Int. J. Engng Ed. Vol. 25, No. 6, pp. 1212–1217, 2009
Printed in Great Britain.

0949-149X/91 $3.00+0.00

The Visual World of Engineers: Exploring the Visual Culture of Engineering as an Essential Element of Communication from Design to Production*

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In the 21st Century world visual intelligence is considered to be a crucial and valuable ability. This digital century, with its rampant development of technology and the availability of alternative communication channels, is changing the way in which people think, as well as their thinking patterns, and the speed of communicating and accessing information. There is everyday exposure to various forms of visual representations of information such as timelines, symbols, tables, graphs, signs, spreadsheets, billboards, etc. Visual forms of communication may carry the information more clearly and effortlessly than the written and spoken forms of communication. It is believed that 'a picture is worth a thousand words'. Indeed, the amount of information that the human being is surrounded with is overwhelming and visual communication is one of the ways to compact and yet clarify this information. Moreover, visual communication may help to deliver information in a way that transcends language barriers. Therefore, imagery is often preferred in operation manuals, aeroplane safety instructions, danger and caution warnings, etc. Visual intelligence and visual cognitive ability are issues in engineering education that would be defined as critical by engineering educators and reflective practitioners. The nature of the engineering profession requires the specialists in the field to be visually literate. The issues of forming the visual culture of engineers are described and discussed in this paper.

Keywords: visual intelligence; visual culture of engineers; technical communication

INTRODUCTION

IT IS BELIEVED that the human world is a world of images. It has been scientifically proven that the human brain processes the world visually. Humans interact with the world through a number of senses but the dominant role is given to vision. The superiority of visual images, as a faster and smarter way of communication, as well as a better way of cognition, is reflected in the language through proverbs and phrases such as: *a picture is worth a thousand words*; *seeing is believing*; or *show me the money*. Most probably this dominance goes back to the humans' cave-in-habitat, with the walls displaying pictures, which were obviously painted in an attempt to communicate some ideas rather than an effort to make the cave look more aesthetic and decorated.

Most anthropologists believe that before the development of oral or written languages, mankind was more closely connected to visual thought. People communicated with gestures and signing before communicating with sounds. In other words, visual communication preceded oral communication. It is also theorised that in ancient communication, events and told stories were re-enacted with gestures before the development of drawing and speech. Sequentially, drawing became a tool to represent natural objects and stories, perhaps blossoming at the same time as spoken language [1].

Based on linear thinking, some writing systems later developed as alphabetic. The development of other written languages resulted in establishing iconographic and ideographic systems. The heritage of Egyptian hieroglyphs and Chinese ideograms still represents the efforts of non-linear, visual thinking civilisations endeavouring to develop written symbols that imitate body language signs and express ideas. Nevertheless, in spite of this split, a language, spoken or written, is both verbal and visual. Cognition of meaning is the high level processing in the brain, which involves semantic, as well as visual processing. Hence, it can be assumed that decoding the visual information should be an automatic and

* Accepted 12 June 2009.

intuitive process. The truth is that perceiving what has been seen is anything but automatic. Two people witnessing the same event or looking at the same object will perceive the details differently in terms of time and complexity.

Visual representation and cognition or, in other words, visual literacy, shapes the structure of engineering work. Engineering sketches, drawings, diagrams, charts, graphs, schematics, etc. are the building blocks of technological inventions, designs and production. In order to be efficient in solving engineering problems, engineers have to employ various kinds of skills but, as stated by Dunwoody *et al.* [2]:

> . . . design is at the heart of engineers' problem-solving activities.

Ferguson points out that technical knowledge was transferred almost solely through visual representations from the 1400s to the recent past [3]. Hence, visual thinking and visual communication are considered to be crucial for engineering.

This paper attempts to clarify the nature and significance of visual intelligence for engineers, to understand the formation of visual culture and discuss the possibilities of enhancing these skills by integrating them across the curriculum.

ARTISTIC SIDE OF ENGINEERING

In order to understand, address, tackle and solve problems in engineering education, one should look in depth at the very nature of engineering. One of the best definitions of engineering was given by the English engineer and writer Thomas Tredgold in 1828, who defined it as follows [4]:

> Engineering is the art of directing the great sources of power in nature for the use and convenience of man.

Is it possible to break down this quotation by putting a full-stop after the word 'art' so that the phrase still remains meaningful when defining engineering? What is the professional identity of an engineer and how far away is engineering from art?

In 1959, Sir Charles Percy Snow published a book putting forward the harshest criticism of the then Western intellectual culture with its destructive tendency to split the science and engineering culture from the arts and humanities [5]. This bifurcation between the two cultures is still in existence. Crawford raises the issue of artists and engineers being at the opposite sides of the barricade, stating that [6]:

> Scientists and engineers regard artists as fuzzy-heads who cannot handle the discipline of rigorous thinking. Artists dismiss technical people as gear-heads who just do not understand the human condition.

Despite this gap, it has to be recognised that there is a lot of art in engineering. It has been stated that pyramids, cathedrals and rockets exist not because of geometry, theory of structures or thermodynamics, but because they were first a visual image for those who designed them [7].

This idea is also supported by Ferguson, who states the following [3]:

> The conversion of an idea to an artefact, which engages both the designer and the maker, is a complex and subtle process that will always be far closer to art than to science

The above statement accords with the words of J. D. North, a British engineer and a member of the Royal Aeronautical Society, who expressed this concept as follows [8]:

> Aeroplanes are not designed by science, but by art in spite of some pretence and humbug to the contrary. I do not mean to suggest for one moment that engineering can do without science, on the contrary, it stands on the scientific foundations, but there is a big gap between scientific research and the engineering product which has to be bridged by the art of the engineer.

Probably, the best way to illustrate the interconnection and interdependence of art and engineering is by mentioning a personality such as Leonardo da Vinci, who was equally talented as an artist, an architect and an engineer.

There is a large group of people who fit into the category of being artistically and practically talented. Another good example could be Benjamin Henry Latrobe, who is claimed to be the first professional architect in America, as well as a civil engineer and a watercolorist [9]. Known as the father of soil mechanics, Karl Terzaghi is also remembered as an artist with constant focus, commitment, and genius [10]. These are just a few examples from history that add to the idea of the similarity of engineering and arts. Indeed, the drawings of an engineer, and the paintings or drawings of an artist have one thing in common—they begin with the transfer of a certain vision in the mind's eye on to a blank page [3].

It needs to be noted that engineers use scientific knowledge and mathematics to solve practical problems. These problems are solved for the benefit of society. Therefore, the issues such as aesthetics, ergonomics, environmental impact (and many others), which are traditionally regarded as part of the humanities, cannot be ignored by engineers.

TECHNICAL COMMUNICATION UNFOLDED

Engineers have an impact on the world in which we live. Equally, the world has a social impact on engineering. Engineers need to communicate with their colleagues in order to accomplish a project, as well as to explain the results, statistics, benefits and impact, to the ever inquisitive public, who hold them accountable for tax-payers' money spent.

Given this characteristic of engineering, it is emphasised that unlike other professions, whose format is in the verbal domain, engineering has an overlapping combination of verbal, visual, kinaesthetic, and mathematical formats [11].

Describing engineering work, Henderson states the following [11]:

> In the world of engineers and designers, sketches and drawings are the basic components of communication; words are built around them. Coordination and conflict take place over, on, and through drawings. Visual objects not only shape the final products of design engineering but also influence the structure of the work and who may participate in it.

The nature of engineering is in communication, either oral and written or visual and, as such, requires these skills to be well-developed.

Visual intelligence is of crucial importance for engineers. It is the ability to manipulate images when thinking visually, as well as the ability and skills to encode and compose meaningful visual communications, decode and interpret visual messages, and give a verbal representation of the content of visual images. Effective visual communication, similarly to coherent writing or speaking, demands a lot of attention to detail. Visual communication also abides by the specific rules of syntax and semantics. Kazmierczak states that [12]:

> Visuals are a system of representation and signification that allows us to produce and communicate thoughts and images about reality.

Although visual communication is not chaotic, visual symbols are not fixed, partially because symbols are limitless, as is the human imagination. Furthermore, visual communication is made up of presentational symbols and images, the full meaning of which is derived from a particular context. It should be noted that visual meaning of images has religious, historical, cultural and professional characteristics, and such images should be used with care, with consideration to be given to the background of the audience.

Visual communication at the professional level must exclude ambiguity. It is normally standardised and unified at least nationwide. In order to embed complex information into flat renditions, engineers implement a lexicon of schematic symbols. Those symbols represent a functional component or a part of the designed object. Some additional visual codes represent specific information.

Discussing the practical epistemology of drafting conventions, Henderson underlines the following [11]:

> The lexicon allows the schematic drawings in which it is employed to remain sufficiently flexible so that engineers can read the coded functions in the layout and understand the interrelations of the various functional components of the whole project.

Enhancing visual literacy and the developing visual culture of engineers are essential issues for engineering education. An engineering graduate should be able to use the power of visual representation in full and be able to: depict the relationships between the functional components of the artefact; give precise information to those involved in the project at any level and stage; use imagery to communicate with managers, sponsors and the public, as well as to perceive the message that is visually encoded.

Visual literacy of engineers involves developing a set of skills that is needed to be able to create a message by means of images, interpret the content of visual images, examine their social impact, as well as manage the time and involvement of others in the production process for the completion of the project.

Bamford states that in order to be visually literate a person should be able to do the following [13]:

- understand the subject matter of images;
- analyse and interpret images in order to gain meaning within the cultural context the image was created and exists;
- analyse the syntax of images including style and composition;
- analyse the techniques used to produce the image;
- evaluate the aesthetic merit of the work;
- evaluate the merit of the work in terms of purpose and audience;
- grasp the synergy, interaction, innovation, affective impact and/or feel of an image.

In terms of professional communication, engineers need to acquire pure professional skills in design and graphics, as well as communication skills that will allow them to use imagery for simplicity, clarity and conciseness of the message to be delivered to a wider range of people. It is also very important that engineers are able to reinforce the visual information with oral or written explanations.

Ultimately, engineers need a broad range of skills and the ability to use them for solving complex problems from the design stage to the production stage, where communication is an essential element for connecting people of different professions and cultures during project management and its realisation. Moreover, visual communication is exceptionally helpful for the globalised market, as it allows for the transcending of language barriers.

TO THE BEST ADVANTAGE OF A CURRICULUM

It was once stated that knowledge that could not be expressed as mathematical relationships was not regarded as useful for engineering education [3]. Engineers should be artistically creative in order to see beyond the boundaries of what we know. The nature of engineering practice reveals that many fundamental competences of engineers are in the spectrum of nonengineering disciplines. This fact is also recognised today by professional engineering societies, bodies and initiatives, for example the Accreditation Board for Engineering and Technology (ABET) [14] and the Conceive-Design-Implement-Operate (CDIO) Initiative [15].

The issues of the development of non-engineering competences have to be attended to, and incorporated into, engineering curricula. In recognising the necessity to develop visual literacy and to use imagery as a powerful teaching tool, Pudlowski states the following [16]:

> The application of graphic forms such as symbols, drawings and diagrams helps in introducing new concepts and rules which are essential for a more complex activity of problem solving. Graphic forms are also helpful in establishing the non-verbal intelligence which is indispensable for this important human activity.

In his teaching of electrical engineering at the University of Sydney, Sydney, Australia, in the 1980s, Pudlowski widely implemented visual communication through electrical symbols, diagrams and drawings. Visual communication was used as a teaching tool, which was simultaneously developing students' visual intelligence, thereby enhancing their professional competences. Moreover, an aptitude test for electrical engineering was developed to assess students' application of visual ability [16].

Another study defines the advantages of developing visual literacy where the following is stated [1]:

- Creating visual communication calls for summarizing information for easy consumption by readers and audiences, which often presents the person creating the communication with new insights and understanding;
- Visual communication addresses the need for global communication of basic but key information;
- Visual communication tends to be easier for other cultures to translate than text;
- If done correctly, visual communication resists misinterpretation;
- Visual communication allows teambuilding with others unfamiliar with the intricacies of your work.

It should be noted that the cultivation of visual culture in engineers and the enhancement of visual literacy are important from the curriculum standpoint. It demands interdisciplinary involvement and implementation across curricula. Specific engineering disciplines should aim at teaching students to become better perceivers and better creators of visual communication, while communication courses should aim at developing the skills to transmit the message perceived from the images using oral or written forms.

A comprehensive review of the general literature on effective communication with particular emphasis on successful strategies, practice and processes as suggested by several authors [17–20] and a review of specific literature concerning the issues of communication for professional engineers [21–23], have both contributed to an observation that some important elements of technical communication may be missing from the content of engineering education. These elements are visual literacy and visual culture of engineers, which must be regarded as a substantial part of engineering communication.

Moreover, through these literature reviews, it was found that the authors of the works under review expressed similar views on non-verbal communication only in relation to signals, body language, gestures, eye contact, tone of voice, etc. Further, visual intelligence and visual communication were mostly addressed with regard to their implementation as visual aids, for example, through the usage and functions of graphics in written work and presentations.

A case study concerning the content of communication courses for engineering and technical students at the top five technical universities, as identified in the *Times Higher Education Supplement* ranking of 2007 [24], was carried out in December 2007. The institutions under study included: Massachusetts Institute of Technology, Massachusetts, USA; the University of California, Berkeley, USA; Stanford University, Stanford, USA; California Institute of Technology, California, USA; and the University of Cambridge, Cambridge, UK.

When analysing the contents of those courses, the same deficiency was found. That is, visual intelligence and visual communication were not treated in the right way as students were not trained to establish appropriate connection between imagery and oral and written speech for communication purposes.

It should be pointed out, however, that the data gathered in this case study were collected thoroughly but only to the extent of its availability on the official university Web sites. Hence, the conclusion that these universities offer technical communication courses that disregard appropriate development of professional visual culture, visual intelligence and visual communication skills, may be arguable. Further, it is important to underline that the practical use of visual communication is in sending a message in a universally encoded format with the well-enhanced ability to enrich it with words. The connection, and the navigation, between imagery and oral or written representations have to be reinforced by practical exercises during the communication courses, and through its components such as English for Specific Purposes (ESP).

CONCLUSIONS

In the engineering curricula the importance of forming visual culture and developing visual intelligence has to be recognised and implemented.

Visual intelligence is built upon a set of skills required for successful engineering practice and effective technical communication from the design to production stages.

In addition, visual intelligence contributes to the enhancement of skills such as: problem solving; creativity; group, time and project management, etc. Hence, it is important to revisit and revise the content of communication courses for engineers. In such courses, visual intelligence should not be limited to visual aids but should be expanded to function as a communication channel for delivering a technical message both to engineering and non-engineering audiences.

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