Alberta/British Columbia, as similar images are seen nightly on weather forecasts.
4. Syntactic location - shaded triangles indicate mountain range; shading along Vancouver Island indicates coastline.
5. Semantic location - triangular mountain symbols shaded on one side to indicate elevation.
6. Pragmatic location - incompleteness of map should not confuse adult viewers from North American culture.
7. Syntactic emphasis - position on page size; complexity of images; directionality of highway routes
8. Semantic emphasis - n/a.
9. Pragmatic emphasis - printed analogy is presented below the pictorial analogy.
10. Syntactic text parallels - picture is placed in upper left corner of page (optimal for catching attention of viewer).
11. Semantic text parallels - verbal labels for provinces and cities; verbal labels are the same in both textual and pictorial materials.
12. Pragmatic text parallels - maps of British Columbia and Alberta are familiar to Canadians; symbols used (mountains, highways, cities) are commonly used in Canadian publications.

familiar with the content of instruction (e.g., subject/content experts). Content ideas receiving consensual support from a small group of subject matter experts should be used in the pictorial illustrations.

To be instructionally effective, the key visual features should be based on sound learning principles and be comprehensible to the viewer. Goldsmith (1987) developed a set of guidelines for analysing the comprehensibility of illustrations intended to be supportive to educational text. These guidelines take into consideration both the communicative value of the picture, and the learner's level of visual literacy. Goldsmith's model, derived from a thorough review of the

research literature in the fields of education and psychology (Goldsmith, 1984), is based on educationally sound principles.

Goldsmith's analytical model consists of twelve elements formed by the interaction of four visual factors (based on learning theory) and three communication factors (based on communication theory), as indicated in Figure 2.

The visual factors are unity (clarity of single images), location (spatial relationships between two or more images within a single picture), emphasis (order in which different images attract viewer's attention), and text parallels (relationship between text and picture). The three communication factors are syntactic (recognizable spatial aspects of images), semantic (recognizable meanings of images), and pragmatic (knowledge and capabilities that the viewer brings to the situation). The critical pictorial features of each illustration can be determined by using the first nine of these twelve elements as guidelines:

1. Syntactic unity: refers to the discrimination of boundaries between images; clearly define the integrity of each image. (See Bogard, 1974; Deregowski, 1968; Deregowski, Muldrow & Muldrow, 1972; Ghent, 1956; Michael, 1953).
2. Semantic unity: refers to the comprehensibility of each image; give each image enough distinctive features to allow viewers to recognize it. (See Fussel & Haaland, 1978; Kennedy & Ross, 1975; Spencer, Harrison & Darvizeh, 1980).
3. Pragmatic unity: refers to the characteristics of viewers that affect their ability to identify an image; consider viewers' cultural & educational background; their familiarity with objects depicted in images, context of images, understanding of implied motion, and sequencing of images. (See Duncan, Gourlay & Hudson, 1973; Ellis, Deregowski & Shepherd, 1975; Freidman & Stevenson, 1975).
4. Syntactic location: relates to depth perception; assist viewer to perceive depth by using texture gradients, figural elevation and overlap, converging lines and shading. (See Benson & Yonas, 1973; Leach, 1978; McGurk & Jahoda, 1974; Olson & Boswell, 1976; Yonas, Cleaves & Petterson, 1978a; Yonas & Hagen, 1973).
5. Semantic location: concerns how each image contributes to perception of overall pictorial depth/meaning; place each image in correct environmental context by using accurate/familiar size and surrounding referents. (See Deregowski & Byth, 1970; Hagen & Glick, 1977; Omari & MacGinitie, 1974; Rock, Shallo & Schwartz, 1978).
6. Pragmatic location: refers to the manner in which viewers resolve ambiguous images; consider viewers' cultural and educational background/experience; reduce ambiguous images by checking potential viewers' understanding. (See Deregowski, 1971; Evans & Seddon, 1978; Nicholson & Seddon, 1977; Silliman, 1979; Sinha & Shukla, 1974; Yonas, Goldsmith & Hallstrom, 1978).

7. Syntactic emphasis: relates to the manner in which images attract and direct the attention of viewers; use colour, position, size isolation, complexity, tonal contrast, directionality, and/or implied motion to draw viewers' eyes to salient features of images. (Luria & Strauss, 1975; Mackworth & Morandi, 1967; Reid & Miller, 1980; Rutherford, Casey, Hasterok & Howell, 1979).
8. Semantic emphasis: refers to the power of the human figure/face to direct viewers' attention; use human figure/face to direct viewers' attention to salient features of images. (See Antes & Stone, 1975; Buswell, 1935; Wolf & Tira, 1970).
9. Pragmatic emphasis: concerns the natural viewing tendencies of viewers; present information that should be viewed first at top of page, and sequence it from left to right on page. (See Braine, 1972; Faw & Nunnally, 1973; Smith & Watkins, 1972; Webster & Cox, 1974; Yarbus, 1967).

After selecting appropriate subject matter and specific pictorial features, it is recommended that the pictures should be drawn by someone with good graphic design skills to minimize learner confusion that can result from poor images (Levie & Lentz, 1982; Zimmer & Zimmer, 1978).

PHASE C: INTEGRATION OF TEXTUAL AND PICTORIAL ELEMENTS

Phase C involves integrating the textual and picture components, or placing the pictures on the pages of text. The specific elements of Goldsmith's model that can be used as guidelines are the syntactic, semantic and pragmatic text parallels:

10. Syntactic text parallels: refers to the spatial and temporal relationship between text and image; when picture contains same information as text, present picture first. (See Bacharach, Carr & Mehner, 1976; Brody & Legenza, 1980; Smith & Watkins, 1972; Whalley & Fleming, 1975).
11. Semantic text parallels: relates to the matching of text and image by textual labels where appropriate; use exactly the same words in both the text and the images. (See Lachman, 1973; Snodgrass & Vanderwart, 1980).
12. Pragmatic text parallels: refers to the interpretation tendencies of viewers; consider viewers' cultural and educational background/experiences, their ability to understand complex images and the acceptability of specific images used. (See Campbell, 1979; Cook, 1980; Honeck, Sowry & Voegtle, 1978; Spangenberg, 1973).

Three additional visual design issues that were considered in the development of the pictures were: the use of realistic pictograms, to reduce the chance of learner misunderstanding (Goldsmith, 1984; Hodgson, 1985); the use of line-

drawings, as lower reading level subjects tend to learn better from less complex visuals (Dwyer, 1987); and the placement of each picture on the upper left-hand part of the page, as neurophysiological studies indicate that this may be the optimal viewing area (Hart, 1984).

PHASED: VALIDATION OF INSTRUCTIONAL MATERIALS

Phase D entails evaluating the textual-picture integration effectiveness by soliciting feedback from both subject content experts, and groups of learners for whom the materials were initially developed. This feedback should be used to guide final modifications to both text and pictures.

To summarize, the instructional design process proposed here includes both a textual and picture design component, using two complementary processes that can act as content checks for one another. This integrated textual/pictorial design model is recommended when the text and picture components are meant to provide the same information, in the verbal and visual modalities, hence functioning in a cognitive and/or compensatory manner.

Instructional Materials Created Using this Model

Wiesenberg (1990) used the integrated textual/pictorial instructional design model in an attribute by treatment interaction (ATI) study designed to investigate the role of analogical pictures in adult learners' acquisition of higher level concepts. Two directional hypotheses were tested.

1. Given that analogical visuals appear to facilitate the learning of more abstract or higher level concepts (Alesandrini, 1984, 1985; Krueger, 1984;Mayer, 1985;Miller, 1984), it was hypothesized that: "instructional materials supplemented with relevant analogical pictures will produce higher performance outcomes in all subjects than will identical instructional materials not supplemented with analogical pictures".
2. Given that learners who demonstrate a preference to use their visual sensory modality appear to learn more effectively from instruction that contains visual elements (Levie & Lentz, 1982; Paivio, 1986), and that learners who do not demonstrate this preference do no necessarily learn more effectively from instruction that contains visual elements (Kyllonen et al, 1984; Lohman, 1984; Taylor et al, 1987), it was hypothesized that: "instructional materials supplemented with relevant analogical pictures will produce higher performance outcomes in subjects demonstrating a more visually-oriented learning style".

SUBJECTS

A total of one hundred and twenty-one subjects, drawn from adult students enrolled in college and university preparation programs in three different Northern Alberta post-secondary institutions, participated in the study. Seventy-five were male and fifty-four, female. Subjects' average age was 31 years, and the average number of years of formal schooling attained before entering their present programs was 101/2. Independent groups t-test revealed that high visual subjects also achieved significantly higher ($t=3.73, p<.001$) mean Verbal Reason-

Figure 3.
Educational Objectives

Overall Educational Objective: ability to put together a career plan.
Type of Instructional Outcome: intellectual ability/skill

Target Objectives:

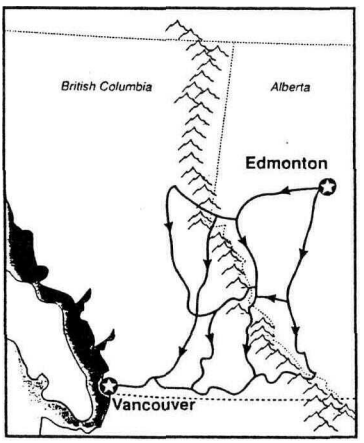
#1	#2	#3	#4	#5
know how to describe planning goals	know how to gather information	know how to create sub-goals	know how to make a master-plan	know how to evaluate a master-plan

Enabling Objectives:

#1	#2	#3	#4	#5
know how to set standards for goal attainment	know how to locate information	know how to choose guidelines	know how to sequence sub-goals	know how to anticipate problems
	know how to collect information		know how to check for conflict with other goals	know how to create ways around obstacles
	know how to evaluate information			know how to revise planning goals

Figure 4.
Page from "Text plus Picture" Version ofthe Instructional Booklet

Section 1. The Planning Process



Entering a new occupation
is like taking a journey

Imagine that you have just decided to drive to Vancouver for a holiday during the Christmas break. You have never driven there before, so you are looking forward to the new experience but are not quite sure how to prepare for the trip.

Now, think about the decision to enter a new occupation (that is, after all, why you are here in school). You are feeling very excited about this major life change and possibly a little unsure about how to go about making the change.

The experience of entering a new occupation and taking a trip along an unfamiliar route are in many ways quite similar. The way that you choose to prepare for both can influence your chances of eventually reaching both kind of goals.

First, being very well informed about your new occupation is important. In a similar way, if you did not know where Vancouver was located, you would be very unlikely to arrive there (you may end up somewhere else instead).

Second, finding out as much as possible about your intended occupational choice (isthere more than one way to enterthis occupation?) is somewhat likefinding out if there is morethan one highway to Vancouver. Knowing about all ofthe possible routes allows you to choose the one that suits you best.

Third, the often very long process of entering an occupation can be made more manageable (and often more enjoyable) if tackled in shorter steps. This is like breaking the long trip of several kilometers into a series of shorter trips. Breaking the journey into steps can make it seem less of a "long haul" and more managable.

ing scores (33.03; SD=8.03) than did low visual subjects (27.06; SD=10.11). In other words, higher visual subjects tended to have better verbal reasoning skills than did lower visual subjects.

METHODOLOGY

The research design used in this experimental field study was a 2 treatment (instructional condition) by 2 level (high versus low visual learning style) factorial design. Once categorized by learning style (68 low and 61 high), subjects were randomly assigned to the two instructional conditions. The two instructional conditions contained almost equal numbers of subjects (65 in the text only and 64 in the text plus analogical pictures).

The dependent variable in the study was the subjects' acquisition of planning concepts at two different levels of complexity, as measured by a multiple-choice test (comprehension) and open-ended questionnaire (knowledge only). The independent variables were the two instructional conditions, and the learning style. As the research literature indicates that both prior knowledge of the concepts to be learned and verbal reasoning ability significantly affect learning outcomes (Dwyer, 1987), these variables were both treated as covariates in this study. Prior knowledge of the planning process was measured in a pre-test session using the performance outcome measure (multiple-choice test), and verbal reasoning ability was measured by the Verbal Reasoning Subtest of the Differential Aptitude Test (see Bennet, Seashore & Wesman, 1982).

Reviews of visual learning as a learning style indicate that this style consists of two unrelated aspects of an individual's information processing behaviour: (a) an ability to use mental imagery, and (b) a propensity to use this ability (Ernest, 1977; Richardson, 1977; Katz, 1983). Visual learning styles were determined by combining subjects' standard scores on an objective measure of visual skills (Space Relations subtest of the Differential Aptitude Tests, see Bennett, Seashore, & Wesman, 1982) and a subjective measure of information processing preference (Individual Differences Questionnaire, see Paivio, 1986). Subjects' learning style was then categorized as either high (if their combined standard scores were positive) or low (if their combined standard scores were negative), a procedure used in previous studies (Ernest & Paivio, 1971).

DEVELOPMENT OF THE INSTRUCTIONAL MATERIALS

In this study, the overall educational objective of the instruction was to teach subjects how to put together a career plan. The instructional materials design process began with the creation of a competency profile developed using a competency-based system of skill analysis (Block, 1974). This profile was then used to clarify both target and enabling objectives (see Figure 3). The content of

the textual instructional technique (a five stage travel planning model) was developed using Gagne's nine events of instruction.

The picture design process began with the decision to use visual analogies to duplicate the content of the textual analogy, to serve both a cognitive and compensatory function (Levie & Lentz, 1982). The pictorial equivalents of the printed analogies were created by first consulting with several subject content experts, and then using Goldsmith's twelve elements as guidelines for determining the salient features required to create the visual depictions of each textual analogy, as indicated in Figure 2. The pictorial analogies were then drawn by a graphic artist. Figure 4 is the first page of Section 1 of the "textual plus picture" version of the instructional booklet.

Content validity of the instructional booklet was established through independent, subject content experts who separately rated: (a) textual message, (b) pictorial message, and (c) textual and pictorial messages together, according to the educational objective each text-picture set was designed to achieve. Overall, the text and pictures were rated by experts as meeting the stated educational objectives at least 75% of the time, with most of the text and corresponding pictures meeting these objectives 100% of the time. Representative groups of adult learners also validated the comprehensibility and appropriateness of the textual and pictorial analogies chosen.

RESULTS AND DISCUSSION

Analysis of covariance, with subjects' prior knowledge of the planning process and verbal reasoning ability acting as the covariates, was used to test the two hypotheses.

The first hypothesis was not supported by the results. When the effects of subjects' prior knowledge and verbal ability were removed, no main effects were demonstrated on either performance outcome measure for instructional condition. The pattern of responses on the two different outcome measures were different, however, depending on subjects' learning style. Non-significant trends in the analysis of the multiple-choice test post-scores (comprehension task) lent some support to the hypothesis for low visual subjects, while non-significant trends in the open-ended questionnaire scores (knowledge task) were exactly the opposite to results hypothesized.

All subjects achieved significant gain in their comprehension of planning concepts across both instructional conditions ($p<.05$). The low visual subjects achieved significantly higher overall performance scores than did the high visual subjects. The subjects learning style, not the instructional condition, was the critical factor in the successful learning of the planning concepts. The more intriging finding was that higher visual and verbal subjects (those subjects who had the highest scores on both the Spacial Relations and Verbal Reasoning Subtests) appeared to be unaffected by the analogical visuals on the comprehension task, but negatively affected by them on the knowledge task. Low visual

subjects performed in exactly the opposite manner. Pearson Product Moment correlations calculated on all nine variables in the study revealed that low visual subjects were relying more heavily on their spatial skills to perform both tasks, than were the high visual subjects.

The second hypothesis was also not supported by the results. Non-significant trends in the data on the knowledge task scores indicate a tendency towards interaction in the opposite direction to that hypothesized, with the high visual subjects achieving less in the "text plus picture" than they did in the "text only" instructional condition. While most of the low visual subjects made better gains on the comprehension task,a small group of low visual Native subjects performed both tasks in exactly the opposite manner to that hypothesized; their performance being apparently unaffected by the level of complexity of the task. It appeared that in their case, the visuals somehow compensated for their lack of visual skill. Pearson Product Moment correlations indicated that Native subjects, versus their non-Native counterparts, had a stronger preference to use imagery (.57 versus. 19) in the comprehension task, and spatial ability (.40 versus. 16) in the knowledge task.

Overall, these results seem to indicate the analogical pictures may serve both a positive role (perhaps as conceptual pegs for lower ability, Native learners in knowledge tasks) and a negative role (perhaps as distracting stimuli for higher ability, Native subjects in knowledge tasks, and for lower ability non-Native subjects in comprehension tasks). Research that compares the performance outcomes of low ability and high ability students on both lower and higher level concept acquisition lends support to this explanation (Cronback & Snow, 1977; Peeck, 1987; Winn, 1982). The results for the low visual Native subjects seemed to support a compensatory model of information processing that suggests that visuals can "short-circuit" learning by reducing the cognitive processing load for low ability learners (Corno & Snow, 1986).

The results of this study imply that a careful analysis of both the learners' preference and ability to process visual information, their individual profiles of verbal and visual abilities, and the level of complexity of the learning task are all important considerations in the design of text-based visually enhanced, self-instructional materials. These results lend support to the use of analogical pictures to complement instructional text designed to teach lower level concepts to learners having relatively low visual skills, or high level concepts to learners having relatively high visual skills.

CONCLUSION

The paper describes a method for producing educationally effective pictures to accompany textual instructional materials for adult learners. The method starts with Gagne's model of systematic instructional design, and extends it by incorporating Goldsmith's method for designing visuals to supplement printed text. The method for designing visuals is based on empirically validated visual

perception and communication principles. The approach of integrating textual and pictorial development has been used successfully in one research study to produce pictures enhancing the learning outcomes of adult learners with different levels of visual learning skills.

Given the current absence of specific visual development guidelines for educators, this model provides a promising method for designing educationally sound pictures that can function in a compensatory manner for adult learners at the pre-university and college level.

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