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The language of learning mathematics: A multimodal perspective

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ABSTRACT

The aim is to develop a multimodal (i.e. multisemiotic) approach to the mathematics register, where language is considered as one resource, often a secondary one, which operates in conjunction with mathematical symbolism and images to create meaning in mathematics. For this purpose, the linguistic features and grammatical difficulties of scientific English are reviewed and compared to the grammatical features of mathematical symbolic notation and mathematical images. From here, the integration of language, mathematics symbolism and images in mathematics texts and the nature of spoken language in mathematics classrooms and associated difficulties are explored. The approach leads to the notion of a 'multimodal register' for mathematics to complement the existing language-based conceptualization of register. The multimodal approach has significant implications for teaching and learning mathematics and the development of strategies for mastering the mathematics register for the effective communication of mathematical knowledge.

1. Introduction

The role of language in teaching and learning mathematics and the types of linguistic structures found in mathematics have been studied since the 1980s (e.g. Adams, 2003; Cocking & Mestre, 1988; Pimm, 1987). Schleppegrell (2007) synthesizes the results of this research in a comprehensive review of the linguistic challenges of mathematics which have been documented over the past 30 years. These challenges include the multimodal formulations (i.e. language, mathematical symbolism and images) of mathematical knowledge and the complex linguistic structures found in mathematical discourse, in particular the complex noun groups ("*a*" and "*b*") which are related to each other ("*a* is *b*") to form long chains of reasoning ("*a* is *b* and *c* is *d*, so *e* is *f*"). In Schleppegrell's (2007, p. 139) own words:

> The linguistic challenges include the multi-semiotic formations of mathematics, its dense noun phrases that participate in relational processes, and the precise meanings of conjunctions and implicit logical relationships that link elements in mathematics discourse.

These findings are largely derived from Halliday's (e.g. Halliday, 1978; Halliday & Matthiessen, 2004) functional approach to language and the concept of a 'mathematics register' as a set configuration of typical meanings, "together with the words and structures which express these meanings" (Halliday, 1978, p. 195). The types of meanings (which Halliday calls 'metafunctions') are experiential (happenings in the world), logical (logical relations between those happenings) and interpersonal

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(for enacting social relations) which are orchestrated through text-forming resources. In what follows, Halliday's descriptions of the linguistic constructions found in scientific English and the resulting grammatical difficulties which arise (Halliday, 2006; Halliday & Martin, 1993) are reviewed. Following this, the types of grammatical constructions found in mathematical symbolic notation and mathematical images (e.g. graphs and diagrams), and the nature of the metaphorical expressions which occur as the three resources (i.e. linguistic, symbolic and visual) combine in mathematics discourse (Lemke, 1998, 2003; O'Halloran, 2000, 2003b, 2005, 2008) are explored.

The aim of the discussion is to develop a multimodal (i.e. multisemiotic - where 'semiotic' means the study of sign systems) approach to the mathematics register, where language is considered as one resource, often a secondary one, which operates in conjunction with mathematical symbolism and images to create meaning in mathematics. The approach leads to the notion of a 'multimodal register' for mathematics to complement the existing language-based conceptualization of register, with a view enhancing our understanding of language in relation to the functions and grammatical features of mathematical images and mathematical symbolism. The multimodal approach has significant implications for teaching and learning mathematics and the development of strategies for mastering the mathematics register for the effective communication of mathematical knowledge.

2. Mathematical language

Halliday (1993a) adopts a historical view to show how scientific English evolved as clusters of features that differ from other registers (e.g. literary texts, news reports, casual conversation). Halliday provides a comprehensive description of the linguistic structures found in scientific writing, and an explanation for the reasons why these features arose during the development of the scientific method. As a central component of this account, Halliday (1993a) explains how processes realized through verbs (e.g. "*a* happens") were reformulated as nouns (i.e. "happening *a*") to foreground and background information for the development of rhetorical arguments in scientific writing – that is, to "to create a discourse that moves forward by logical and coherent steps, each building on what has gone before" (Halliday, 1993a, p. 64). The repackaging of linguistic processes as nouns means that processes are represented as *things*, making it linguistically possible to relate physical processes to each other and to interpret the results to order and predict events in the physical world. Halliday (1993a, p. 66) describes the stages in the repacking of processes as entities as follows:

1. Relate nominalized processes (happening *a* and happening *x*) to each other:
   - *a* happens; so *x* happens
   - because *a* happens, *x* happens
   - that *a* happens causes *x* to happen
   - happening *a* causes happening *x*
   - happening *a* is the cause of happening *x*
2. Relate nominalized processes (happening *a* and happening *x*) to interpret physical world:
   - *a* happens; so we know *x* happens
   - because *a* happens, we know that *x* happens
   - that *a* happens proves *x* to happen
   - happening *a* proves happening *x*
   - happening *a* is the proof of happening *x*

Halliday (1993a) explains how the process of packaging processes into noun groups (or 'nominal groups') permits concepts to be organized into technical taxonomies for categorizing theoretical, methodological and technological knowledge; the second major feature of scientific English. The technical taxonomies made possible through the repackaging of information in noun groups adds further complexity to scientific English:

> [C]oncepts are organized into taxonomies, and constructions of concepts (processes) are packaged into information and distributed by backgrounding and foregrounding; and since the grammar does this by nominalizing, the experiential content goes into nominal groups. The verbal group signals that the process takes place: or more substantively, sets up the logical relationship of one process to another, either externally (*a* causes *x*) or internally (*b* proves *y*). (Halliday, 1993a, p. 64)