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## **Which textual features are difficult when reading and solving mathematics tasks?**

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Despite the digital revolution much of the mathematics practiced in schools is still tightly bound to two-dimensional texts. This emphasis on text is neither surprising, nor inadequate, since mathematics has developed through a long history with the use of written text, consisting of natural language, mathematical notation and images. Natural language is our native language consisting of letters and words (see e.g., [www.oed.com](http://www.oed.com)). Different features of the mathematics text are also important in written tests, since reading the text is part of the assessment. If the text is hard to read, that difficulty can be relevant as part of assessing the communicative competence in mathematics. Crucial is, however, whether potentially difficult textual features are part of what the assessment aims at. This issue is investigated in the current study, using a synthesis of statistical results and qualitative analyses of task text.

A critical question is where to draw the line between necessary and unnecessary reading demand and how to judge which textual features are irrelevant and therefore should be avoided in mathematics assessments. In the current study this aspect of reading demand is addressed through a small meta-analysis of four studies where different textual aspects in task text are analyzed in relation to task difficulty and task reading demand. The theoretical starting point for the current research is an understanding of language as an essential part of mathematics. It has been argued theoretically that the understanding of a mathematical object develops as the student develops her or his discourse on that object (see e.g., Sfard, 2008). An understanding of mathematics discourse as part of what mathematics is, is in line with the theoretical interpretation of the statistical measure for *demand on reading ability* (DRA) used in the studies included in the meta-analysis conducted in the current study. DRA is a measure of the unnecessary reading demand in a mathematics task, and within this interpretation lays also an assumption of a kind of reading demand that is relevant in mathematics tasks (see also Dyrvold, Bergqvist, & Österholm, 2015). The purpose of the study is to contribute to the knowledge about which textual features in tasks are demanding and whether that difficulty is a mathematics relevant difficulty. The research questions are: i) what conclusions can be drawn regarding reading demand in mathematics tasks in relation to textual features?, and ii) how can the conclusions based on statistical analyses be interpreted in relation to a qualitative analysis of mathematics task text with a high reading demand?

The study consists of a meta-analysis and a qualitative analysis of tasks that stand out in the quantitative analysis. Only four studies are included in the meta-analysis but even such a small meta-analysis do contribute to the development of knowledge since the analysis enables conclusions to be drawn that would not be possible to draw with-out such an analysis. The qualitative analysis has a systemic functional perspective (Halliday & Matthiessen, 2014) and includes also images and mathematical notation.

The meta-analysis focuses on textual features in relation to two quantitative measures; task *demand on reading ability* (DRA) and task *difficulty*. Results in relation to those variables (difficulty and DRA) are relevant to interpret together since they represent different aspects of how a task can be demanding. The measure DRA is obtained through a principal component analysis (PCA) on students' results on PISA reading and mathematics tasks. The result of the PCA is several components that explain different parts of the results on the tasks. The components are statistically disjoint, and therefore the DRA represents demand on a reading ability that is not part of a mathematical ability (see also Dyrvold et al., 2015). Through the analysis, every PISA mathematics task obtains a loading value on that component, a value interpreted as the tasks DRA.

The results reveal several features of the natural language that distinguishes tasks with a high DRA, but also that the images are more tightly integrated with the sentences in tasks that have a low DRA but are difficult to solve. For tasks with high DRA, the sentences are knitted together through the Themes (the topic of the sentence) and Rhemes (what is presented in relation to the theme) something that is not as pronounced in task with low DRA (Theme and Rheme are explained by e.g., Halliday and Matthiessen, 2014). One example of that can be found in the following sentences. The Themes are underlined. “The sculpture is a half circle with the radius 2m. The half circle is inscribed in a square.” Those sentences represent a linear progression since the Rheme of the first sentence becomes the Theme of the next sentence.

The results from the meta-analysis reveal other features than the natural language (words and letters) that are related to difficulty but not to DRA. Tasks with high DRA and tasks with low DRA are alike when it comes to presence of natural language, images, and symbols but for tasks with a low DRA there are more references within natural language and between natural language and images or symbols. In summary, the textual analyses reveal features of the text in tasks with high DRA that enlighten what the high reading demand may stem from, since the textual analyses indicate that the progression between Themes and Rhemes can be a distinguishing feature for tasks with high DRA, whereas references to images may not play such a role.

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