INSTRUCTIONAL GRAPHICS IN AN ONLINE LEARNING ENVIRONMENT

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ABSTRACT

With the development of new technologies it is now possible to select a variety of graphics, to digitalize them, and then to create new compositions. These different ways of representing knowledge will place different information processing demands on learners. Will these different ways improve the learning experience of the learner? The general subject of visual learning and technologies of instruction, with particular reference to the presentation of instructional graphics in print and online learning environments, is explored. Consideration is give to commonalities, comparisons, and constraints in the presentation of instructional graphics in print and online learning environments.

INTRODUCTION

Driven by the desire to make instructional material more appealing, or by the belief that "a picture is worth a thousand words", educators are increasingly adopting visual approaches to presenting information. Technological advances now make the generation and distribution of visual material cheaper and easier. Information literacy has been defined as "the ability to locate, evaluate, manage and use information from a range of sources for problem solving, decision making and research" (Bruce & Candy, 1995). In what ways does the shift to visual approaches of presenting information impact on the ability of learners to locate, evaluate, manage, and use information for their learning needs?

Graphics are one of the ways that humans communicate (Saunders, 1994). They are considered to have a variety of roles in enhancing learning, including improving interest and motivation, attracting or directing attention, augmenting the learning of less able readers, aiding long term recall and assisting learning by showing something that is difficult to explain with words alone (Hartley, 1994). Instructional graphics "are those that incorporate particular design features intended to bring about learning or that are specially supported in various ways in order to achieve instructional goals" (Lowe, 1998).

INSTRUCTIONAL CONSEQUENCES OF USING GRAPHICS

Signs and symbols, ranging from depictions in wood carvings and cave paintings, through the ancient Egyptians' invention of writing, to the development of alphabetic systems, have been used to mediate experience and information since ancient times (Biggs & Moore, 1993; Seel & Winn, 1997). Each symbol system has employed different media and been used for different purposes. Signs and symbols are a universal medium of learning and cognitive activity, and they involve the use of all forms of perception. The recognition of mediated messages is dependent on the conventions used to represent information being known. If the conventions are not known, the mediated message cannot be recognised and, therefore, cannot be understood. For example, if one is not familiar with the conventions of how letters are combined to form words and sentences or with the conventions, in our society, of reading words from left to right and a page from top to bottom, then the message in this paper cannot be understood. The conventions need to be learned and mastered to allow cognitive processing to occur efficiently. The learning and mastery of the conventions for representing information becomes increasingly important as the information becomes increasingly technical and abstract (Seel & Winn, 1997). The relevant symbol systems of mediated messages need to be internalized by the learner so that the learner can use the symbol systems as tools for thinking (Salomon, 1979, cited in Seel & Winn, 1997).

The useful and relevant properties of the signs and symbols in graphics need to be extracted by the learner in order to create mental representations of the message that is being mediated through the graphic. The learner needs to engage conscious attention to deliberately and sequentially organize, and then extract meaning from, the information in the signs and symbols. Two types of information are involved in this interpretive process: the information supplied by the prior knowledge of the learner, and the information supplied by the signs and symbols. The learner needs to have knowledge of the sign system and be able to recognize and identify the marks and other graphic material. The learner needs to reverse the 'transformation' from real world situation to its symbolic representation. They do this by finding the relationships and changes depicted in the signs and symbols and converting them to the real world situation depicted. They then need to flesh out the representation by relating it to what they already know. The learner's prior subject knowledge and the task that they have been given influence this process.

The possibility exists that the way information is internally represented by the learner is related to how it is presented through different media, and may be influenced by the specific formats chosen to present that information. Representing information graphically may influence the way that the learner represents the information internally. The ways in which graphics present information may also be influenced by the medium in which they are presented. Media have the potential to provide new ways for mentally representing the world and for reasoning about the world. Laurillard (1999) poses the possibility that, with each technological development, the learner's relationship with knowledge changes. In the pre-Guttenberg era, when knowledge was mainly communicated through oral means, knowledge was constructed in particular ways in order to maximize retention of what was considered important. This changed as printed text became more widely available. The need to memorize information, for example, did not have the same priority. The advent of micro worlds, in Laurillard's opinion, provides a greater opportunity for the learner to experience and to explain the world (Laurillard, 1993).

PRINT AND ONLINE LEARNING ENVIRONMENTS

Ingram (1999) has compared print and online learning environments from a variety of perspectives and concluded that the main differences between print and online text fall into three broad areas:

1) differences in the convenience of physically using the text,
2) differences in the technical aspects of the texts,
3) differences in how learners interact with the content of the text.

She found that each form of text has its own advantages and disadvantages and that extensive research is needed into a number of different aspects related to online texts. Hartley (1994) states "it would seem worthwhile ... to pursue the idea that people might process online text differently from printed text. If there are differences, then we can consider changing the design of the presentation either to accommodate or enhance them" (p 154).

The particular attributes of an online learning environment provide teachers with powerful new ways to represent knowledge that are not available in a print environment. The didactic possibilities for teachers are greatly extended (Schnotz, 1999). These different ways of representing knowledge will place different information processing demands on learners. Generally, however, the information processing demands on the learner are not being considered. Technology may be advancing but humans still have the same information processing capabilities and limitations. The questions to ask are, "will it improve the learning experience of the learner?" and "what needs to be done to support the learner in those cases where additional processing demands are made of the learner?"

The medium also impacts on the ability of learners to locate, evaluate, manage, and use information. Lowe (1993) lists resolution, orientation and proportions, movement, closeness of view, and learner control as characteristics to consider when assessing the strengths and weaknesses of various media. Table 1 compares graphics in print and online environments according to these characteristics.

	Print	Online
Resolution	Resolution, color, and page size are determined by the author/publisher/ID and are also stable once created. Print environments have a medium to high resolution (300dpi +).	Low resolution (72 dpi). There are limitations with scanning graphic material (number of colors, resolution of scanner and storage). The learner's computer will determine resolution and color. Higher image resolution requires longer download times, more disc space, greater display time and longer printing time. The learner's computer not being able to handle data or process information can cause problems.
Orientation and proportions	Graphics provided in a permanent, flexible, and easily accessible form. Diagrams can be printed 'portrait' or 'landscape' as best suits the diagram. It is easier to make side-by-side comparisons of graphics. Large detailed graphics can be displayed. The content and detail of graphics remain stable.	Images can be cropped, output level, brightness and contrast can be adjusted, and targeted areas can be modified. The fixed screen and set proportions of the learner's computer does restrict the amount and detail of graphic to be displayed. There will be large demands placed on computer memory and processing in order to load new images, process graphics, and store recorded data.
Movement	Require a series of diagrams and accompanying explanation to illustrate process or movement.	Provides additional choices to authors and instructional designers in creating and displaying instructional graphics. 2-D and 3-D images can be created and then moved, rotated and/or resized. Animation can be incorporated. Material can be viewed from a variety of perspectives and positions. It can be disassembled and reconstructed and actions and responses invoked. Multimedia and virtual reality environments can simulate the real world with varying levels of realism. Consideration needs to be given to the processing demands of animation particularly continuous animation.
Closeness of view	Details in printed diagrams are easily focused on and exploration of the diagram assisted by natural peripheral vision.	Resolution limitations of computer leads to finer details in a diagram disappearing. Magnifying tools provided in computer programs lead to an unhelpful fragmentation of the diagram.
Learner control	The learner is able to view a graphic for as long as they need in order to understand the graphic and they are able to highlight or underline information they identify as relevant and important.	The learner may have limited control over the presentation rate of graphics and thus limited time to explore and understand a graphic. When animation is added to a graphic, the learner may have less time and greater processing demands to cope with the graphic unless they have control over the speed and duration of the presentation.

Table 1. A comparison of graphics in print and online environments (after Lowe, 1993).

COMPARING TEXTS AND GRAPHICS

While graphics can have an inherent interest for some readers, others may find certain graphics less assessable than others (i.e. cartoons cf. graphs). Words, in themselves, are not found to be interesting (Hartley, 1994) while graphics may either attract or distract readers to the subject content or to the accompanying text. Conventional wisdom would say that graphics help to explain text, but the reverse is also true. Graphics are not necessarily self explanatory. They need text to explain them. When 'reading' text or graphics for information, learners need to have knowledge about where to look for the information they need, knowledge about what the elements of the medium are, knowledge about the sequence to follow when reading the medium, and knowledge about how to connect the information in each medium. Table 2 compares texts and graphics according to these dimensions.

While the online learning environment can provide the means to deliver both static and dynamic graphics, perceptual and cognitive processing demands need to be considered when developing graphics for an online learning environment. Technical constraints also need to be considered

The cognitive demands of integrating text and graphics appear to differ according to whether the graphic is static or dynamic. The willingness of learners to study graphics improves when the graphics are animated, but their understanding of the processes illustrated seems to be impaired or distorted (Wright et al., 1999). In some circumstances, the processing demands of dynamic graphics have been found to have a negative effect on learning (Lowe, 1999). Dynamic graphics can prevent learners from performing relevant cognitive processes and so may not be beneficial for learning (Schnotz et al., 1999).

ILLUSTRATION GENRE

There are different **ways** of representing pictures and different **types** of subject matter. Goodman (1968, cited in Salomon, 1994) and Eisner (1970, cited in Salomon, 1994) grade symbol systems according to their level of resemblance to their referent, ranging from conventional, arbitrary forms and representational, realistic depictions, to qualitative representations of an idea or feeling. Lowe (1998) distinguishes levels in *representations,* or genres, which range from concrete, realistic, and literal – such as photographs – through to abstract, such as words and diagrams. For example, a photograph of a flower is a realistic depiction of its referent (the flower), whereas a scientific diagram showing a cross section of a flower, and a stylised artistic flower, are more abstract or qualitative representations. He also distinguishes between levels in *referents,* or subject matter, which range from those that are accessible and physical, such as a flower, to the invisible and not physical, such as the nucleus of an atom or the effect of gravity.

	Text	Graphics
Knowing where to look	Text is highly standardized and general strategies can be applied.	Graphics vary in structure and there are no general automatic reading routines. Difficulty is greater when the content is specialized or unfamiliar.
Knowing what the elements are	Universal rules identify information (e.g. conventional letter recognition, grammar, text division, headings etc). Specific knowledge of subject matter is required to understand vocabulary.	No universal rules to 'mark off' elements identifying information. Specific subject matter knowledge is required to segment the graphic into information units.
Knowing what sequence to follow	Information presented in a linear chain. Conventional reading sequence to follow (left to right, top to bottom) provides comprehensive treatment of subject if followed.	Greater possibility of incomplete or inappropriate explorations of the topic. The content rather than convention prescribe reading sequence.
Knowing how to connect information	Relational terms and organisation connect ideas. Structural markers are used to signal various levels of information.	The functional or conceptual relations of the topic may not be properly reflected by the visuo-spatial information. Various levels of information (overarching ideas and minute detail) are presented simultaneously.

Table 2. A comparison of text and graphics (after Lowe, n.d.)

Graphics that deal with abstract representations of invisible, non-physical referents pose particular challenges for learners. For example, in economic models, the referent is a real world, complex economic situation. It is invisible and not accessible. Taylor et al. (2000) state that "economic models can be described with words, with numerical tables, with graphs or with algebra"(p 16) – all highly abstract representations. Consider an economic model of trade between two countries represented by a graph. While a graphically literate learner who is not an economist may be able to 'read' the graphs in general terms (i.e. as an hyperbolic function with two intercepts), they will not be able to extract the domain specific meaning – what the graphs represent in economic terms.

PROCESSING DEMANDS OF GRAPHICS

So how do learners locate and process the information embedded in a graphic? and what factors impact upon this? The very start of information processing (the pre-attentive phase) is likely to be dealing with gaining a global or holistic impression of the graphic (Lowe, 1998). Broad scale organizational influences on perception will work to separate the visual information so that the learner can discriminate between the individual parts. Gestalt effects on perception will work to impose structure on the visual information. Because human viewing is highly selective, visual signals that differ substantially from the rest of the visual field, anything unusual, unexpected or in contrast with the surroundings, will draw the learner's attention. This needs to be considered when using animation in an online learning environment as it could distract the learner, leading to an inappropriate use of the learner's finite cognitive resources.

People often do not realize how demanding even a single, static illustration can be for someone who is new to the subject matter portrayed. Like text and numbers, graphics are a form of information. The learner needs to use two types of information to interpret a graphic: their own prior knowledge, and the information supplied by the graphic. The learner needs to draw on their prior knowledge of the subject as well as their prior knowledge of the elements of a graphic. During viewing, the elements of the graphic need to be identified and interpreted. The learner needs to reverse the 'transformation' from the real world situation to the graphic. Relationships and changes depicted in the graphic need to be identified and converted to the real world situation depicted. They need to flesh out the representation of the real world situation by relating it to what they already know. How well this is done is influenced by the learner's knowledge of graphics, the learner's knowledge of the subject, and the learner's task. Novices who lack knowledge of the subject, or who lack knowledge about how to read graphics, may miss aspects that are obvious to a subject expert.

CONCLUSION

As educators, our aim is to help our students understand the presented subject matter. Educators are increasingly adopting visual approaches to presenting information and technological advances now make it possible to select a variety of graphics, to digitalise them and then to create new compositions. While the presentation of instructional graphics in print and online learning environments has certain commonalities, there are also particular advantages and constraints in using each medium that needs to be considered. As a result, learners are encountering different information processing demands as they seek to locate and manage information presented in graphic material. These need to be considered when preparing instructional graphics for learners.

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