Content Mapping

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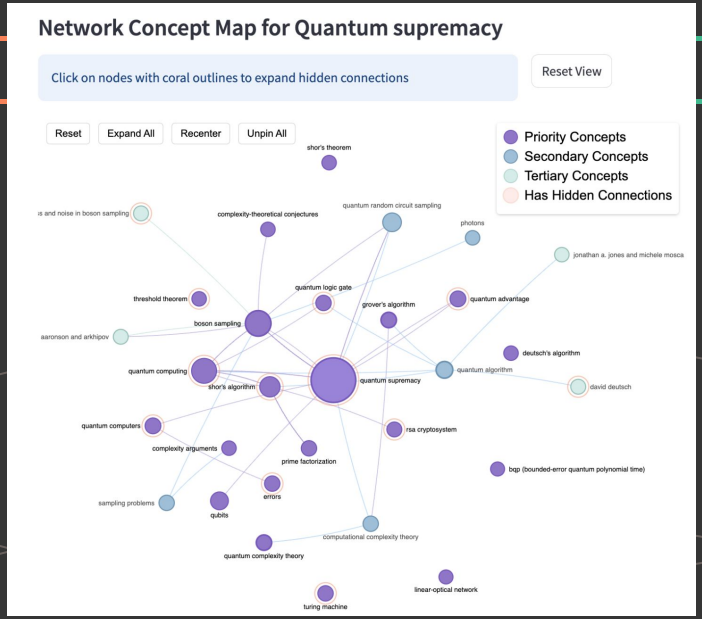
Contents

Introduction

The problem the paper and authors want to solve is **cognitive load**, especially within academic contexts, and helping out people who have ADHD or other cognitive varieties that make them process things differently.

And so the solution they try is with **cognitive mapping** which is a more visual approach to portray information, compared to traditional linear reading with massive blocks of text.



https://simplified-cognitext.streamlit.app

Research Questions

1. How effectively can **LLMs identify key-concepts** across different diverse academic disciplines without domain specific training?

2. What **differences** exist in the extraction and representation of knowledge relationships **across different academic disciplines**?

3. To what extent do automatically generated concept maps **reduce cognitive load** and improve reading comprehension compared to traditional learning linear reading?

Related Papers

1	Cognitive Load in Educational Contexts	Complex text having high cognitive demand. Therefore relocating cognitive resources using visual maps which help with the thinking process.
2	Automated Concept and Relation Extraction for Education	Generative context-aware prompt-tuning method so non-experts can in educational contexts without having an expert, in specific disciplines.
3	Visualization Techniques for Knowledge Representation	Content mapping in general. Showcasing how it can indeed reduce cognitive load, and also promote more diversify thinking methods.

Cognitive Theory

1

Intrinsic Load

Task complexity.

The process power required to understand the complexity of tasks.

2

Extraneous Load

Instructional Design.

The process power required to understand what to do for said task, or instructions for it.

3

Germane Load

Learning Process.

The process power required to learn from the content.

Methodology

1

Dataset Preparation

Gathering 10 wikipedia articles from 10 different disciplines and removing HTML, reference, and label sections.

2

Text processing module

Using different process approaches to create different maps, to compare what is the best way to separate text.

- Section-Level Processing
- Paragraph-Level Processing
- Paragraph-Pruned Processing

3

Extraction Framework

Prompts that were made to extract concept and relation for comparison.

- Concept Extraction: Primary, Secondary, and Tertiary
- Relation Extraction: Local and Global

Methodology

4 **Evaluation Framework**

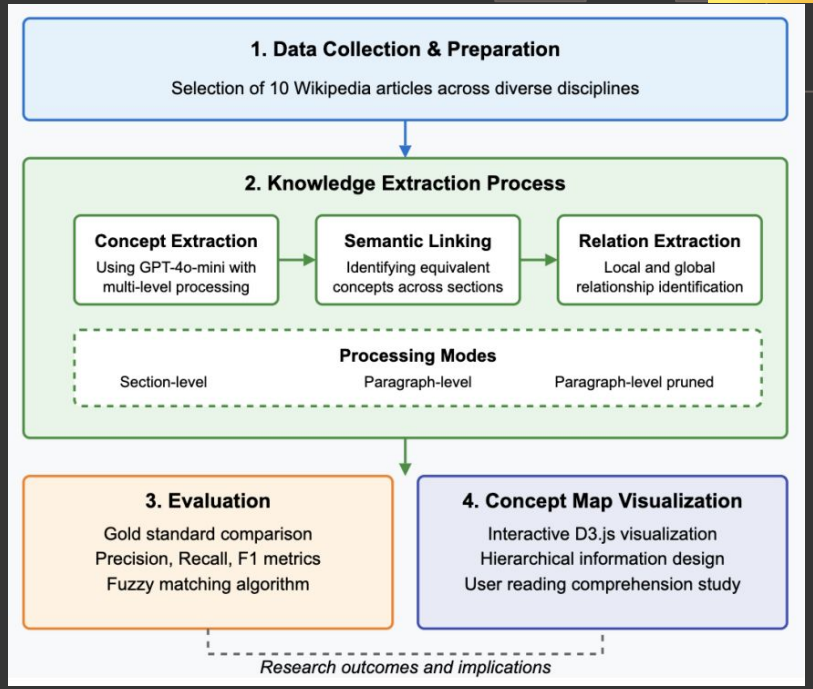
2 undergraduate annotators (from STEM and liberal arts) manually score concepts and relations on a scale.

5 **Concept Map Visualization**

Creating the actual concept maps and including navigation tools to help explore the maps.

6 **User Evaluation**

14 Undergraduates, 2 papers (linguistics and physics) and were assessed after reading papers.



Results

Extraction performance

Section level processing was the superior method for the most part, although doesn't do good when it comes to recall.

But Paragraph level processing does better in the recall side of things, and of courses means worse in terms of precision.

(Section level processing is better at finding the right key concepts, but fails to find them all, while paragraph level processing doesn't find the right ones but get get more concepts within the small perimeter of text it gets.)

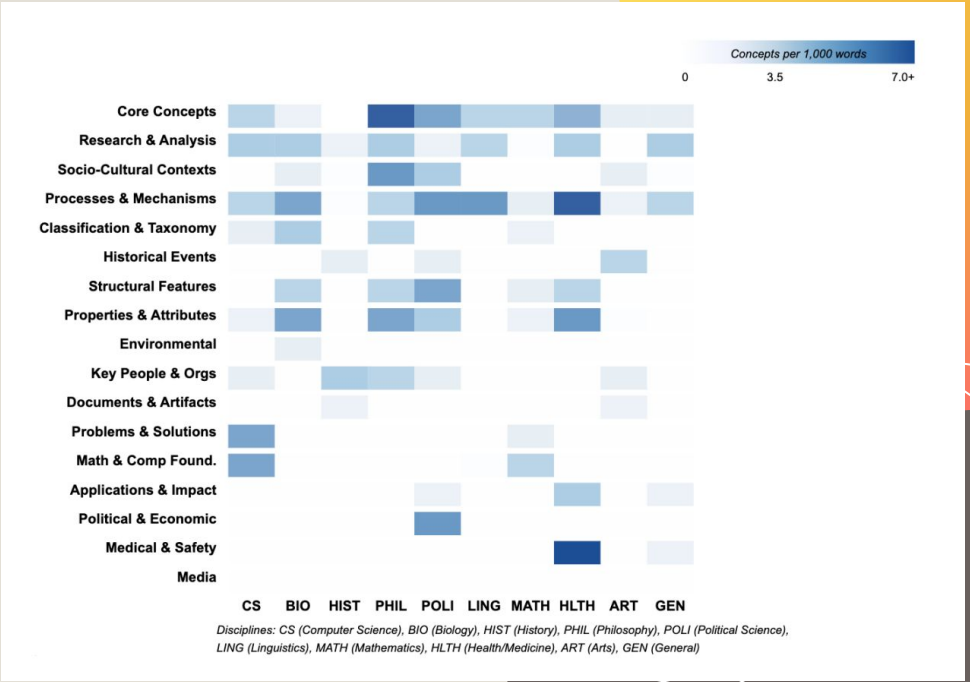
	Section-Level			Paragraph-Level			Paragraph-Pruned		
Discipline	P	R	F1	P	R	F1	P	R	F1
CS	81.53	59.40	68.72	55.71	69.41	61.81	64.89	67.54	66.19
Biology	89.86	68.17	77.52	59.92	79.62	68.38	69.10	76.75	72.72
History	85.47	65.83	74.38	62.29	81.35	70.55	71.43	75.09	73.21
Philosophy	80.63	53.70	64.46	56.42	72.13	63.31	65.51	70.25	67.80
Politics	83.92	67.15	74.61	61.93	81.63	70.43	68.19	72.76	70.40
Linguistics	82.14	49.62	61.87	50.92	62.62	56.17	60.12	63.75	61.88
Art	83.21	63.54	72.06	58.32	75.02	65.62	66.46	70.15	68.25
Math	79.13	58.37	67.18	53.94	71.62	61.53	63.18	68.83	65.88
Medicine	82.98	66.82	74.03	54.66	73.28	62.61	67.84	69.49	68.65
General	87.35	69.18	77.21	60.77	78.38	68.46	71.95	74.60	73.25
Average	83.62	62.18	71.20	57.49	74.51	64.89	66.87	70.92	68.82

Results

Concept and Relation Distribution

Shows number of concepts per 1000 words in each discipline. Showcasing the difference in how each discipline has a variety of methods on conveying concepts and relations in between.

Eg. Computer Science being a more problem solving based discipline has less concepts than say Philosophy which is really heavy in different abstract concepts.



Results

User Study Results

The overall results being...

Subjects taking ~23% more time spent on concept maps **BUT**...

Subjects also took ~14% less time on the assessment **AND** reduces cognitive load by a whole ~32%

While the assessment score is basically the same, showing that at the cost of more time, cognitive load can be reduced by a lot.

Metric	Without Tool	With Tool
Reading Time	26.5 min	32.5 min
Assessment Time	21.3 min	18.3 min
Mental Effort	7.3	5.0
Correctness	97%	98%

Analysis and Discussion

1

Extraction Performance

The results really show how each discipline conveys their concepts, like philosophy being more conceptual, compared to the health and medicine field having a lot more procedural knowledge.

2

Concept Map effectiveness in reducing Cognitive Load

Although the subject took more time looking at said concept maps, they overall performed better with the overall same results in the assessment, and greatly accomplishing the goal of reducing cognitive load.

3

Implications for Educational Technology

These results can be used to help student or other people in order rid of cognitive fatigue or to learn more effectively and thinking in more diverse ways.

And even the future possibility of catering the maps to specific disciplines as well, to be more specific and help with more advanced knowledge rather general concepts.

Additionally, with the features of navigation within the concept maps, it really does promote free exploration, and encourages people to find their own method and ways to learn, and infer their own message from the visual format while catering to their own learning style, which will greatly help people ADHD and other diverse thinking processes.

Conclusions and Limitations

The overarching conclusion of the paper is that concept mapping can be a really effective tool at helping people reduce cognitive loads at the cost of time, and just as a general tool to help with complex academic texts.

The limitations of the experiment were mostly corpus size, only choosing a single paper per discipline really doesn't give much insight into the entire discipline.

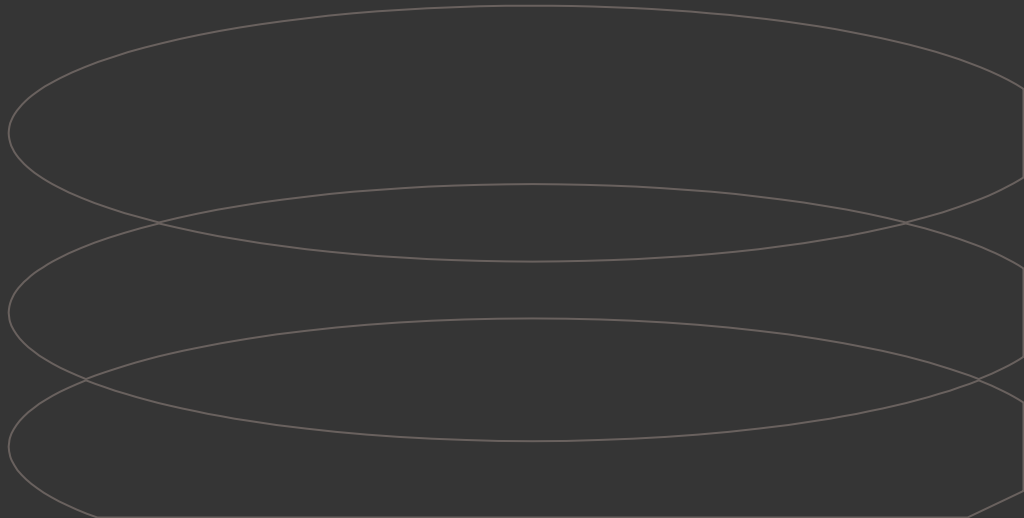
And also the annotation having been relied on 2 undergraduate student made the standards set potentially less reliable.

The technology might also having only a slight problem of not being able to convey or figure out more complex relationships like causation.

Commentary

I think this is a really cool way to cater towards people who do indeed struggle with cognitive process, especially with complex information. But I personally think that it's a complex thing, where reduce cognitive load may be good for humans now, but in the long run who knows if this will be what we rely on.

Of course it's essential for certain people, but if everyone were to 'think less' and rely on imagery too much then we may lose reading comprehension period. And so I think humanity needs to find a middle ground in between but that would be hard to find a solution for.



Questions?

Quiz

What is the purpose of the concept mapping approach?

A. To improve LLM summarization

B. To provide an alternative to linear reading and reduce cognitive load

C. To increase reading speed

D. To create new ontology for cross disciplinary-curriculum

Quiz

Who are more likely to have trouble with extraneous load? (Instructional Design)

A. Neurotypical students

B. Students with ADHD

C. STEM majors

D. Graduate researchers

Quiz

What is NOT a benefit of concept mapping?

A. Reallocating cognitive resources to a different area for more diverse thinking

B. Having clearly shown visual imagery of relationships between concepts

C. Helps people who struggle with complex text reduce cognitive load/fatigue

D. Reducing time spent reading through text

Quiz

Do you think concept mapping a reliable resource of real-use cases?