Framework of linguistic properties to compare mathematics tasks in different languages

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Introduction

The aim of this study is to construct a framework of linguistic properties of mathematical tasks will help to explain why some different natural language versions of the same mathematical tasks statistically function differently. It will be used to compare different language versions of PISA mathematics tasks in order to provide a possible explanation of differences in item functioning that are due to inherent properties of different languages. It will also provide advice on how to formulate "good" tasks that take account of what we know about how language properties are connected to difficulty, do not have high unnecessary demand of reading ability, and can be well-translated.

Theoretical perspective

Mathematical communication cannot be separated from mathematics. The study is based on a functional approach that language has evolved along with our human needs, including the specific need of communicating mathematically (Halliday, 2004). This view is supported by earlier research suggesting that different languages might have different inherent properties when it comes to expressing mathematics. For example, the relative transparency of Chinese mathematical terms can be an advantage for students compared to the etymological opacity of many English mathematical terms (Han & Ginsburg, 2001). The framework needs to be structured in a way that is meaningful in a mathematics education context. A functional perspective facilitates comparison between task versions in different languages, as one function may be expressed through different properties in different languages. At the same time, a particular property may also perform different functions in different languages and in different contexts.

Designing the framework

Based on our own previous research and preliminary literature review, we have begun with a list of properties for which there are indications that they might affect the reading and/or mathematical difficulty of the task. We are conducting a structured literature review looking for evidence of connections between text properties and difficulty, particularly properties that can be seen as typical for, or somehow related to, mathematical aspects of the tasks. For each property includ-

ed in the framework there should be empirical evidence of difficulty associated with the property, which may come from fields beyond mathematics and science. The framework should include information about each property including methods used to measure the property, empirical and/or theoretical connections to aspects of difficulty and relevance for mathematical tasks. For example, abstract phrasing can be more difficult to understand than specific or concrete examples (Cox, 1978). However, abstraction is itself a practice associated with mathematics and may be a deliberate part of the mathematics or mathematical literacy demands of the task. The framework should also include information about whether properties are mandatory or optional in different languages and thus which can be deliberately varied in one language, but not in another.

Refining the framework

The initial list of properties is being refined with respect to the results of the literature search. We are also investigating the text of some of the PISA mathematics tasks in several languages (English, Swedish, German and Spanish) to see which properties vary between language versions. These textual comparisons will be used to inform the functional structure of the framework. The functional approach will be further articulated with respect to the specific functions of mathematics tasks. There may be some alignment with the metafunctions of Systemic Functional Linguistics in terms of what is special to mathematics texts (ideational), what is special to test tasks (interpersonal) and what the generic language features are (textual) (Matthiessen & Halliday, 2009). There may also be some properties connected to difficulty such as properties of length (word length, sentence length) which are better understood as formal components of the text than as functional components.

Applying the framework

The framework should be able to be used as a tool in future empirical studies, as well as being of use in the creation of mathematical text, for example to test writers, or teachers with second-language students.

References

Cox, W. F., Jr. (1978). Problem solving as a function of abstract or concrete words. *Contemporary Educational Psychology, 3*, 95-101.

Halliday, M. A. K. (2004). *The language of science.* London: Continuum.

Han, Y., & Ginsburg, H. P. (2001). Chinese and English mathematics language: The relation between linguistic clarity and mathematics performance. *Mathematical Thinking and Learning, 3*(2&3), 201-220. doi: 10.1080/10986065.2001.9679973

Matthiessen, C. M. I. M., & Halliday, M. A. K. (2009). *Systemic functional grammar: A first step into the theory.* Beijing: Higher Education Press.