Linda Qin

Breaking the Working Memory Barrier:
Introducing a Novel Digital Tool to Improve Understanding of Mathematical Texts

Abstract

With the digitalization of academic material, there exists opportunity to utilize external tools to improve understanding of notation-heavy text. Prior research has shown a connection between working memory limits and conceptual learning. This study examines the creation and efficacy of a digital tool (nicknamed 'Ender') that acts as a crutch for working memory, through saving and resurfacing variable definitions across texts.

Hypotheses

H1. The Ender tool will increase efficiency of reading through notation-heavy text.
H2. The Ender tool will improve understanding of equations encountered in notation-heavy text.
H3. Through improving understanding of equations, the Ender tool will increase overall comprehension of notation-heavy text.
H4. The Ender tool will have a greater effect on those who have less experience reading through notation-heavy text.

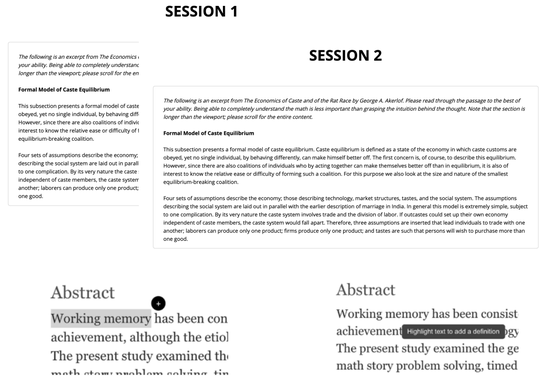

Figure 2.1: Initiating the creation flow

Figure 2.2: Input option

Figure 2.3: Overview of screen

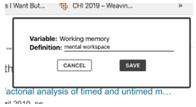

Figure 2.4: Close-up of card

Methods

46 Harvard students in STEM concentrations
2 economics passages by Nobel laureate George Akerlof
(randomized tool and passage order)
Questions after each reading: main idea, support, parallel topics and ability to connect to external situations, detailed recall of equations and variables

Mechanical Turk grading of responses
Three per response; median value taken

Market for Lemons

What is the main argument of the paper?

Points	If response includes… (cumulative; each point includes most information from previous levels as well)
0	n/a
1	[wrote something]
2	information symmetry,' 'information asymmetry' [or] market, buyers, sellers
3	symmetry is good [or] asymmetry is bad
4	(a)symmetry **affects** quality of goods (/cars/lemons) [or] quality of information
5	Asymmetry results in a market where no **trades occur**

Figure 3.3: Preview of grading rubric

Results (Overall)

Multivariate analysis of variance, with and without Ender
Higher average values for main argument, percentage understanding, and questions 4 & 5 (details)
Significance found for percentage understanding and question 4 (2.5% and 24% increase, respectively)

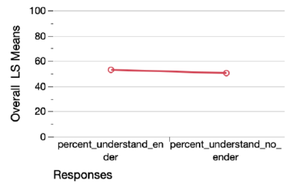

Figure 4.1: Average reported percent understanding, weighed by num tool uses

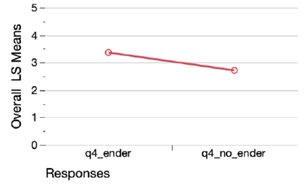

Figure 4.4: Average scores on question 4, weighed by num tool uses

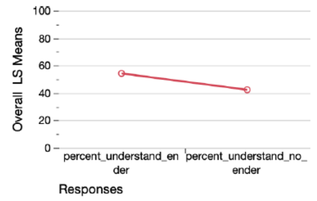

Figure 4.7: Pct understanding for those with no experience

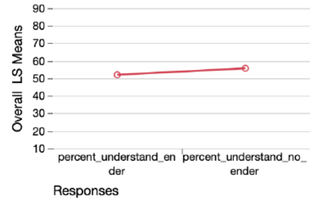

Figure 4.8: Pct understanding for those with some experience

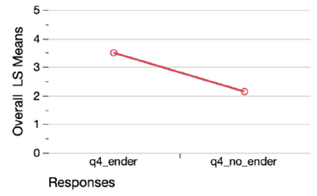

Figure 4.9: Q4 scores for those with no experience

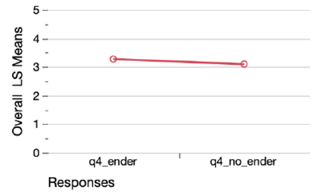

Figure 4.10: Q4 scores for those with some experience

Results (By Exp)

When grouping responses by previous experience (none vs. some; with 18 and 28 people respectively), steeper increases were found for those with no outside experience reading mathematically-heavy text (12% increase for understanding, 38% increase for equation recall, both significant at the 5% level). Results for participants with prior experience showed either an insignificant minimal increase or slight decrease when grouped.

Conclusion & Next Steps

Ender was created as a crutch for working memory, in hopes of improving understanding of mathematical text. Although no relationship was found in overall and bigger-picture comprehension, self-reported understanding of the text and detailed understanding of equations were improved through the usage of the tool, especially for participants with little background in similar text.

For next steps, there exists a tradeoff between time and understanding when using the tool; automating this process through NLP may increase efficiency and overall performance. This tool can also be analyzed outside of an economics and university context, such as in reviewing academic journals, or in English literature when many characters are introduced.