

Understanding Mathematical Expressions: An Eye-Tracking Study

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Extended Abstract

Intuitive knowledge management and user interfaces need a good understanding of the respective users and practices. We are especially interested in the target group of users of mathematical knowledge. One important mathematical practice consists in using mathematical expressions, which evolved as concise and precise representations of mathematical knowledge and as such guide and inform mathematical thinking.

We present an exploratory eye-tracking study in which we investigate how humans perceive and understand mathematical expressions. The study confirms that math-oriented and not math-oriented users approach them differently and reveals implicit mathematical practices in the decoding and understanding processes. Mathematical expressions are widely used in technical documents, therefore fitting mathematical user interfaces have to be created that empower their users to better utilise those tools of the trade. With our eye-tracking experiment we have identified a set of mathematical practices when decoding a math expression.

We observed that math-oriented and non-math-oriented participants have different visual approaches for math detection. In particular, non-math-oriented subjects read even complex mathematical expression from left to right as if it were text. In contrast, math-oriented probands decomposed mathematical expressions with clearly organized procedures. They chunked the expression into sub-expressions. They decoded the mathematical expression from left to right until the first meaningful sub-expression was grasped and then turned their attention towards unciphering this subexpressions. The relations among the distinct items within the subexpressions were also attended too, even among cross-relations between distinct subexpressions. Literals and variables were easily distinguished by most readers, whereas variable names were not the pivotal point essential for problem solving. This might have been different with mathematical symbols, that did not necessarily include all parameters of their information. The suggested six hypotheses enable a deeper understanding of the way mathematical expressions are perceived.

Interestingly, we could verify that the math-oriented subjects decoded a complex mathematical expression according to the MathML content tree of the expression in question. The existence of a content-oriented markup format at the same time as a presentation-oriented one is therefore justified for the aimed-for target-group of the MathML web format.

Note, that the set of mathematical practices is still hypothetical but it gives rise to interesting new perspectives for the design of mathematical user interfaces, particularly mathematical search engines.

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