VISUAL THINKING IN THE CLASSROOM: INSIGHTS FROM RESEARCH LITERATURE

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In this paper, an attempt has been made to integrate insights from three sources of research literature pertaining to the nature and use of visual images: history of science, cognitive science (both top-down and bottom-up approaches) and pedagogical practices. Children should be made familiar with the use of visual resources and visual thinking from early childhood. Drawings can be used as an effective tool during this process, assuming the status of a non-verbal language. Based on their preferred mode of thinking and communication, 'visual' and 'verbal' thinkers have been identified. Also domains such as design and biology are more visual than others. However, visual thinking is essential for creative reasoning and problem solving, especially in science. Therefore there is a need to acculturate children into its working procedures from the early school years.

"The problem is not a lack of visual resources; we are flooded with images. The problem is our readiness to understand and use these images critically and constructively" (Mathewson, 2005).

Three sources of research literature on visual thinking

There has been often conflicting literature on the nature and use of visual thinking and reasoning, especially in the context of classroom practice. Pedagogical implications have been drawn from three sources of research literature. Self-reports of scientists on the cognitive processes which have contributed to a discovery is one of them. Further, historians of science have inferred about the kinds of reasoning employed by scientists based on available literature, interviews with others involved in the process, and the prevalent scientific culture and practice of that period (Kierns, 1999). Research in cognitive science has elucidated our understanding of the properties and characteristics of visual images. The major research program using a bottom-up approach was pioneered by Shepard and Kosslyn (Kosslyn, 1994). They viewed imagery as 'internalised perception' and established its similarity to properties and characteristics of percepts (referred to as 'classic images') (Tversky, 2005). Johnson-Laird (1983) proposed that people form mental models with a dynamic relationship between its parts, which in turn helps reasoning and problem-solving. These models are however schematic unlike classic images. Visual imagery has also been studied in complex domains such as design (Tversky, 2005) and human physiology using a top-down approach. There is a third source of literature comprising of classroom-based research which may not draw from research in cognitive science, but lays emphasis on the rich classroom experiences of educational practitioners. The aim of this paper is to provide a short review of literature from the three different areas of research mentioned, with a view to enrich our understanding of the nature of visual thought and reasoning, and the role of pedagogical practices in developing it.

The diverse realm of the 'visual'

The word 'visual' in its most basic sense refers to the perception of continuous, simultaneous stimuli or information from the environment through mechanisms of vision (as opposed to 'verbal' which is sequential and non-depictive). Perceived information is processed for two different attributes through separate pathways in the brain. They are: properties of the object such as size, shape, colour, etc., metric or spatial information pertaining to the object as well as spatiotopic mapping, that is, its location in space with respect to other objects (Kosslyn, 1994). The products of visual perception are also included in the diverse realm of the visual, and comprises of visual images (representations in the mind which are depictive and formed in the absence of the stimulus it represents), drawings, diagrams, video, photographs, etc. A facility with the use of visual modes of representation requires enculturation into a style of thinking and reasoning different from that of natural language. Such facility necessitates a familiarity with its working procedures from early childhood. Children should be taught to observe everyday events, objects and people, draw scenes and objects from different viewpoints, use sketch-pads to scribble down ideas, converse with oneself using drawings, etc. (Anning, 1997). There is then a gradual movement from an experience-based understanding to a level of abstraction known to lead to scientific discovery (Mathewson, 2005). The first step is hands-on learning followed by didactic (demonstrations), depictive (illustrations), modeling (active, working models, visual and gestural material), encoding (schematic signs and symbols), creative discovery (novel visualisations, problem-solving), and intuitive discovery (imagery leading to new knowledge such as in the case of Faraday and Einstein).

Drawings as tools to express and understand a visual language

The use of drawings in the classroom as a medium of expression is an important step in this process of familiarisation with a visual medium. Drawings have been popularly viewed as serving an aesthetic purpose, and to be the privilege of a talented few. Historically however, it was commonly used to record personal or culturally significant images for domestic and religious purposes (Anning, 1997). In the context of work, two different purposes attached to drawings could be identified. Firstly, an individual's mental images are given tangible form through exploratory sketches, scribbles and rough calculations. These initial impressions aid an artist (specially a designer) while revisiting and reworking ideas before a solution is reached.

A second purpose is to externalise ideas through a system of graphic conventions unique to that discipline. This is best exemplified in the case of Barbara McClintock, the Nobel-prize winning cytogeneticist who reasoned using a language different from the conventions of molecular biology during the period of the 1960s and 1970s. McClintock used photographs to communicate developmental "change over time", best seen and represented in maize. Maize is considered to be an organism unsuitable for genetic studies because of its complex genetic organisation. It however displayed intricate developmental patterns which McClintock studied and communicated using photographs. The choice of a photograph was beneficial since it represented four-dimensional change over time which a two dimensional diagram could not convey effectively. A photograph also fulfilled gestalt functions by representing a complex whole which a drawing or 'cartoon' could not depict. Such non-diagrammatic representation was opposed to the diagrammatic conventions of physicists and chemists who had moved into the emerging discipline of molecular biology. A line-drawing has the advantage of extracting relevant information and ordering it to draw attention to the intended information alone, but in the process greatly simplifies it.

Drawings also assume the status of a non-verbal language especially in early childhood by helping children externalise conceptions as well as feelings about certain objects or events. Brooks (2002) used a Vygotskyan approach to explore the function of drawings in a collaborative environment and as a tool for thought comparable to language. In the Reggio Emilia schools in Italy, practicing artists work alongside children in ateliers or studios: shared workspaces where children "experiment or manipulate combined visual languages in isolation or in combination with verbal ones" (Edwards, 1993). However, these are not common approaches in Indian classrooms where a verbal form of encoding and expression is still emphasised by the teacher and curricular materials.

Visual thinking as a cognitive style

A visual language is an indispensable medium for designers and architects, who use multiple modes of representation such as scribbles, gestures, writing, drawing and computer-aided tools (Yi-Luen, 2001). These flexible styles of working encourage a familiarity required to develop an ease of working with a new medium. It has been documented that some children have a greater propensity to use visual images and drawings, and invariably move into professions such as engineering or design which require the use of these modes. Alcock and Simpson (2004) have documented some interesting differences in styles of working, reasoning and attitudes of 'visual' and 'verbal' thinkers. The reported findings were the results of a study carried out on students of a first year course on real analysis at a British University. Students who visualise tend to introduce diagrams during interview tasks; gesture while explaining arguments; explicitly indicate a preference for thinking of pictures or diagrams rather than algebraic representations, and refer to a sense of meaning derived from a source other than formal expressions. They were also quickly convinced of the correctness of their conclusions, but were unable to produce a written argument. This led them to overlook or not attach significance to formal definitions. It was found that students who had comprehended correctly were able to move flexibly between visual and formal expressions, and sought to form relationships between them. This drive to search for systematic links and construct an integrated understanding interfered with their tendency to visualise. However the conflict helped them to resolve any initial alternative conceptions without having to be repeatedly prompted by the interviewers. They engaged in a kind of Piagetian accommodation to reconcile an informal understanding with formal material presented in the classroom (Piaget, 1966).

As in the case of design and architecture, the domain of biology is inherently visual. It is pertinent to recall Fox-Keller's (2004) question in the context of validation of biological knowledge: "And are there not circumstances in contemporary scientific practice when the mere observation of a phenomenon is so satisfying and compelling that no further explanation is required?" She further adds, "Is clarity in thinking always and necessarily of higher epistemological value than clarity in seeing?"

Visualisation in the process of scientific discovery

Scientific discovery takes recourse to the generation, transformation and manipulation of visual images. It is a cumulative process which develops during the course of an infant's cognitive development through the integration of facts, images, themes, encoded thinking, problem-solving and metacognitive skills. The visual content of science can be grouped into a list of master images (for e.g. symmetry) (Mathewson, 2005). Simon (1996) proposed the existence of "transformational reasoning" which is neither inductive nor deductive, but draws on the characteristics of both forms. This reasoning process is set in motion when learners actively search for or try to get a sense of "how things work". It exploits an ability to understand the workings of a system and translate it into a mental or physical representation that can be "run". The result is a dynamic process by which a new state or continuums of states are generated. Such reasoning has been implicated in the process of creative discovery as seen from reports of scientists, popularly called "thinking out of the box".

The invention of the microscope and the development of calculus were two important technical achievements of the seventeenth century (Fox-Keller, 2004). They weighed in opposing directions and led to the growth of two separate disciplines: the life sciences and the physical sciences. The two cultures of thinking it developed were also seen (unfortunately) to be opposed to each other. There is therefore a need for the teacher and curricular materials to encourage flexibility of working with multiple modes. The use of visual resources for thinking and communication should be one of these modes of teaching and learning from the early school years. It also allows for greater freedom to the learner to choose a style of representation and communication that he or she may have an aptitude or inclination for.

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