USING EDUCATIONAL RESEARCH RESULTS TO IMPROVE GRAPHICS FOR INSTRUCTIONAL MATERIAL

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Abstract

Graphic designers and illustrators intuitively believe that their graphic embellishments such as pictures, photographs and graphics will aid a learner when they use instructional material. The results of empirical studies however indicate that graphic embellishments have a limited effect and only contribute to learning under very specific conditions.

Scholars working in the fields of educational psychology have published extensively on variables that aid reading, recognition, recall, and comprehension. Their study fields included the use of supplementary, decorative, informative and explanative pictures, as well as using visual sequencing and animation. These empirical studies for example, indicate that pictures are distracting and should be avoided when the aim is to teach people how to read. Animated graphics have some value in a learning situation but can also place additional cognitive demands on a learner and might not facilitate learning.

Designers must develop knowledge of published research, consider the expected outcome of the learning material, and must know which type of graphic will most likely have the best cognitive effect given the learner and the text. Designers must pre-test their images in conjunction with the learning material in order to eliminate visual barriers and the possibility of inappropriate visual language that could cause miscommunication. Graphic designers can, by applying the results of published research, improve the inherent learning value of graphics when used with instructional material.

Key Words*: Instructional material, learning with pictures and graphics*

Introduction

Studies indicated that pictures can help learners to understand and recall prose and instructional text when the pictures are used in conjunction with the text (Levin and Lesgold 1978; Levie and Lentz 1982; Goldsmith 1984; Moore and Skinner 1985; Pettersson 1993; Mayer, Bove, Bryman, Mars and Tapangco 1996). Researchers, to the contrary have also reported that pictures can even have a negative effect when beginner readers learn how to read (Samuels 1970; Concannon 1975; Solman Singh and Kehoe 1992; Wu and Solman 1993; Solman and Wu 1995).

This paper will briefly report on when pictures do not facilitate the learning process, animated graphics and learning, and the importance of pre- and post-testing learning material that contain graphics.

When pictures do not facilitate the learning process

Researchers agree that pictures interfere with the process of learning how to read and that pictures with a decorative function do not assist the learning process. The first part of this section will discuss studies which found that pictures interfere in the process of learning how to read, while the second section will discuss the null facilitating effect that pictures with a decorative function have when they are combined with instructional text. Scholars frequently quote Samuels (1970) and Concannon (1975) who, in their review of published research, found seemingly little or no evidence that pictures will facilitate learning. The review of Samuels looked at studies that investigated the effect of pictures on subjects when they learn to read; the use of pictures to aid comprehension; and the influence of pictures on attitudes. A common element of the studies is that the text could be understood without the pictures, or where the goal of the lesson could be achieved even if the

pictures were removed. With reference to some of his own work and nine other studies, Samuels (1970:402) remarked that researchers appeared to agree that pictures interfere with readers' ability to acquire a "sight" vocabulary. The customary procedure for investigating the use of pictures in learning single words consists of comparing the learning effect of words combined with a picture, with the learning effect of words without a picture. The experimental design used by researchers is either a pre-test, post-test or a post-test-only design in different combinations, whilst control groups are not always used by the researchers. Solman *et al.* (1992) extended this standard research design with four variations of the test material. Their test material variations consisted of a large picture above a small word, a small picture below a large word, a small word without a picture, and a large word without a picture. They used sixteen children with a mean age of 5.6 years and excluded those that could name more than one correct word in a pre-test. A different set of words and word-picture flash cards were used in the pre-test. Each subject received the material in random order in learning and test trials until they named three words correctly in any of the four variations, in three successive trials. The proportion of correctly named words, inclusive of all the previous trials, was taken as the criterion of achievement. The children correctly named 19.5 percent of the two variations where a word was combined with a picture, and gave a 40 percent correct response for the two variations where a word was presented alone. Solman *et al.* (1992) duplicated this experiment with sixteen new subjects of the same age group, but enhanced the pictures by doubling the thickness of the pictures' lines, extended the viewing time for the picture-word combination to eight seconds and reduced the viewing time of the word-only cards to four seconds. Their results were similar to those of the first experiment in spite of the additional emphasis on the pictures in the second experiment. The subjects obtained a mean score of 16.8 percent for the picture-word cards and 43 percent for the word-only stimuli. In discussing their results, they (*Ibid.,* 1992:149) remarked: *"These results again demonstrate the deleterious effect of pictures when young children learn to name words, and they provide further support for the blocking explanation of this picture and word problem."* The reason for this interference effect of pictures in the learning-to-read process is attributed to the principle of least effort. A subject will select that item from a complex stimulus that will require the least amount of effort to produce a correct response. The picture will require less effort to provide a response than a word that they still have to learn, and the shift in attention from the picture to the word fails to materialise with some learners..

Decorative pictures

Decorative pictures are pictures that embellish text and which have an element of artistic expression to them. The functions of decorative pictures are a numeration function, namely to increase the sales of the printed material, and a motivational-attentional function, namely to attract attention and to motivate. Decorative picture may include decorative border and graphic embellishments. Woodward (1993:118), in a review of the instructional purpose of illustrations in textbooks, remarked that publishers tend to use illustrations as a marketing tool to attract attention, to create a positive effect and to change illustrations on the book covers to create the effect of a new and revised textbook. Illustrations are also used to serve social policies and for political purposes. Levie and Lentz (1982:198), in their extensive review on the effects of text illustrations, remarked that illustrations would not automatically help students to learn messages that are contained in the text. Suffice it to note that there is consensus in the literature that decorative pictures or text-irrelevant pictures do not facilitate recall and comprehension and do not assist subjects with inferential questions (Mayer 1993; Levin *et al*. 1987; Levie and Lentz 1982; Levin 1981). Decorative pictures do not repeat or explain information in the text and cannot help a reader to make inferences or understand the text. Decorative pictures are text-irrelevant and have no link to the instructional text.

Animated graphics and learning

Animation refers to the type of dynamic visual in which the creation of movement is applied to static object/s, particularly those that are manipulated on computer. The general assumption behind the use of animated visuals is that they have an essential instructional effectiveness in presenting unfamiliar or difficult subject matter. For instance, extracting information from animation of weather maps (Lowe 1999), to provide an explanation on how a particular process works, Dynamic visuals such as animations have different characteristics in terms of what they are able to represent (Lin, Chen and Dwyer 2006). Perhaps some of the obvious typical features of dynamic visuals are that they are able to provide users with two different elements, namely: images and movement (ChanLin 2000 and Rieber 2000) and their ability to show direct visualisation of changes that occur over time (Betrancourt

& Chassot 2008). ChanLin lists a number of areas for which dynamic visuals, such as animation can be used in a learning context: One of these areas is for comprehensibility and memorisation, another area; animation can be used in a variety of ways, such as in attention-gaining strategies or pointing arrows for emphasising a point. Dynamic displays can also be used to represent theoretical concepts, such as statistical concepts, as can be seen in a study by (Bodemer, Ploetzner, Feuerlein & Spada 2004) changes in population over time (as studied by Ainsworth & Van Labeke 2004) as well as computer algorithms (Narayanan & Hegarty 2002). Lewalter's (2003) experiment suggests that dynamic visuals are conducive for communication of spatial aspects and dynamic processes as it allows a complete visualization of spatial constellations and dynamic processes, while with pictures, static indicators such as shading or arrows must be used to represent this information. According to Tversky, Morrison and Betrancourt's (2002) analysis, there are two principles stating the specifications at which dynamic visuals, such as animation, may be successful in learning, even though these do not confirm the superiority of animation to the static images. These are the congruence principle (external visuals must be created/structured similarly with the internal), and the apprehension principle (graphics should be recognised and visualised correctly). A paper by Hegarty (2004), states that dynamic visuals can be used to depict processes that are visible in the actual world, such as a machine that is in motion. Dynamic visuals can also be used to present procedures that are hidden, but are spatially distributed, for instance changes in temperature in a weather map, (Lowe 2003; Hegarty 2004). Dynamic visuals can directly display changes in space over time, either incrementally or constantly (Ploetzner & Lowe 2004). Furthermore, if dynamic visuals are also made interactive, learners can be given some control over how these changes are presented to them (Chan & Black 2006).

According to Lowe (2001), in order for a dynamic visual such as animation to fulfill its potential as a tool for learning, its function must not only be to be attractive but must also consist of the cognitive function that can be used to develop other important parts of learning such as comprehension, recall and problem-solving. The following is a summary of some of the advantages of animated visuals:

- Animated visuals offer a better match between the subject matter and its representation because of its capacity to represent the dynamics explicitly.
- Clearer to the viewer because the subject matter can be viewed from different angles. The depiction can hence advance from description to explanation. This is similar to what Tversky and Kessell (2006) as well as Rasch and Schnotz (2009) stated: that the one advantage that animated visuals seem to have over static visuals is that static visuals include only structural (visuo-spatial) information, while animated pictures entail structural as well as temporal information.
- Clearer because unlike static graphics, they do not require various additional symbols (such as arrows, dotted lines, etc.) to convey the dynamic aspects of the content indirectly. This means the display can be less cluttered and learners are not required to carry out the decoding processes necessary to interpret these symbols in order to understand the changes that the subject matter undergoes.

How animated visuals may not improve learning

One other interesting notion that is shared by the researchers is an appreciation of the fact that dynamic displays are not always easy to understand and may also impose additional cognitive demands that are not available to static visuals to the learner when creating a mental representation of the dynamic content. For example, when viewing a frame-by-frame animation or video, one views one frame at a time, and once the animation or video has advanced beyond a given frame, the previous frame is no longer available to the viewer (Hegarty 2004). Therefore this may be severe on the working memory, especially in cases when information presented earlier in the animation should be integrated with information that is presented later. In contrast, when viewing a static display, viewers can re-examine different parts of the display as much as they wish (Ainsworth and Van Labeke 2004). However, it can also be said that the ability to introduce each step independently in animations reduces the clutter of static illustrations, in which all of the steps are shown at once (Stith 2004).

Using pre- and post-testing to validate the effectiveness of visual communication material

Sims-Knight (1992), Yarber (1995), Pott, Toppich and Christiansen (1996), Hugo and Smit (1998) and FHI/AIDSCAP (2003) recommended that, in order to improve the effectiveness of any visual material, it must be pre- and post-tested. FHI/PATH (2002) explained that pre-testing precedes the finalisation

of communication material so that it can be revised based on the pilot audience's reactions and suggestions. Visual communication material can be pre-tested and revised several times to ensure that visually and graphically communicated messages will be comprehended and well received by targeted audiences. The essence of this process includes checking for the appropriateness of all the elements used – for example, whether the illustrations and drawings comprehensively resemble what they represent and also whether the text is simple enough for the intended audience to understand. It must also be ensured that all the graphic elements, such as colour, are used correctly in term of the cultural context and the visual literacy of the audience.

FHI/PATH (2002) suggested that for an effective pre-test, the following factors should be considered before the first, subsequent and final drafts are presented to the target audience: (i) Developing a profile of the target population amongst whom the pre-test will be conducted; (ii) Selecting times that suit the target population; (iii) Determining and scientifically selecting the size of the pre-test sample or an approximation thereof; (iv) Selecting the interviewer(s) who will be conducting the pre-test interviews; (v) Selecting the note-taker(s) who will be taking notes during the pre-test interviews; and (vi) Involving the artist/graphics team in the pre-test process.

Much of the negative public reaction to visual health promotion messages can be linked to inadequate pre-testing or insufficient reaction to comments emanating from the test sample (Piotrow, Kincaid, Rimon & Rinehart 1997). Enough time must be allocated for pre-testing, revising and retesting, until the material is satisfactory. In other words, reaction to all issues arising from the pilot testing can ensure the suitability and functionality of such material. Therefore, to successfully measure the effectiveness of any visual communication material for meaningful learning or understanding, such material must be tested for comprehension and, if possible, for retention. Post-testing, on the other hand, assesses the success or failure of the material.

Cultural sensitivity of visual communication material

FHI/PATH (2002) explained that culture affects how people communicate, comprehend, and react to health promotion campaigns. Hugo and Smit (1999) argued that culturally inappropriate messages could lose their credibility and cause more harm than good. Hugo (2002) explained that graphic design elements such as colour combination, typeface, images and their rendering should be clothed culturally. Hugo and Smit (1998) and De Lange (1999) also recommended in their studies that visually-based communication material be fashioned in a way that is relevant to the intended users' cultural contexts. Research has shown that locally relevant images and messages used in visual materials are found to be effective, because they are culture and religion compliant (FHI/PATH 2002). Involving a community in the planning process through to the presentation stage is likely to prevent the violation of norms and traditions particular to a specific community. Acknowledgement and respect of cultural differences are factors that can contribute to the success of the material. Some examples of attitudes and values that are interrelated with culture include the accepted roles of men and women, the value of traditional medicine versus western medicine, favourite and forbidden foods, manner of dress, and body language, particularly whether touching or proximity is permitted in specific situations (Hugo 2002). Hugo and Smit (1998) and Hugo (2002) made some suggestions for improving the appropriateness of visually-based health education messages to suit multicultural communities, namely:

- Allowing the participation of target audience representatives in the process of designing health messages;
- Properly investigating the socio-cultural consequences and difficulties of using specific symbols or media; and
- Adapting messages that mirror the multicultural audiences of different communities.

Conclusion

Wall posters that promote the learning of sight words contain text and pictures, are often found in 1st grader classrooms. These and other learning materials are richly decorated with graphics and pictures but they will not necessarily help a beginning reader learn how to read. Decorative embellishments in learning material do not contribute to the learning effect because they do not convey information and act as distractor in the material. Despite the general assumption concerning the advantage of dynamic over static visualisation (ChanLin 2000; Rieber 2000), it can seen that dynamic visual with text can have essentially the same effect on students' learning as static visual with text. When looking closely

at characteristics of both types of visuals, it seems as if there are some areas where dynamic visuals can be used (ChanLin 2000; Narayanan & Hegarty 2002; Ainsworth & Van Labeke 2004; Bodemer et al. 2004), and other areas where pictures and other static visuals are more appropriate (Lai 1998; Hibbing & Rankin-Erickson 2003; Mayer 2003; Carney & Levin 2002). Therefore, various types of external representations combined with text have varying functions and can help create a "mental model" (Mayer 2003), rather than simply receiving or absorbing knowledge (Mayer 1989; Suwa & Tversky 2002; Hibbing & Rankin-Erickson 2003). The review found that the subjects' prior knowledge (ChanLin 1998; Guan 2002), the content of the instructional material (Leung & Pilgrim 1995; Weiss et al. 2002; Lin, Chen & Dwyer 2006), and the testing method (Lowe 1999; ChanLin 2000;) are but some of the variables that can determine if an external representation can increase a subject's comprehension and if such comprehension can be accurately measured.

For any visual communication material to be more effective, the designers and producers of health promotion and educational messages must ensure that all the visual elements are appropriately utilized. Designers must apply the basic design principles, such as the right colour and typeface and the use of appropriate imagery in a manner that would minimise distractions and miscommunication and aid comprehension.

Visually based communication material must still be handled by a team of experts, based on the scientific information available on the problem, the social and cultural values of the audience, and the environment in which such material will be used. Effective visual communication can be a valuable component in the medical management of for example HIV/AIDS. It is the designer's responsibility to be certain that the message tells the intended story and that the information is delivered in a clear, easily understood "language" with no possibility of misinterpretation. Thus, designers must first develop total knowledge (research) of what they are talking about, whether in a publication or an illustration. They must then decide exactly what they want to say and how they want the viewer to understand what is being said. The material must be pre-tested before the message is exposed to the audience, thus eliminating potential visual barriers and the possibility of inappropriate visual language that could cause miscommunication.

Accessing research results from educational journals may provide designers with the information they need to improve the use of graphics when designing material with an instructional content. Educational researchers have publish useful guideline when and when not to use pictures in combination with instructional text and how one can improve on using dynamic and static image to improve the educational effect.

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