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Cognitive load theory, visual literacy and teaching design history

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ABSTRACT

This research takes the stance that identifying a previously unseen design example is a problem-solving activity that novice learners, particularly those who lack visual literacy skills, find extremely difficult. Learning in design history often involves presenting students, after they have been given a lecture, with appreciation activities of design examples. Such activities often do not take into account the limited capacity of working memory in that multiple examples of previously unseen material is shown and students are required to answer open-ended questions on a design's visual characteristics without any teacher instruction until students provide an appropriate answer.

According to Schnotz (2002), semantic processing is required in order for the viewer to comprehend a picture as opposed to merely perceiving it. Koroscik, Short, Stavropoulos and Fortin (1992) recommended that educators should not expect students to discover meaningful or accurate ideas about an artwork without teacher direction and input. These conclusions can also be applied to the teaching of design history. This research discusses the application of cognitive load theory, a theory usually applied to the teaching of maths and science, and theories of visual literacy to provide a theoretical underpinning for supporting techniques to improve students' ability to recognise designers' styles in higher education. Specifically it is suggested, that providing well-designed worked examples would be a more effective instructional method for promoting novice learning.

I. VISUAL LITERACY AND LEARNING

In order to become a visually literate individual it is necessary to develop familiarity with tradition and technology of visual representation (Kintgen, 1988). To understand the visual representations of the artist or designer, the skill of decoding qualitative semantics and syntaxes needs to be explored and understood. Similar to verbal language, visual forms are also coded in syntax, roughly equivalent to spoken communication (Boughton, 1986). Dondis (1973) took the basic elements, namely dot, line, shape, direction, tone, colour, texture, dimension, scale and movement and compared these to linguistic grammar and syntax to provide a similarity. The purpose for comparing visual elements to language structures is an attempt to make visual communication transparent and easy to comprehend. Effective instructional design for the novice learner should aim for such clarity in order to provide the viewer with appropriate knowledge and skills to begin to comprehend and hence decode the qualitative semantic syntax of an art or design work.

Visual education is concerned with visual communication that is developed through learning how to appreciate and critique art and design, as well as through the practice of art making and designing. Through the process of educating vision, skills for developing visually literate individuals can be encouraged. The "need to develop visual literacy in pupils...obviously touches on the need for them to be fluent in the use of symbols for demonstrating understanding as they evaluate and make art" (Cunliffe, 1992:146).

Once the visual syntax of the artist is understood a defined path becomes apparent to access the work and hence to decode the visual message and reach a level of understanding and comprehension. When an inappropriate set of expectations (codes) are used to decipher images the viewer could fail to find meaning in the art work, for they have not learnt to 'read' the syntax of the artist (Boughton, 1986). If students can be taught to understand these qualitative syntaxes in a more specific manner through focused art study, then they can interpret art as well as have access to decoding other visual messages outside the realm of the visual arts. "What is required when reading and making works of art is to try to understand the visual code that is being used and how this relates to the purpose or function of the work of art" (Cunliffe, 1992:149).

In order to represent an image pictorially one must have "some knowledge of the visual symbol systems, its vocabulary, concept, conventions, and some technical skills to manipulate art material" (Feinstein, 1982:46). All this acquired knowledge and experience combines together in the visually literate individual. One of the roles of the art and design educator is to teach the skill and knowledge of reading visual images. One way of achieving this is too reduce the complexity of visual images and provide easy access to the language. The objective of developing in students visual competencies required to analyse art and design knowledge will more likely be fostered when instructional design avoids extraneous cognitive load by removing ambiguous unnecessary detailed information from the curriculum.

II. COGNITIVE LOAD THEORY AND LEARNING

Educators need to take into account when designing instructional material the limited capacity of working memory to process large amounts of often, unnecessary information. It was the pioneer researcher Miller (1956) who was one of the first to demonstrate that short-term memory had a limited processing capacity. He discovered that individuals could hold only seven pieces of information at once in their short-term memory. Miller called this discovery 'the magical number seven plus or minus two', as he surmised that the number of elements an individual could remember varies from five to nine. More recently, Greene (1992) showed that working memory's capacity for holding information was less related to the passage of time and more related to the interference caused by other information. Greene (1992) discovered that it was the quantity of information not the time taken to remember or hold the information that affected whether individuals forget. Other studies by Anderson (1983) and Baddeley (1992; 2001) also draw attention to limited capacity of working memory for holding information.

Taking this into account, when teaching art or design to novice learners with limited visual literacy skills, educators should consider reducing the amount of material they use in their teaching so that they do not overload the limited capacity of student's short-term or working memory. One theory, which encapsulates these concepts that has developed effective methods for instructional design of visual material in education is Cognitive load theory.

Cognitive load theory uses our knowledge of our cognitive architecture to devise instructional methods for improving student learning. Cognitive load theory (e.g. Paas, Renkl & Sweller, 2003; 2004; Sweller, 1988; 1989; 2003), has contributed widely to the fields of education and training. This theory takes into account human cognitive architecture and its role in processing information in short-term and long-term memory. In particular it addresses the importance of designing instructional material that considers the limitations of human working memory. Cognitive load theory takes the stance that instructional design that uses worked examples is a superior instructional method for teaching novice learners new material than providing problem-solving tasks.

Within the context of art and design education, the use of well designed worked examples that integrate the appropriate written knowledge with the relevant visual example can effectively focus the learners attention on the important aspects of the work that needs to be learnt. Via this method, students have access to information that provides an appropriate interpretation of the main features of the work. This allows students to distinguish between superficially irrelevant information and real and valuable knowledge of the art or design work. Ausburn and Ausburn found that the "superficiality of pupils' comprehension of much of what they view, suggests that higher order visual literacy skills do not develop unless they are identified and taught" (1978: 288).

III. WORKED EXAMPLES VERSUS PROBLEM-SOLVING

Art appreciation and criticism in the classroom is usually taught using problem-solving strategies that require the student to provide their own solutions to open-ended questions on specific art examples, with little guidance or input from the teacher during this process. There are a number of advocates in art education who support the theory that discovery learning is an effective learning strategy (Dorn, 1998; Jausovec, 1994). According to Davies, Conneely, Davies and Lynch, "spontaneity is useful for what educationalists call 'discovery learning', in which students generate and internalise their own way of understanding concepts and principles" (2000:122). They believe that discovery learning is a reaction against the 'didactic method' where facts are given which students memorise. Discovery learning in art and design education can be an effective learning strategy for students who have domain specific knowledge, however for students without such knowledge, supplying appropriate worked examples consisting of the visual with a list of significant features could be a more effective method.

The argument for using worked examples in instructional design in art and design education is based on the premise that critiquing art and design is a problem-solving activity for novice learners. In order to further explain their purpose, worked examples needs to be defined. A worked example can be defined as: an instructional method that provides a domain specific example to follow and study of a problem that includes a worked-out solution (often in steps). A large number of studies on instructional design have examined learning from worked examples, particularly in the fields of mathematics, physics and computer programming (e.g. Ward & Sweller, 1990; Paas & van Merriënboer, 1994; Carroll, 1994; Tuovinen & Sweller, 1999).

Only recently has this methods of instructional design been tested in the area of teaching design history. Specifically in the Rourke (2006) study, which was based on the concept of Cognitive load theory and the literature of visual literacy and the influence this can have toward effective teaching of design history in higher education. It investigates, in a real situational format of lecture followed by tutorial, the effectiveness of worked examples compared to completing problem-solving tasks. In this study both experiments (one with first year design students, the other second year art education students) were divided into three stages conducted over a three-week period of a university semester. Stage one of the experiment was a lecture with visual examples on five designers from the Art Nouveau or the early Modernist period (approximately 1880-1914). Stage two consisted of a practice session, where the Experimental group received five worked examples and five practice exercises and the Control group received ten problem-solving tasks. In Stage three of both experiments both the Experimental group and the Control group completed a three-page test. The principle conclusion drawn from two experiments was that novice learners who have a moderate level of visual literacy skill are more successful at identifying a designer's work after

studying worked examples compared to novice learners provided with problem-solving tasks. The data for these experiments can be found in another paper written by Rourke and Sweller (2007) titled: 'The worked example effect using ill-defined problems: Learning to recognise designers' styles, which is under editorial consideration with 'The Journal of Educational Psychology'.

IV. ENCODING AND RETRIEVAL OF INFORMATION FROM PICTURES

There has been a number of studies that have examined the encoding and retrieval of information from pictures (Friedman & Bourne, 1976; Kunen, Green & Waterman, 1979; Mandler & Johnson, 1976; Mandler & Ritchey, 1977). The results from these studies are not easily generalised to visual art processing according to Koroscik (1982), who has studied the complexities of visual art processing specifically in relation to the characteristics of pictorial information processing. Koroscik (1982) discovered that prior knowledge, the amount of time allocated to studying the artwork, and the level of the task demanded, all affected students ability to learn visual material.

Koroscik proposed that: "individuals with prior knowledge of visual art process more information than those who lack such information" (1982: 21). For students with specific knowledge of art have the schemas that allows them to process more information in working memory. A schema is defined, as a cognitive construct that permits us to treat multiple elements of information as a single element classified according to the way it will be used (Chi, Glaser & Rees, 1982; Sweller, van Merriënboer & Paas, 1998). The learner's level of expertise can have an effect on their ability to solve problems in mathematics, similarly, the problem-solving strategy of art critiquing can be a problem for the novice learner who lacks the schemas to effectively analyse a work of art or design.

Koroscik (1982) study also found that remembering information was influenced by the length of time that was spent viewing the art examples, as other studies indicate (Craik & Lockhart, 1972). Koroscik (1982) claims that participants who had 4.5 minutes to respond to an artwork remembered significantly more than those given 1.5 minutes. This result may seam obvious, but what was interesting was that the type of information that was remembered did not differ significantly, with structural information remembered before semantic information. Research by Koroscik, Desmond & Brandon (1985) suggested that comprehension of art involves a complex interaction between encoding its structure (or formal qualities) and its meaning (or semantic characteristics).

The elemental structure of the artwork is usually the first aspect that the viewer can identify whereas semantic information requires a more indepth reading of the work. Koroscik suggested that as a result of the need to provide longer viewing times for effective learning, that "one might question the traditional practice of displaying large collections of artworks to students in slide presentations. Students might be better served if classroom viewing activities provided for the detailed examination of a smaller number of artworks" (1982: 21).

V.PRECONCEIVED CONSTRUCTS EMBODIED IN VISUAL IMAGES

There are other factors to consider along side the format of the instruction being used when developing student's visual literacy skills such as teaching student's to identify the preconceived constructs embodied in visual image. Feldman (1986) said that a passive viewer cannot react to visual images with critical understanding and "to be visually illiterate is to be 'un-free' in the sense that the individual is a victim of the persuasive devices, or rhetoric of visual communication" (Boughton quotes Feldman, 1986:135). Learning to read visuals should not only include learning the preconceived constructs for decoding images, it should also include understanding aesthetic literacy through knowledge and personal vision. "Aesthetic literacy involves the knowledgeable appreciation of art. This means bringing to awareness already present, taken-for-granted definitions of and attitudes towards art for purposes of examination, refinement, and elaboration" (Hamblen, 1986: 68).

Visual literacy in art and design education can be problematic to teach as Raney suggested, for in "Western culture, vision is associated with reason, logic, knowledge and control on the one hand, and on the other hand with mobilisation of fantasies, primitive desires and unconscious forces beyond our control. Thus visual representation has a double identity: it is both rational and amendable to analysis, and irrational and resistant to analysis" (1999: 46-47). This paper takes on board the former premise that visual literacy skills and in particular design history knowledge has a logic that can be learnt via effective worked examples.

VI. CONCLUSION

Sless said that art has failed to educate vision, and one of the reasons could be that the "visual literacy movement.... has demanded a break of the traditional links between art and visual education" (1977:5). Though Sless's comments are dated, they still can be applied to teaching art and design history in the 21st Century. For visual literacy skills obtained through developing ability in art and design criticism, art and design appreciation, aesthetic awareness and experience with the art making process and design process can also lead to improvement in general visual literacy communication. As art and specifically design logic can be understood in form and content, visuals communicate meaning and this form of visual communication has a grammar that can be learnt. Students should be provided with experiences in education to promote visual literacy skills so that the messages in visual culture can be critically read and understood. There is the belief that pictures are "surpassing text in their ability to record, transmit, and create new knowledge" (Blystone, 1992:1).

Research has found that writing outline planning strategies can reduce cognitive load during writing (Galbraith, 1992; Flower, 1994). As with writing, key point summary lists beside the visual images can also be used as an effective

teaching tool if appropriately used to direct the learner's attention towards what needs to be learnt about the visual image. "Cognitive load theory suggests that effective instructional material facilitates learning by directing cognitive resources towards activities that are relevant to learning" (Chandler & Sweller, 1991:293). Effective instructional material should not only focus the learner's attention on the content that needs to be learnt but if appropriately designed, also on transferable skills that can be applied to future learning enterprises. A number of research studies have found positive results when using worked examples to promote both knowledge acquisition and the transfer skills required to apply new knowledge to different learning situations (Sweller & Cooper, 1985; Cooper & Sweller, 1987; van Merriënboer, 1990).

When a student writes down the list of key points provided with the visual image they have combined and recorded multiple interactive elements, which means that this information no longer needs to be held in working memory. This allows the student to then concentrate on studying other aspects of the visual image because their attention has been directed to the relevant facts of this image so they no longer have to hold extraneous or irrelevant information in their limited working memory.

Cognitive load theory (e.g. Paas, Renkl & Sweller, 2003; 2004; Sweller, 1988; 1989; 2003), has contributed widely to the fields of education and training over the past two decades. As has been explained, one instructional method generated by Cognitive load theory that takes into account the limited capacity of working memory is the use of worked examples. It can be surmised that Cognitive load theory will continue to be used in education and training to explain the worked example effect, which it generated, until an alternative becomes available.

This theory assists towards explaining why novices learn more effectively via worked examples compared to completing problem solving tasks. Worked examples assist towards making visual communication transparent and easy to comprehend and provides the learner with appropriate knowledge to begin to decode the qualitative semantic syntaxes of a design or art work, as has been explained previously. For it has been argued, that educators need to provide the learner with a defined path to access the visual syntaxes of a work so that they have the necessary tools required to decode the visual messages embodied in a art or design work that assist towards comprehending its meaning. Worked examples in this instance, provides one instructional method for reducing the load on the limited capacity of working memory by decreasing the complexity of visual images and providing easy access to the language required to fully comprehend an art or design work as this paper has explained.

Through combining the concepts of Cognitive load theory with the visual literacy literature a theoretical argument has been presented to support the stance that instructional design that uses a series of simple training tasks in the form of worked examples may assist novice learners towards both the development of visual literacy skills as well as the acquisition of domain specific knowledge.

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