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Subject Language in Mathematics Textbooks - Verbal Text Fragments Supplemented by Other Semiotic Resources

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Different subjects have developed their own ways to construe meaning. To be able to convey the message, specific linguistic means are used in particular ways depending on the subject. The subject language in mathematics is characterized by the utilization of verbal language together with the semiotic resources mathematical notation and images. Each semiotic resource contribute to different functions of language and one resource can modulate the meaning made by another resource. Thus, adding one semiotic resource enhances the affordances of the other, a phenomenon referred to as meaning multiplication (e.g., Lemke, 1998). The intricacy of how the semiotic resources can be used together is indeed an asset, but at the same time this intricacy increases the demand on the reader. There are several reasons why students of mathematics must appropriate the subject language and learn to read mathematics. For example, language not only determines what is possible to communicate within a subject, but also modulates the way we think (e.g., Pederson, Danziger, Wilkins, Levinson, Kita, & Seng, 1998). In addition, texts with multiple semiotic resources are an important means to enhance students' conceptual knowledge (e.g., Kilpatrick, Swafford, & Findell, 2001).

Important contributions have been made to characterize the subject language in mathematics (e.g., Morgan & Tang, 2016; O'Halloran, 2005), but much is still unknown or needs further analysis. There are also features about the subject language in mathematics that are taken for true, but for which the empirical evidence is weak (Österholm, & Bergqvist, 2013). Since knowledge about the particular features of a subject language is a prerequisite for teaching the subject, there is a need to develop our understanding about how we communicate in mathematics to solidify the basis on which language-conscious mathematics teaching must be built.

One distinguishing feature of printed mathematics texts is the mixture of mathematical notation and words, even in short fragments of text (Ribeck, 2015). In this study, we aim at characterizing the subject language in mathematics by linguistically analysing such verbal text fragments (hereafter referred to as VTFs), sorting out how the totality of semiotic resources interact to make the message complete. The categories taken into account in the analysis concern information structure (i.e. Theme and Rheme) and semantic roles (i.e. Participant, Process and Circumstance). In line with this focus, the following research questions are posed:

RQ 1) What characterizes VTFs in mathematics textbooks regarding their linguistic content?

RQ 2) What role do VTFs and the semiotic resources mathematical notation and images take in relation to each other to make the message complete?

The analysis of relations between the different semiotic resources is based on a functional perspective on language, with a particular focus on means that are used to create a mental representation of reality. Royce’s (2007) framework for intersemiotic complementarity between the semantic categories Process, Participant and Circumstance is used. Intersemiotic complementarity is a concept that catches how the means of different semiotic resources in a text interact to provide a coherent message. Since mathematical notation is an important resource in mathematics texts the framework is modified to include also mathematical notation (cf. Dyrvold, 2016). In addition, we use the notion of Theme and Rheme (Halliday 1994), which is seen as crucial to the organisation and construal of meaning from a reader's perspective.

Methodology, Methods, Research Instruments or Sources Used

The data used in this study builds upon previous results from Ribeck (2015), where VTFs are automatically extracted from a corpus of 5.2 million words originating from Swedish secondary and upper secondary textbooks. For every word in the VTFs, a parser has added information about part of speech and syntactic function. In the current study these VTFs are analysed quantitatively and qualitatively. Two different analyses are conducted, each relating to one research question.

The first step aims at identifying the most common types of VTFs. Here, the VTFs are coded and analysed for their linguistic characteristics. This quantitative analysis will reveal patterns among the VTFs as to what information they convey.

In the next step, the common VTFs that have been identified are analysed in relation to the other semiotic resources. The focus is laid on how meanings are construed around Themes and Rhemes and the means used to obtain cohesion between Participants, Processes and Circumstances represented by the different semiotic resources. In the analysis of the thematic progression between Themes and Rhemes (see e.g., Danes, 1974) the role of the VTFs is taken as the starting point for the message that is construed in the text. Thereafter, the roles of all semiotic resources are included in the analysis to describe the information structure throughout the text. The analysis of cohesion between Participants, Processes and Circumstances is bidirectional; first potential cohesive relations to other semiotic resources indicated by the VTFs are analysed, second the content represented by the other semiotic resources are analysed in relation to the VTFs.

Conclusions, Expected Outcomes or Findings

This study is expected to contribute knowledge about a particular feature that distinguishes the mathematical subject language from other subject languages in natural and social sciences, namely its substantial share of VTFs (cf. Ribeck, 2015). The utilization of two different analyses enables us to elucidate the subject language of mathematics from different point of views. It may be argued that verbal language in multimodal texts only makes sense in their context, and consequently is not meaningful to analyse separately. However, the VTFs are present in the textbooks and the reader needs an understanding of their textual function. Thus, we argue that a deepened understanding of the separate semiotic resources is a necessary first step towards understanding the intricacy in how they together construe subject-specific meaning.

The analysis of the role of the VTFs in relation to the other semiotic resources is expected to offer a rich understanding of a crucial characteristic of the subject language in mathematics, namely how the semiotic resources complement each other. The combination of resources may either be necessary for a particular message or redundant to each other, something that will be highlighted by the
bidirectional analysis.

The results will contribute to characterize the subject language in mathematics, which is necessary to plan and implement teaching that strengthen students’ language competence.

References


Intent of Publication

Educational Studies in Mathematics