Bridging Knowledge Gaps Between Cognitive Goals Across Multiple Readings Of Academic Papers

Project Video | Project Website | Project Code

Introduction

Reading academic papers is a common, or even day-to-day, practice for most students and researchers. However, despite its common among researchers, it still remains to be a daunting task to most of them. One major reason is that academic papers are often more than just words on a page - they are packed with data, figures, tables, and statistical analyses that researchers must interpret alongside the main text. Navigating these dense, data-rich papers requires more than traditional reading skills; it demands the ability to extract key insights, synthesize information across different formats, and assess the reliability of presented evidence. Not only that, with different purposes and information they encounter during reading, readers often have to proactively switch between these tasks, which makes reading even more challenging. Additionally, the challenge doesn't end with the first reading. Researchers often need to revisit papers days, weeks, or even months later, only to struggle with recalling key insights, retracing their thought process, or relocating important sections.

In the pursuit of lowering the burden of reading academic papers, many experienced researchers have written articles and blogs sharing their suggestions on how to read papers correctly and effectively. At the same time, with thriving development across various devices, new tools keep coming up to create innovative ways for readers to consume papers.

Nevertheless, existing tools fail to compromise the readers' need, overwhelmed by the complex nature of paper, lacking a structured way for readers to keep track of their thought process and acquired knowledge. And without an effective tool to capture and organize their evolving understanding, readers may find themselves repeating work, losing track of their reasoning, or missing crucial details. To relieve these concerns, we propose the re:ad system, an all-in-one interactive reading tool that supports readers keeping track of their reading process and insights, managing different cognitive goals while reading, and organizing acquired knowledge.

Problem statement

Our formalized problem statement is as follows:

We define cognitive goals as the specific mental objectives that readers adopt to extract, interpret, and synthesize information. The dense structure of scientific papers necessitates that readers manage multiple cognitive goals. Many readers find it challenging to bridge knowledge gaps between these goals across multiple readings.

User Research

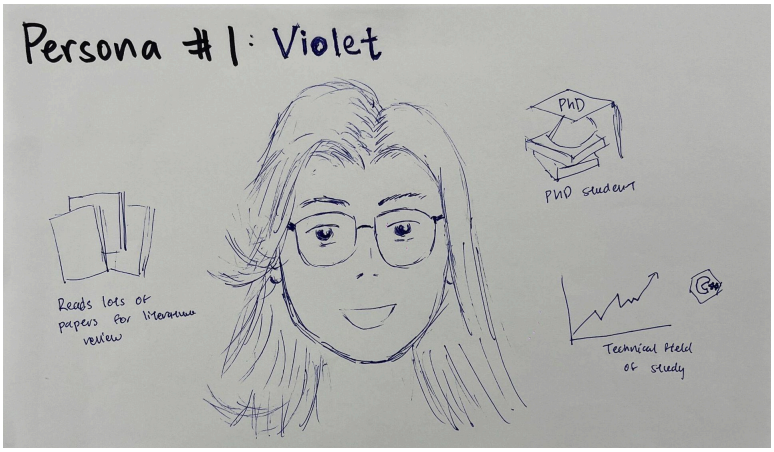
User Research Goals + Methodology

For our project, we wanted to explore the common pain points that users from different backgrounds experience when reading data-intensive academic papers. Moreover, we want to see how users approach reading an academic paper. This could involve questions such as: which sections do they focus more on? How many times do they re-read the paper? Do they read linearly or nonlinearly? What does their note-taking process look like when reading a paper (or do they take notes at all)?

Because of this, we wanted to develop an approach to user research where we are able to gain insights on how their experiences reading papers in the past, as well as observe how they approach reading an academic paper. This naturally led us to execute a hybrid approach with an interview and a think-aloud study. The interview portion will allow us to gather both structured and open-ended insights from users, and allow them to draw from their past experiences. Through closed questions, we can collect background information such as education level and research or work interests. Meanwhile, more open-ended questions will help us understand their approach to and experiences with reading academic papers better. On the other hand, the think-aloud study will provide us a firsthand look at how users interact with academic papers, allowing us to observe their reading behaviors and identify common challenges they encounter that they might not be aware of and thus mention during the interview. The think aloud study will also give us an insight on how users interact with papers already, which will help us build more intuitive interactions in our solution.

User Research Results

From our user research, we determined two main user groups to target and scenarios . The first is the more technical user, someone who tends to read a lot of papers and goes in great depth and breadth around a research subject. We represent this user with the persona, **Violet**:



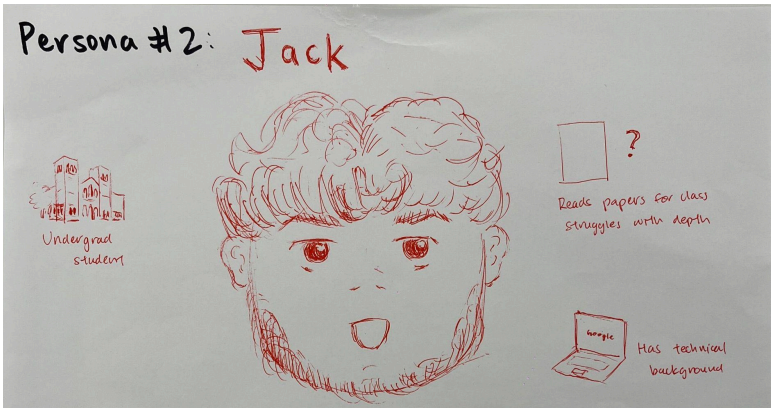
Violet is a PhD student in a data-intensive, technical field (think statistics, machine learning, and their applications). She regularly conducts literature review for both depth in her current focus as well as breadth to keep track of new contributions across her area of study, meaning she often reads multiple papers a day.

We determined that a regular scenario with which Violet would interact with papers would be as follows:

Violet is conducting literature review in a field related to her area of study, but not exactly the same. She is familiar with many of the common terms, but is unfamiliar with some of the formulas or models. As she potentially needs to read 20 or more papers within a week to complete her review, she needs to be able to quickly get up to speed and process information with papers she has only foundational-level knowledge in. To help, she reads on an iPad or a similar device that lets her highlight and make annotations on the paper so that she can cross-reference materials easier. With some papers, she merely skims them to understand their basic contributions, but for others she needs to dive more in depth. When skimming, she finds that she often misses info that would help understand contributions requiring a few passes through papers, and when diving deeper, she often has to manually parse referenced papers or check data analysis on her own. When diving deeper, she tends to read more linearly as she cares to be very thorough in those cases, but she wishes for a more efficient way to take in all this information without as much manual effort.

We found that technical users like Violet would benefit from a tool that is able to quickly pull context from relevant papers she's reading, or provide links between important concepts or contributions of a paper. In this scenario, this would significantly help in improving the efficiency of her research and literature review.

Our second persona represents the less technical reader, who has interest in papers whether for class or personally and is able to understand them at a high level, but being less technical may struggle with the level of depth or breadth of a user like Violet. We represent this user with the persona, **Jack**:



Jack is an undergrad student in a technical field who is required to read papers for several of his upper division classes. He has read papers intermittently in the past, and while he has some technical knowledge, he struggles to follow some papers which go into great technical depth. For the purpose of his classes, understanding them at a high level via their general contributions and results suffice.

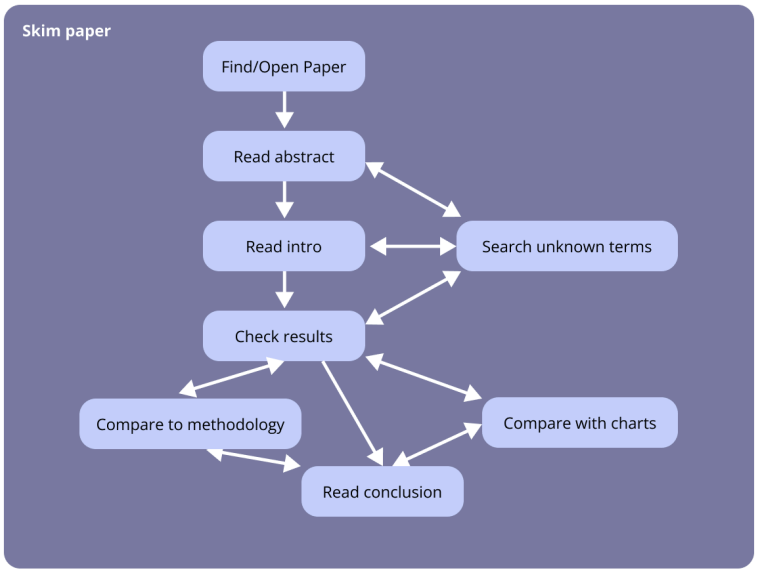
We determined that a regular scenario with which Violet would interact with papers would be as follows:

Jack is reading a new assigned paper for his class. The paper is about some novel machine learning methods and goes into great depth in its mathematical and algorithmic foundations, as well as the data used in its experimentation. As a result, there are many complex formulas and a variety of diagrams comparing the novel model to existing baselines. Jack is familiar with some but not all the baselines, and while he has a foundational understanding of machine learning, he is unfamiliar with some of the more complex optimization techniques used in the paper. He skims most of the methodology and focuses most of his time on the results, discussions, and conclusion portion of the paper to get a sense of its contributions. As a result, he often jumps back and forth between sections of paper, reading in an erratic manner and constantly searching up terms and things he's unfamiliar with. He wishes that he didn't have to switch his focus from reading to searching as often as it makes it difficult to gather a clear understanding of papers.

In this scenario, a tool that is able to pull in context and provide it on hover or with just singular clicks would be extremely helpful, as this would prevent the need for him to search for things on his own, interrupting his flow through the paper. Additionally, similar to Violet's scenario, any tool which can link together significant contributions within a paper would also help Jack streamline his otherwise erratic reading.

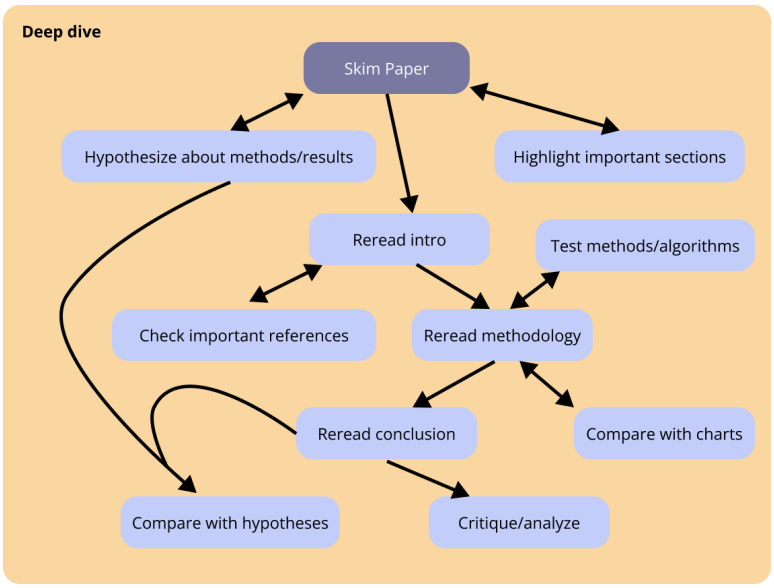
These two scenarios provide insight into our process maps, which are inspired by the reading habits of our two personas.

Our first process map describes how one skims a paper:



Violet may be checking this paper out because it's referenced in a paper she's doing a deep dive on, or it has a new contribution she's never heard of, and wants to check if it is relevant to her research. Jack may be checking this paper out because it's been assigned for class, or it was related to a paper he was assigned for class and he wants more background knowledge.

Our second process map describes a more thorough deep dive, which can involve an initial skim that involves additional steps:



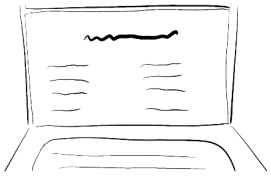
Violet likely needs to do this several times over the course of a literature review and thus would like to do them as efficiently as possible. Jack may do this for a deep critique of a paper and an attempt to broaden his knowledge. We found that users may often read and reread papers multiple times with different intentions and goals - i.e., sometimes they read just to skim,

sometimes they're diving deep for greater depth, sometimes they're focusing on the methodology in order to better understand implementation details, etc.

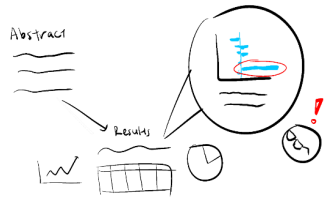
Design Goals

When it came to designing a system to address the pain points of our personas and their scenarios, we had a few key goals in mind initially. We wanted to create an interface that improved the reading experience by organizing one's notes, thoughts, and annotations in a more effective and robust way than existing methods, while also providing visualizations to help users extract and maintain knowledge from complex papers to minimize the number of rereads and thus increase one's ability and efficiency when it comes to reading papers. We also wanted our tool to have the ability to meaningfully separate users' different reads and intentions. Finally, we wanted our tool to be helpful for both of our personas and thus across different levels of technicality. We anticipated a workflow based on the following storyboard:

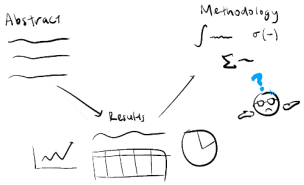
User begins searching for papers


User begins reading the paper they've found

User reads abstract/intro, highlights key terms, and forms hypotheses about the text

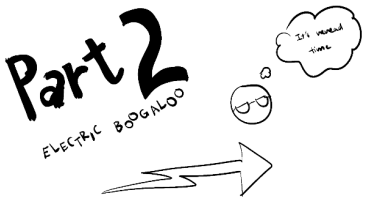


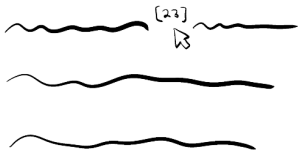
User reads results/methodology, finds points of interest



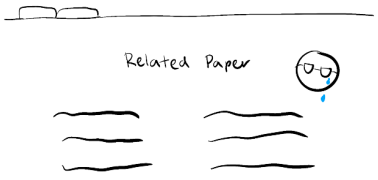
User reads results/conclusion, has difficulty interpreting all the details

User's attempts to understand the paper on first read leads to confusion

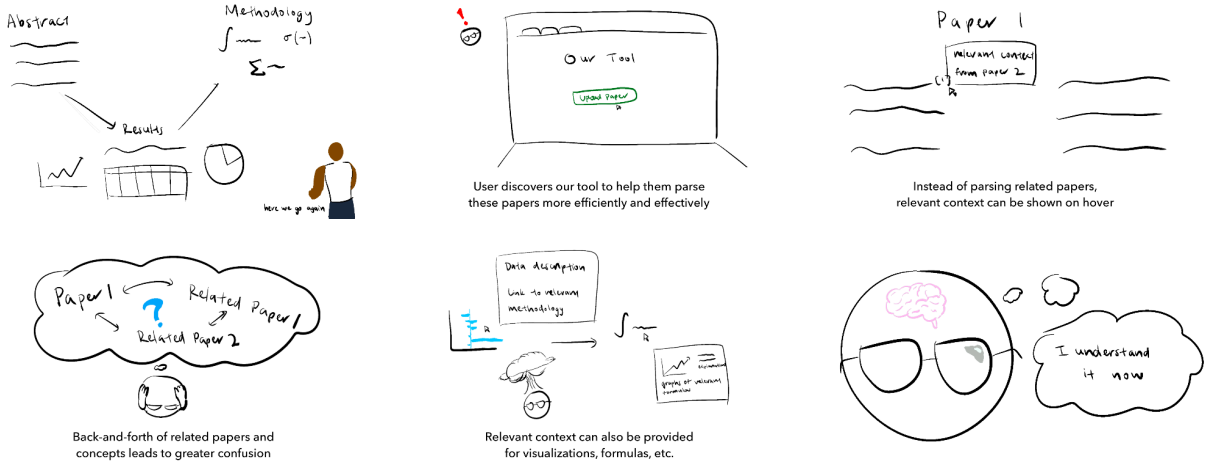




User begins rereading the paper and decides to look at a referenced paper for more context



Similar issues arise with the new paper



Back-and-forth of related papers and concepts leads to greater confusion

User discovers our tool to help them parse these papers more efficiently and effectively

Relevant context can also be provided for visualizations, formulas, etc.

Instead of parsing related papers, relevant context can be shown on hover

We determined that the tool to address these pain points for our potential users would consist of three main components. We would have one portion of the paper where users can make highlights as they would in any other annotation software. Novelly, these highlights would then create nodes on a graph that are automatically linked chronologically to help users keep track of where in the paper they've been focused on as they read along. Each node would also have the ability to be linked manually to other nodes and have additional information added to it, such as notes, or generated summaries/definitions of terms from the highlighted sections of the paper. These generated summaries and note-taking capabilities were features that we found to be universally applicable across levels of readers. One can also create multiple reads, denoted by separate highlight colors, for their multiple passes or intentions. This graph and highlight system would directly address our goal of developing a visualization technique that enhances the reading of a paper, providing users with a way to quickly connect information they gather in their reading while also retaining this information for future reference and bridging gaps in knowledge across different passes across the paper.

Crit Results

After partaking in the in class Crit, we found 3 critical points of feedback to address in our design.

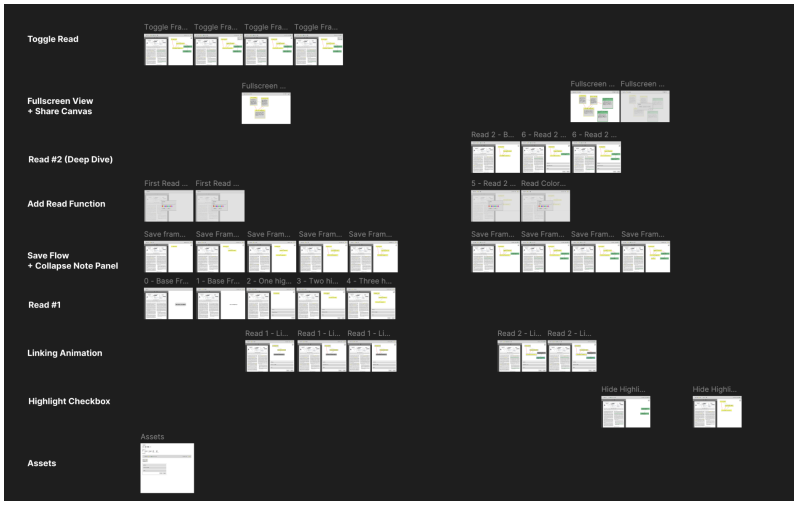
1. Add support to name nodes instead of just using the highlighted text so nodes are more distinguishable.
2. Clarify what is the purpose of adding reading intentions and what each highlight color represents.
3. Establish a justification for adding temporal links. Consider adding links based on the content's position in the paper instead of the time it was highlighted.

System Design & Implementation

Initial Prototype

When developing a prototype of our system, we took into consideration feedback from the Crit as we developed our lo-fi designs using Figma. We made sure to include aspects from the Crit feedback, such as editable labels for nodes, and clear labeling of the highlight color tools as being “reads.” In our final deployed prototype, we also included a tutorial in order to help users understand the purposes behind these features more directly.

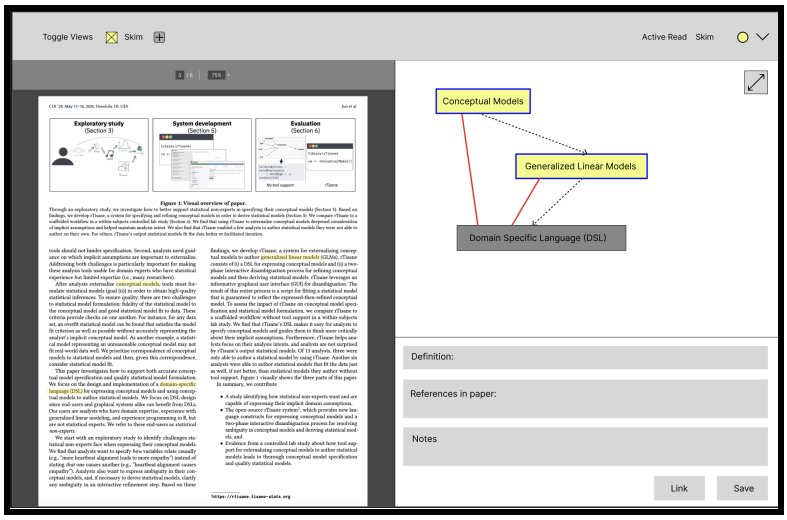
We first iterated on our main flows and user interface using Figma, where we were able to quickly prototype our interface.



As seen in the figure above, we utilized Figma’s prototyping feature to visualize the different flows our users will go through using re:ad such as: toggling between different reads, adding a new read, linking nodes, and many more. From this prototype, we were able to see what was possible and not possible, as well as receiving feedback from our classmates on what we could improve on.

System Design

We then took this prototype, as well as the advice we received from crit, and moved to development. Our stack mainly consisted of React + Typescript, with other libraries that allowed us to develop the features that we wanted to implement. Here is a link to our GitHub. Since our main user interface consisted of three main panels as shown below in our Figma prototype, we broke down our frontend into three main components:



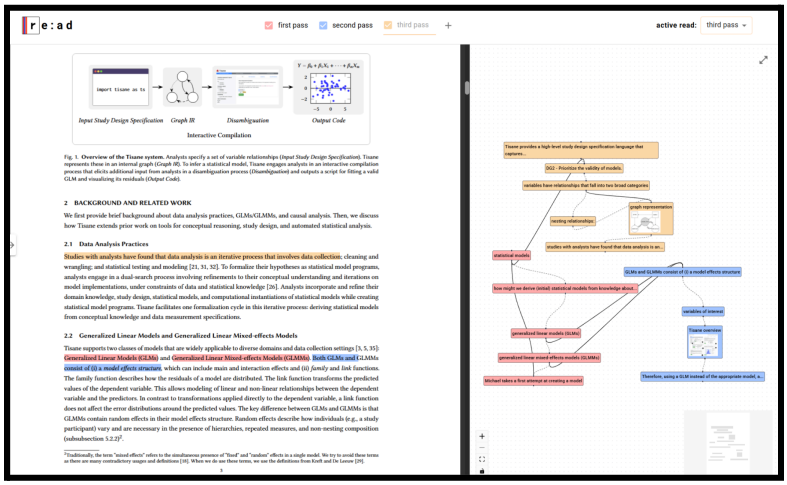
In each of these three main components, we implemented different features such as:

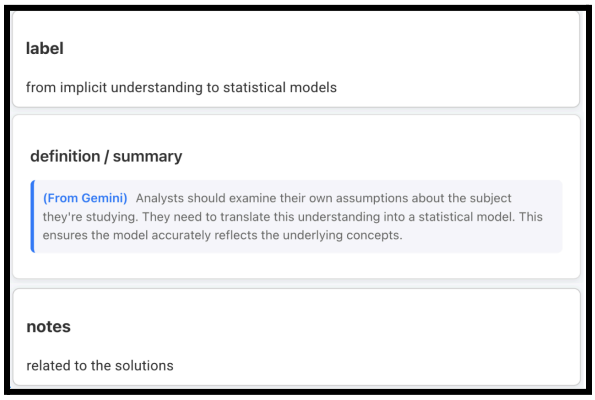
1. `graph-component`
    a. **Highlight Node**: the node variant that is shown to users when highlighting, a more concise view, where users are able to see only the text they have highlighted or label they have attached
    b. **Overview Node**: the node variant that is more comprehensive, shown to users when they are in fullscreen mode, shows their notes taken for that node as well
    c. **Relation Edge:** the edge variant for user-defined links, users will be able to link different nodes, even across different reads, using this edge variant
    d. **Temporal Edge:** the edge variant that is auto-generated between consecutive highlights, allows users to keep track of their chronological flow of highlights.
2. `node-components`
    a. **Node Editor:** the panel where users are able to take notes on each highlight, as well as connecting Gemini API to provide users with AI-assisted definitions and explanations on the content they have highlighted.
3. `paper-components`
    a. **PDF viewer + highlighter:** we utilized **react-pdf-highlighter-extended** to allow us to load a pdf, allow users to view it, as well as make highlights and screenshots that are superimposed on top of the PDF, as well as providing us with a callback function to create a node upon a highlight
4. `nav bar`
    a. The nav bar plays an integral role in our functionality, as users are able to create new reads, switch between different reads to become their active read, as well as select/deselect reads to filter out certain highlights from both the paper panel as well as the graph panel.

We also implemented improvements from the advice that we obtained from crit.

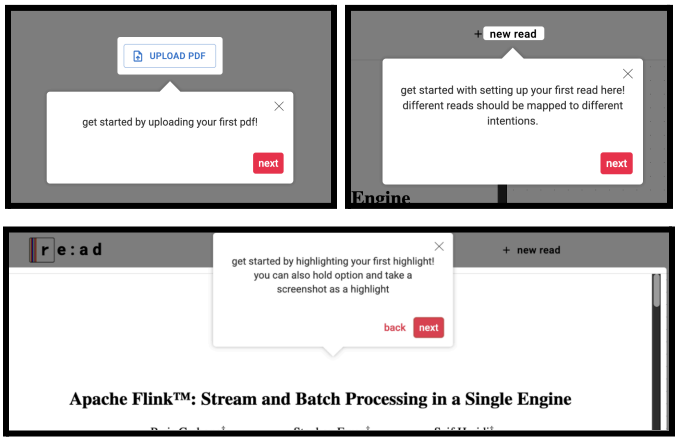
1. **Deleting Nodes + Highlights:** Our initial prototype did not consider the flow for deleting a node/highlight, and users that we interviewed expressed the need for this functionality. Thus, in our development, we ensured that this feature is implemented. Now, users are able to delete nodes within the editor panel. This will remove the node, the highlight, as well as all edges (both temporal and user-defined) that are attached to the node
2. **More intuitive linking mechanism:** In our initial prototype, to link nodes with user-defined nodes, users had to go in that node's editor panel, and click a link button, which will then prompt them to click other nodes that they want to link to. The feedback we received prompted us that this mechanism was not intuitive enough, and not natural. Thus, to improve on this, we thought about what users would be most naturally used to, and drawing from our experience creating mind-maps, we decided to allow users to establish links by dragging their cursor from one node to another.

Thus, this is how our final system looks, where the first figure includes our paper viewer/highlighter panel, as well as the graph panel. Furthermore, the second figure illustrates what our node editor panel looks like, where users are able to take notes, as well as view the AI-assisted definitions and explanations.





Moreover, from our first iteration of the development, we noticed that our system had a lot of features that are hidden, or not apparent to a user using re:ad for the first time. For example, users are able to take screenshots as highlights for figures and charts, and to do this, users would have to hold the option key while dragging the screenshot area. Thus, we decided to iterate on our development, and include a guided walkthrough for first-time users, showing them the main functionalities of our tool. We utilized **react-joyride** to guide users through the main interactions of our tool as shown below:



Difficulties

Through development, we faced challenges that limited us from implementing all the functionalities that we outlined in our initial Figma prototype. Moving forward, here are the two features we would want to implement:

1. **References:** This feature would have allowed users to jump to different sections in the paper where the phrase/word they highlighted appears. This could've helped make the reading experience less scattered, and allowed users to follow the common ideas being expressed in the paper more smoothly.
2. **Save, Export, Share:** We wanted our framework to allow users to save their graph for future reference as a PDF or image, which they can also share to their peers. We thought it would be interesting for users to be able to use this tool to not only take notes for themselves, but use it as a community where they can share their notes, as well as view other people's notes on the same paper.

Evaluation & Findings

Protocol Motivation

From our motivating questions which were:

1. How does our interface enable users to capture and externalize their cognitive goals while reading data-intensive scientific papers?
2. What is the efficacy of our interface in bridging different cognitive goals across multiple reading sessions? Further, do users use the multiple reads feature through its intended purpose, or do they use their own approach?

We wanted to capture how users are able to grasp their distinct cognitive goals, while assessing their ability to bridge knowledge between these goals while using our tool. This led us to frame our evaluation with the intent to see how users can utilize read to achieve these two goals, but keep it as open-ended as possible, to gauge how different users are able to utilize the multiple reads feature with different approaches.

For our evaluation, we want to see how users directly interact with the tool, observe how it helps them read and understand papers, as well as identify common pain points they feel. Because of this, we are doing a similar approach that we used in our initial user-research, where we use a hybrid of interview and think-aloud study. To fully understand the potential flaws in our system, when introducing our tool, we will be only providing a high-level description of what the tool is, and exclude any specific explanations on how to interact with the tool. We will also emphasize that there is no right or wrong answer, and they should feel free to interact with the tool in a way if they were using this for the first time.

In terms of the logistics of the study, we will be contacting individuals similar in profile to those we reached out to during our initial user research. The intended users of our tool remain individuals who engage with research papers in their work or academics, regardless of their experience level, or how often they interact with papers. We will be doing evaluations either over Zoom or in-person, depending on the user's availability. We will be taking notes during the think-aloud study, as well as gather insights during the interview at the end. Lastly, we will also be informing participants of the data collected and obtaining their consent when we request for their participation in the evaluation.

When providing feedback, our instructor emphasized the importance of testing the feature of distinguishing multiple cognitive goals through differing highlight colors. To incorporate this feedback, we utilized a two-pass evaluation protocol which will be explained in the next section.

Our Protocol

In the initial phase, which is the think-aloud, we will be giving them a paper which they will have to upload onto re:ad, and use re:ad to highlight, take notes, and separate their highlights based on their intentions. Through this process, we will be focusing on the following:

1. How often participants highlight (extensively vs. selectively).
2. What types of information they highlight (definitions, key ideas, statistics, etc.).
3. Whether they take notes in addition to highlighting.

4. Whether they make links between highlights.

After the think-aloud, we will be asking follow up questions in our interview that cover three main insights we want to uncover. We outline the categories below, as well as sample questions for each category:

1. Understanding Highlighting Behavior
    a. “Can you walk me through what you highlighted and why?”
    b. “Did you take notes on any of your highlights? If so, what kind?”

2. Evaluating Multi-Read Feature
    a. “Did you go back and re-read any part of the passage or your highlights?”
    b. “Did your reading goal change between different parts of the session?”

3. Recall and Understanding
    a. “Did your highlights help you recall more insights?”
    b. “Would you have made the same connections without the tool?”

Finally, we will also ask them to explain the key insights they have extracted when reading the paper, and through this response we aim to see how much the tool has helped them understand the key concepts outlined in the paper.

Overview of Evaluation Participants

We conducted our evaluation protocol with eleven participants ranging from undergraduates, master’s students, and PhD students. This enabled us to capture both of our personas (Jack and Violet) by including a wide range of paper-reading experience levels.

Qualitative Results

From our interview notes, we decided to perform a thematic analysis to capture the main, common points that many users were experiencing when using re:ad. After sifting through the notes, we arrived at the following codebook. We have broken down the analysis into the general, broad theme, sub-themes, description about the specified sub-theme, as well as supporting quotes from our interviewees to support each sub-theme.

Theme	**Sub-theme**	**Description**	**Supporting Quotes**
Reading Process	Separation of Concern/Intent	Being able to separate and compartmentalize different intentions when reading a paper	*“I think this separation of concern (i.e., read feature) makes me focus on a specific goal when reading, which helps me organize the highlight content and knowledge. “*
	Visual Aid (Color)	Using different colors for	*“The color encoding also helps me identify*

		nodes to separate different topics/intent	*different "reads" and make it visually appealing."*
	Focus	An increased level of concentration when reading the paper	*"During the second read, because of this prompt I was honing in much more on the exact methods the authors were going to propose to test their hypotheses."*
Challenges Faced in User Interaction	Difficult Connection	Hard to interact with UI to establish connections between nodes	*"Hard to make connection and move nodes"* *"context connections were also difficult to make"* *"Connecting was a bit challenging, since the area to establish a connection is very small and felt like the mouse needed to be at the exact right spot for it to start a connection"*
	Ambiguous Commands	Some commands were hidden from the user (specifically the ability to screenshot parts of the paper using the option key)	*"It was not clear how to screenshot, and mentioning this earlier to the user could be helpful as the diagrams were present in the paper"*
	Graph interface	Some elements of the graph interface was hard to interact with	*"graph interface was difficult to use - text size too small, unable to move nodes around"*
Intention in Multiple Reads	Keyword Highlighting	When users use highlights to highlight important keywords and terms and take note of their definition	*"Labelled first read as "Key words and Definitions" and used this read to initially highlight all words that seemed like key terms* *Used gemini generated summary to help them take notes on each node and said it gave them good understanding of the main ideas"*
	Purpose	Highlighting the paper's intent and emphasizing why we are doing what we are doing	*"After this, I went and created a new read / "highlight category" to highlight any parts of the paper that show the purpose behind this paper"*
	Methodology	Highlighting the paper's methodology and approach to the study	*"focusing on just methodology passages"*
	General	Highlighting anything that looks important – key ideas, questions	*"Used a more general approach, where they were highlighting anything that might have been important (words, phrases, sentences)"*

From the thematic analysis, we were able to compartmentalize our findings into four categories. This breakdown emphasizes user feedback on a reading interface, user's reading processes, UI challenges, and how different users treat different reading intentions.

Users told us that separating reading intents helped improve focus and organization, as their reads feel more targeted and systematic. They are now able to iteratively build an understanding on the paper by segmenting their thought process into different intentions. In terms of interactions, the color-coded visual aids enhanced readability. However, UI challenges emerged when users struggled to connect and move nodes due to the small size of draggable area, as well as facing unclear commands (such as the hidden screenshot functionality, where users can hold option and drag to take a screenshot as a highlight), and experiencing difficulties with the graph interface due to small text size.

Regarding reading intentions, users adopted different strategies when breaking down their intentions. Readers had different intentions such as keyword highlighting for definitions, emphasizing the paper's purpose, focusing on methodology, or generally marking important information.

Quantitative Results

The quantitative evaluation of our system aimed to capture numerical data that reflects the methods in which participants used our system. We initially struggled to establish this quantitative framework given the organic and irregular nature of the reading and notetaking process. Ultimately, we decided to focus on what we believe to be the two essential features of our system: highlights and connections.

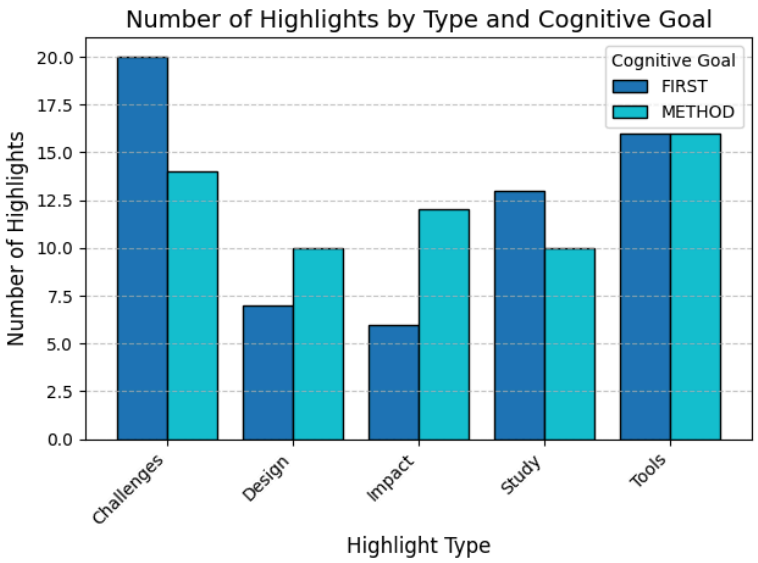
To capture highlights and connections, we created a dataset from our eleven evaluation participants. This consisted of 124 entries (one for each highlight) with the following schema:

- user: The user who made the highlight.
- highlight: The text snippet selected by the user.
- cognitiveGoal: During our evaluation, we asked users to make a first pass and then another pass to discern the paper's methodology. These are the two cognitive goals present in the dataset.
- cognitiveGoalIndex: A numerical index that maps the highlight temporally within a single cognitive goal.
- unit: The length of the highlight.
- type: The category of the highlight, aligned with one of five predefined themes: Challenges, Study, Design, Tools, or Impact.
- connections: Links between highlights that share contextual or conceptual relationships.

It is necessary to discuss the 'type' field in greater depth. For each data point, we classified the 'type' based on the highlight's content into one of five categories:

- Challenges: This category covers usability challenges in tool design, such as making the specification process easier and guiding users on important implicit assumptions.
- Study: This category includes findings from exploratory studies.
- Design: This category covers principles, methodologies, and frameworks for structuring conceptual models and translating them into statistical models, as covered by the paper.
- Tools: This category refers to discussion about software, languages, and frameworks that the paper discusses to support conceptual modeling, statistical modeling, and data analysis.
- Impact: This category includes content on the effects of rTisane on analysts' ability to create accurate conceptual and statistical models.

From this dataset, we created the following chart showing the number of highlights made for each 'type,' divided by each cognitive goal:



The the above figure provides some insights into how highlights are distributed across different types and how this distribution shifts between the FIRST and METHOD cognitive goals:

- Some highlight types have a relatively balanced distribution between the FIRST and METHOD cognitive goals, while others show a strong preference for one over the other.
- We see that challenges had a significant decrease in highlights during the METHOD pass, indicating users initially focus on challenges, but then less so during later reads.
- We also see that design and impact highlights were focused on more heavily during the METHOD cognitive goal.
- **Even though participants only read the introduction twice, each time with a different cognitive goal, the overall number highlights doesn't decrease significantly, which**

implies the density of information in the paper and how different cognitive goals lead to reader's attention on different pieces of information.

- Finally, longer passages are the most common highlight unit among both FIRST and METHOD cognitive goals.

Discussion

Key Takeaways

We derived the following key takeaways from developing and evaluating our system:

1. The density of scientific papers requires the use of multiple cognitive goals in order to understand paper content. Support for connecting multiple cognitive goals is lacking among existing tools.
2. re:ad allows users to improve focus and organization by enabling them to segment their reading process through constructive graph development.
3. Users adopted different strategies when breaking down their reading process, and the iterative nature of these processes could be modeled through our cognitive goal framework and the system's multiple read feature.

Limitations and Future Work

A primary area of limitation was our quantitative evaluation. Given the time constraints of the evaluation period, our dataset was quite limited in scope. As such, it was difficult to derive any actionable insights from our current data. We believe if we were to collect more data about highlighting type/unit distribution over multiple cognitive goals, we may be able to make our tool more opinionated. Given trends about what highlight types are common with specific cognitive goals, we may be able to alter the node editor interface to provide specific tool support based on the current cognitive goal.

One such example is as follows: When users highlight entire paragraphs, they are likely focusing on big-picture comprehension or structural organization within a document. Given the frequency/length of the highlight, we could choose whether or not to include a summary panel as opposed to a definition panel (for a single term) based on the frequency with which people highlight long passages versus single words.

We envision a more comprehensive quantitative evaluation protocol that would involve tasking users to read an entire research paper (rather than a single section) using our tool. We would ask them to perform multiple reads on the paper (without specifying the specific cognitive goals that each additional read would entail). Using the dataset schema we outlined above, this comprehensive protocol would enable us to gather more holistic data on highlight

type/frequency and to obtain organic data surrounding the types of cognitive goals users develop while using our tool.

Mistakes and Lessons Learned

Through the iterative design process, we received feedback and reflected upon our decisions following each major phase of development.

After the initial user research phase, we realized we had only explored our problem partially. In a sense, our user research initially concluded on the expanding portion of the first diamond in the double diamond analogy presented in class. While our interviews provided us with insight into the paper reading process itself, we needed to develop more detailed personas. This was critical since our proposed idea involved the tracking of changes to cognitive goals throughout the reading process, yet we lacked data regarding possible cognitive goals that exist. We resolve this by conducting another round of user research through a survey. From this, we managed to obtain a larger sample size of paper readers to get a better sense of the varieties of backgrounds and cognitive goals that we could focus on.

After the first in-class crit, we realized that our problem statement was too vague. The audience found it difficult to understand why we kept on repeating terms such as “reading intention” and what this really meant in the context of our proposed system. From this, we learned that specificity is essential in developing a problem statement. Creating an ecosystem of nomenclature (such as “cognitive goals”) and defining exactly what each term means was critical in enabling us to communicate our intent and results with greater direction during the final presentation and showcase.

After the evaluation, we realized the importance of time in developing rigorous systems. Particularly when performing a quantitative analysis of the evaluation results, we felt that the open-ended nature of our tool coupled with the time constraints of the evaluation period meant that we were not able to identify any real trends within the data we collected. In the end, our quantitative study was more of a proof of concept for what we might have been able to do with a more comprehensive evaluation protocol and more time to carry out this protocol.

About the Project

re:ad was developed by Brian Roysar, Michael Shi, Ollie Pai, and Yuwei Xiao for the Winter 2025 offering of CS 239: Introduction to Human-Computer Interaction, taught by Professor Eunice Jun. We hope to continue developing the system’s features to (1) streamline the interface and (2) provide support for exporting the knowledge graphs created using the tool. Ultimately, we envision re:ad becoming a social platform for paper readers to share their reading processes and derive insights from viewing other’s knowledge graphs.