Graphical Devices in Instructional Illustrations:

Designers' Intentions and Viewers' Interpretations

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Abstract

This study examines the interpretation of instructional illustrations extended by non-pictorial graphical elements. It builds on the authors' prior research in which frequency analysis of data collected from 593 participants, 3rd grade through adult, showed that in all but two sample groups fewer than one third of the simple instructional illustrations used were interpreted as intended by the designer at 85% of responses or above (Boling, Eccarius, Smith & Frick, 2004). The current study includes additional data from surveys administered to 122 Taiwanese college students and compares those data to results obtained from college-age students in Malaysia and the United States. The results from these analyses support findings from the previous study, suggesting that cultural differences may impact a person's interpretation of images with and without graphical elements. Further research is required to investigate the process of interpretation and to understand differences in interpretation between viewers of different cultures.

Introduction

Many research studies have demonstrated that, under certain conditions, graphics and illustrations in instructional materials improve learning outcomes (Anglin, Vaez, & Cunningham, 1996; Levin, Anglin, & Carney, 1987). Instructional visuals have been implemented almost ubiquitously in instructional materials and are delivered using a variety of media (Pettersson, 2002). Formal studies have indicated that illustrations occupy a relatively large percentage of the printed space in textbooks (Evans, Watson, & Willows, 1987; Pettersson, 2002) as has a study in progress by the authors of this paper. To date we have measured page space taken up by instructional illustrations in a total of 26 science textbooks ranging from grade 1 – grade 10, published between 1990 and 2000 in the United States and under consideration for adoption in the state of Indiana. The average percentage of page space devoted to instructional illustrations ranged from a low of almost 17% (9th grade biology) to a high of 36% (1st grade science), with individual differences between books ranging from 7.9% for a 10th grade biology text to 37.48% for a 1st grade science text.

However, the widespread use of instructional illustrations does not necessarily indicate that these illustrations are being designed effectively or used appropriately. Our previous study (Boling, *et al.*, 2004) indicated that learners do not always interpret images in the way that the designer intended, and more research is clearly needed to understand fully how learners use and interpret instructional illustrations (Anglin *et al.*, 1996; Cooper, 2002). This study is one of several interrelated studies establishing the need for further research into the use and interpretation of instructional images.

Picture perception and interpretation

Theories about how human beings perceive images are at the root of prior research into the efficacy of instructional illustrations (Anglin, Cunningham, & Vaez, 1996). Anglin *et al.* (1996) provide a brief overview of the major theories of picture perception. From their perspective, how pictures carry meaning and the kinds of meaning pictures can carry are among the pertinent questions that have "provoked conjecture from philosophers, psychologists, art historians, semioticians, and computer scientists" (p. 866). They distinguish these varied perspectives in terms of the relative amount of emphasis each theory puts on the respective roles of the image and the viewer in the picture perception process. From our reading of the works cited by Anglin, *et al.*, we discriminate these views as those concentrating primarily on *picture perception*, or recognizing what is in a picture, and *picture interpretation*, or deciding what a given picture is supposed to mean.

A number of perception researchers place primary emphasis on the image, assuming that form plays the principal role in determining what is understood by the viewer (Anglin *et al.*, 1996). One prominent example of this perspective is Gibson's (1979) resemblance theory of perception. According to this theory, the impetus of picture perception is the structure of the stimulus (Gibson, 1979). These researchers tend to focus on how viewers recognize the literal content of a picture ("that's a cow). Other researchers emphasize the role of the viewer in assigning meaning to an image, as when Gombrich (1972) states simply, "no image tells its own story" (p. 250) and describes the role of the viewer as constructing meaning from the image. Since most of these researchers do not discriminate, except in passing, between perceiving that there is a cow depicted in a picture and interpreting the reason for the cow being shown, these discussions of picture perception can become confusing. They focus either on the image or on the viewer of the image, but tend to leave the creator of the image out of the picture, so to speak.

Semiotic framework

The theoretical perspective from the field of semiotics places emphasis on the role of the receiver in the process of picture perception. Semiotics, the science of signs, is characterized by the stand-for relationship: the relationship between an object or sign, and whatever it stands for (the referent). Sless (1986) and Knowlton (1966) argue that the two components of the stand-for-relationship traditionally analyzed by semioticians, the sign and the referent, are incomplete without proper consideration of the audience receiving the sign. According to Sless (1986), it is somewhat useless to study signs without acknowledging the role the audience plays in interpreting the sign. It is clear that he perceives the image viewer as an active participant in the perception process and not simply a passive recipient of meaning. In 1981 Sless addressed this issue as follows:

> It is always tempting to think that the physical form of the message alone constitutes the basis of its meaning and this has led to the misleading practice of analyzing the message independently of the author or audience. The message may be physically a distinct entity but the mere fact of calling it a message makes it analytically inseparable from either the author or the audience. The only analytic separation possible is between the audience/message relation on the hand and the author/message relation on the other. (p. 27)

He also took issue with the common practice whereby a semiotician explores the participation of this viewer by proxy; that is, uses his or her own interpretation process, or the imagined process of a viewer, to speculate on how an image is interpreted by all viewers. The natural extension of these ideas is that, in order to study fully the efficacy of instructional illustrations, researchers must focus on how viewers interact with and assign meaning to an image and must ask viewers themselves what they think an image is supposed to mean.

Cross-culture interpretation of instructional images

Kennedy (1974) offers a thorough survey of older studies that explored cross-cultural interpretation of instructional images, criticizing the methods and assumptions of some researchers who reported that individuals from cultures that do not produce pictorial images or that had not seen photographs were unable to interpret such images when first presented with them and citing studies that indicate people from all cultures (not to mention chimpanzees and pigeons) are able to recognize the content of images.

Researchers (including Kennedy) do recognize, however, that culture and experience do, in fact, play a role in picture perception and interpretation (Gustafson, 1994; Pettersson, 2002). Gombrich suggested in 1972 that viewers are more apt to interpret an image appropriately when they come to it "with a knowledge of social customs and conventions" (p. 244), and that without an understanding of the culture and context of the image, viewers are likely to interpret the image differently than was originally intended by the creator of it. McCloud (1996) suggests further that the meanings of specific graphical elements included in an image (speech balloons, speed lines and so on) may also be culturally bound.

In general, the theoretical perspective of the field of semiotics has yet to be deeply explored by researchers in the development and implementation of instructional graphics. While many studies have determined that instructional visuals are effective under certain conditions, few studies have endeavored to understand how learners interpret the images they are presented with in instructional situations (Anglin, Vaez and Cunningham, 1996).

Semioticians also offer insights into potential explanations of the differences in image interpretation that might be based on cultural background.

Graphical Elements

Despite what appears to be a largely cross-cultural ability to recognize objects depicted in pictures, the visual content of an illustration is frequently a vehicle used to communicate a more complex meaning or intention. Beyond their ability to present a visual representation of a given object, visual illustrations do not constitute a universal language. The use of graphical devices (like arrows) to extend the meaning of illustrations adds complexity to the problem.

INSERT FIGURE 1 ABOUT HERE

This study, and the one from which it is derived, address a specific type of instructional illustration that is characterized by the addition of graphical elements. These graphical elements, which are frequently non-pictorial, are intended to extend the meaning of the illustration “beyond that which can be shown literally” (Boling, *et al.*, 2004). As we describe in that report of research, “These [graphical elements] serve as a useful shorthand method for representing phenomena such as thought, speech, or past or future action, which are not visually evident when viewing a scene” (p. 4). Perhaps the most widely recognized graphical element of this type is the speech bubble or speech balloon (McCloud, 1994; Eisner, 1985; Carrier, 2000). According to Eisner (1985), graphical elements, such as the speech balloon, serve as artists’ attempts to capture and communicate intangible or immaterial elements.

McCloud (1994) posits that designers and artists *invent* graphical elements as new ways of representing what would otherwise be invisible to the image viewer. This idea introduces one of the potential hazards of using graphical elements in instructional illustrations; while the purpose and meaning of the element may be perfectly clear to the artist, the viewer may not interpret the artist's *invention* as originally intended. This might be particularly true when the designer of an image comes from one culture and the viewer (interpreter) comes from another.

Purpose of the Study

In their previous work (Boling, *et al.*, 2004), the authors of this study used frequency analysis of data collected from 593 participants, 3rd grade through adult, to show that in all but two sample groups fewer than one third of the simple instructional illustrations (extended by the use of non-pictorial graphical elements) were interpreted as intended by the designer by 85% or more of the sample group. Specifically, using a 16-item image-based survey, the prior study compared the responses of US third-grade students and US tenth-grade students, US third-grade students and US college students, US college students and Malaysian college students, and US college students and US teachers of the deaf. We also suggested that the cultural background of the viewers appeared to have some influence on whether or not they were able to interpret the meaning of simple instructional images as intended by the designer of those images. The current study was undertaken to extend that previous study by including additional data from surveys administered to 122 Taiwanese college students and comparing those data to results obtained from college-age students in Malaysia and the United States.

Methods

The surveys used were two sets of 16 simple images. The first survey included graphical elements that clarified and extended the meanings of the 16 images, while the other survey omitted these graphical elements. Samples of each are shown in Figures 2 and 3.

INSERT FIGURES 2-3 ABOUT HERE

Several lines were provided below each image for participants to use. Participants were asked to write a short response to each image indicating what they thought it meant. Samples of actual responses appear in Table 1.

INSERT TABLE 1 ABOUT HERE

A total of 299 undergraduate college students participated in this phase of the study, divided by country and type of survey as shown in Table 2.

INSERT TABLE 2 ABOUT HERE

Participants outside the U.S. were invited to respond in their preferred language. Non-English responses were translated by native speakers of the languages used (Chinese and Bahasa Meayu), and then coded by native speakers of English. Surveys were scored independently by one of several researchers to determine whether the participants had interpreted the 16 images consistently with the designer's intended meanings.

Data analysis

The purpose of the data analysis was twofold. First, we examined the Taiwanese surveys, with and without graphical elements, to determine if the responses matched the designer's intended meanings for the images. This analysis was identical to that carried out for the individual groups included in the original study.

On both surveys (with and without graphical elements), the researchers scored responses with a "1" if the written responses matched the meaning intended by the designer; a "0" was scored if meanings did not match. Inter-observer agreement was measured by duplicating coding of a random selection of surveys and calculating the interclass correlation coefficients for each item on the surveys. In addition, the researchers conducted a Cohen's kappa test for a measure of agreement between the researchers' coding. A significant difference was indicated if $p < .05$. There were no significant differences in kappa scores for any of the 16 items on both surveys, with and without graphical elements.

We then determined whether or not there was a significant difference between interpretations of pictures with graphical elements made by members of the three groups included in the current study. The groups compared in this study were as follows: a) US college students and Taiwanese college students, b) US college students and Malaysian college students, and c) Taiwanese college students and Malaysian college students.

Given that this study compared three different groups, ANOVA would traditionally be the appropriate statistical analysis. However, ANOVA assumes that the variance in each population of scores is homogeneous (Howell, 1999). The heterogeneity of variance in the groups' scores required the researchers to conduct two-tailed independent sample t-tests to make group comparisons.

The researchers performed *two-tailed* independent sample t-tests for determining statistical significance between pairs of means for each picture, since there was no *a priori* expectation of which group would be higher or lower. Furthermore, since the US college students' responses and the Malaysian college students' responses had already been compared with other groups in the previous study, the total number of pairwise group comparisons was six for each picture in both studies. To prevent the inflation of the conventional Type I error rate of $p < 0.05$, it was divided by six in both the previous study and this one. Thus, the researchers rejected the null hypothesis that there was no significant difference between groups if the two-tailed t-test if the probability of a Type I error of was less than 0.0083.

Results

In this section, we first report findings regarding the interpretation by Taiwanese students (the group not included in the previous study (Boling, *et al.*, 2004)) of images with and without graphical elements. We then report the results of comparisons among the Taiwanese, Malaysian, and US college students' interpretations of images with graphical elements.

Taiwanese surveys

After determining there was inter-observer agreement between the coders, the researchers calculated proportions for the 64 Taiwanese respondents who interpreted pictures with graphical elements, and for the 58 Taiwanese respondents who interpreted pictures *without* the graphical elements. Frequencies of responses are reported in Table 3.

INSERT TABLE 3 ABOUT HERE

On 14 out of the 16 items (88%) *without* graphical devices, the frequencies of matching responses (those coded as matching the intention of the designer) were 50 percent or less. The items most frequently interpreted consistently with the designer's intention were "talking" (image 8, 66%), and "signing" (image 11, 74 %). On the other hand, 12 out of 16 items (75%) *with* graphical devices were interpreted consistently with the designer's intentions 50 percent or more of the time in the current sample. Nonetheless, the average proportion of correct interpretations of pictures *with* graphical devices was about 0.55 in this Taiwanese sample. This contrasts with a mean of about 0.22 for pictures *without* the devices. While these Taiwanese respondents in this sample were about 2.5 times more likely to correctly interpret a picture *with* vs. *without* a graphical device, the former were likely to *not* interpret the picture as the designer had intended about 4.5 out of 10 times – even when the graphical device was present,

INSERT TABLE 4 ABOUT HERE

Comparison of *US college students and Taiwanese college students*

We determined that there were statistically significant differences in the way US college students and Taiwanese college students interpreted the intended meaning of images *with* graphical devices for 3 of the 16 items (see Table 4). Specifically, Taiwanese college students scored statisitically significantly lower than US college in interpreting the designer's intended meaning of "TV speech," item 13 and "looking," item 14, whereas the Taiwanese group scored significantly higher for item 4 (gift "happy")..

Comparison of US college students and Malaysian college students.

We found significant differences in the way US college students and Malaysian college students interpreted the intended meaning of the images for 6 out of the 16 items (see Table 4). In only one case did the Malaysian college students score significantly higher than US college students. In particular, Malaysian college students accurately interpreted the designer's intended meaning of "gift (happy)" (item 4) significantly more often than did the US college students (as did the Taiwanese respondents also), while the US college students interpreted the designer's intended meanings of "baseball" (item 7), "signing" (item 11), "transformation" (item 12), "TV speech" (item 13), and "looking" (item 14) significantly more often.

Taiwanese college students and Malaysian college students.

Finally, we found significant differences in the way Taiwanese college students and Malaysian college students interpreted the intended meaning of the designer for 4 out of the 16 items (see Table 4). In all cases, Taiwanese college students scored significantly higher than did the Malaysian students ($p < .05$). The items included "flower swaying" (item 2), "talking" (item 8), "transformation" (item 12), and "dead lizard" (item 16).

The results from these analyses support findings from the previous study, suggesting that cultural differences may impact a person's interpretation of images with and without graphical elements.

Discussion

The results from this study are consistent with Boling *et al.*'s (2004) findings in that Taiwanese participants interpreted images with graphical elements more consistently with the designer's intended meaning than they did images without graphical elements. This was evident from the Taiwanese college students' interpretations with graphical elements in 14 out of the 16 cases. The image in which the graphical device did not increase the frequency of Taiwanese college students' accurate interpretation was "signing" (image 11)[1]. Specifically, 74 percent of the students interpreted the image without graphical devices consistently with the designer's intended meaning, while only 52 percent who saw the image with the element were correct in their interpretation. We speculate that some Taiwanese students may have associated the speech balloons with verbal speech only rather than applying the notion of "speech" in the balloon to the action of the hands in the image. The overall finding is not surprising since the images were created specifically to include the graphical elements as a key part of their meaning. However, this finding and the related finding from the previous study indicate that many respondents do attend to the graphical elements in deciding what an image is supposed to mean, since they are between 2.5 and

[1] Image 9 (sleep/cook) was not interpreted correctly by any of the Taiwanese respondents, regardless of whether the graphical device was present or not.

100 times more likely to give a meaning consistent with the designers intention in the presence of the graphical elements than in the absence of them.

Conventional symbols, non-conventional symbols and frequency of accurate interpretation

As with Boling *et al.*'s previous (2004) study, a symbol that is conventional and heavily promoted, the prohibition symbol in the "no running" image (image 10) is interpreted consistently with the designer's intention with very satisfactory frequency. However, graphical devices that are less conventional or used in different situations to extend meaning differently, such as the arrow indicating "ball moving toward window" (image 7), do not guarantee a high frequency of correct interpretation. It is important to note that, while some graphical elements have higher frequencies of correct interpretation, the overall incidence of consistency with intended meanings is relatively low – particularly when compared to what might be the desire of an educator who hopes to support learning through images. The low frequency of accurate interpretation seems to indicate that designers of instructional graphics cannot rest on the assumption that learners will automatically and correctly interpret what was intended by the designer.

Interpretation and culture

Findings from this study suggest that individuals from different cultural backgrounds do interpret some pictures differently. In particular, US college students scored significantly higher than Taiwanese college students in their interpretation of 2 images, while they scored significantly higher than Malaysian college students in the interpretation of 5 images. Interestingly, Taiwanese college students also scored significantly higher than Malaysian college students on 4 images. However, it is not clear from this study what aspect of cultural experience may account for these differences in interpretation between the groups, although it is probably useful to note that the images used in the study were created by a native US designer with experience illustrating instructional materials for the US market. We anticipate further research into the interpretation of instructional pictures, including studies aimed at exploring how such interpretation happens, how interpretations consistent with designer's intentions might be fostered, and how cross-cultural interpretations might be supported through design.

Limitations

The survey used in this study did not situate the task of image interpretation in an instructional context, nor were images accompanied by explanatory text. Participants were simply asked to view the image and record their initial impressions of meaning. Survey respondents are not able to rely on the contextual clues that would normally be available to them in instructional situations.

In addition, the survey protocol for this study did not give researchers the opportunity to gather data about the participants' reasoning as they interpreted the images. Our data were limited to the few words or sentences that the respondents recorded on the survey from which we made judgments about their interpretations. Furthermore, it is important to note that the responses on the survey were translated by a native speaker of the respondents' language. While we assume that the interpretations were accurate, we are aware that differences of expression between languages can affect the ease with which we code some responses as consistent or inconsistent with designer's intentions. Furthermore, the images in this survey were not classified by any kind of typology, so within subjects comparisons could not be made; we could not ask whether an individual respondent had more or less trouble with a certain kind of graphical element than with another one.

Implications and Future Research

Given the limitation of the study, we are unable to make broad generalizations from these data regarding any specific influence of culture on the interpretation of instructional illustrations. However, we feel that we can caution designers of instructional materials to consider the real possibility that target audiences may interpret images differently than intended. When instructional visuals play a crucial role in learning, designers should test their images on target audience members before widespread implementation, particularly if the materials have to function across cultural boundaries (see Figure 1). We also anticipate potential benefit from offering learners explanations of graphical devices in advance of their use in cases where large, or critical, bodies of instructional illustrations are to be used to support learning.

In order to understand more about the dynamic processes that occur when individuals from different cultures interpret images, future research will include data collection regarding participants' reasoning as they interpret images and provide for collection of these data in authentic learning contexts. We also anticipate completing a qualitative analysis of the specific individual responses in this study to learn more about the particpants' attention to and interpretation of graphical elements.

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Table 1. Sample responses for "flower swaying" and "dead lizard" items; all responses from participants who saw the graphical elements (not all responses shown here were coded as accurate).

Flower swaying	**Dead lizard**
The flower is swaying back and forth.	Lizard
The wind is blowing.	Lizard laying down
The wind blew the flower.	That lizard was run over by an old lady in a car
The flower is drooping.	"Hope I don't get run over!"
The flower is leaning the wrong way.	Gross!

TABLE 2. Number of individuals responding by country of groups surveyed

	Surveys with devices	**Surveys without devices**
US college students	34	39
Malaysian college students	50	54
Taiwanese college students	58	64

TABLE 3. Proportions of Taiwanese responses that matched designer's intended meaning for those who saw ("with": N=64) and did not see ("without": N=58) the graphical elements

Picture		Taiwanese *with* (N=64)	Taiwanese *without* (N=58)
1	bunny hopping	.63	.50
2	flower swaying	.63	.09
3	fast car	.52	.36
4	gift (happy)	.66	.00
5	running place to place	.14	.00
6	hat (wondering)	.61	.28
7	baseball	.38	.38
8	talking	.97	.66
9	sleep/cook	.00	.00
10	no running	.92	.00
11	signing	.52	.74
12	transformation	.50	.00
13	TV	.34	.10
14	looking	.53	.14
15	dog wagging	.73	.12
16	dead lizard	.69	.16

Table 4. Proportions of accurate interpretations of images *with* graphical devices for the cultural groups. (Boldly bordered pairs of cells indicate statistically significant differences: darkly shaded cells indicate the better performing group in a pair of cells in which differences are significant)

		Taiwanese	**US**	**Malaysian**	**US**	**Malaysian**	**Taiwanese**
		(N=64)	**(N=34)**	**(N=50)**	**(N=34)**	**(N=50)**	**(N=64)**
1	**bunny hopping**	.63	.74	.66	.74	.66	.63
2	**flower swaying**	.63	.38	.34	.38	.34	.63
3	**fast car**	.52	.74	.72	.74	.72	.52
4	**gift (happy)**	.66	.24	.52	.24	.52	.66
5	**running guy**	.14	.21	.10	.21	.10	.14
6	**hat (wondering)**	.61	.82	.66	.82	.66	.61
7	**baseball**	.38	.56	.22	.56	.22	.38
8	**talking**	.97	.94	.78	.94	.78	.97
9	**sleep / cook**	.00	.00	.00	.00	.00	.00
10	**no running**	.92	1.00	.94	1.00	.94	.92
11	**signing**	.52	.71	.38	.71	.38	.52
12	**transformation**	.50	.65	.18	.65	.18	.50
13	**TV speech**	.34	.76	.44	.76	.44	.34
14	**looking**	.53	.91	.64	.91	.64	.53
15	**dog wagging**	.73	.82	.58	.82	.58	.73
16	**dead lizard**	.69	.68	.42	.68	.42	.69

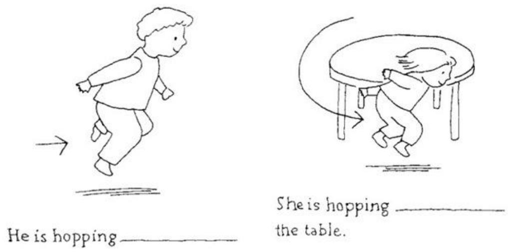

Figure 1. Drawn from Grade 2 Literacy Place ESL/ELD Workbook, Scholastic, 2000. In this example, the child fills in the appropriate words ("forward" and "around" respectively) according to the extended meanings indicated by the arrows.

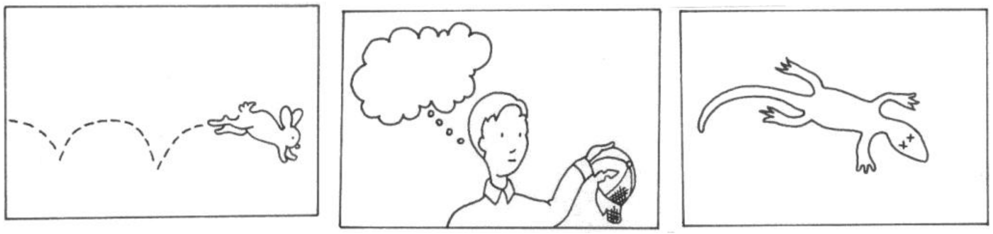

Figure 2. Sample images containing graphical elements (dotted line indicating path of prior motion; thought balloon; x-ed out eyes indicating illness or death).

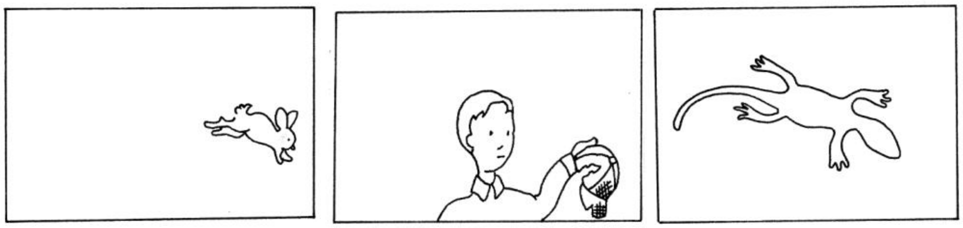

Figure 3. Sample images identical to the previous versions, with the exception that the graphical elements meant to extend their meaning do not appear.