‘READING’ GEOMETRICAL DIAGRAMS: A SUGGESTED FRAMEWORK

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Mathematics is a multimodal/multisemiotic discourse where different modes of communication take place such as verbal language, algebraic notations, visual forms and gestures. These different modes offer different mathematical meaning potentials. Based on Halliday’s SFL, Morgan (1996) has developed a linguistic framework to describe the verbal components of mathematical texts. O’Halloran (2005) also developed a framework to describe the mathematical visual graphs and symbolism. Still, there is a need to develop tools to describe other modes such as geometrical diagrams and gestures. This paper shows only one aspect (ideational/representational) of a suggested framework to read geometrical diagram/shapes which is developed based on school-students' work and textbooks.

BACKGROUND

Halliday (1985) developed a Systemic Functional Linguistics (SFL) framework in which he argues that any language (and linguistic text) fulfils social purposes: to understand and represent the world (ideational function), to communicate and create social relations with others (interpersonal function) and create coherence (textual function). Even though this framework was initially developed to account for verbal modes of communication only, it has been extended to include other (non-verbal) modes too. The multimodal approach developed by Kress & van Leeuwen (2006) is an example. They have developed a grammar to ‘read’ images using ‘representation, interactive and compositional’ corresponding to Hallidayan terms respectively. There are other researchers who extended the use of SFL such as: Lemke’s studies in science education and language (e.g. 1998) and the application of SFL in mathematics education by Morgan (1996) and O’Halloran (2005).

Mathematics is a multimodal/multisemiotic discourse where different modes of communication take place such as verbal language, algebraic notations, visual forms and gesture. These different modes may offer different meanings or they may convey one set of meanings (Kress & van Leeuwen, 2006). The verbal language in (mathematical) texts, for instance, despite of its power, has limited ability ‘to represent spatial relations such as the angles of a triangle (..) or irrational ratios’ (Lemke, 1999, p. 175). Thus we need diagrams or algebraic notations to represent these qualities or quantities enabling us to re-examine the argument. In the same manner, gestures help in representing a dynamic act in which both the language and visual representations have limited ability to do so. It is the deployment of all of these (and other) modes which carries the ‘unified’ meanings.

Because of the limitation of the space available, I present only the ideational/ representational meaning. Following Morgan (1996) and Kress & van Leeuwen

(2006), the ideational meaning is realised by looking at the representation of the mathematical activity. In any verbal-mathematical text, the transitivity system, suggested by Halliday (1985), is an effective tool to look at that representation. In images, Kress & van Leeuwen (2006) considered the presence of a vector is a distinguishing feature of narrative representation while the absence of a vector suggests conceptual representations. However, this feature is not -the presence of vector- within the geometrical diagrams has conventional mathematical meaning (parallelism for example) which is not necessarily expressing an action. I also addressed diagrams which express (mathematical) actions and do not include vectors (such as dotted lines, shading, see below). The distinctive feature(s) of the narrative representation is the presence of a *temporal* factor while the absence of that factor suggests the conceptual representations. By temporal factor I mean that one can trace a timeline to follow in the diagram and that timeline suggests (action) processes that have been done. Now I turn on to describe these processes illustrated by examples [1] from students' texts produced for my research, textbooks and internet.

NARRATIVE REPRESENTATIONS: (DESIGNING MATHEMATICAL ACTIVITIES)

I argue that geometrical diagrams have representation of or about mathematics and mathematical activities which have been done or are being done and these activities can be unfolded by tracing a temporal factor *within* the diagram itself. Here, I characterise four structures of the diagrams: directional, dotted, shaded and construction.

(1) Directional structure

In these diagrams, the *temporal* factor is presented by a vector (*arrow*) indicating the mathematical activity. There are two cases:

- Movement or physical action: such as transformation (rotation, reflection and translation), enlargement, sliding, folding, sequence, etc. (Diagram 1)

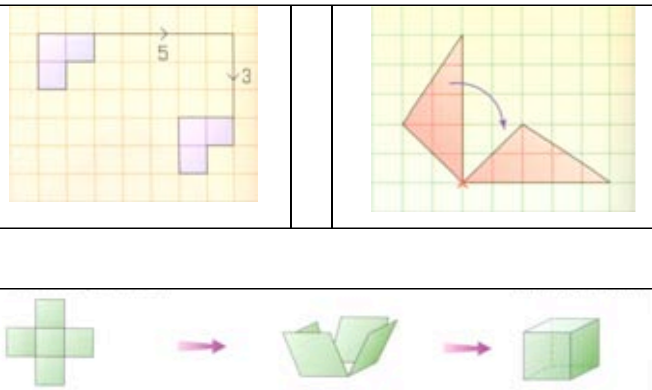

Diagram 1

- Measurement: to specify a length of a side or a value, (Diagram 2)

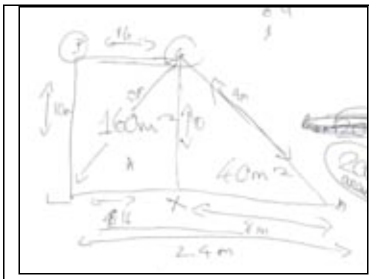

Diagram 2

(2) Dotted structure

The *temporal factor* is presented by *dotted (dashed) lines* and it suggests a work has been done or added to the shape either to solve the problem or to 'show' some features or parts. Again, I suggest two structures:

- Actions: to show additional work such as extending a line, (un)folding, dividing into parts, etc. (Diagram 3)
- Axis: represent an axis or a line of reflection. (Diagram 4)

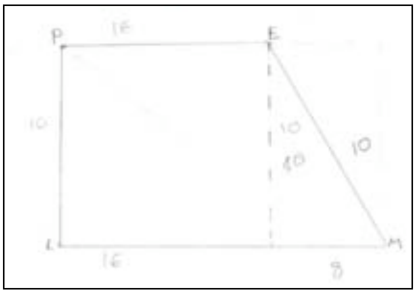

Diagram 3

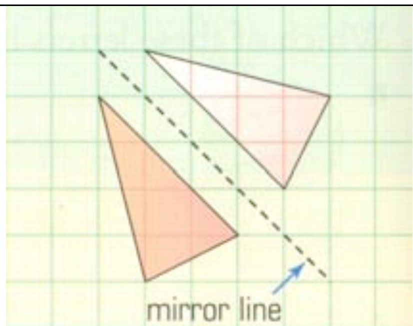

Diagram 4

(3) Shaded structure

The shading process implies a process that has taken place 'afterwards'. (Diagram 5)

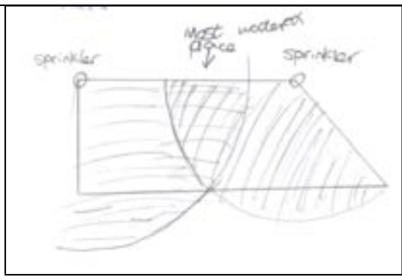

Diagram 5

(4) Construction structures

The temporal factor is realised by the arcs, marks made with compass as a result of the construction process. (Diagram 6)

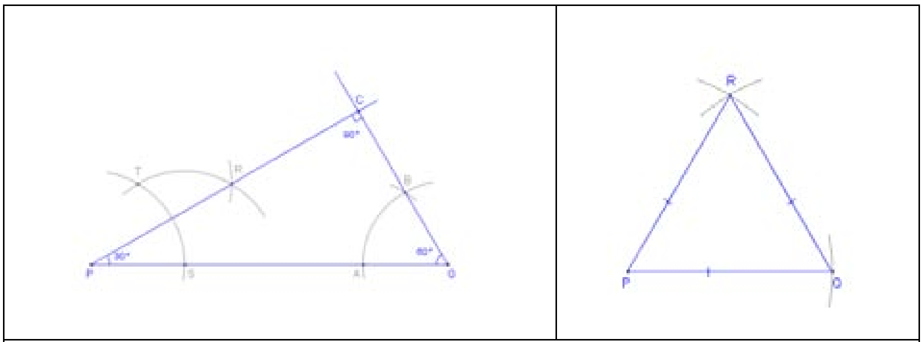

Diagram 6

CONCEPTUAL STRUCTURES: (DESIGNING MATHEMATICAL OBJECTS)

The distinguishing feature here is the absence of an action or temporal factor. The depicted elements or participants stand by themselves in a timeless sense. These conceptual structures mostly offer information such as definitions, relationships between shapes/diagrams. Kress & van Leeuwen (2006) distinguish between three types of conceptual processes; classificational, analytical and symbolic. It is the latter which is of interest of my study and which I have found applicable in the context of geometrical shapes. Of course the other two processes have their application in mathematical visual representations such as the pie diagram (representing a classificational process) and Venn diagram (representing an analytical process). My focus will be on the symbolic structures within geometry context. However, I will keep the conceptual term for such structures in my study to include the symbolic structures, anticipating more development to the suggested framework.

Symbolic structures:

According to Kress & van Leeuwen (2006, p. 105), 'symbolic processes are about what a participant *means* or *is*'. Again, Kress & van Leeuwen distinguish between two types of symbolic structures; Attributive and Suggestive.

1. **Symbolic Suggestive**: In these structures, the meaning or/and the identity are suggested by the depicted participant itself or, in other words, the participant has these qualities. In geometry context, definitions of shapes are good examples of these structures. (Diagram 7)

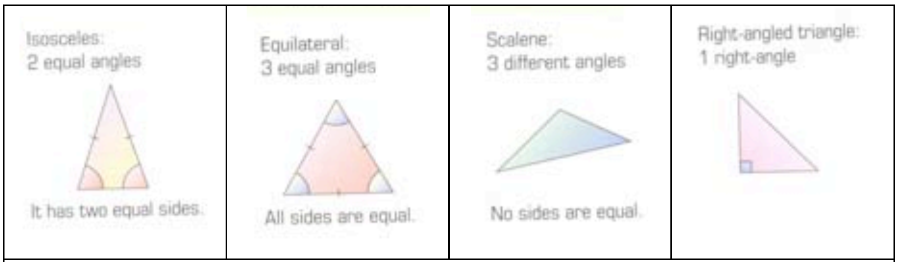

Diagram 7

2. **Symbolic Attributive**: In these structures, the meaning or/and the identity are given to the depicted participant. In geometry context, I found giving names or pointing to specific parts of the diagram is a good example to these structures (Diagram 8).[2]

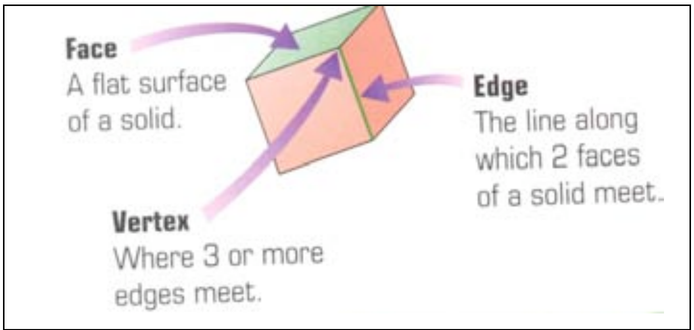

Diagram 8

FINAL COMMENT

This version of the suggested framework is the second one and it is still under development. In this paper I presented the most developed aspect so far, the ideational meaning, or what the geometrical diagram is representing about mathematics and mathematical activity. Still, many questions and issues are being raised such as the labels or notations within diagrams and what meanings they might convey (Diagram 9), why do students choose to draw two small circles representing the sprinklers in Diagram 5, or what is the relation between the verbal and the visual in the text and why did some students start their texts with diagrams and not with writing. Such questions, among others of course, are being faced in my research and involve the interpersonal/interactive and the textual/compositional aspects. These will be included in this framework but could not be presented fully here because of the space available.

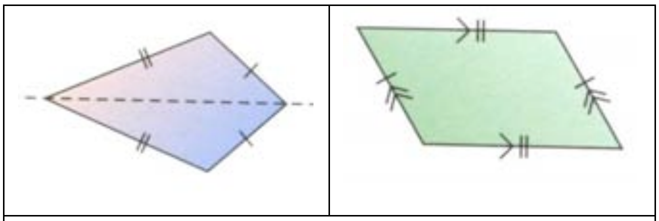

Diagram 9

NOTES

1. Diagrams 1, 4, 7, 8 and 9 are taken from textbooks for year 7, 8 and 9 by Allan, Williams & Perry (2004, 2005)- Framework Maths by Oxford University Press. Diagrams 2, 3 and 5 are taken from students' texts produced in my research. And Diagram 6 is taken from a website (http://www.mathopenref.com/).

2. Here, in Diagram 8, the arrows are coming from 'outside' the diagram pointing to specific parts of the diagram without mathematical activity being carried on. These arrows are different from the arrows in the narrative representations where they suggest mathematical activity such as rotation or measurements.

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