PaperCast

Building interaction for Getting back into reading

Master Thesis

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Acknowledgement

This topic originated from the elective Graduation Launchpad, but it also comes from my own experience—I have been a book lover since I was a child. In fact, for most of my childhood, reading was my main source of joy. I believe this closeness to books and reading eventually led me to choose and dedicate myself to this topic.

It has been a great pleasure to embark on this journey of exploring reading and trying to create better reading experiences for others. But this journey was not always easy—it was my first time taking full responsibility for such a big project. Without the support and help of my mentors, friends, and family, I could not have accomplished it.

First, I want to thank my mentors: Tilman, Christina, and Alice. Tilman, you were always encouraging while also motivating me to explore and challenge myself, while also reminding me to trust myself. Christina, you gave me very concrete help and also encouraged me when I felt I wasn't doing my best. The time you took to review my work and provide thoughtful, detailed feedback was invaluable. Alice, I am really glad that you joined my project as my additional mentor. You always went out of your way to help me, showing empathy and understanding my struggles, and finding ways to support me. Together, you formed a truly special team. You were strict with the project because you wanted me to achieve my best, but you also cared deeply about me as a person, helping me feel motivated and supported. You not only helped me build confidence and trust in myself, but also cared about my career and future beyond this project. I feel very lucky to have had you as my mentors.

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Finally, I want to thank my parents, Yun and Fang. Without their support, I would not have had the opportunity to explore this path. Even though we are far apart, they have always encouraged me and believed in me. I am especially grateful that they continued to support me even when sometimes my choices did not align with their expectations. From the bottom of my heart, I thank them—I couldn't thank them more.

Executive Summary

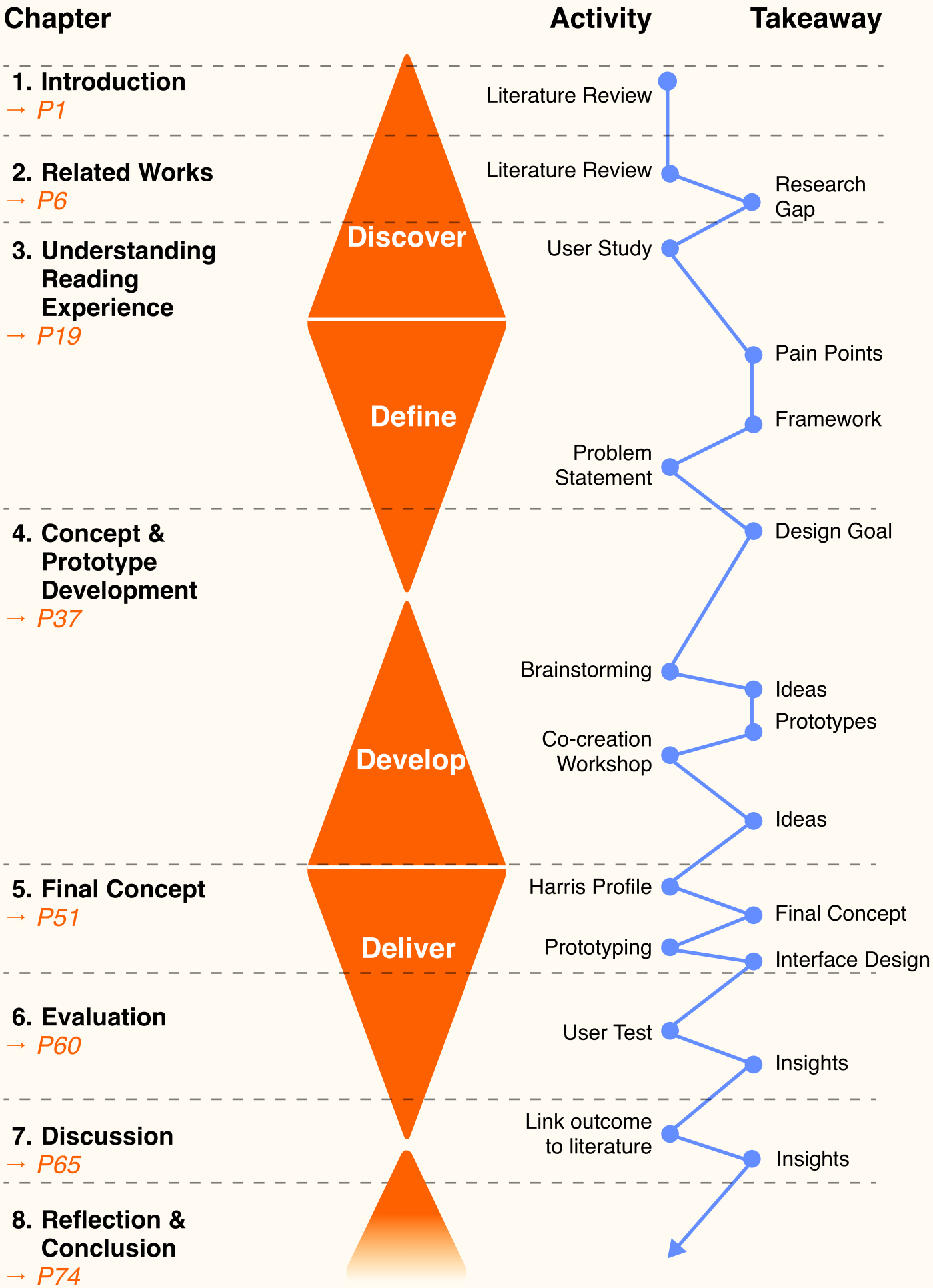
Context
Long-form reading fosters comprehension, critical thinking, and empathy but demands sustained attention, making interruptions both common and disruptive. These breaks hinder understanding, delay progress, and diminish the reading experience. While existing work has sought to reduce such effects, advances in AI open opportunities for personalized, dynamic support. Yet, research remains sparse, with only early evidence suggesting AI's promise and reader acceptance.

Project approach
This gap motivates the central research question of this project: **"How can we design interactions that leverage AI to better support readers in managing interruptions during long-form reading?"** The question was grounded in a literature review across four domains: long-form reading, interruptions, reading support, and AI as a design material. To explore it, I adopted a user-centred design approach within the Double Diamond framework, integrating co-design methods. I conducted a diary study, a co-creation workshop, and a user test—altogether following a design research approach.

Outcomes
1. **Design outcome:** I developed a high-fidelity prototype based on the final concept-PaperCast. The user test showed that AI-generated podcasts, as an engaging and dynamic interaction, can increase motivation and help readers re-enter and sustain engagement in scientific paper reading. However, trustworthiness is crucial in this context-scientific paper reading. AI-generated content must remain traceable to the original text without overwhelming the user, striking a balance between accessibility and information overload. The interactivity of the podcast also creates a active-reading experience instead of passive reading.
2. **Process contribution:** The project demonstrated how AI's uncertainty, generative ability, and adaptability can be treated as a design material. The final interaction form emerged from the co-creation workshop, while user needs identified in the diary study and co-creation were translated into interface constraints and guidance. These ensured that AI's dynamic outputs remained consistent, predictable, and controllable, shaping a reliable user experience.
3. **Research insights:** From the diary study, I identified key pain points of long-form reading interruptions and developed a framework linking reading experience and interruption dynamics. This provides a foundation for understanding the challenges of resumption in complex reading tasks.

Future work
Building on this project, future work should focus on refining and iterating the current design, followed by a more comprehensive evaluation to validate the insights. Such evaluation could also examine how interactive, AI-generated content impacts task performance—particularly reading comprehension. Beyond this, the design could be explored across other user groups, modalities, and domains to assess its broader potential. Finally, further research is needed on how AI not only shapes interactions but also influences the design process itself and the role of the designer.

Reading Guide



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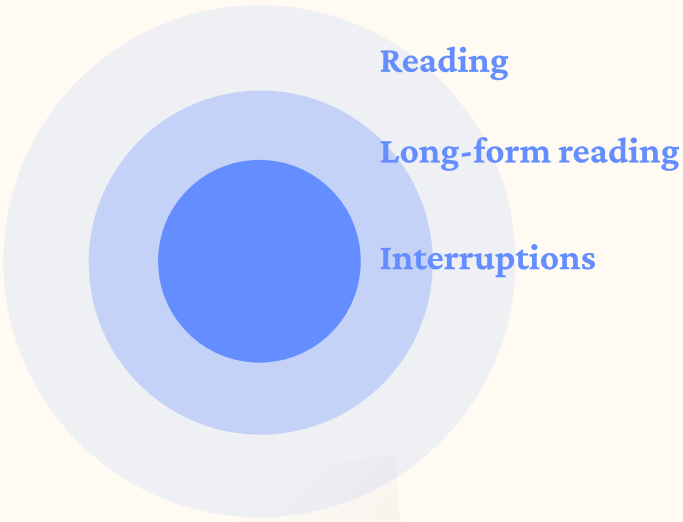
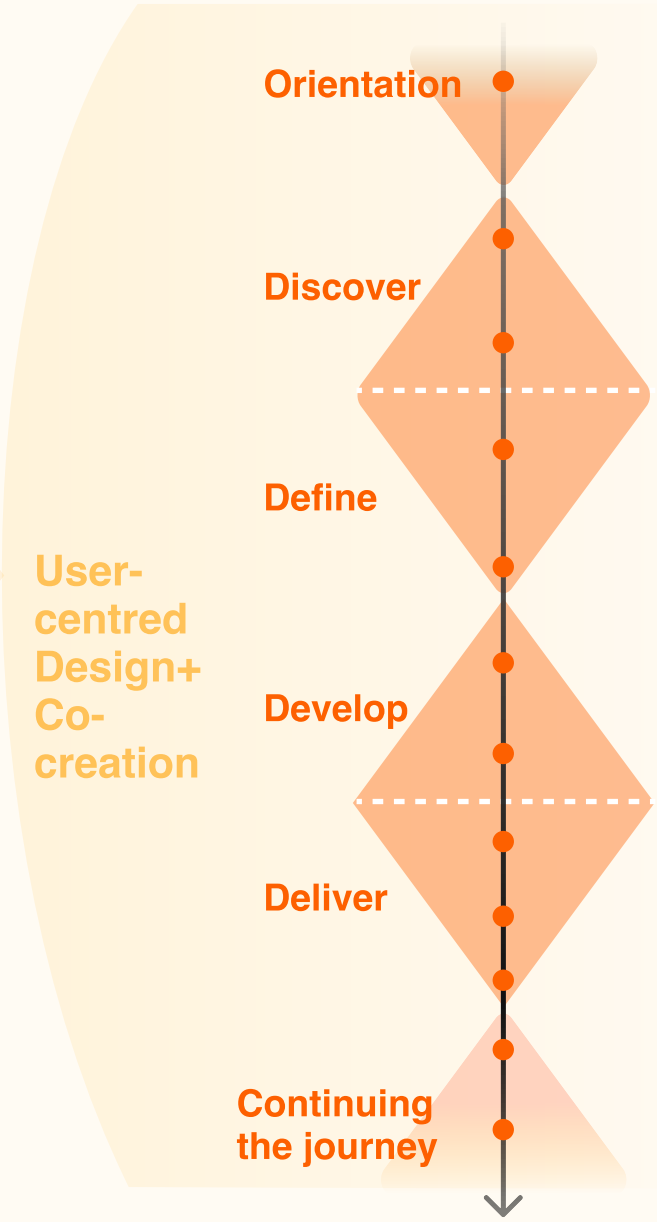
1 Introduction

This chapter introduces the broader context of long-form reading and the specific challenges posed by interruptions. It then demonstrates the central research question and outlines how I addressed it through a user-centred, co-creative design process. In the end, it also presents the project's main contributions and innovations.



"How can we design interactions that leverage AI to better support readers in managing interruptions during long-form reading?"



1.1 Broader Context

Reading is a complex cognitive activity that offers wide-ranging benefits. Among its forms, long-form reading plays a key role in developing reading skills, enhancing comprehension, and fostering cognitive progress.

Reading has been defined as “the process of taking in the sense or meaning of symbols, often specifically those of a written language, by means of sight or touch” (Merriam-Webster, 2023). It is also a complex cognitive activity involving word recognition, language comprehension, and active self-regulation (Duke & Cartwright, 2021). Beyond being a fundamental life skill (Jerrim & Moss, 2018), reading offers many benefits: It can bring pleasure (Krashen, 2004, p. 28), support cognitive development (Sullivan & Brown, 2015), contribute to mental health and well-being (Gallagher, 2019), and even reshape our ways of thinking and the trajectories of our lives (Wolf, 2018).

Texts come in various lengths, from haiku and tweets to academic papers and triple-decker novels. Among these, reading long-form content—such as novels, academic literature, and historical works—is especially important for cultivating reading skills, enhancing comprehension, and fostering cognitive progress.

First, long-form reading helps to **develop reading skills** and **improve comprehension**. Reading requires the use of working memory to recognize words and understand language, but our working memory capacity is limited. By increasing the speed of word recognition and the efficiency of language comprehension, less working memory is used for perceptual decoding, leaving more capacity for understanding the meaning of the content (Willingham, 2017, pp. 57–59). Given that long-form texts often contain rich vocabulary and complex syntax structure, they can effectively train perceptual and linguistic abilities such as verbal reasoning, phonological awareness, and theory of mind (Duke & Cartwright, 2021). These improvements lead to a deeper understanding of the content. Empirical evidence supports this: for example, Jerrim and Moss (2018) found that teenagers who read fiction have significantly stronger reading skills than those who read little or none. Other studies also show that book reading, regardless of genre, is linked to better reading comprehension abilities (Torppa et al., 2019).

Furthermore, long-form reading **cultivates sustained attention** and **higher-order cognition**. Such texts require sustained cognitive effort and the ability to keep track of multiple components, encouraging readers to enter a “deep reading” mode (Baron & Mangen, 2021). In this mode, readers maintain long periods of concentration, reflect on the content, and think critically—in contrast to the superficial skimming often associated with short-form contents on social media. Deep reading is believed to enhance attentional control, build empathy, perspective-taking skills and expand background knowledge. It is also shown to strengthen the analogical, inferential, and empathic connections that can nurture critical thinking skills. These skills can help readers resist manipulative or superficial information, whether in print or online (Kovač & Van Der Weel, 2018; Wolf, 2018).

In summary, long-form reading remains one of the most important ways to develop reading skills, improve comprehension, and foster empathy, critical thinking, and a deeper understanding of the world.

1.2 Specific problems

Interruptions in long-form reading harm reader’s performance and experience. While prior research has tried to address this issue, recent advances in AI bring new opportunities. However, work in this area remains limited.

Long-form reading, despite its benefits, presents **substantial cognitive challenges.** Such texts typically contain greater depth and breadth of vocabulary and exhibit higher complexity in argumentation, syntax, and grammar, which requires for sustained cognitive involvement and effort (Baron & Mangen, 2021; Kovač & Van Der Weel).These demands make long-form reading particularly vulnerable to the negative effects of interruptions.

Given the extended time and higher cognitive resources required for long-form reading, interruptions are both common and inevitable. These can be internal (e.g. readers may intentionally pause to rest when they feel mental fatigue or external (e.g., someone's message pops up on the screen)(Chevet et al., 2022).Compared to simple tasks, interruptions in complex activities such as long-form reading have a greater negative impact (Speier et al., 2003; Hirsch et al., 2022). They **disrupt reading performance and experience**, impairing deep comprehension—especially the ability to connect and synthesise information across the text(Foroughi et al., 2015). They also hinder re-engagement with the original task and introduce significant overhead that could delay the completion of the task up to 4 times (Iqbal & Bailey, 2005; Leiva et al., 2012). Beyond performance, interruptions can cause annoyance (Chevet et al., 2022), and induce stress, frustration, time pressure, and higher effort as readers try to compensate for interruptions by working faster (Mark et al., 2008).

Researchers have explored various strategies to mitigate the effects of interruptions in long-form reading. Examples include providing summaries before or after the interruption (reviews and previews)(Srivastava et al., 2021), visualising key information such as character relationships (Fujishima et al., 2024), and offering visual cues like bookmarks (Jo et al., 2015).While these methods can help, they are typically pre-defined, lacking the flexibility to adapt to diverse contexts and reader needs. This limitation, combined with the rapid progress in AI capabilities, opens new possibilities for more dynamic and personalised support.

Recent advances in **AI offer new possibilities** for supporting long-form reading. AI systems have demonstrated capabilities in enhancing comprehension through interactive summaries and visualisation (Hoque et al., 2023 ; Ye et al., 2024), encouraging critical thinking and bias awareness (Zavolokina et al., 2024), and providing sustaining engagement through interaction and personalisation (Chen et al., 2025; Chen et al., 2023). However, research on using AI to address interruptions in long-form reading remains limited. A recent study by Srivastava et al. evaluated AI-generated priming cues—such as text summaries, images, and mind maps—and found they could effectively help readers resume fictional articles after interruptions. They also found that participants want to use AI tools that integrate seamlessly into reading to assist during interruptions (Srivastava et al., 2025).

This gap motivates the central research question of this project:

How can we design interactions that leverage AI to better support readers in managing interruptions during long-form reading?

1.3 My work

This project took a user-centred approach. The work shows AI's potential for personalised, multi-modal reading interactions and the value of co-creation in producing high-quality designs.

To address the research question, I adopted a **user-centred design** approach, suitable for problems with a clear intended impact but an open form of manifestation (Van Boeijen et al.,

2020, pp. 14-15,57). To capture user needs and creativity more effectively, the project integrated **co-design methods** (Sanders & Stappers, 2013, p. 29,61), which enables designer ,user and other non-design professionals work together to solve the problem creatively. The overall process was guided by the **Double Diamond** model, a worldwide recognised design process that captures convergent and divergent thinking—the core of the design process(Design Council, 2005). The process combined multiple methods: it began with desk research, diary studies, and interviews to gain insight into the domain of interest. These insights were then synthesised using problem statement and design goal. Next, creative methods such as brainstorming and co-creation workshops were applied to develop ideas. Finally, storytelling and experience prototyping were used to test and refine the concepts (shown in the figure next page).

This project is innovative in two ways. First, it actively involved users as contributors in the innovation process, enriching design outcomes with their perspectives. Second, it treated AI as a novel design material, grounded in principles of human–AI collaboration, expanding the possibilities for AI-assisted reading experiences.

The project demonstrates that AI can enable personalised, multi-modal interactions in reading, resulting in richer experiences and sustained engagement. It also shows that the integration of user-centred design and co-creation is effective in capturing user needs and directly contributing to high-quality design outcomes.

On a broader level, the work highlights AI's potential to positively transform human–computer interaction and support complex cognitive processes such as long-form reading.

1.4 Summary

Long-form reading is essential for developing reading skills, improving comprehension, and enhancing cognitive processes. It is also considered one of the most important ways to cultivate empathy, critical thinking, and a deeper understanding of the world. However, given the extended time and higher cognitive resources it requires, interruptions in long-form reading are both common and inevitable. Such interruptions can significantly disrupt deep comprehension, delay task completion, and negatively affect the reading experience. While prior work has explored ways to mitigate these effects, recent advances in AI offer the possibility of providing more personalised, dynamic support. Yet, research in this specific area remains limited, with only early evidence showing AI's effectiveness and reader acceptance—highlighting its strong potential for supporting long-form reading during interruptions.

To address this gap, this project adopted a user-centred, co-design approach, with the process guided by the Double Diamond model. This project is innovative in actively involving users throughout the design process and in exploring AI-assisted reading experiences. The results show that AI can enable personalised, multi-modal interactions, creating richer reading experiences and encouraging sustained engagement. It also shows that the integration of user-centered design with co-design/ co-creation methods are effective in capturing user needs and producing high-quality design outcomes. On a broader level, it highlights AI's potential to positively transform human–computer interaction and support complex cognitive processes such as long-form reading.

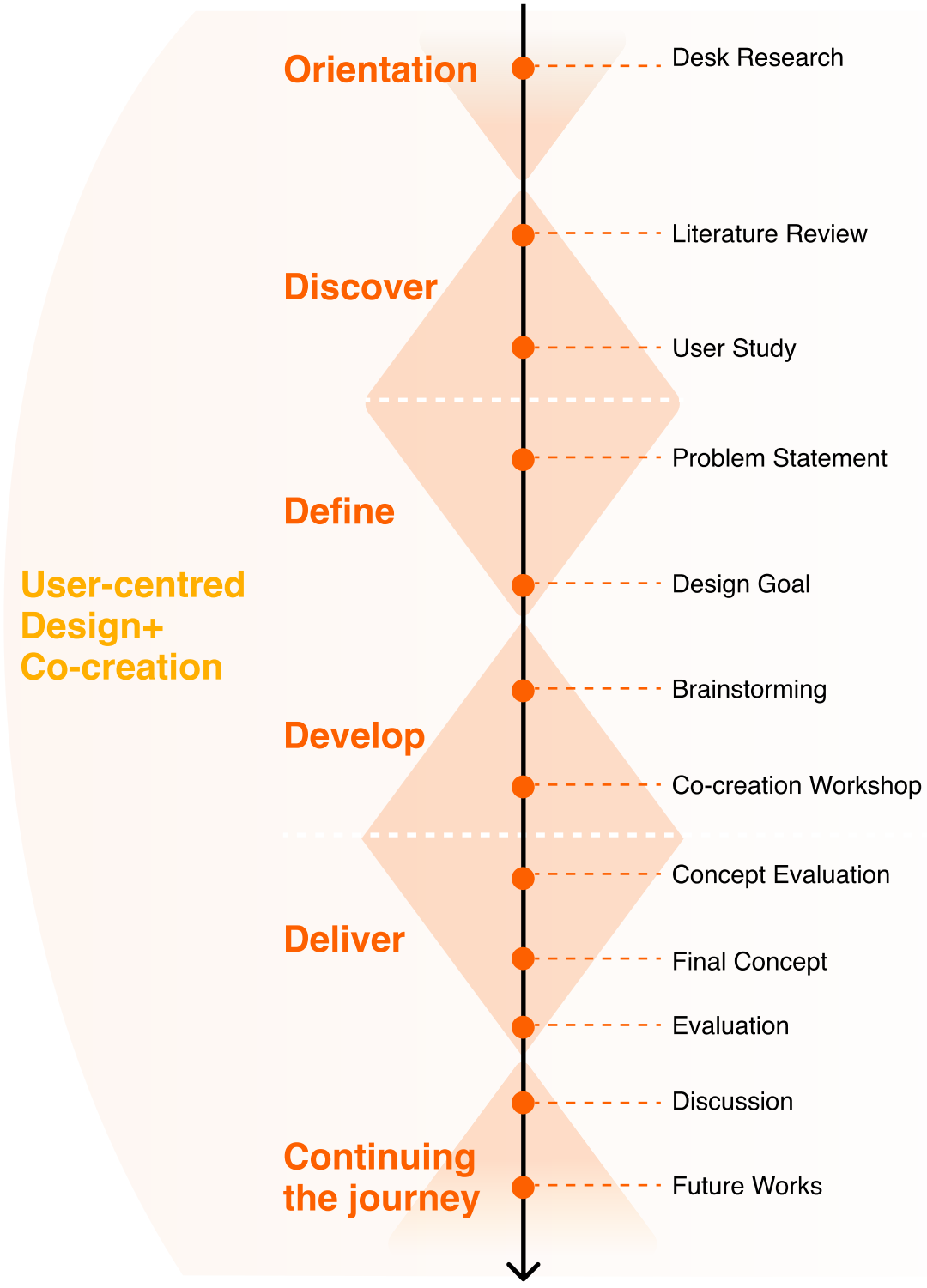
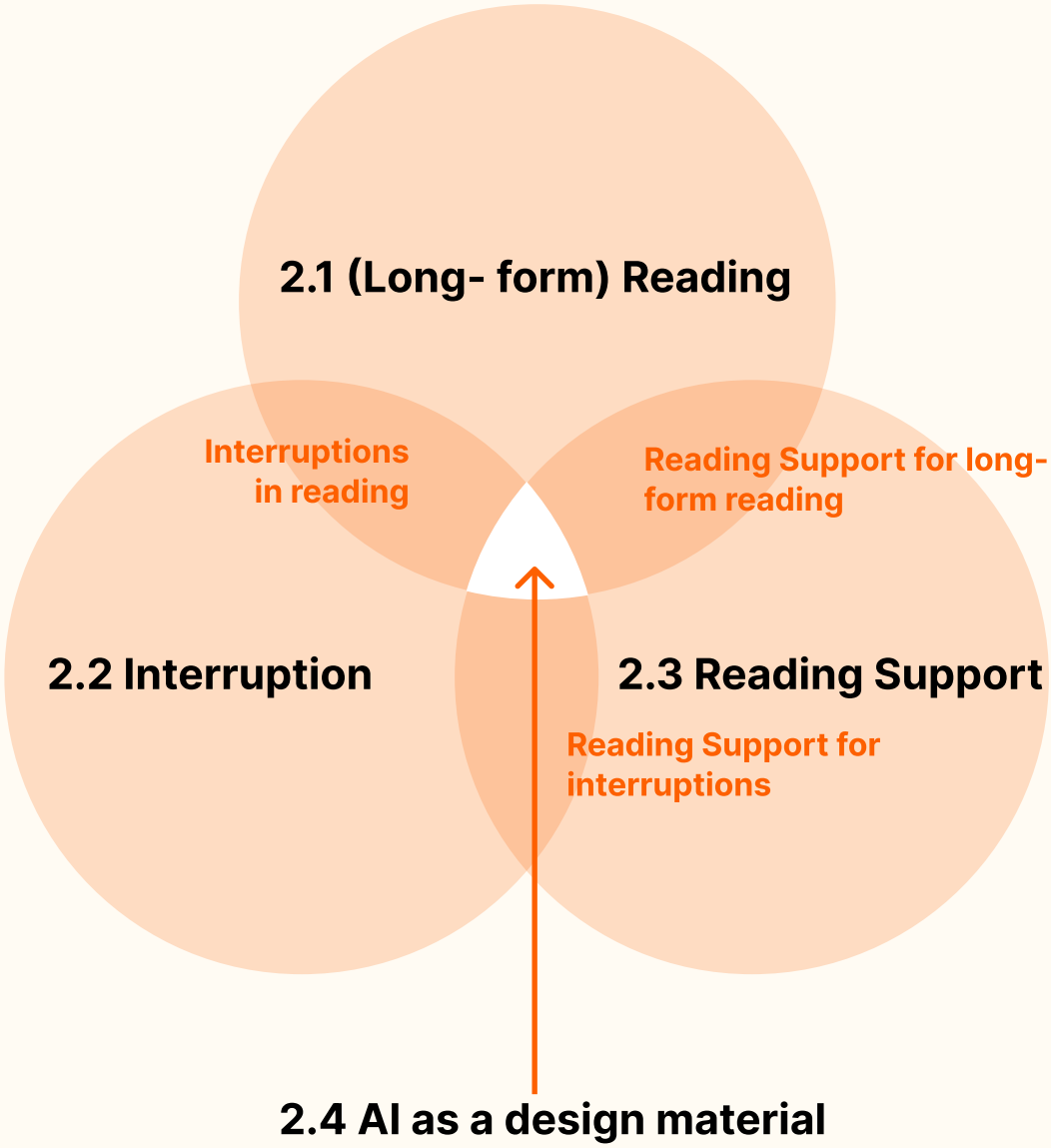


Figure 1. Project approach

2 Related Works

To gain a more concrete perspective on the problem, this chapter conducts a literature review of prior research relevant to the project. It examines four areas: the definition and experience of long-form reading, the impact of interruptions on reading, existing reading support systems, and the influence of AI on interaction design and its potential in supporting reading.



2.1 Long-form reading
2.2 Interruption research
2.3 Reading Support
2.4 AI as a design material
2.5 Summary

2.1 Long-form Reading

Long-form reading can be defined as substantial in length and high in cognitive demand. It is essential for fostering reading skills and cultivating cognitive progress.

2.1.1 What is long-form reading?

There is currently no universally agreed definition of long-form reading. In much of the literature, **text length** is the most common criterion. For example, a 2018 meta-analysis on reading comprehension covering 54 experiments between 2000 and 2017 defined long texts as those exceeding 1,000 words (Delgado et al., 2018); a study on long-form reading on mobile news from Pew Research Center similarly classified online news articles over 1,000 words as long-form(Mitchell et al., 2024); and the website longform.org, which collects and recommends non-fiction works, specifies long form as texts over 2,000 words (Botticello, 2023). Researchers in their study on long-form reading in higher education, define texts over 800 words as long-form, and further refine this into categories of "short long-form" (800–2,000 words), "medium long-form" (5,000–10,000 words), and "long long-form" (>10,000 words)(Baron & Mangen, 2021). In another article on contemporary reading trends, Miha Kovač and Adriaan van der Weel (2018) set the threshold even higher, defining long-form texts as those exceeding 20,000 words (mainly print books), while medium-length texts (5,000–20,000 words) include serious journalism and scientific papers. Some studies instead define long-form by **page count**: for instance, an international study on students' academic reading format preferences defined long texts as those over seven pages (without specifying page size)(Mizrachi et al., 2018), while another study on undergraduates' academic reading behaviours used thresholds of long-text of five and ten pages (Mizrachi, 2015).

In experimental research, long-form is often defined pragmatically by the materials selected. For example, Srivastava et al.(2025) examined AI-assisted long-form reading on mobile devices using articles of approximately 1,500–1,700 words; Mangen and Kuiken (2014) employed a 2,700-word narrative text to study narrative engagement across paper and iPad; and Mangen et al. (2019) used a complete 28-page mystery book (about 10,800 words) to compare comprehension across print and Kindle. These cases show that, although explicit definitions are not always provided, researchers consistently use texts longer than 1500 words.

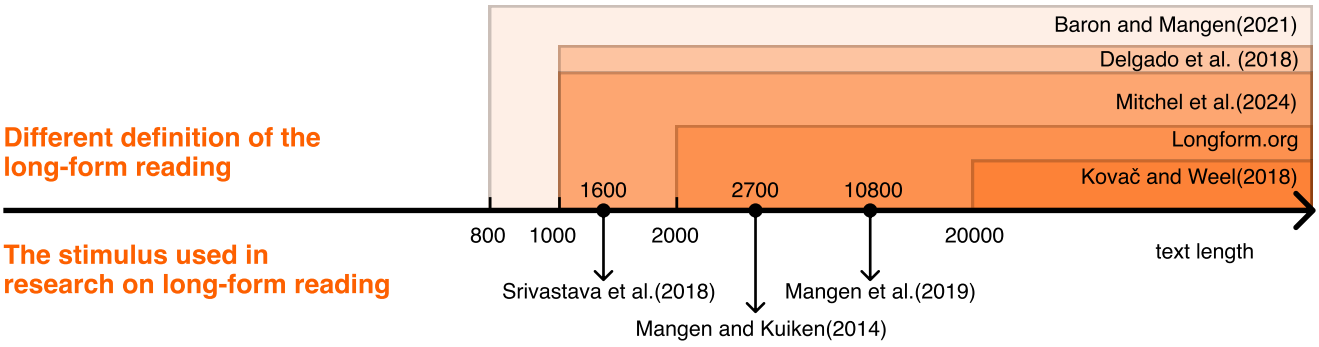


Figure 2. Definition of long-form reading

Beyond length, **cognitive demand** is also an important factor. Texts of equal length may place very different burdens on readers. For example, a 30-page biology paper is likely to be more demanding than a 30-page crime novel, due to its technical vocabulary, complex logic, and dense syntactic structures (Baron & Mangen, 2021). Certain genres are consistently recognised as long-form reading targets, including scientific papers, literary fiction, and narrative non-fiction (such as history, biography, and serious journalism). While their features differ, all of these require sustained attention and complex comprehension: fiction often involves following a continuous plot line and remembering characters with their relationships; narrative non-fiction requires processing detailed timelines and related events and figures; and scientific papers demand engagement with sustained arguments, evidence, and conclusions, as well as linking them to readers' prior knowledge.

In summary, long-form reading can be understood as engagement with texts that are **both substantial in length and high in cognitive demand**. Typical examples include scientific papers, literary fiction, and narrative non-fiction, which challenge readers by requiring extended concentration and higher-order comprehension.

2.1.2 Why does long-form reading matter?

Long-form reading is **essential for developing reading skills and comprehension**. In an international study involving 250,000 teenagers, Jerrim and Moss (2018) compared five text types—magazines, non-fiction, fiction, newspapers, and comics—and found that long-form fiction had the strongest association with young people's ability to read, understand, and interpret continuous text. This result was later replicated in Spain(Jerrim et al., 2020) and extended further. A Finnish study by Torppa et al. (2019) corroborated these findings, showing that leisure reading of books (genre not specified) was positively correlated with better reading comprehension, whereas reading shorter digital texts was negatively correlated (Torppa et al., 2019).

These results can be explained by Willingham's theory of working memory during reading (Willingham, 2017). Working memory is the limited space where thinking occurs. Just as novice drivers struggle to talk to passengers because their working memory is consumed by basic driving tasks, beginning readers have limited capacity for comprehension if decoding requires too much effort. Through repeated practice, processes like steering in driving become automatic, freeing capacity for other cognitive activities. Similarly, fluent reading depends on automatisation: word recognition (e.g., decoding, sight recognition) and language comprehension (e.g., reasoning, verbal inference) (Willingham, 2017; Duke & Cartwright, 2021). Long-form texts, with their rich vocabulary and complex structures, are ideal training grounds for automatisation, enabling readers to achieve deeper comprehension.

Beyond these reading skills and comprehension, long-form reading contributes to broader cognitive benefits. It **strengthens attention** and **cultivates other cognitive abilities**. The notion of literature as training for close, sustained concentration dates back to Victorian England (Dames, 2007). More recently, Inge van de Ven et al (2023) have shown that reading long literary works fosters "cognitive patience"—the ability to maintain focused attention, delay gratification, and resist multitasking. This cultivation of sustained attention is considered to be one of the key benefits from deep reading during long-form reading. Since long-form reading requires greater cognitive involvement, as readers must track multiple components and engage with complex structures, deep reading is needed (Baron & Mangen, 2021).

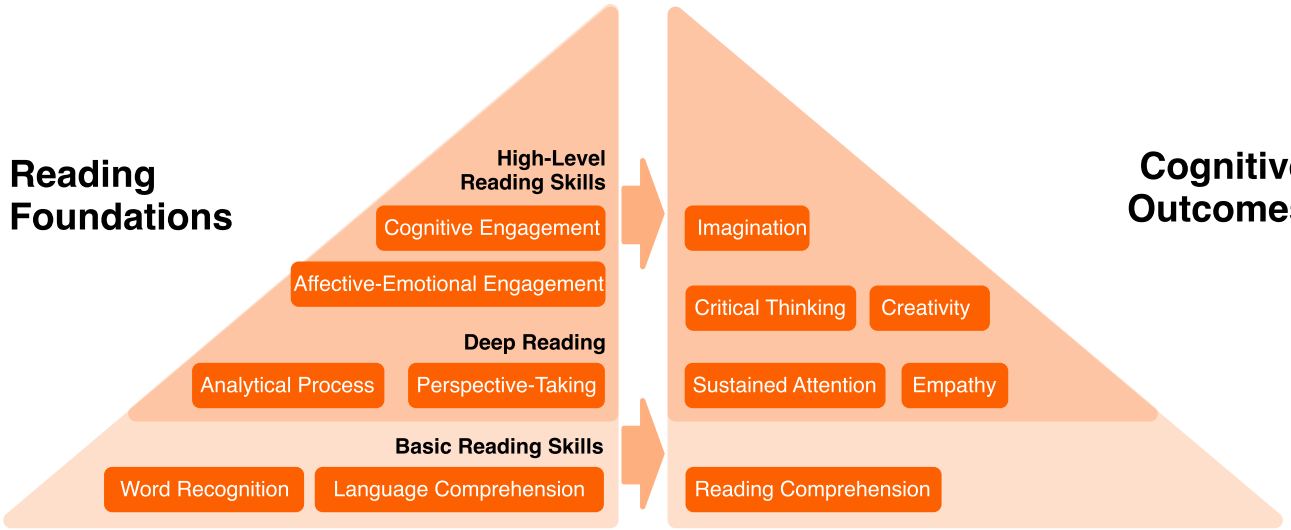


Figure 3. Benefits of long-form reading

Deep reading is the array of sophisticated processes that propel comprehension and that include inferential and deductive reasoning, analogical skills, critical analysis, reflection, and insight (Wolf & Barzillai, 2009) .It also fosters empathy and perspective-taking: when reading Pride and Prejudice, readers may identify with Austen's heroines; when reading historical narratives, they may empathise

with the struggles of ordinary people in times of conflict (Wolf, 2018). Such experiences expand readers' internalised knowledge of the world and strengthen their ability to take other perspectives.

Moreover, deep reading's analytical processes closely mirror the scientific method. Like scientists moving through cycles of observation, hypothesis formation, testing, and interpretation, readers also progress through these steps while engaging with complex texts. They begin by observing and perceiving information, then connect new material with what they already know through analogical reasoning, forming concepts and hypotheses in their mind. As they continue reading, they test and evaluate these provisional ideas. This analytical cycle becomes even more strengthened when reading scientific papers. For instance, in Gordon Legge's study on visual span, readers must first gather and organise observations, then assess whether the hypotheses, methods, and conclusions build on prior evidence, whether the methods are replicable, and whether interpretations align with the data (Legge et al., 2001). Simultaneously, they integrate new concepts with prior knowledge. This recursive process strengthens analogical, inferential, and critical reasoning. By cultivating these analytical skills, deep reading enables readers to resist superficial content, misinformation, and conspiracy theories.

These benefits from deep reading during long-form reading can be explained by the development of higher-level reading skills—cognitive and affective engagement with texts beyond decoding or information retrieval (Schüller-Zwierlein et al., 2022). Long-form reading is a practice that fosters these higher-level skills, which include comprehension, empathy, critical thinking, as well as creativity, imagination, and mental imagery (Schüller-Zwierlein et al., 2022),Van Der Weel & Mangen, 2022).
In sum, long-form reading matters because it:

1. **Trains reading skills** that could automatise reading processes, deeping comprehension.
2. **Cultivates sustained attention and deep reading**, which engages analytical processes that foster empathy and critical thinking.
3. **Develops higher-level reading skills** essential for creativity, imagination, and cognitive growth.

Therefore, long-form reading continues to serve as a vital foundation for personal growth, intellectual advancement, and civic engagement in today's world.

2.2 Interruption Research

Task interruptions negatively affect both task experience and performance. Reading interruptions, as a part of task interruptions, also harm reading experience and performance, such as low comprehension and low satisfaction.

2.2.1 Task Interruptions

A task interruption is commonly defined as the temporary suspension of an ongoing primary task in order to perform another unexpected secondary task (Hirsch et al., 2022). Interruptions can come from external factors—for example, receiving a phone call while writing—or internally, such as deciding to take a break. These are referred to as external interruptions and internal interruptions, respectively. Initial empirical evidence suggests that these two types occur at roughly equal frequencies (Mark et al., 2005).

Overall, task interruptions negatively **affect both task experience and performance** (Couffe & Michael, 2017). At the experiential level, interruptions are associated with annoyance, anxiety, frustration, and stress (Bailey & Konstan, 2006; Mark et al., 2008). At the performance or behavioral level, interruptions can lead to forgetting to resume the primary task (Dodhia & Dismukes, 2008), or, if the task is resumed, requiring longer completion time (Bailey & Konstan, 2006). Compared with uninterrupted tasks, interrupted tasks increase the likelihood of repeating already executed actions or forgetting necessary ones (Altmann et al., 2017). In real-world contexts, such effects can result in accidents: for example, in healthcare, nurses may accidentally inject the same drug twice or misrecord medication history (Johnson et al., 2017).

To explain these disruptive effects, psychological models highlight the demands interruptions place on task-switching, goal memory, place-keeping, and prospective memory (Hirsch et al., 2022). External interruptions, in particular, are often described as unfolding in two temporal stages: the interruption lag and the resumption lag. These stages are further elaborated in frameworks such as DETOUR (Couffe & Michael, 2017), which detail the underlying cognitive processes (shown in the figure on next page).

The disruptiveness of task interruptions is influenced by three main groups of factors:
Task-related factors: the similarity between the primary and secondary task, their complexity, and the duration of the interruption.
Situational factors: the frequency and timing of interruptions, and the availability of preparation time or external cues to help resume the primary task.
Personal factors: although many individual characteristics may affect interruption handling, most research has focused on working memory capacity, training, and motivational rigidity (Hirsch et al., 2022).

Based on these insights, several strategies have been proposed to manage task interruptions. For instance, interruptions to complex tasks tend to have more severe negative effects (Speier et al., 2003), and interruptions involving similar tasks are more disruptive (Gillie & Broadbent, 1989). Therefore, it is advised to avoid interrupting complex tasks, especially when the secondary task is highly similar to the primary one. In addition, providing opportunities to prepare for the interruption or offering external cues upon resumption can help individuals return to the primary task more effectively (Hirsch et al., 2022).

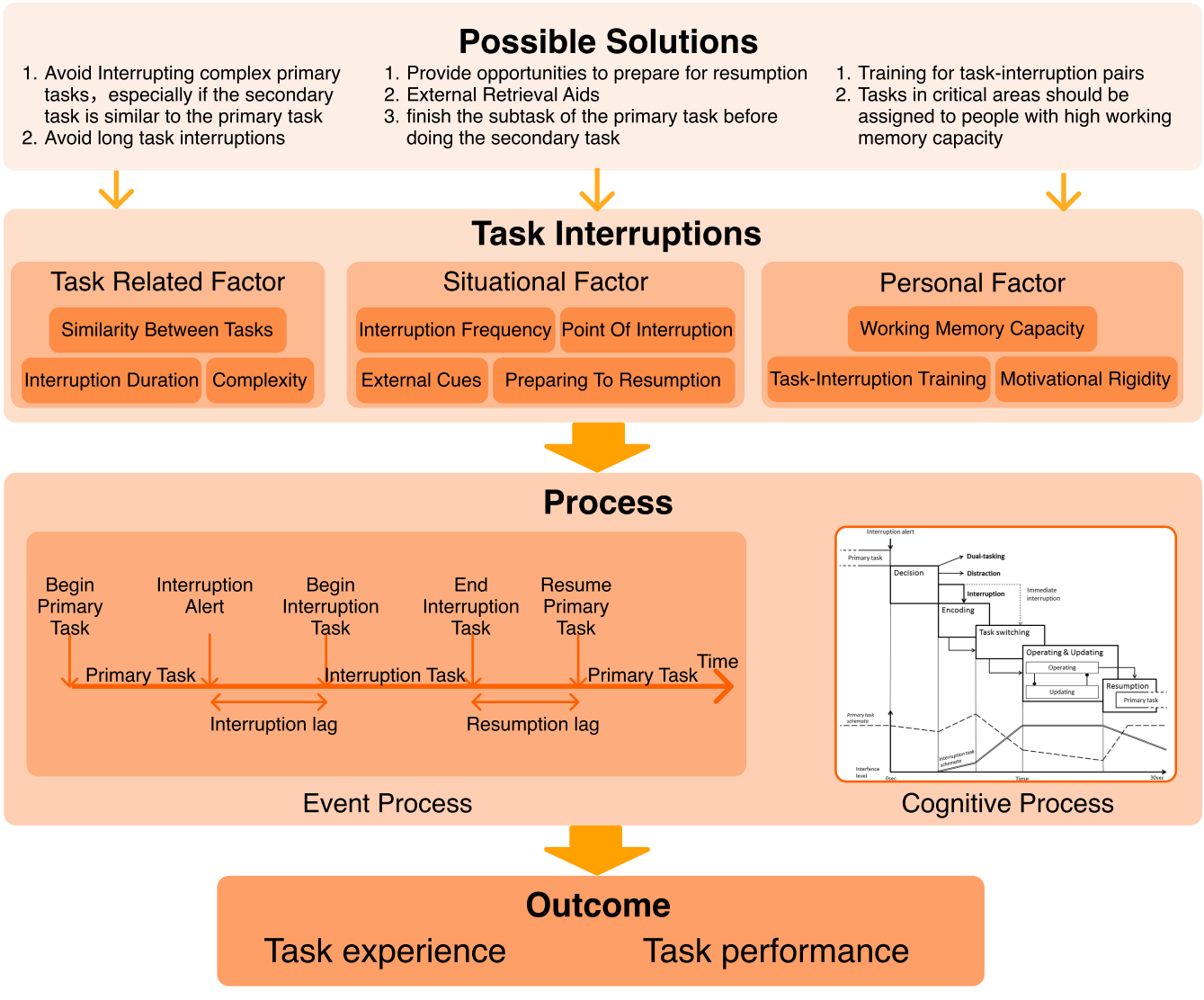


Figure 4. Diagram organized from Hirsch et al(2022) and Cyril Couffe et Al 's work (2017)

2.2.2 Reading Interruptions

It should be noted that the majority of these findings focus on external interruptions. Research on internal interruptions, is more limited, partly because they are harder to control in experimental settings. Nevertheless, some studies have begun to address this gap. JinJin and Dabbish (2009), through observation and interviews, identified seven categories of self-interruptions in tasks on computer, describing their motivations, potential consequences, and benefits. Adler & Benbunan-Fich (2013), based on flow theory and self-regulation theory, analysed the internal interruptions triggered by negative or positive emotions. And they found that negative triggers of self-interruptions could unleash a downward spiral that ultimately impairs performance. Finally, Katidioti et al. (2016) compared internal and external interruptions in a behavioral experiment combined with pupillometry. They found that self-interruptions were more disruptive, as they increased task completion time. The authors suggested that preparation for self-interruption introduces additional decision-making time, which does not occur with external interruptions.

Interruptions in reading can also be classified into external and internal types, depending on their source. External interruptions are triggered by environmental factors (e.g., notifications, instant messages), while internal interruptions are intentionally initiated by the reader. In addition to these intentional forms, there is also an unintentional attentional disruption—mind-wandering. In this case, readers' eyes continue to scan the text, but their thoughts drift toward unrelated content. The impact of interruptions can also be categorised into **experience and performance** sides.

The effects of **external interruptions** on reading have been widely studied, particularly in terms of performance and experience. On the performance side, Glanzer et al. (1981) introduced arithmetic problems as interruptions during reading and found that reading speed slowed after interruptions, which can be explained by the resumption lag between the end of an interruption and the return to the primary reading task. Similarly, Foroughi et al. (2015) used math problems as interruption tasks during reading passages and showed that interruptions harmed comprehension, especially the ability to connect information across passages, though recognition of isolated information was less affected. This aligns with Delaney and Ericsson's (2016) theoretical claim that interruptions disrupt access to text encodings stored in long-term memory, which are necessary for resuming reading.

Other experiments have simulated interruptions resembling real-life scenarios. Fox et al. (2008) investigated the effects of instant messaging on students' reading performance and found that participants who used instant messages during reading took longer to complete the task and were less efficient. Using eye-tracking, Luke and Jensen (2022) demonstrated that notifications and pop-ups during reading led to more rereading and lower comprehension. Similarly, Santhosh et al. (2024) confirmed that notifications in digital reading severely disrupted flow and reduced comprehension. On the experience side, Santhosh et al. (2024) reported that such notifications also caused frustration, lowering readers' satisfaction.

In contrast, research on **internal interruptions** in reading remains relatively limited, likely because they are harder to elicit in controlled experiments compared to external ones. However, evidence from task interruption research suggests that internal interruptions can be even more disruptive than external ones (Mark et al., 2005; Katidioti et al., 2016). Deng (2019), for example, found that university students often interrupted themselves during self-study when they experienced boredom, low interest, frustration, or when tasks became too difficult. Self-interruptions also occurred after completing sub-tasks, such as checking one's phone.

In the case of **mind-wandering**, it impairs comprehension when readers fail to notice the mismatch between cognitive processing and the text being viewed (Chevet et al., 2022). Moreover, the cost of mind-wandering rises with text complexity: readers wander more frequently during complex texts, and this has greater negative effects on comprehension (Feng et al., 2013; Bonifacci et al., 2022). Working memory capacity also plays a role, with low-working-memory readers more prone to mind-wandering (Bonifacci et al., 2022). After mind-wandering, readers often reread previous sections—nearly half the time, according to Varao-Sousa et al. (2017). Reading medium is another factor: mind-wandering occurs more frequently on screens than on paper, especially under time pressure.

Chevet et al. (2022) conducted a study simulating real-world reading interruptions and found that multiple forms of disruption affected both comprehension and reading experience. They also reported that attention disruptions were more frequent in the first half of reading compared to the second, possibly because readers became more engaged with the text as they progressed, lowering their willingness to shift attention. Overall, most interruptions were experienced as annoying and reduced satisfaction during reading.

Overall, research on reading interruptions has extensively examined external interruptions, consistently finding that they impair comprehension and create negative experiences such as frustration. Studies on internal interruptions and mind-wandering are still comparatively few, but existing evidence suggests that these interruptions may be equally or even more disruptive. Moreover, **little is known about how interruptions affect the reading of long-form texts specifically, especially in the real world—a gap that motivates further research.** The next section will review existing reading support systems and explore how they address reading interruptions.

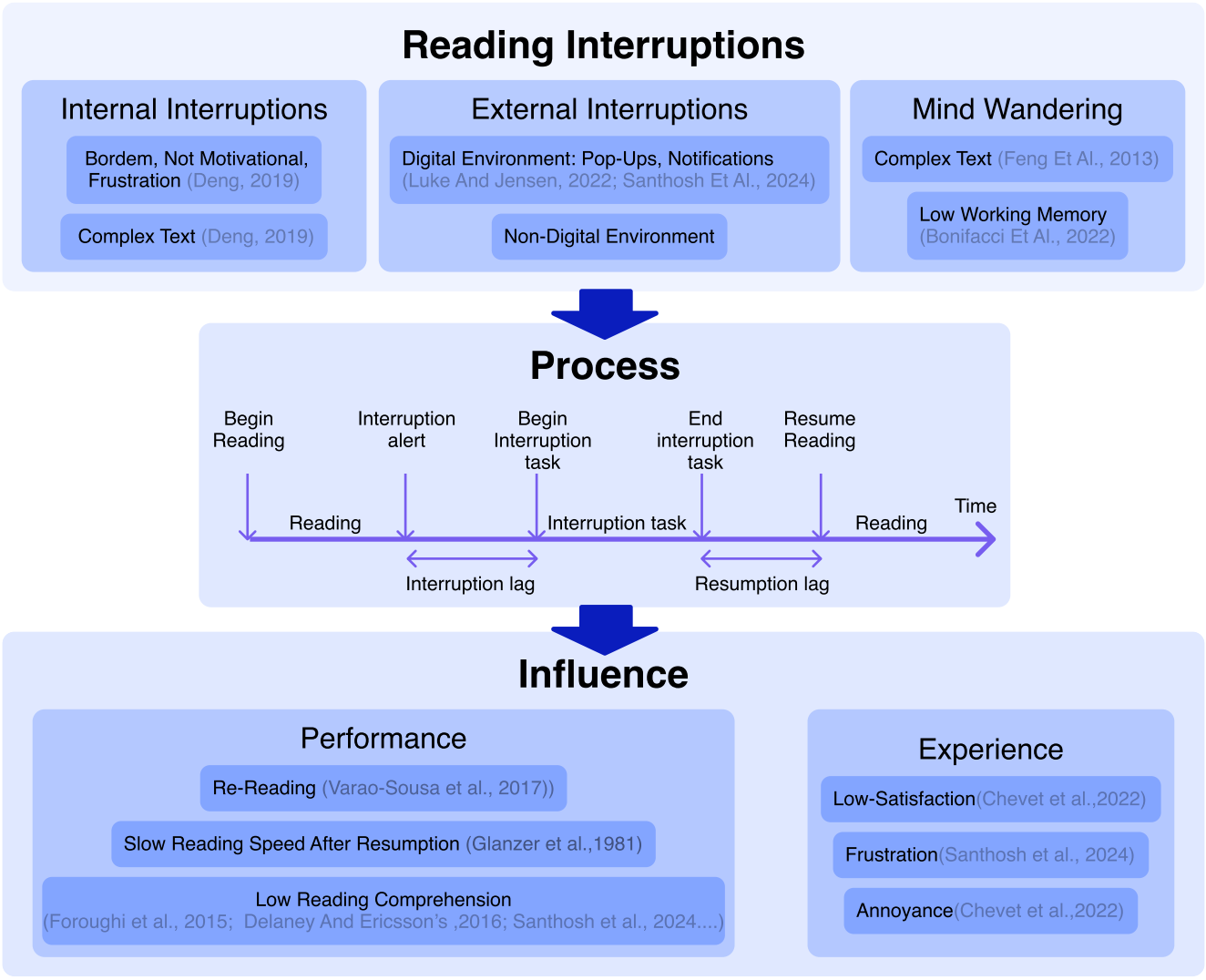


Figure 5. Interruptions in reading and their process, influence

2.3 Reading Support

Long-form reading support has been shown to reduce cognitive load and improve comprehension through diverse approaches. Yet research on managing interruptions in reading—especially in long-form reading—remains limited. Reading support in general lacks personalized interaction.

2.3.1 Reading Support for Long-form Reading

A number of reading support interfaces have been developed to reduce the cognitive burden of long-form reading and enhance readers' overall experience.

Tjärnhage et al. (2023) examined the use of scrollytelling—a combination of storytelling and scrolling—in long-form **news reading**. They found that this dynamic interaction could invoke emotional responses, thereby increasing engagement with the topic and supporting a broader fundamental understanding of the content. However, the effect was also shown to depend on individual preferences.

For academic contexts, Kim et al. (2023) proposed Papeos, a novel interface that augments research papers with localized video segments from academic talks. Their findings showed that this dynamic, multimodal reading experience reduced mental load, scaffolded navigation, and facilitated reading comprehension of papers. Also for academic papers, Head et al. (2021) developed ScholarPhi to address the difficulty of comprehension when key information positioned elsewhere in a document or in another paper. ScholarPhi provided just-in-time, position-sensitive definitions of terms and symbols, which improved accessibility and comprehension of research texts.

For narrative texts, Nishihara et al. (2021) introduced an interface that visualizes time-series information about characters and their locations, helping readers remember and track the complex content of long novels.

Together, these studies demonstrate that support for long-form reading can take diverse forms, including multimodal augmentation, visualization, and dynamic interaction. Moreover, different genres pose different challenges, and interfaces often target specific problems—for example, terminology comprehension in academic papers or character tracking in novels. Overall, the shared goal of these systems is to **improve comprehension and enhance the reading experience**.

2.3.2 Reading Support for Interruptions

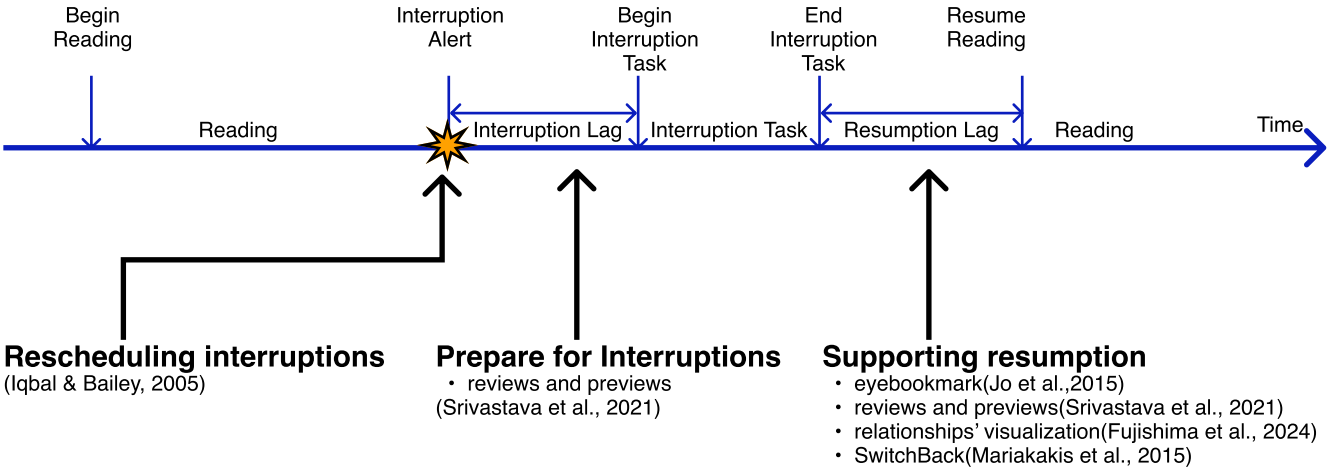


Figure 6. Reading support for interruptions

There are generally three approaches to address and mitigate the effects of interruptions in reading:

1. **Preparation before interruption.** Providing opportunities to prepare for resumption can reduce disruption (Hodgetts & Jones, 2006). Srivastava et al. (2021), for example, compared the use of short summaries of either previously read content (reviews) or upcoming content (previews). Their results showed that such summaries helped readers re-engage with the reading task after interruptions.

2. **Rescheduling interruptions.** Another approach is to reschedule interruptions to a more suitable point, such as after finishing a subtask of the primary task (Iqbal & Bailey, 2005). Although this strategy has been demonstrated in task-interruption research, there is little direct evidence of its application in reading interfaces.
3. **Supporting resumption after interruption.** External retrieval aids provide cues to help users decide where to resume, either by reminding them of the last action performed or by pointing to the next action to be taken (Hodgetts & Jones, 2006). Jo et al. (2015) proposed EyeBookmark, which uses eye-tracking to provide a visual cue for resumption. Similarly, Mariakakis et al. (2015) introduced Focus and Saccade Tracking, using a front-facing camera to guide users' attention during mobile reading. More recently, Fujishima et al. (2024) developed an interface that visualizes relationships among characters in novels, helping readers remember narrative structures and return to the reading flow.

Beyond reading, related work in learning tasks has explored similar strategies. Schneegass and Draxler (2021), through a literature review and focus groups, described a comprehensive design space for mobile learning task resumption. They confirmed the same three strategies—delaying notifications, preparing users for interruptions, and supporting resumption. Their work mainly focused on the cues for supporting resumption and found that visual resumption cues have been thoroughly studied, but other modalities remain less explored.

Taken together, these approaches primarily address situational factors that influence the disruptiveness of interruptions in task. In contrast, task-related factors (e.g., task complexity or similarity) are largely determined by the task itself, and personal factors (e.g., working memory capacity, training for task-interruption pair, motivational rigidity) got less attention(Hirsch et al., 2022). The reason could be that they are harder to influence through interface design and often require costly interventions outside of interface. As a result, most reading support systems to date have focused on situational strategies such as preparation and resumption cues, while research on supporting task-related or personal factors remains scarce.

In summary, reading support interfaces for long-form reading have taken diverse forms, employing multimodality, visualization, and dynamic interaction to reduce cognitive load and enhance the reading experience. However, relatively few solutions specifically address interruptions in reading. Where personalization is attempted, it often comes with high costs—for example, requiring eye-tracking technologies (Jo et al., 2015). Furthermore, there is very few solutions focusing on the interruptions in long-form reading.

2.4 AI as a design material

2.4.1 Why do I introduce AI in this project?

Long-form reading inherently imposes a high cognitive load on readers, as it requires sustained attention, integration of complex arguments, and management of extensive vocabulary and syntax(Baron & Mangen, 2021). Prior research on reading support has demonstrated that novel interaction forms—such as visualizations (Nishihara et al., 2021), multimedia augmentation (Kim et al., 2023) , or dynamic storytelling approach (Tjärnhage et al., 2023)—can enhance engagement and understanding. However, the extent of cognitive burden varies substantially across individuals, depending on factors such as prior knowledge, language proficiency, and decoding ability((Willingham, 2017; Duke & Cartwright, 2021,Gerth & Festman, 2021). From the perspective of interruptions, the situation is also complex: interruptions differ in type, frequency, and the characteristics of the primary task(Hirsch et al., 2022). Despite these complexities, current reading support solutions still rely on relatively rigid interaction paradigms. They provide limited adaptivity, low personalization, and minimal sensitivity to users' states; and when attempts are made to capture such states (e.g., through eye-tracking(Jo et al.,2015), the cost are often high. In contrast, AI has enabled innovative forms of interaction, introducing a new dimension of personalization and adaptability. These capabilities make AI **a promising approach to address the limitations** of existing reading support and to explore more dynamic and user-centered approaches.

2.4.2 How to use AI as a design material?

In design research, the concept of a design material emphasizes how the properties of a material both constrain and afford possible designs. Unlike traditional physical materials, using AI as a design material poses unique challenges. Designers often have limited understanding of AI's capabilities, which can lead to an over-reliance on existing functions and a lack of innovation. At the same time, the inherent unpredictability of AI outputs makes sketching and prototyping processes harder to control (Yu, 2025). These challenges arise largely from the uncertainty of AI's capabilities and outputs. To capture this, Yang et al. (2020) developed the AI design complexity map, which categorizes AI systems into four levels (shown in the figure below) and shows how each level introduces different design challenges.

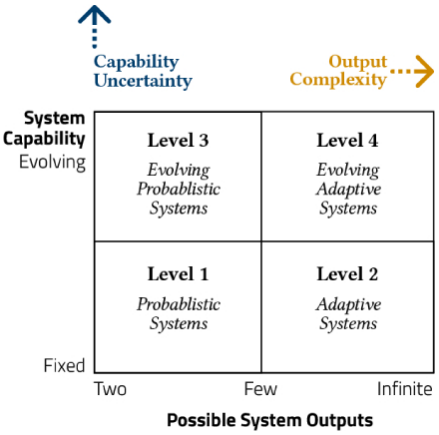


Figure 7. The AI systems with 2 dimensions of complexity (Yang et al., 2020)

To address these challenges, design processes themselves need to adapt. Windl et al. (2022) identified four main approaches for integrating AI into design:

- **A Priori**: The AI model is developed before design begins, requiring designers to adapt to the model's constraints. This approach risks inflexibility.
- **Post-Hoc**: The design is completed first, and the AI model is later built to fit the design requirements. While maintaining design independence, it may overlook the model's technical limitations.
- **Model-Centric**: The AI model is placed at the core of the project, with designers working closely with AI specialists on almost all technical aspects. This fosters deep collaboration but requires technical immersion from designers.
- **Competence-Centric**: Designers and AI specialists work in parallel, emphasizing diverse expertise and synchronizing their efforts throughout the process.

Beyond process models, researchers have also proposed concrete guidelines for human–AI interaction. Amershi et al. (2019) outlined 18 guidelines across four phases: initially, during interaction, when wrong, and over time. Li Lin et al. (2025) further proposed 11 guidelines and 33 strategies for human–generative AI interaction, structured around four stages: intent, in-the-loop, outcome, and over time(shown in the figure 8 on next page). Song et al. (2024) examined the design of human–AI collaboration more broadly, identifying multiple roles that AI can play and the capabilities required in different scenarios(shown in the figure 9 on the next page).

Together, these frameworks and guidelines provide methodological and practical foundations for treating AI as a design material, offering ways to build innovative interaction design and better relationship in the human-AI collaboration.

"In this project, I adopted the Post-Hoc approach (Windl et al., 2022). Given my limited technical expertise in AI development and the time constraints of the project, this method allowed me to maintain design independence while still incorporating AI capabilities into the solution."

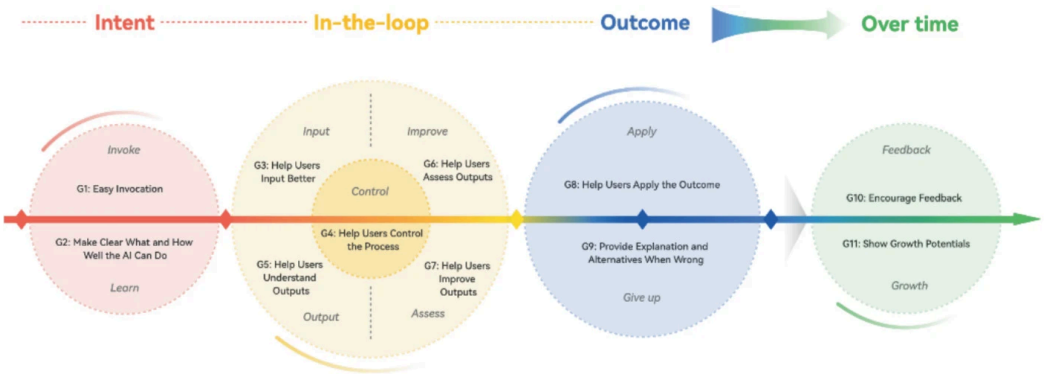


Figure 8. Framework of human-GAI interaction(Lin et al., 2025)

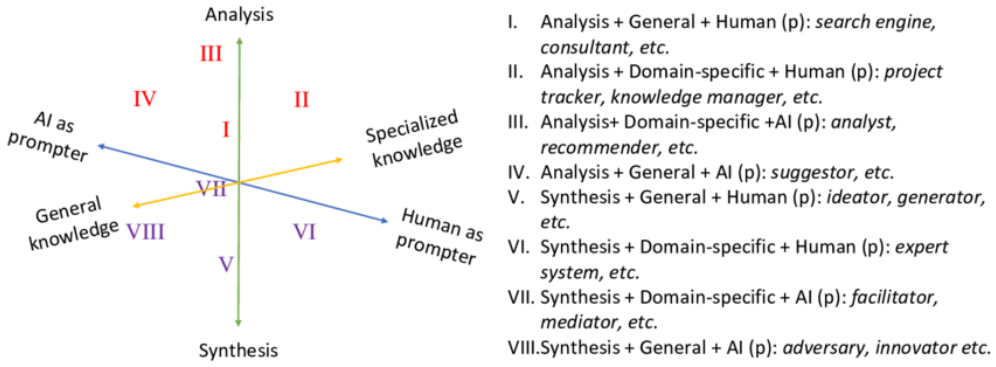


Figure 9. Role of AI in human-AI collaboration(Song et al., 2024)

2.4.3 AI in reading support

To better understand how AI can be used in reading support—and to gain a clearer sense of its capabilities—I conducted a review of some existing AI-enhanced reading systems.

For narrative reading, StoryMate is an LLM-empowered interactive story-reading tool that provides personalized interactions aligned with children's personalities, preferences, and contexts. It not only adapts to readers but also guides them toward active thinking (Chen et al., 2025). StoryExplorer offers interactive visualizations that help readers extract narrative structures. It also enables reader to collaborate with AI to build their own storytelling (Ye et al., 2024). Simliarly, Portrayal offers an interactive visualization system for analyzing characters in a story (Hoque et al., 2023).

For news and general reading, ClarifAI employs large language models to detect propaganda in news articles and provide context-rich explanations, nudging readers toward more critical online news consumption (Zavolokina et al., 2024). Qorib et al.(2024) introduced Constrained Timeline Summarization (CTLS), which generates personalized timelines where events meet specified constraints, enabling readers to gain tailored insights into news stories. Marvista takes a broader perspective, supporting the entire online news article reading process (Chen et al., 2023). Before reading, it helps filter texts based on available time or guiding questions. During reading, it prompts reflection through AI-generated questions. After reading, it produces a collaborative human–AI summary that combines AI processing with user behavior and input, even linking sentences to their origins in the text. In doing so, Marvista delivers a personalized and interactive reading experience that enhances comprehension.

For scientific reading, Paper Plain (August et al., 2021) integrates multiple supports for medical literature, including definitions of unfamiliar terms, in-situ plain-language summaries, guiding questions, and overall plain-language summaries. This not only makes scientific papers more accessible but also increases reader confidence. Paper Plain is part of a larger initiative to explore dynamic, AI-driven reading interfaces for research articles, aiming to improve discovery, efficiency, comprehension, synthesis, and accessibility(Lo et al., 2024).

Finally, **for general support**, Ziwei Gu et al.(2024) introduced Grammar-Preserving Text Saliency Modulation, an AI tool that highlights textual content more accurately to help readers efficiently extract key information. Srivastava et al. (2021) evaluated AI-generated priming cues (such as text summaries, images, and mind maps) and found that they helped readers return to reading after interruptions in fictional articles, improving reading speed and willingness to use seamlessly integrated AI tools.

Drawing on the framework for human–AI collaboration (Song et al., 2024), these systems can be categorized into three main AI roles in reading support:

- **Consultant**: AI answers readers' questions to reduce cognitive burden when dealing with complex texts.
- **Analyst**: AI analyzes the text, providing visualizations, timelines, or highlights, sometimes allowing user customization or interaction.
- **Guider**: AI nudges readers toward beneficial behaviors such as active thinking, critical reflection, or self-regulation.

According to Song et al. (2024), these roles require AI to demonstrate at least recognition, prediction, reasoning, and, in some cases, generation capabilities. The interactive qualities of AI also depend on who initiates the interaction. For instance, in StoryMate, the AI initiates interactions by sensing children's states and directing them toward active reading (directivity), while dynamically adjusting its behavior based on the reader's condition and the content context.

These examples of reading support shows the diverse ways that AI can support in reading with different roles and capabilities. They also show that AI not only does not undermine the ability to develop reading skills, but it also has the potential to help people develop cognitive progress, such as critical thinking skills(Chen et al., 2023).

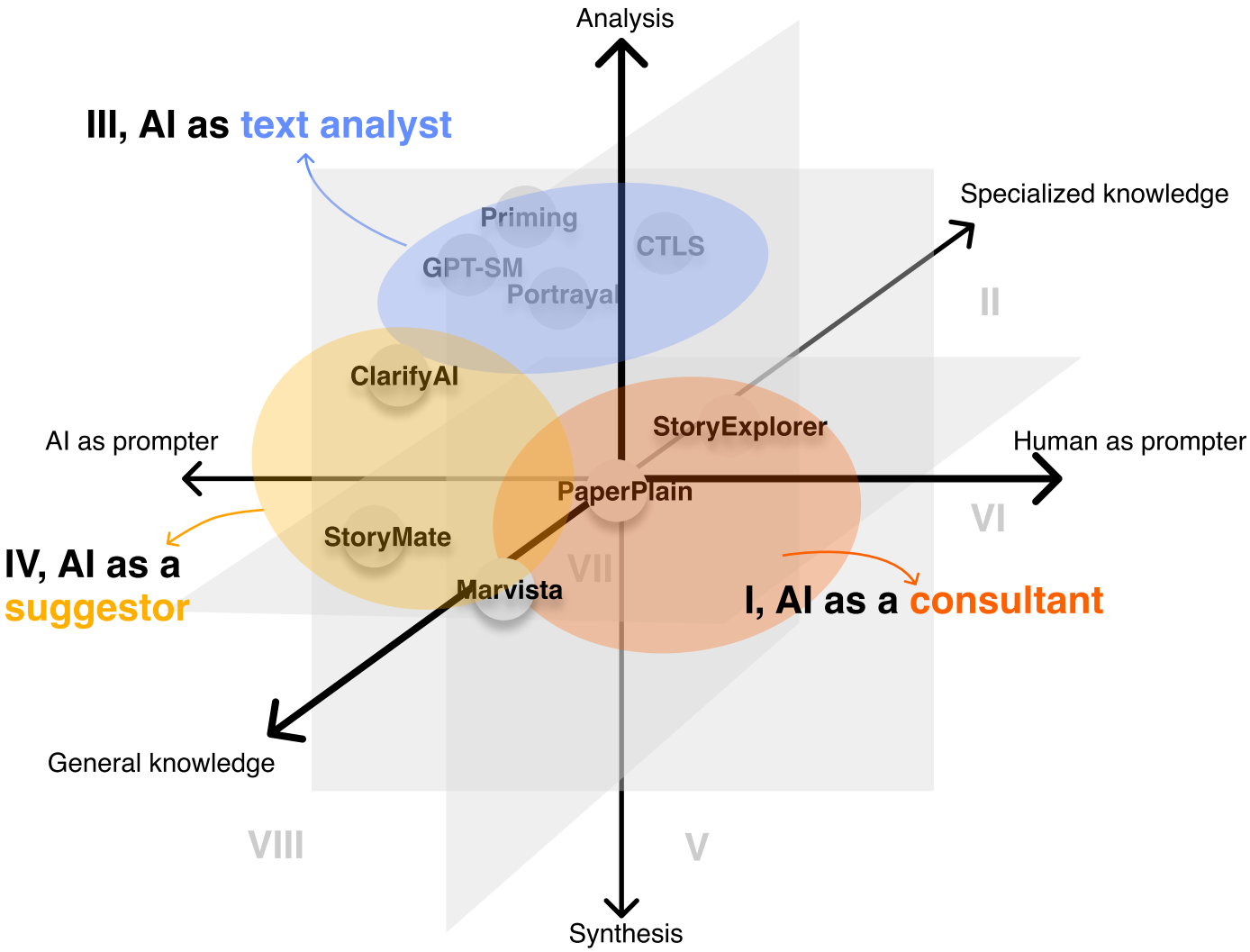


Figure 10. Roles of AI in the current reading support systems from Song et al.(2024)

AI role	AI system	recognition	prediction	reasoning	generation	genres
Consultant	Marvista	■	■	■	■	online news
	Paper Plain	■	■	■	■	scientific papers
	StoryExplorer	■	■	■	■	narrative
Suggestor	ClarifyAI	■	■	■	■	online news
	StoryMate	■	■	■		narrative
Text Analyst	GPT-SM	■	■	■	■	general
	Postryal	■	■		■	narrative
	CLTS	■	■	■	■	online news
	Priming	■	■	■	■	general

Figure 11. The AI capabilities required in the current reading support systems

2.5 Summary

"How can we design interactions that leverage AI to better support readers in managing interruptions during long-form reading?"

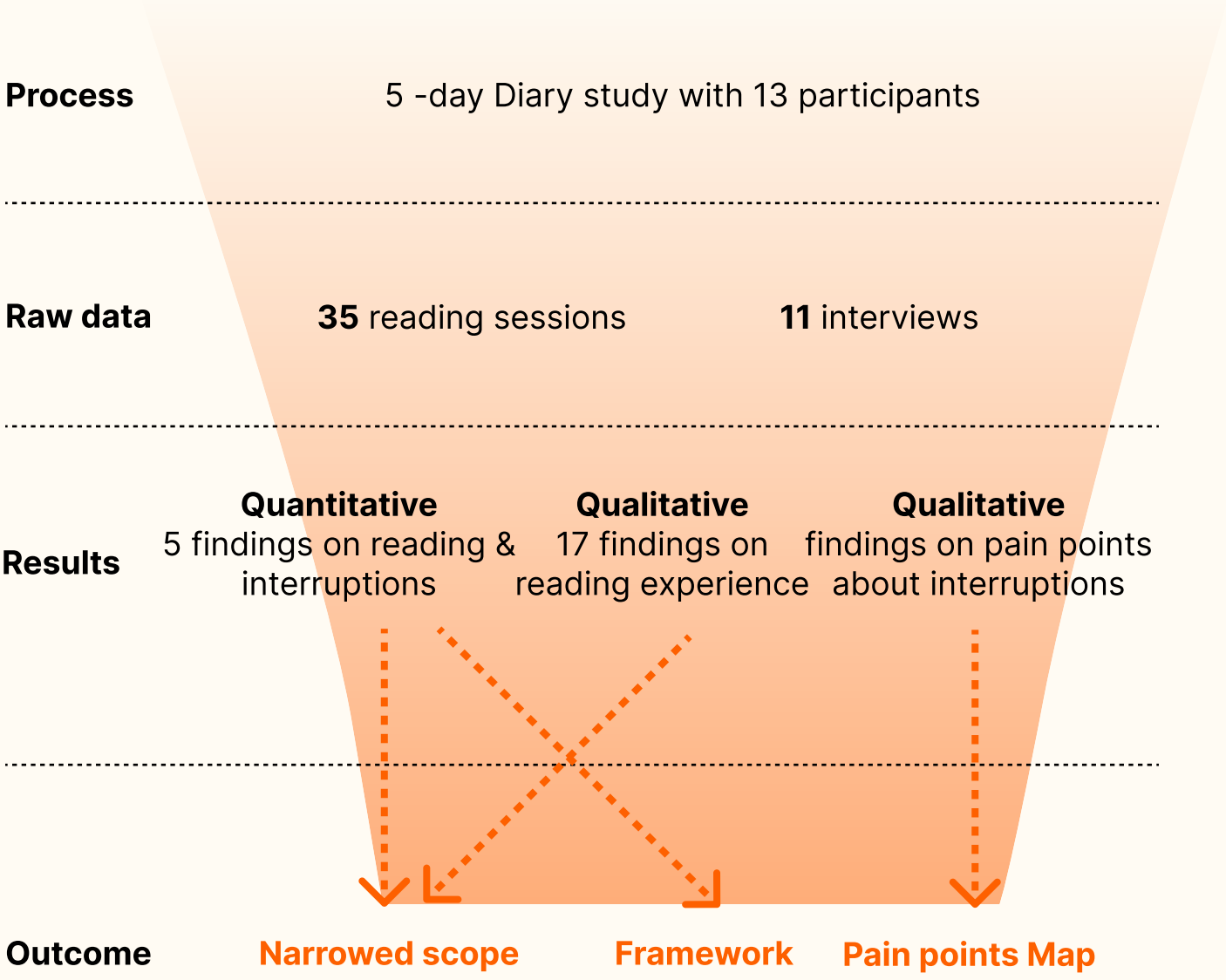
This chapter reviewed prior literature to establish the background for this project and to lay the groundwork for the upcoming user study. Four areas of research were examined: (1) **long-form reading**—what it is and why it matters; (2) **interruptions**—how they are defined, what effects they have, and how they affect the task, starting from task interruptions in general and then focusing on reading; (3) **existing reading support** systems in long-form reading and interruptions—their types and limitations; and (4) **AI as a design material**—its potential to reshape interaction and support reading, as well as its capabilities and challenges.

The review shows that long-form reading has no single, universally accepted definition, but is characterized by two core features: **substantial length and high cognitive load**. Importantly, the cognitive demands vary across genres (e.g., scientific papers versus narrative fiction). Interruptions are pervasive in such demanding tasks and may be external or internal, both of which disrupt performance and experience; in reading, they harm comprehension and reduce satisfaction. To mitigate these challenges, prior research has introduced reading support interfaces that use multimodality, visualization, and dynamic interaction to reduce cognitive load and make the experience more engaging. Research on the intervention for mitigating interruptions in reading has primarily focused on three strategies—**preparing for interruptions, rescheduling them, and supporting resumption**. Currently, there are very few solutions focusing on the interruptions during long-form reading.

AI offers a promising direction to address these limitations by enabling more adaptive and personalized interactions. Yet, introducing AI into design is not without challenges, as its capabilities and outputs are uncertain. To better understand how AI can be used in this project, I reviewed existing AI-powered reading support systems. This analysis identified common roles that AI can play—such as consultant, analyst, and guider—along with the core capabilities and interactive attributes they require, including adaptability, directivity, and directability. Such attributes are especially relevant for long-form reading interruptions, which are highly dynamic and individualized, depending on both the type of interruption and the background of the reader. Although research in this area remains limited, the existing study (Srivastava et al., 2025) suggests that AI can indeed enhance comprehension in long-form reading and that readers are willing to engage with AI tools—highlighting the potential of AI to address this challenge.

3 Understanding Reading Experience

In order to understand real-world reading experience and explore how interruptions shape the experience of reading long-form content. A five-day diary study was conducted.



3.1 Goal

Why use user study method-diary study?

As described in the last chapter, previous research on reading interruptions has largely been conducted in laboratory settings, while studies focusing specifically on interruptions during long-form reading remain limited. Yet interruptions strongly affect both **reading performance and reading experience**. To better understand this problem—particularly from the user experience perspective—and to inform the overarching research question "How can we design interactions that leverage AI to better support readers in managing interruptions during long-form reading?"—a user study is essential.

A diary study is a study in which participants provide data on a regular basis over an extended period of time, concern naturally occurring phenomena by its nature (Nezlek, 2020). Diary studies are particularly suitable because during the study, participants are asked to repeatedly fill out questions which capture momentary data on feelings, cognition, behavior, and social context in real-life situations (Janssens et al., 2018). Long-form reading typically spans extended periods of time and may be distributed across multiple days, making diary study an appropriate method to capture these dispersed experiences.

Another goal of the user study is to help **define the design scope**. The current research problem is still broad, and given the project's time constraints, narrowing the scope is necessary to ensure focus and feasibility.

Research questions of the diary study

This diary study aims to understand real-world reading experiences and to explore how interruptions shape the experience of long-form reading. Specifically, it seeks to answer the following questions:

1. Which scenario is worth further research on?
    a. What kind of long-form contents?
    b. On what platform do people read long-form content?
    c. How often and where (location, platform) do interruptions occur?
2. What is a good reading experience?
    a. What affects reading experience?
    b. How do interruptions and resumptions affect the reading experience?
        i. How do participants feel about different types of interruptions?
        ii. How do interruptions affect resumption (difficulty & sentiment)?
        iii. How do people experience the process of getting back into reading?

3.2 Methodology

3.2.1 Participant

Participants were recruited through online channels within the IDE faculty, TUDelft. In total, 13 individuals initially enrolled in the study, all of whom reported that they regularly engaged with long-form materials—such as novels, narrative non-fiction, or scientific papers—at least twice a week. Two participants did not complete the study, leaving a final sample size of 11.

- **Sample size.** N = 11 (13 initially enrolled, 2 did not complete).
- **Demographics**. Participants were between 18 and 34 years old. Eight (62%) identified as female, two (18%) as male, and one (9%) as non-binary. In terms of native language, six participants (46%) were Chinese speakers, three (23%) were native English speakers, and the remaining two (31%) spoke Turkish, Spanish, Thai, or Kannada. All had sufficient English proficiency to take part in the study. Nine participants (82%) were students, and two (18%) were working professionals.

- **Reading habits**. Most participants reported reading long-form content several times a week (nine participants, 82%), while two (18%) read daily. Primary reading platforms and typical reading contexts (e.g., at home, in transit) varied across participants.

All data were anonymized. Prior to participation, informed consent was obtained from each participant through a consent form.
In addition, two separate participants were recruited for a pilot test conducted before the main study. The pilot served to refine and clarify study materials and procedures.

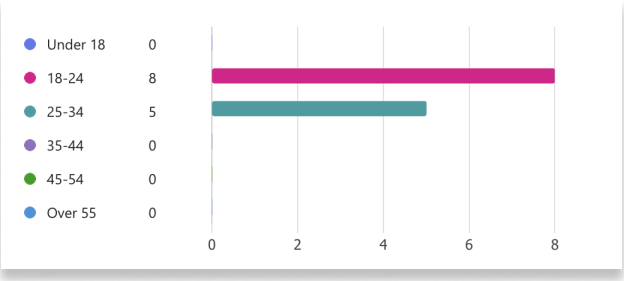


Figure 12. Age Group

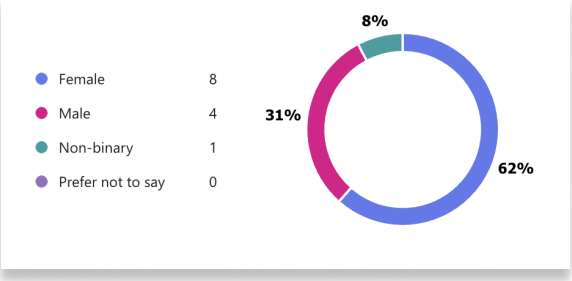


Figure 13. Gender

3.2.2 Material

The study did not restrict specific reading materials; participants were free to choose their own long-form content, such as novels, narrative non-fiction, or scientific papers. This approach ensured that the reading tasks reflected participants' real-world practices and preferences.

At the start of the study, participants completed a **demographic data collection form** (see Appendix). During the study, they were asked to record interruptions using **an interruption log form** (paper-based or online). The log form required participants to note the timestamp, type of interruption, and a brief description of the interruption.

After each reading session, participants completed a **digital reflection questionnaire** (see Appendix). This questionnaire collected contextual information about the reading session (e.g., platform, location, content type) and asked participants to evaluate resumption difficulty and report their coping strategies.

All diary entries and interruption logs were anonymized. To ensure anonymity, each participant generated a personal participant code, which was used consistently across all study materials.

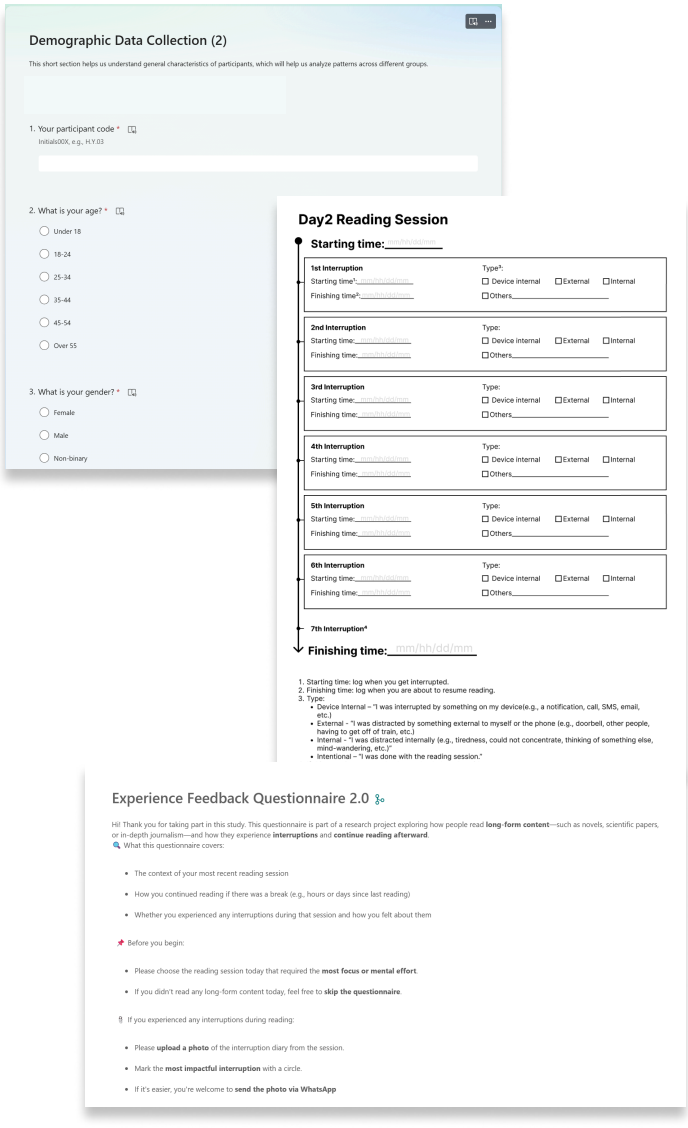


Figure 14. Materials for the user study

3.2.3 Procedure

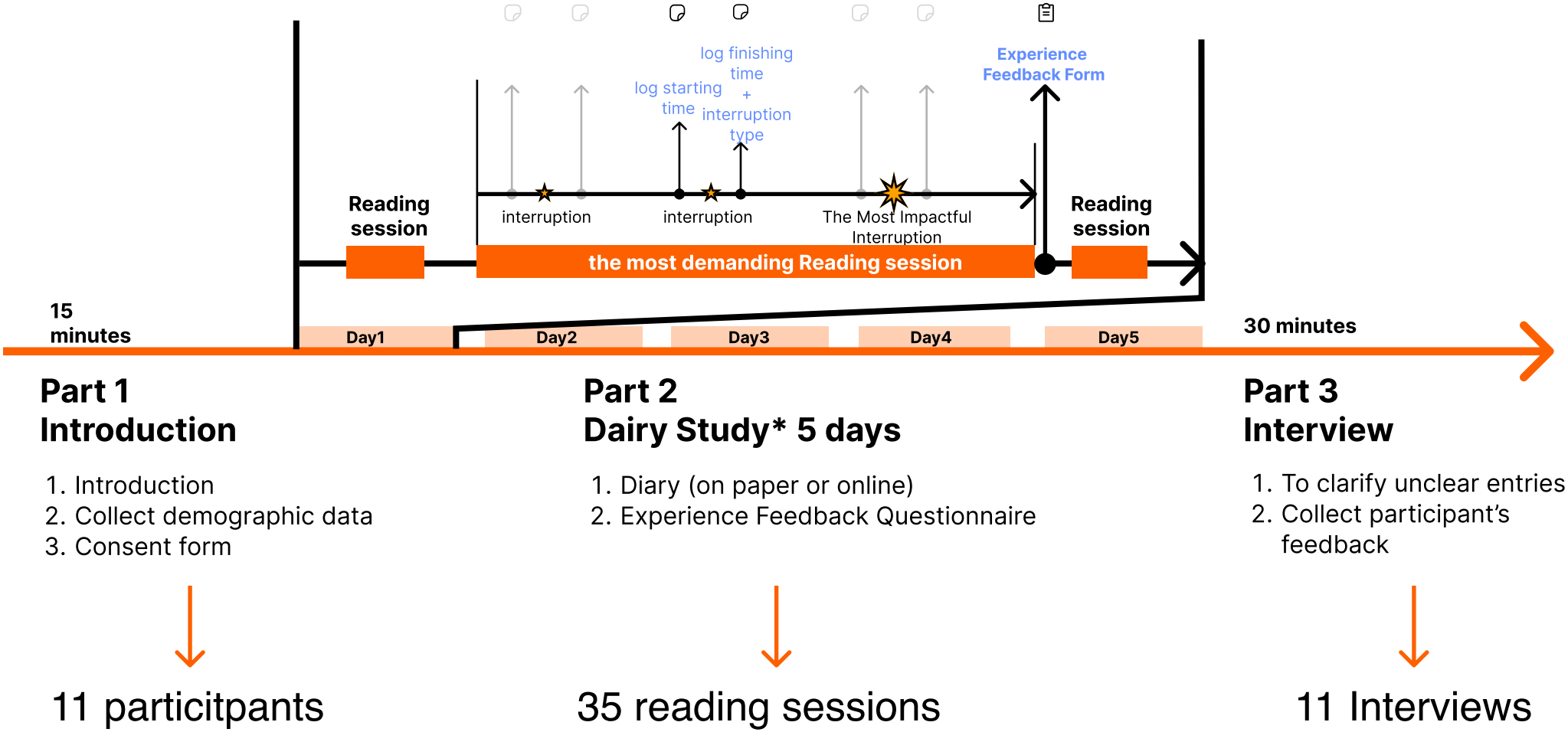


Figure 15. Process of the user study

1. Welcome & Consent (Day 0)
The author (experimenter) introduced the procedure of the experiment to the participant. Participants received an overview of the study as an instruction, and then signed the consent form, and filled in the demographics collection form.

2. Daily Routine (Day 1-5)
Over the following five days, participants were asked to select and log at least one substantial reading session on a minimum of two different days. **A substantial session** was defined as one that participants considered meaningful, complete, or worth reflecting upon, based on their own judgment. At the start of a chosen session, participants were instructed to ask themselves: "Is this a substantial session I want to log today?" If so, they kept the interruption log form nearby and recorded each qualifying interruption (lasting between 1–10 minutes, with type specified) in real time. After the reading session—ideally within three hours, or at the end of the day—participants reflected on the most impactful interruption and completed the reflection questionnaire.

3. Post-Study Interview (Day 6)
On the final day, participants took part in a short interview with the experimenter. The purpose of the interview was to discuss their overall experiences, validate the reflection, further explore what constitutes a good reading experience, and collect any additional feedback. At this stage, participants also submitted their interruption logs to the experimenter.

Pilot Test
Prior to finalizing the procedure, a pilot test with two participants was conducted. The pilot ensured that participants could identify and reflect on the most impactful interruption, and helped refine both the materials and the procedure of the study.

3.2.4 Analysis method

Both **quantitative** and **qualitative** data were collected in this study. Quantitative data were obtained from the interruption logs and reflection questionnaires, while qualitative data came from the post-study interviews as well as the open-ended responses in the interruption logs and reflection forms.
For the qualitative data, a **thematic analysis** approach was applied. Thematic analysis is defined as a method for analyzing qualitative data by identifying recurring themes or patterns within the dataset, thereby supporting a deeper understanding of the phenomenon under study (Qumbisa et al., 2024).
Following the separate analyses of quantitative and qualitative data, the findings were synthesized and organized according to the research questions, ensuring that both types of data contributed and made the conclusion concrete.

3.3 Results

3.3.1 Quantitive Data

The diary questionnaire captures 35 individual reading sessions contributed by 11 participants.

3.3.1.1 Contextual information :

- **Reading Platforms:** PCs were used in 14 of 35 sessions (40 %). Physical paper followed closely with 12 sessions (34 %). Mobile devices (tablets, smartphones or e-ink readers) made up the remaining 9 sessions (26%).
- **Content types**: Literary fiction and scientific papers are tied as the most common genres (12 sessions each, 34 %). Narrative non-fiction accounts for 7 sessions (20 %), with a handful of one-off entries such as manga or design guidelines.
- **Reading languages**: The material was predominantly in English (≈ 80 % of sessions), the rest split between Chinese-only and mixed English/Chinese.
- **Physical location and setting**: A large majority of sessions happened at home (28 sessions, 80%). Public-transport reading (train or bus, plane) added 4 sessions. The environment was usually "some background noise" (57%), occasionally very quiet (31%). Only 11% of sessions were judged to be distracting.

Finding 1 Type of Contents X Reading Platform

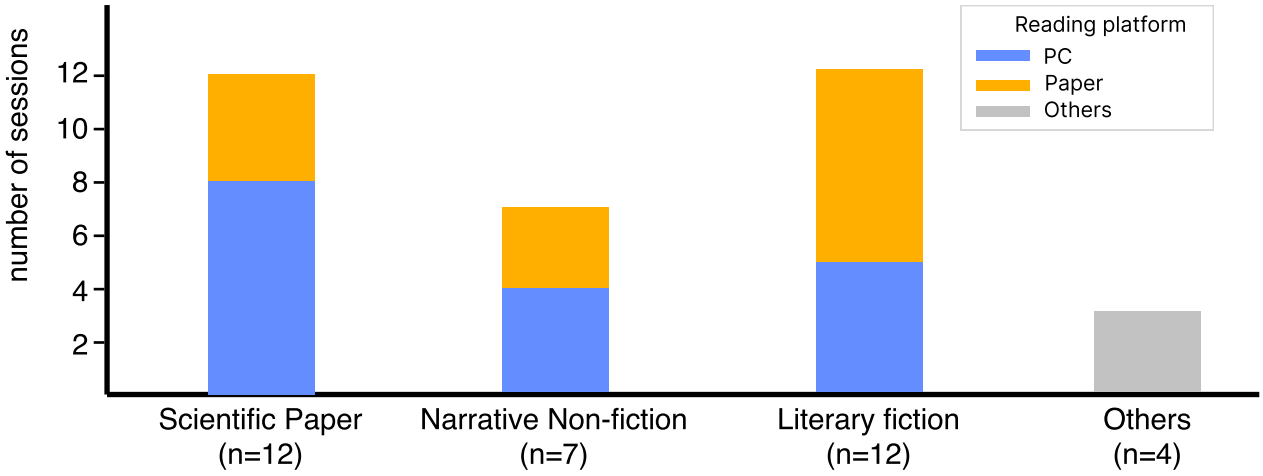


Figure 16. Distribution of reading sessions across content types and platforms

- **Scientific papers** (n=12) were mostly consumed on PCs (8/12, 67 %), though a quarter of sessions were on paper (3/12, 25 %) and one combined printed-and-iPad session (1/12, 8 %).
- **Literary fiction** (n=12 sessions) was read predominantly on paper (7/12 sessions, 58 %), with smaller shares on e-ink devices (2/12, 17 %), tablets (2/12, 17 %), and smartphones (1/12, 8 %).
- **Narrative non-fiction** (n=7) skewed toward PCs (4/7, 57 %), with 2 sessions on paper (29 %) and 1 on a tablet (14 %).
- Articles (n=1) and manga (n=1) were each read exclusively on smartphones (100 % each), while news essays (n=1) and design guidelines (n=1) were only read on PCs (100 % each).

Finding 2 Type of Contents X Reading Location

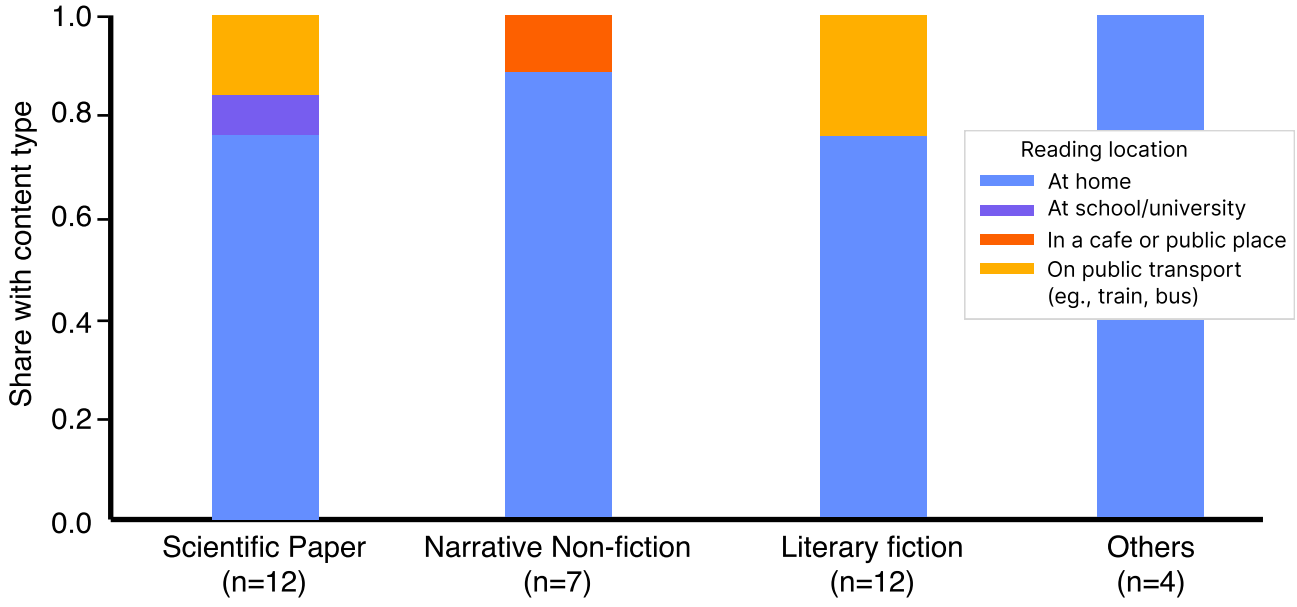


Figure 17. Distribution of reading locations across content types

Home is the most dominant location for reading long-form (80%, 28/35), public transport(train, bus, plan) accounts for another 14.3%(5/35).

- Most of the **Scientific paper** were read at home (9/12), with 2 of them read on public transport.
- Most of the **literary fiction reading** happened at home, with 3 of them on public transport.

3.3.1.2 Getting back into reading after interruption

Finding 3 Difficulty of resumption X length of interval(over 10 minutes)

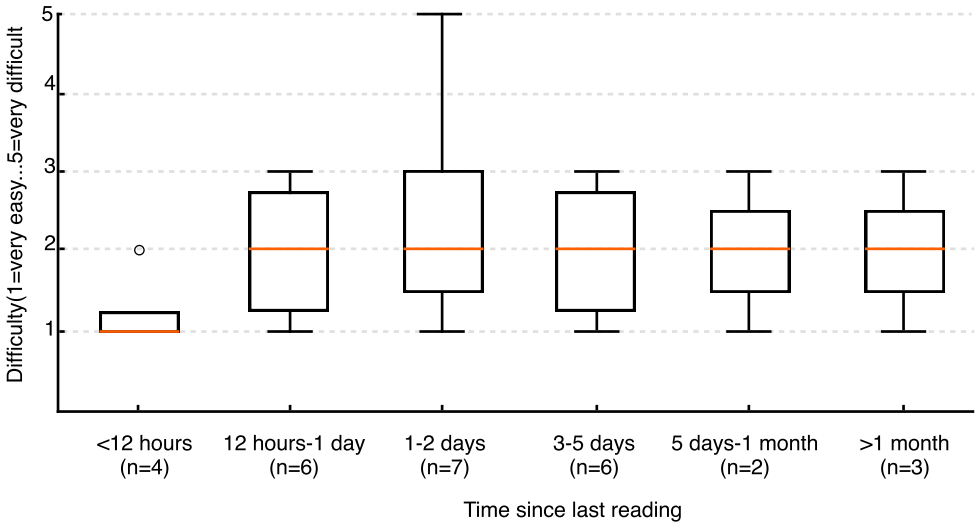


Figure 18. Difficulty of resuming reading after interruption (>10mins) across different lengths of interval

Without distinguishing between reading content, the reading difficulty tends to be the lowest within 12 hours. After 12 hours, there seems to be no significant change. This might also be related to the relatively small sample size (as shown in the figure left).

Finding 4 Difficulty of resumption X type of interruptions(less than 10 minutes)

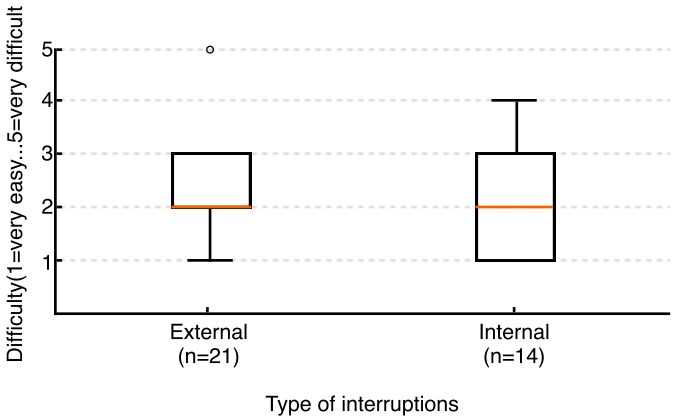


Figure 17. Difficulty of resuming reading after interruption by type of interruption (external vs. internal).

External interruptions account for ≈ 60 % of all “most-impactful” interruptions in this sample. The responses on difficulty of resumption after Internal interruption are more evenly spread across the 1-to-5 scale (counts at 1 → 4), so some readers find them trivial while a smaller group struggles. And responses to external interruptions are clustered in the lower range (1-3). The Mean difficulty of both types is almost identical (External ≈ 2.3, Internal ≈ 2.3)

3.3.1.3 Evaluation of the overall experience

Finding 5 Overall feelings X type of contents

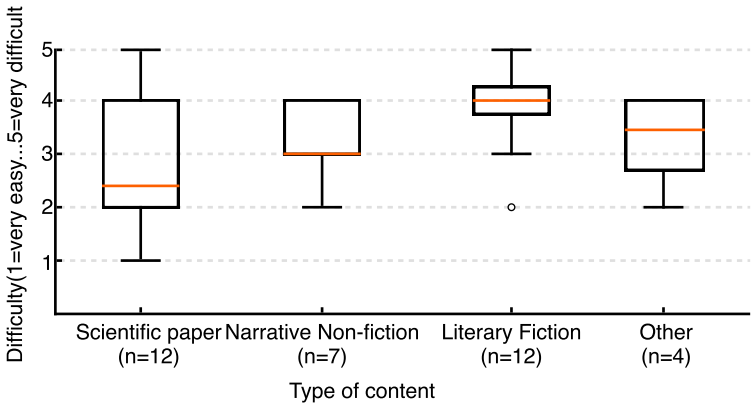


Figure 19. Overall reading experience ratings across content types.

Literary fiction delivers the best feeling (high median, low variability). Scientific papers are the most variable and often **less enjoyable**.
Scientific papers (n=12): Mean 2.92, median 2.5. Some sessions were good, but many were scored low.
Narrative non-fiction (n=7): Mean 3.29, median 3.0. The overall feeling is rarely excellent but generally okay.
Literary fiction (n=12): Mean 3.92, median 4.0. Most sessions rated 4, with occasional 5s.

3.3.2 Qualitative Data

After the 5-day diary study, I conducted one-to-one follow-up interviews with the 11 participants who completed the experiment. The interviews were designed in line with the overall research goals. Broadly, they aimed to validate the findings from the quantitative data and to discover reasons behind user behaviors. For example, one interview question—"What platform do you use for reading and why?"—was intended to explore the relationship between content types and reading platforms. Another question—"What factors influence your reading experience?"—focused on developing a higher-level understanding of reading experiences.

The interviews were audio-recorded, transcribed, and key information was extracted. Using thematic analysis, these keywords were then organized into five overarching themes-**the whole reading experience, how the factors affect the reading experience, about the interruptions, getting back into reading, reading assistance.** There were also several more focused sub-themes centered on interruptions in long-form reading. These themes were further structured into two main parts. The first part was a framework describing reading experiences and their influencing factors, corresponding to the user study objectives of identifying which scenarios are worth further research and what constitutes a good reading experience. The second part focused specifically on pain points related to interruptions, corresponding to the user study objective of examining how interruptions and resumptions affect the reading experience.

3.3.2.1 Thematic analysis on reading experience

The whole reading experience:

01 Reading experience is affected by 4 factors, and the degree to which everyone is affected by these factors varies:
1.Goal 2. Own conditions
3.Reading contents 4. Environment

P1 *"First, I think **my own condition** is important, and then is the **environment**, for example, if my brother is crying then I cannot focus. The **contents** is also important: the difficulties of the content and my interests affect the experience."*

*"First, **the goal** of the reading affects my experience. For example, I value more on experience when I am reading for pleasure. While task-oriented reading would be different, I don't care about the experience. The environment is also important...* P6

02 The impactfulness of the factors changes over the stages of reading. During reading, the environment posts a big impact, which could be neglected after reading. After reading, whether the goal is accomplished becomes the most important criteria to evaluate the experience.

P2 *" When I am reading, the environment affects me more. And after the reading, the environment does not matter that much. Whether I achieved my reading goal is more important."*

How the factors affect the reading experience

03 **Environment**
The degree to which environmental noise/ interruption affects an individual depends on its relevance, urgency and stability.

P4 *"I get more distracted when the train is arriving at my destination."*

P1 *"If the surrounding people is speaking dutch which I don't understand, I actually won't be affected. On contrary, if it is in Chinese...*

04 **Content**
It relates to task-relevance, reader's current knowledge, reading proficiency, writing style (personal preference)

P3 *"If the content is related to my current knowledge, it is easier for me to get inspired. It is also enjoyable for me to connect new things to my current knowledge."*

P6 *"Stop the reading to search for some words in google translate is annoying"*

05 **Content**
Paper reading requires more cognitive workload than literary fiction reading.

P1 *"when I am reading a paper, I really try to understand the logic and details. When I am reading a story, the details seem less important."*

06 **Goal**
The goal of reading influences the criteria for a good reading experience: if one reads for leisure, a comfortable environment seems more important; if one reads to complete a task, one's own state (whether they can finish it) seems more crucial.

P2 *"If I am reading for learning something new, then I try to focus to understand the contents. If I am reading a story, I am actually wanting myself happy."*

"If I am reading a novel, I would like to have good weather, cozy sofa, no distraction from environment - so I can entertain myself as much as possbile. While when I am reading a scientific paper, I want to fully understand the information, so I need enough focus and no distraction." P1

07 **Own Condition**
Own condition affects by reader's mental state, own knowledge background, reading proficiency, personal preferences.

P1 *"I need to clear up my mind to focus on the paper"*

P8 *"The writing style of the paper is simply so boring for me."*

About the interruptions:

08 Reasons behind the internal interruptions:
1. Not interested in the contents
2. The reading level does not match the content, such as language proficiency.
3. Fatigue
4. Others

P7 *"the harder the content itself, the easier to be internal distracted(mind-wandering)."*

"I feel happy to get interrupted during reading papers, so I can get rid of the boring paper." P8

09 Finishing with a clear cut of the content brings a greater sense of accomplishment and is more natural(like breathing). And it also makes it easier to get back to reading. By contrary, mid-way is harder to get back.

P7 *"Stop when finishing the part can be a better experience, because it brings a sense of achievement."*

P4 *"I perfer to finish my reading with a clear cut because midway of a section is harder to get back."*

P10 *"I perfer to stop at clear break points, such as paragraph and chapter endings."*

P6 *"Reading can be similar to breathing. I dont want to be interrupted in the middle of an exhale.*

10 Internal interruptions are generally perceived by readers as negative. When such interruptions occur repeatedly, they may lead to feelings of self-disappointment or even self-doubt. As a result, readers often seek to minimize these internal disruptions.

P2 *"If I interrupt myself too many times, I would view myself not focusing and then self-doubt, which is a bad reading experience."*

P5 *"Internal interruptions are more uncontrollable than external ones. They are also harder for me to recover from."*

11 Internal and external interruptions are not entirely independent. Internal interruptions can also transform into external ones.

P6 *"I sometimes looked for contents-related information online, but later I got distracted by other information and then I turned to check my rednote (social media app)."*

Getting back into reading

12 **Strategies**:
re-read previous parts, re-read marks by active reading (notes, highlights), read the abstracts, jump multiple times to locate themself.

P4 *"Sometimes I reread the contents. Sometimes I jump multiples times until I found the things that I feel unfamiliar and then I continue."*

13 Readers look up for logic chain, important arguments, facts, names and numbers. It may also differ according to people's needs and contents

P10 *"when returning to content, I focus on recalling the logic chain and main arguments. I also sometimes look for connection points between different papers. Numbers or names are also can be important."*

P13 *"I read a few sentences back to recall the memory or try to find where I was last time."*

14 **Why it is hard to get back into reading?**

1. multi-tasking(read multiple contents at the same time
2. the content of scientific paper is abstract
3. the task occurred during the interruption diverted much attention from the contents
4. insufficient understanding of the content itself
5. Lack of motivation
6. Long interval since last time reading

P8 *"I don't have a mental picture of the paper as I have when reading fictions. The mental picture helps me get back."*

P3 *"I find it hard to switch between papers, such as looking for tabs."*

P9 *"low-motivation and dense contents make the reading very hard."*

P10 *"When multiple related contents make it harder to remember and getting back, because information are mixed in memory"*

15 Not only the contents will help readers get back into reading, the other elements of the experience (e.g., feeling) will aslo be helpful.

P3 *"Apart from the hints related to the contents, the experience details, such as the feelings that I had during last reading is also helpful for me to get back into reading."*

Reading assistance

16 **purposes of reading assistances**

1. Bridging the gap caused by insufficient reading proficiency
2. Seeking additional knowledge out of interest
3. Isolating themselves from distracting environment
4. Emotional support

P5 *"I used reading assistance to understand old english words in the novel that I am reading."*

P7 *"Maybe AI can help me manage the external interruptions...."*

P6 *"information searching can be positive or negatvie. It is postive for searching for relevant knowledge out of interest. But it also brings negative impact...*

P2 *"Besides the support for reading the contents, I also need emotional support as encouragement...."*

17 The use of reading assistance tools is often not perceived as an interruption to the reading process, as readers remain within the flow of reading. However, it is important to note that such tools can sometimes lead to distraction.

P6 *"reading assistance, such as other's comments, makes me distracted sometimes. They enlightened me but also distracted me."*

3.3.2.2 Thematic analysis on interruptions in long-form reading

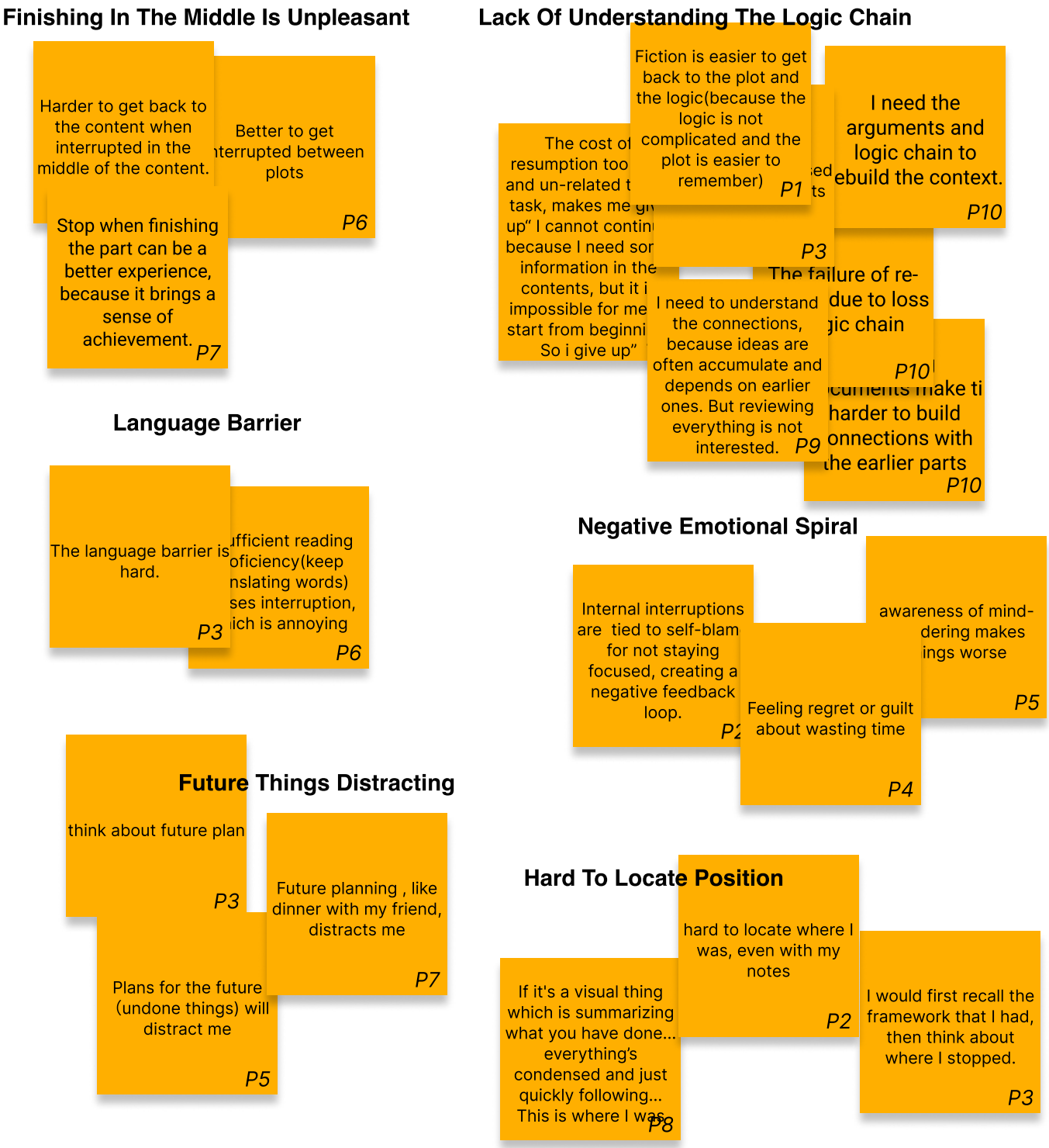


Figure 20. Thematic analysis of interruptions in long-form reading (part 1)

Figure 21. Thematic analysis of interruptions in long-form reading (part 2)

3.4 Discussion

3.4.1 Answering the RQs

RQ1:What scenario is worth further research on?

From the 35 reading sessions collected, two-thirds were concentrated in literary fiction and scientific papers (Quantitative-Finding1, hereafter *Quanti-F1*). A relationship also emerged between content type and platform "book-like" long-form genres (e.g., literary fiction, narrative non-fiction) were predominantly read in physical formats, whereas shorter long-form content (e.g., scientific papers) was consumed digitally—particularly on PCs *(Quanti-F1)*. One reason for this preference is that the latter often requires additional reading aids, such as looking up terminology or English vocabulary *(Quali-F5, 15)*. At a deeper level, this correspondence may be explained by differences in reading purposes: fiction is often read for pleasure and self-enjoyment, whereas papers are more frequently read with task-oriented goals (e.g., fully understanding arguments and logic). Consequently, fiction readers prioritize comfort (e.g., reading on the sofa with a cup of tea), while paper readers focus on efficiency and information access *(Quali-F6)*.

Furthermore, most reading sessions (80%) took place at home, with only a minority occurring in public or other settings *(Quanti-F2)*. Possible explanations include the greater controllability of home environments, which support concentration, as well as the habit of bedtime reading among some participants.

The scenario selected for further research is discussed in **Section 3.4.2**.

RQ2: What is a good reading experience?

RQ2.1: What factors affect reading experience?

Reading experience was found to be influenced by four main factors: environment, reader's own state, reading goal (motivation), and content *(Quali-F1)*. For example, a good experience when reading scientific papers typically requires a focused environment, high alertness, content that matches the reader's proficiency and prior knowledge, and relevance to their academic or professional goals. Under such conditions, readers sometimes reported generating new insights connected to their background knowledge *(Quali-F4)*.

Interruptions also emerged from these factors. External interruptions primarily stemmed from the environment, while internal interruptions were more complex: they could arise from the reader's state (e.g., lack of focus) or from an interaction between the text and the reader's condition or purpose—for instance, when the content felt uninteresting or too difficult to continue *(Quali-F8, 14)*.

More specifically, reading scientific papers was reported as less enjoyable than other content types *(Quali-F4)*. Interviewees attributed this to low motivation, high difficulty, and limited language proficiency. Moreover, content type influenced interruptions only indirectly. For example, poor content quality could trigger internal interruptions *(Quali-F8)*, which in turn created resumption difficulties such as repeated re-reading, eventually leading to frustration *(Quali-F14)*.

A more detailed account of these factors and their interrelations is presented in **Section 3.4.4**, where I outline the framework of reading experience.

RQ2.2: How do interruptions and resumptions affect the reading experience?

The impact of interruptions on readers varied by type as well as by individual preference. External interruptions were more frequently perceived as impactful, although the overall difficulty of resumption was reported to be similar across interruption types. Internal interruptions, however, showed a wider range of effects *(Quanti-F4)*. Some participants described them as less controllable and potentially triggering a negative emotional spiral *(Quali-F10)*.

Individual preferences also shaped how interruptions were experienced. For example, participants who were less motivated by or dissatisfied with the reading content reported more frequent interruptions—an observation consistent with prior work (Deng, 2019). The timing of interruptions further influenced resumption difficulty and overall reading experience *(Quali-F9)*. Interruptions occurring at natural breakpoints, such as the end of a section, were often perceived as easier and more natural to resume, aligning with Hirsch et al (2022).

In general, resuming reading was not always straightforward. Short interruptions were usually easier to recover from, as memory of the text remained fresh. In contrast, longer interruptions often made resumption more difficult *(Quali-F15)*. Motivation also played a critical role: when readers lacked sufficient motivation, they sometimes—consciously or unconsciously—extended the interruption period.

To further examine how interruptions and resumptions shape the reading experience, particularly the pain points that generate negative effects, I conducted a stage-based analysis informed by prior literature on interruption phases. This analysis is presented in **Section 3.4.3**.

3.4.2 Decided Scenairo

Given the time constraints of this project, it was not feasible to explore all issues related to long-form reading. Therefore, I narrowed the scope to focus on **students reading scientific papers on PCs**. The reasons for this decision are threefold:

1. **Practical accessibility.** The scenario of students reading research papers is relatively easy to access, which facilitates participant recruitment for subsequent experiments, design activities, and testing.
2. **Challenging yet promising**. Compared with other genres, the reading experience of scientific papers was reported as less satisfying (Quanti-F4), largely due to their difficulty, complexity, and task-oriented nature. These challenges, however, also present opportunities for impactful interventions.
3. **Feasibility of integration.** Scientific papers are typically read on PCs, where some readers already rely on auxiliary tools. This medium and existing habit of using aids provide a natural entry point for integrating AI-powered assistance, thereby increasing the feasibility of the project.

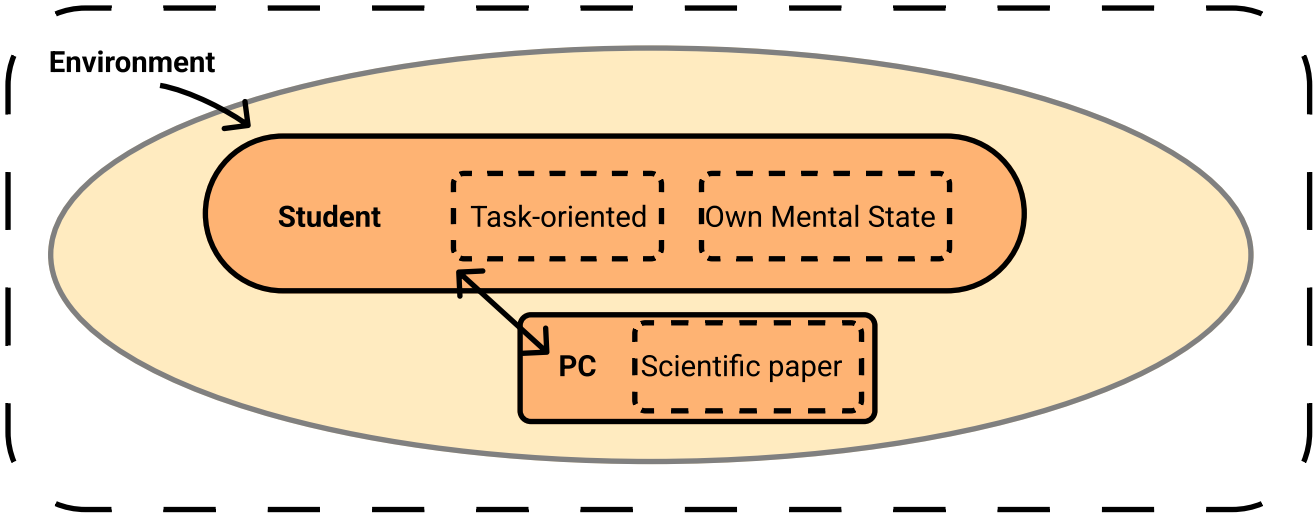


Figure 22. Project scope

3.4.3 Key pain points about the interruptions

Based on the interruption framework synthesized (especially the stages of interruption) in the literature review, the findings were organized into different interruption phases (see the figure next page. The negative effects were categorized into two dimensions: reading experience and reading performance (comprehension). Some pain points were found to span across multiple phases of interruption. A final pain-point framework was developed to visualize these interrelations.

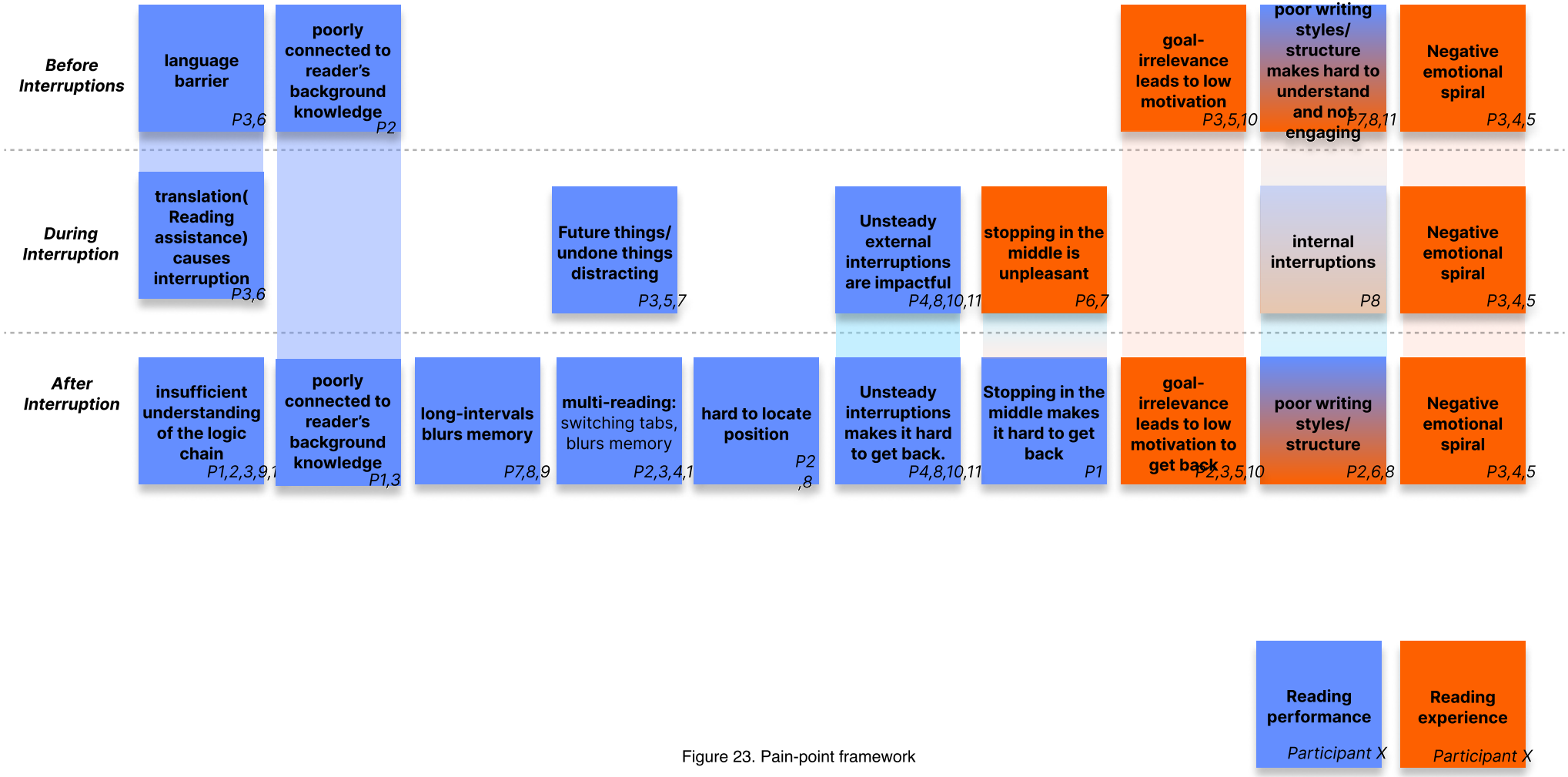


Figure 23. Pain-point framework

3.4.4 Framework

Based on a systematic synthesis of the qualitative findings (see Appendix), I developed a framework that maps the interrelations among factors shaping the reading experience. It shows how content, motivation, environment, and reader state influence one another, and how these dynamics are further affected by interruptions.

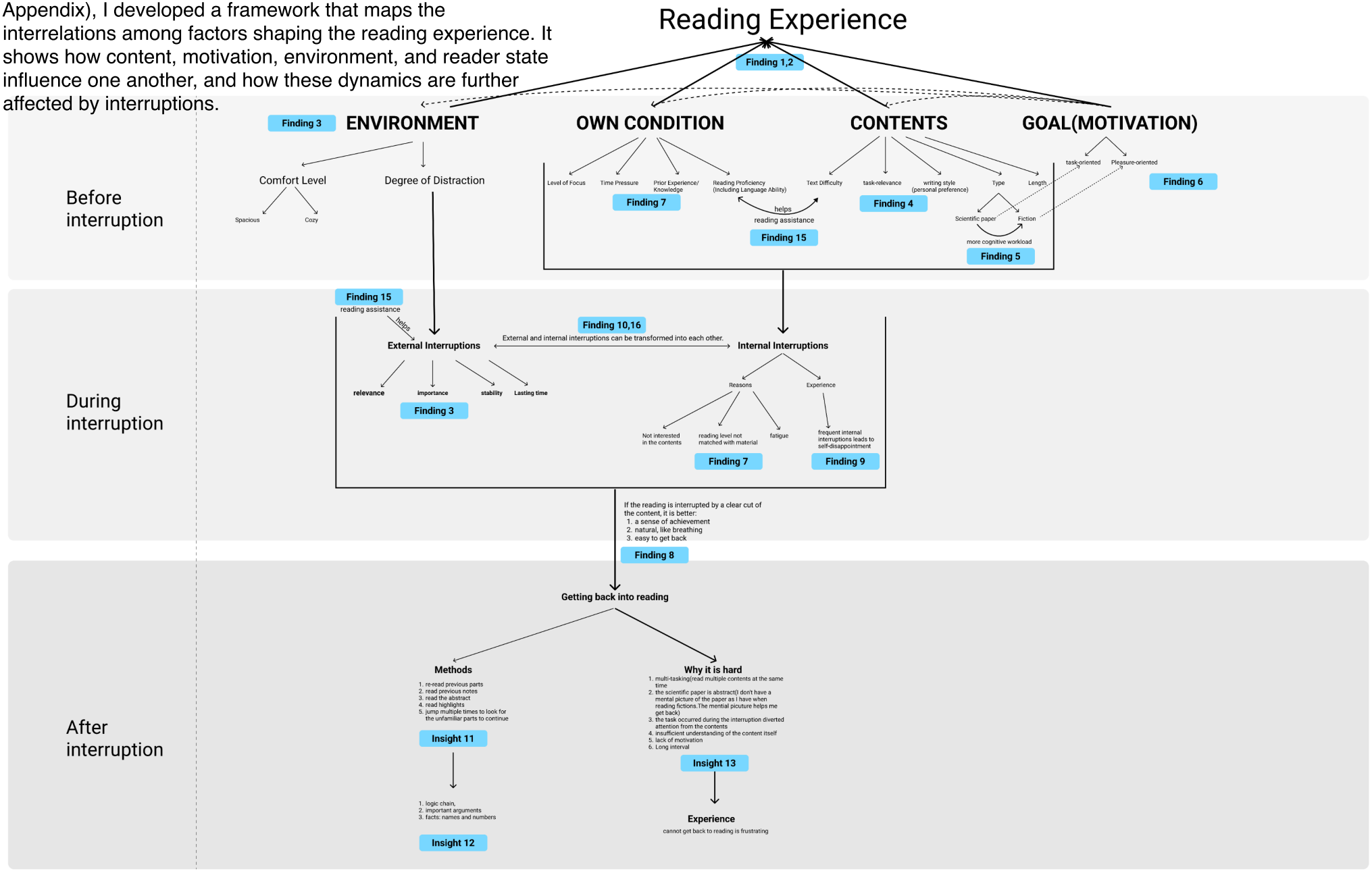


Figure 24.Conceptual framework of the reading experience across interruptions.

Reading scientific papers is widely regarded as a cognitively demanding task. This difficulty arises from their inherent characteristics: high reading proficiency is often required, alongside familiarity with specialized background knowledge. Furthermore, the writing style is typically dense and formal, making the content less engaging. When the structure of the paper is poorly organized, comprehension becomes even more challenging.

For students, reading papers is often task-driven rather than intrinsically motivated. Despite their lack of interest, they are still expected to understand complex content. This lack of motivation is exacerbated when the content appears unrelated to their goals or existing knowledge.

The reading process is further disrupted by both external and internal interruptions. External interruptions—especially those that are unexpected or unstable—can abruptly break concentration. Meanwhile, internal distractions, such as thinking about unfinished tasks or future plans, silently pull readers away from the text.

After an interruption, returning to the reading task is not always straightforward. Readers often struggle to resume due to an insufficient understanding of the paper's logic chain or blurred memory —especially if they have been switching between multiple papers or if there has been a long gap since the last reading session. These challenges are intensified when the paper lacks a clear structure or relevance to the reader's background, making re-entry cognitively taxing and emotionally discouraging.

Altogether, the interplay of cognitive difficulty, motivational barriers, interruptions, and structural complexity creates a negative spiral that hinders comprehension and discourages re-engagement with scientific texts. This downward spiral often triggers negative emotions such as self-doubt and disappointment, which in turn lead to more internal interruptions and reduced confidence in one's ability to understand the material — further compounding the difficulty of returning to reading.

3.4.5 Limitations

This user study has several limitations.

First, due to the study design, especially in the quantitative part, the setting might not fully reflect real-world reading. Participants were required to log interruptions and reflect on them, which in itself sometimes created additional interruptions (as reported in both the pilot and main study). This procedure also increased participants' awareness of interruptions, and in some cases even led them to minimize interruptions deliberately. In addition, because the logging had to be done on paper, participants tended to choose reading locations where the form could be conveniently filled in, which might affect their location of the reading session.

Second, the limited number of participants and recorded sessions reduced the reliability of some quantitative findings.To address this, selected interview questions were used to validate and complement the quantitative results.

The demographic constraints also exist: I only tested with people aged below 34, which ignores all readers above that age group.

Finally, the results of this user study was a combination of quantitative and qualitative data. The analysis was constrained by my limited experience in integrating quantitative and qualitative data, which may have left some insights underexplored.

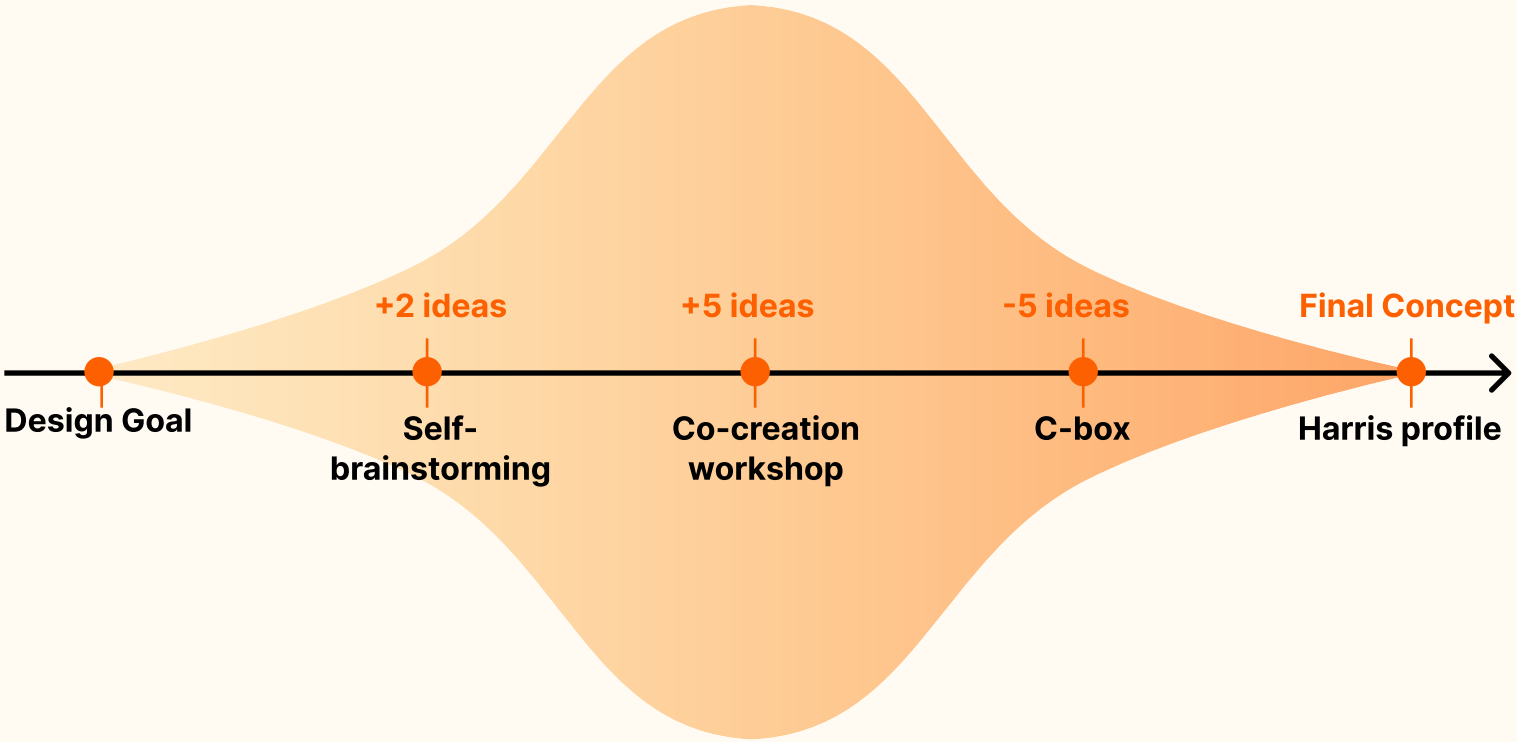
3.5 Summary

This chapter investigated interruptions and reading experiences in real-world contexts through two guiding research questions: **Which scenario is worth further research? and What is a good reading experience?** To address these questions, I designed and conducted a five-day diary study with 13 participants, of whom 11 completed the study. In total, 35 reading sessions (primarily quantitative data) and 11 interviews (qualitative data) were collected.

From the analysis, I identified **five quantitative findings and seventeen qualitative findings.** These results informed the answers to the two research questions. First, I decided to focus subsequent research on the scenario of students and researchers reading scientific papers on PCs. Second, I identified key problems related to interruptions in long-form reading and developed a framework linking reading experience and interruptions, which explains how factors such as motivation, content, and environment interact and shape comprehension and engagement. Together, these findings provide a foundation for defining the design goals and problem scope in the next chapter.

4 Concept & Prototype Development

Building on the pain points identified in the user study, this chapter establishes the design goal and explores possible solutions through ideation. To explore ideas thoroughly, I applied both brainstorming and co-creation workshops. The resulting concepts were then evaluated and refined using C-box and Harris Profile methods, leading to the final concept.



4.1 Problem Space& Design Goal

4.1.1 Problem Space

The user study revealed a wide range of pain points related to interruptions in long-form reading. To prioritize and focus on the most relevant issues for this project, I used C-Box method. This was achieved by mapping these pain points onto two dimensions: impactfulness (how many stages of the reading process they affect) and commonness (how many participants mentioned them)(Van Het Industrieel Ontwerpen, 2014). This mapping helped to identify the final focus area, highlighted in the orange circle.

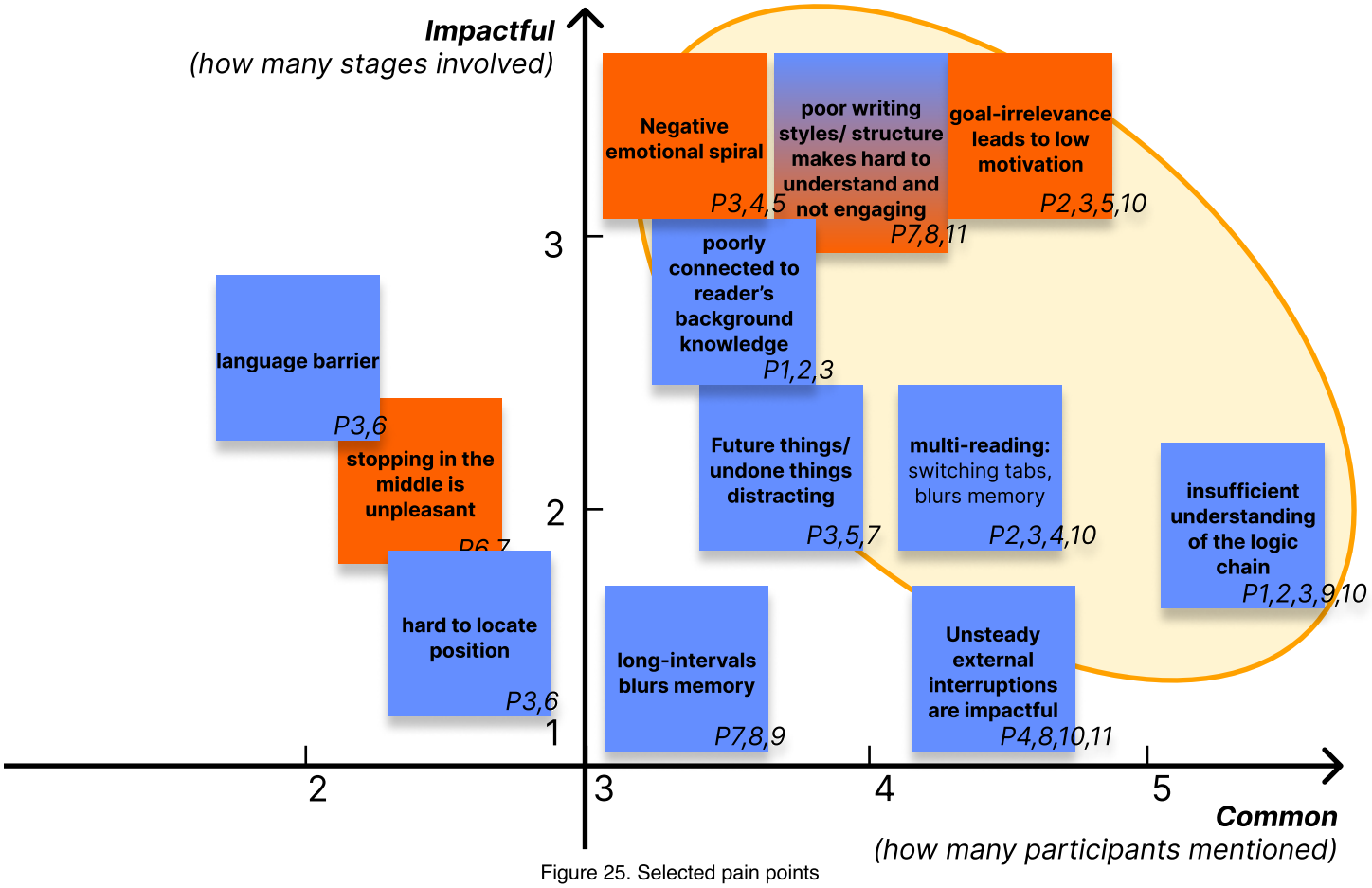
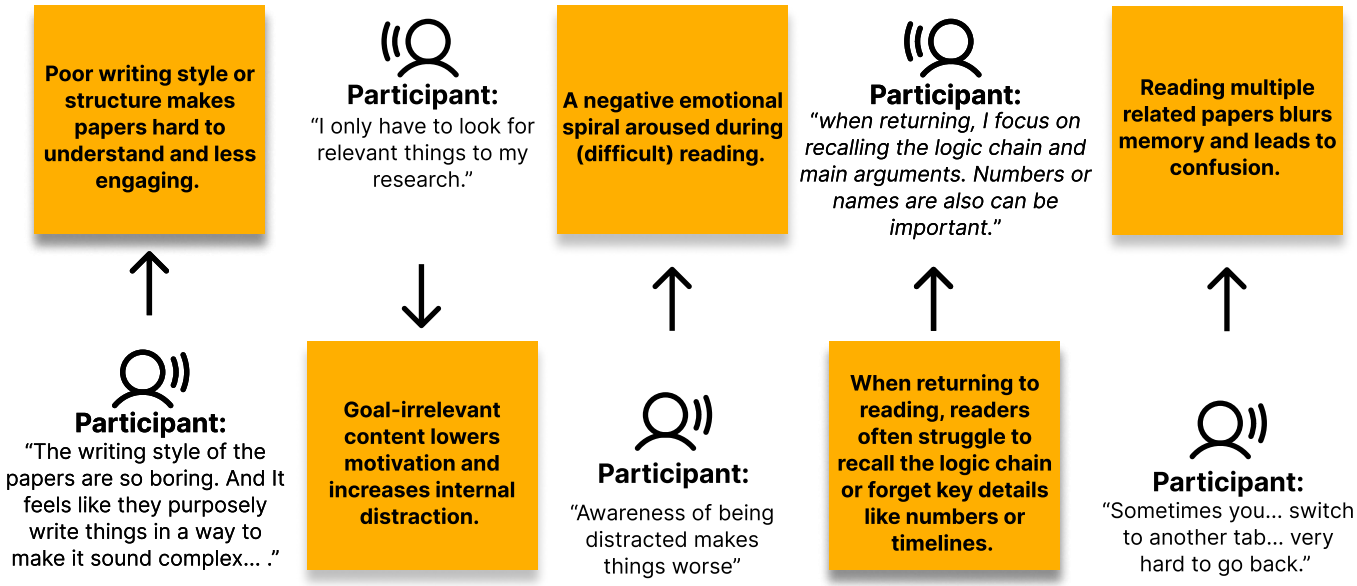


Figure 25. Selected pain points



4.1.2 Design Goal

The design goal actually includes two fields: experience and interaction. The experience should make the user feel **motivated, confident and supported**, and the interaction should be **clear and engaging**.

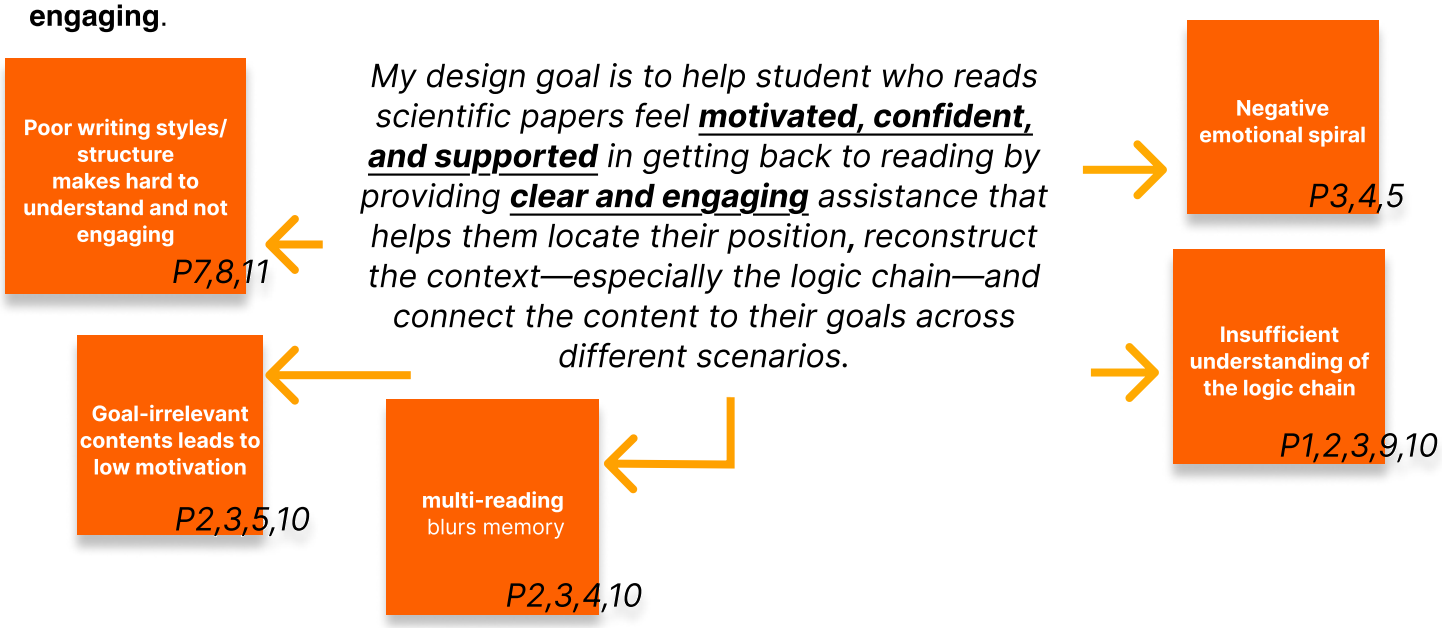


Figure 26. Design Goal

4.2 Ideation

The ideation process consisted of two parts. First, I conducted self-brainstorming and prototyping based on insights from the interviews and my interpretation of the pain points. This phase had two goals: (1) to independently explore the solution space and refine my understanding of the design goal, and (2) to test the feasibility of integrating a Large Language Model (LLM) into early prototypes, which provided an impression of their technical capability and informed later evaluation.

The second part involved a co-creation workshop. To further explore the solution space and ensure that the final concept aligned with user needs, I held the workshop with six participants, where we generated and evaluated concepts.

4.2.1 Self-brainstorming

Based on the pain points identified and my understanding of readers, I had two ideas and developed corresponding prototypes.

Idea 1 Smart Pop-up

Concept

This concept mainly focuses on the pain point—insufficient understanding of the logic chain. When resuming reading after an interruption, readers often struggle to reconstruct context because they forget key information such as jargon definitions or the reasoning that connects one sentence to the next and so on.

The Smart Pop-up interface is designed as an on-demand feature triggered by selecting a word or sentence. This design minimizes learning cost by blending with users' existing reading habits. An underlying LLM processes the selected text to infer user intent and retrieves relevant information. For instance: If a term is selected (e.g., NLP), the system provides contextual support categorized into definition, related concepts, logic/reasoning, evidence, examples, counterarguments, with the definition prioritized. And if a sentence is selected, the system focuses on reconstructing the underlying logic chain, again drawing on the same categories but prioritizing logical reasoning.
Through this interaction, readers can more easily rebuild context after interruptions. The pop-up format is designed to be clear, responsive, and low-effort, ideally helping readers feel more supported and confident when resuming scientific papers.

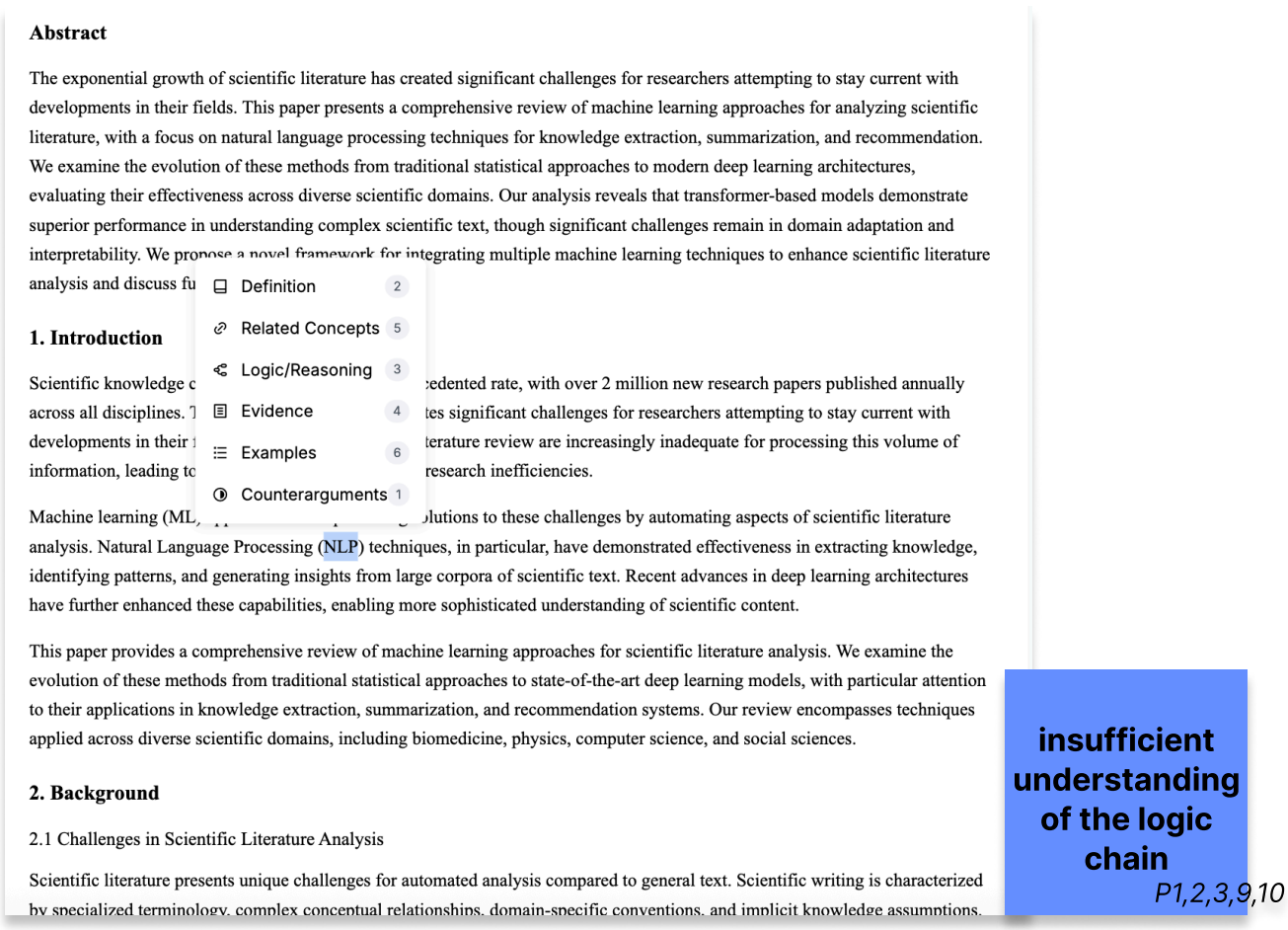


Figure 27. Interface of Idea 1 & corresponding pain point

Interaction flow

1. **Select Text:** Users highlight/ select any word, phrase, or sentence in the reading area by clicking and dragging with the mouse.
2. **Pop-up Appears**: A pop-up menu appears above or below the selected text, showing AI-generated categories and the number of relevant findings for each.
3. **Choose a Category**: Users click on a category (e.g., “Definition” or “Evidence”) in the pop-up.
4. **See Highlights**: It highlights the most relevant content in the document (in yellow) corresponding to the chosen category.
5. **Repeat as Needed:** Users can repeat the process for any other selection or category.

Core-features

- **AI-Powered Contextual Assistance**: When you select any word or sentence in the reading area, the AI analyzes the selection in the context of the entire document and offers categorized insights.
- **Smart Pop-up Menu**: A floating pop-up appears above (or below) your selection, showing categories such as: definition, related concepts, logic/reasoning, evidence, examples, counterarguments. Each category displays a count of relevant items found.
- **One-Click Highlighting**: Click any category in the pop-up to instantly highlight the most relevant content in the document, making it bold and yellow for easy reference.
- S**eamless Reading Experience**: The interaction is intuitive, with interaction based on the existing behavior of the reader, which makes it easy to learn and accept.

Idea 2: AI Contextual-Aware Tailor

Concept

It mainly focuses on these two pain points—poor writing styles/ structure makes it hard to understand and not engaging; goal-irrelevance leads to low motivation. Both reflect the broader issue that readers bring different contexts—such as goals, style preferences, and background knowledge—into the reading process. Misalignment between the text and these contexts contributes to low motivation and poor understanding of the contents, which makes it difficult for readers to get back into reading.
So this concept mainly focus on the phase of the reading before interruption. It helps reader by tailoring the contents according to reader's preferences, goal, which can deepen reader's understanding of the paper and make the reading process enjoyable. And it may also motivate people to get back into reading with the favoured writing style. For instance, reader can use it to re-create the paper based on their own background knowledge level and reading proficiency, so they dont need to worry about the terminologies in the paper.
In this way, it aims to acheive the design goal by providing supportive, confidence, motivational experience and engaging interaction.

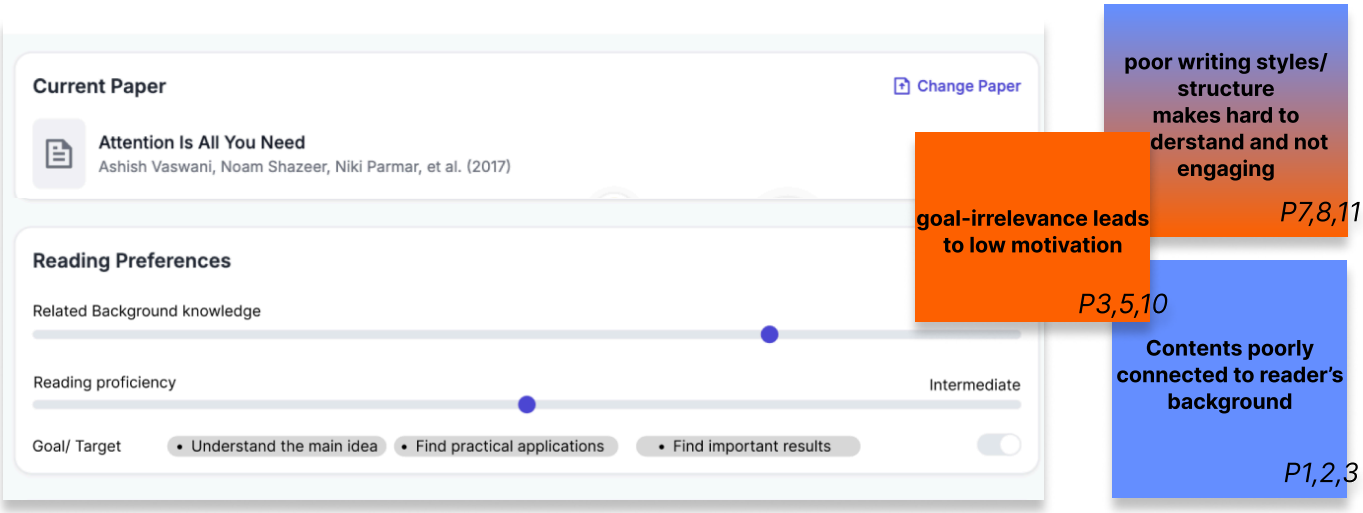


Figure 28. Interface of Idea 2& corresponding pain points

Interaction

1. Set Reading Context: when a user opens the app, they are presented with a form to set their reading context: Related Background Knowledge: (e.g., None, Basic, Medium, Advanced) Reading Proficiency: (e.g., Beginner, Intermediate, Advanced, Fluent/Native) Reading Goal: (e.g., Understand the main idea, Find practical applications, etc.)
2. Get a Personalized contents: after filling out the form. The app sends the user's context and the text to the backend server. The backend uses an AI model to generate a summary tailored to the user's context and goal.

Core-features

1. Key features:
   a. **Context-Aware Interface**: easy-to-use form is intuitive for users to set their context and goals without much effort.
   b. **Personalized Paper Reading Experience**: It can re-create the contents to the user's background knowledge (e.g., None, Basic, Moderate, Advanced), English reading proficiency (e.g., Beginner, Intermediate, Advanced, Fluent/Native), reading Goal (e.g., Understand the main idea, Focus on methods, etc.). Contents are written at the appropriate level of complexity and use vocabulary suited to the user's proficiency and focuses on the aspects of the text that matter most to the user's stated goal.

4.2.2 Co-Creation Workshop

4.2.2.1 Methodology

To break the limitations of my own thinking and to ensure the concepts aligned with reader's needs, I initiated a co-creation workshop. The workshop has two goals: create new ideas together with users; gain feedback on my current prototypes. Before the formal workshop, a round of pilot test was implemented to validate the duration, procedure, material.

Participants

I recruited six students from the IDE faculty at TU Delft. Three of them had joined my previous user study (diary study). All of them reported that they read scientific papers reguarly. All data were anonymised. Prior to participation, informed consent was obtained from each participant through a consent form.

Materials

The workshop used three types of materials:

1. I**ntroduction slides:** These provided background on the researcher and the project, explained the impact of interruptions in long-form reading, and highlighted the importance of addressing the problem. The slides also included a short self-introduction to create a friendly atmosphere.
2. **Digital collaboration board**: The main activities took place on miro.com (see Appendix), where step-by-step instructions and dedicated spaces for collaboration were prepared.
3. **Paper-based brainstorming tools**: Each participant received an A4 sheet to sketch or describe their ideas. They then tore the sheet into individual ideas, discussed them with others, clustered similar ideas, and placed them together on a larger A3 sheet.

Procedure

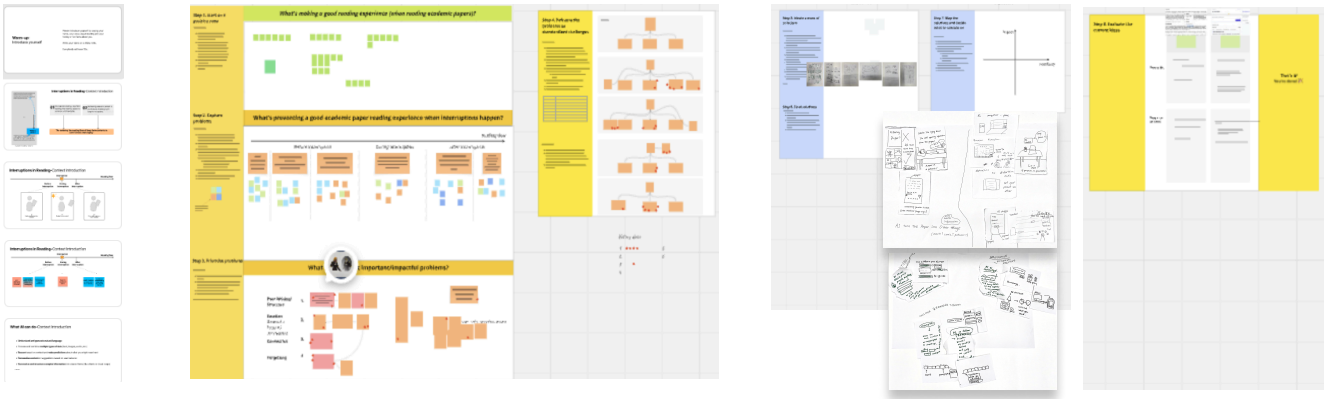


Figure 29. Procedure and materials of the co-creation workshop

4.2.2.2 Results

In this section, the results were present along the corresponding activities to help the reader understand where the data came from. The results can be catergorized into three partrs: Insights validation, Ideation, Feedback on my ideas/prototypes.

Insights validation

Activities for participants
1. Feedback on the pain points I found from user study and think about other pain points.
2. Vote and then cluster them
3. Get the top-voted painpoints

From the previous user study, five core pain points had been identified. During the co-creation session, participants voted on these pain points to determine which should be prioritized for ideation. As shown in the figure below, four pain points were selected as most important, while "Goal-irrelevant content lowers motivation and increases internal distraction" was removed from the list.

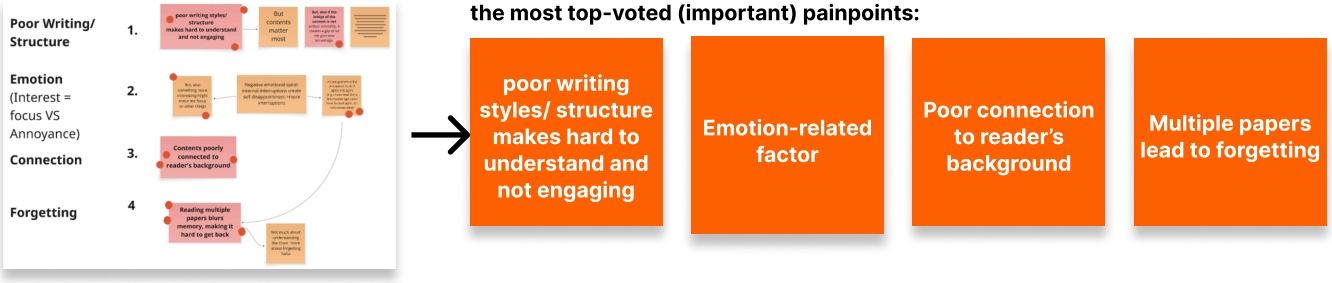
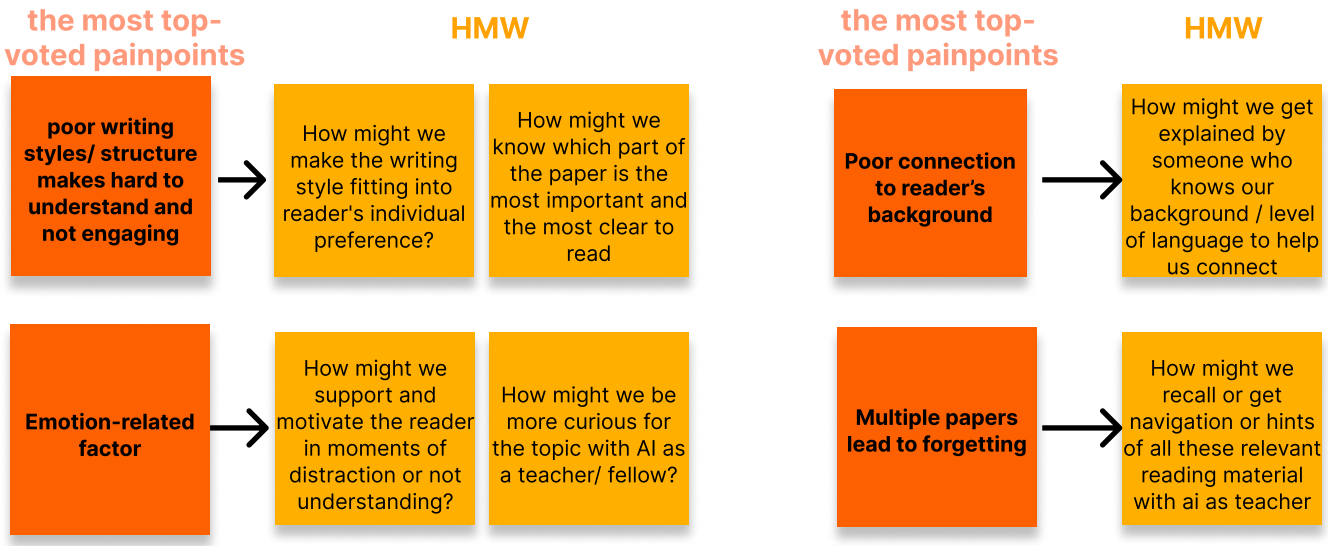


Figure 30. Selected pain points

Ideation

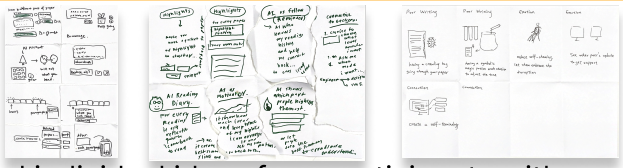
Activities for participants
1. Write HMW (How Might We) to every pain point
2. Vote for the HMW that is specific and inspiring.

Building on the selected pain points, participants collaboratively reformulated them into How Might We (HMW) questions. These HMW questions then served as the foundation for the subsequent ideation activities.

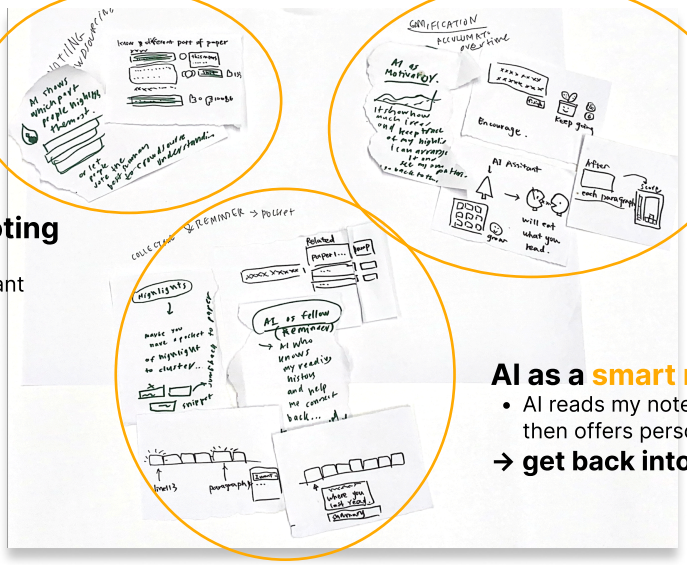


Activities for participants

1. Choose the HWMs that most resonates with you
2. Crazy 8s- 8minutes for 8 ideas
3. Split into 2 groups, cluster the ideas



Original individual ideas from participants with crazy8



AI highlights with crowdsourcing voting

- AI shows what other readers feel is important

→understand the contents better

AI supportor

- as a visualized diagram that shows your progress of the book that you already read
- as a digial plant
- ...

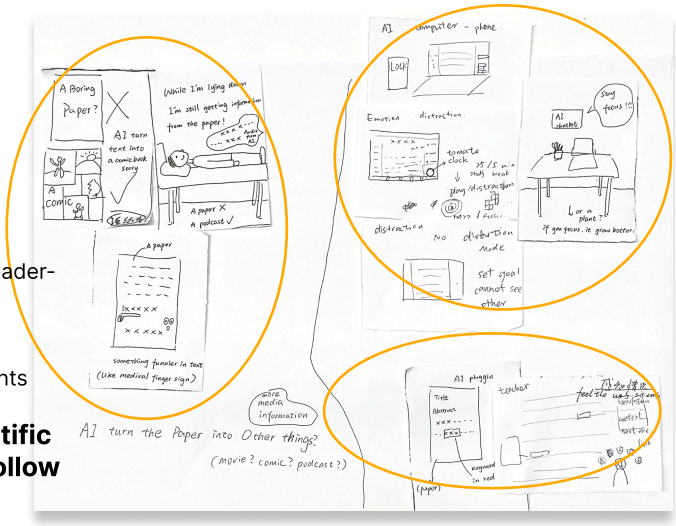
→ less internal interruptions

AI as a smart reminder

- AI reads my notes and understands reading history, then offers personalised reminder to help me back.

→ get back into reading with ease

Group A



AI podcasts

turn the contents into reader-preferred way:

- podcasts
- comic books
- hand-shaped highlights
- other writing styles

→ makes the scientific contents easy to follow

AI Focus Buddy

- detects reader's cognitive status and remind reader to stay focus
- isolate reader from distraction
- focus mode

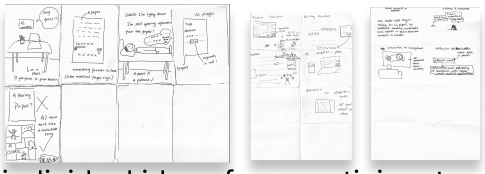
→ reduce distraction

AI Swiss Army Knife

- provide multiple functions so reader doesn't need to switch to other apps

→ reduce distraction

Group B



Original individual ideas from participants with crazy8

Figure 31. Clustered ideas from participants

Activities for participants

1. Come up with 2 final ideas each group.
2. map the ideas into impactful and feasible scale.

Participants mapped the concepts into the scale and gave their reason. Some of the very representative comments have been listed below.

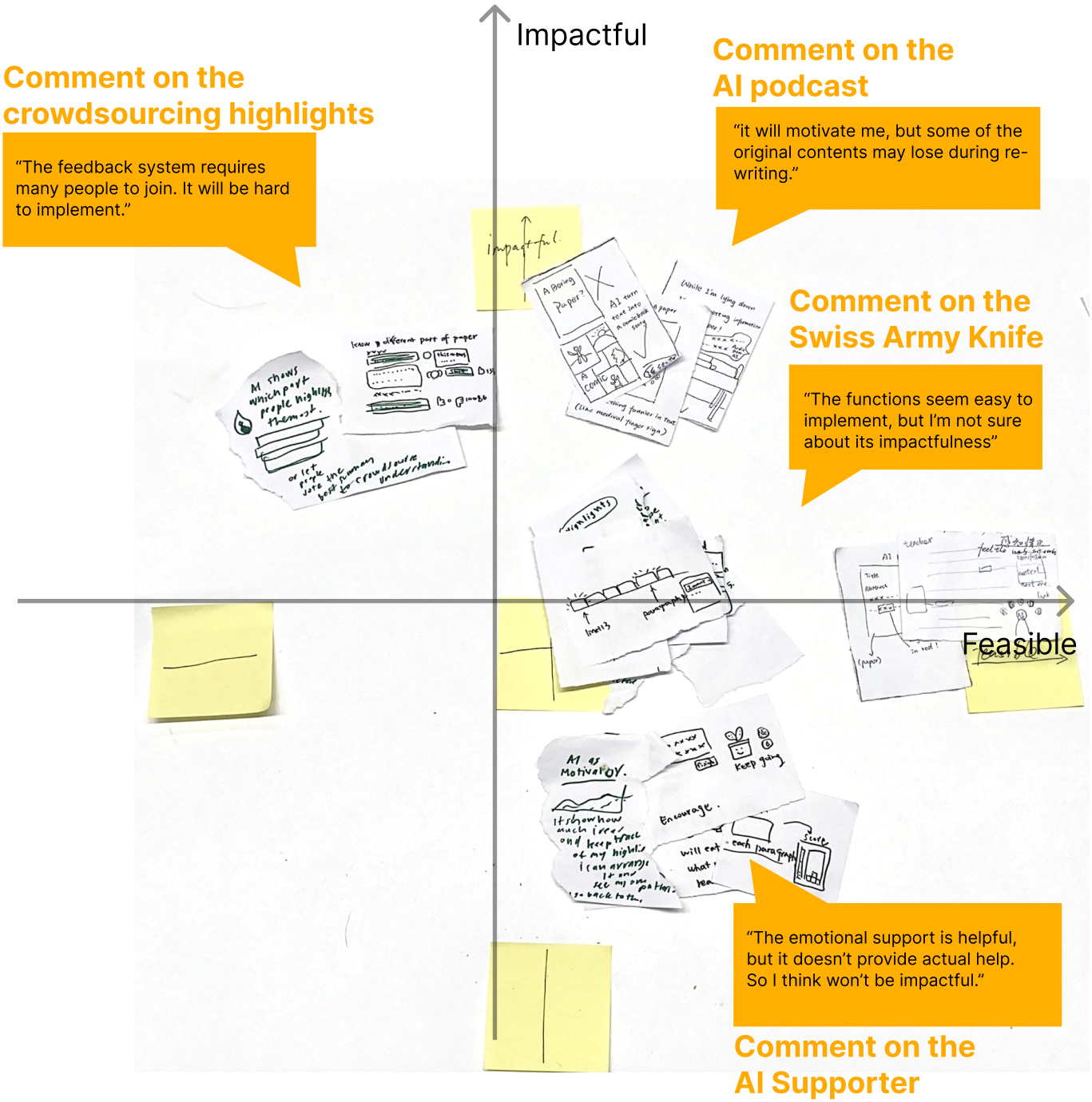


Figure 32. Selected ideas mapped on the scale(Impactful VS feasible)

Feedback on my current ideas

Activities for participants

1. Participants viewed my previous idea and tried my prototypes.
2. Gave feedback on two dimensions: "things I like" and "things could be better".
3. Then they also put my ideas into the scale.

Idea 1 Smart Pop-up

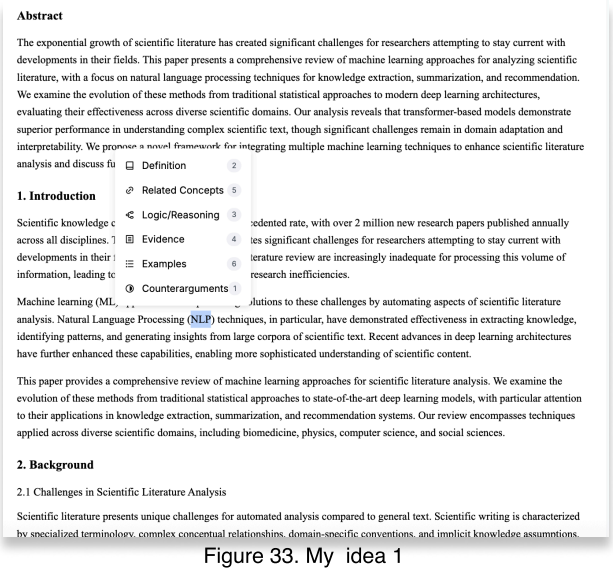


Figure 33. My idea 1

1. help to **relate past memories**.
2. help proficient people

1. a little **complicated to choose**
2. could **link to other papers**
3. might **cause distraction**

Idea 2 AI Context-aware tailor

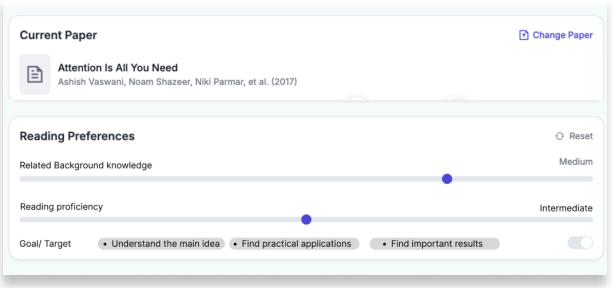


Figure 34. My idea 2

1. suitable for people who want to quickly know the topic
2. **easy to operate**, I don't need to type in prompts by myself.

1. slider may not be the best option: sometimes people find it **hard to evaluate themselves**. Choices would be better.
2. re-write will **lose some of the original contents**, and it will be less informative.

The ideas were also plotted into the scale with dimension impactful and feasible. The reason why they think smart pop-up is more impactful is mostly because it provided an easy way for reader to access the information they want. And for the idea 2 "AI context-aware tailor", they think that re-writing the contents could sometimes hurt or distort the original meaning, which can be important for paper reading.

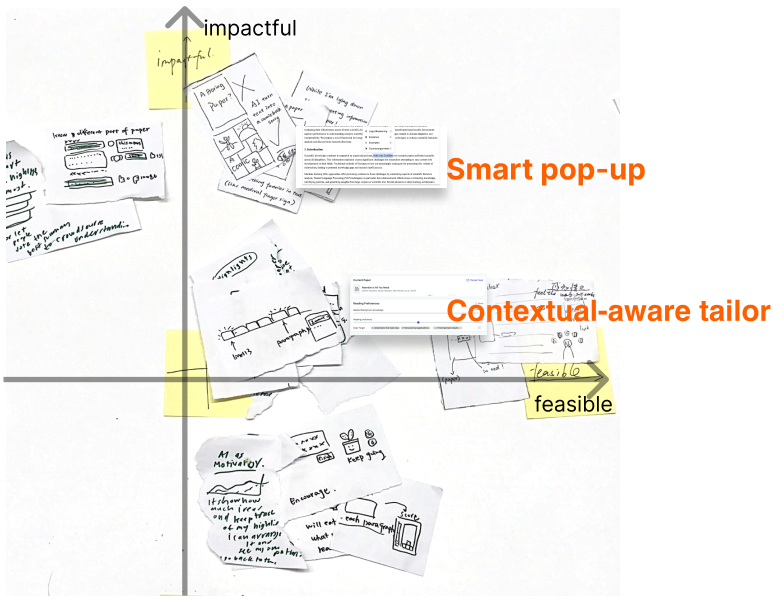


Figure 35. Scale with my two ideas added

4.2.2.3 Discussion on co-creation workshop

Reflection on the Result

The workshop generated six new concepts from participants, five of which were selected and mapped on a two-dimensional scale (impactful vs. feasible). Participants also evaluated my self-brainstormed ideas and plotted them on the same scale. Their discussion highlighted several insights:

- Beyond simply integrating existing external AI tools into the reading process, rich and diverse forms of interaction were valued. These interactions were perceived to increase motivation and engagement in reading—and in resuming—scientific papers. However, participants also noted potential risks: when interactions involved re-creating or changing original content (e.g., AI-generated summary, or reading scientific papers through listening tools), some felt this could harm the integrity of the original text, which they considered essential.
- Because of the inherent difficulty of reading scientific papers, participants expressed a demand for emotional support. Yet they emphasized that emotional support alone was insufficient; what they valued more were functional tools that could actually reduce workload and cognitive burden, as these were considered more impactful.

In summary, participants envisioned **AI tools that could be seamlessly integrated into existing reading workflows while offering practical support to reduce cognitive load**. At the same time, they stressed that such tools should **provide engaging interaction**s that increase motivation—without harming the accuracy and integrity of the original text.

Reflection/ limitations on the Co-creation session

1. The quality of the ideas was partly dependent on **participants' understanding of AI**. A critical methodological challenge was how to introduce AI as a design material. In this workshop, I provided participants with a set of cards illustrating AI's abilities (see figure on the right) and reminded them to consider these during the "How Might We" phase. While this was helpful, more effective approaches could be explored—for example, involving an AI expert to support participants, or offering a primer on recent advances in AI.

AI as ..	Role Example
Summarizer	Spotify creates a "year in review" of your listening.
Teacher	Explains concepts and jargons.
Visualizer	Google Maps shows a route overview before starting.
Reminder	Fitbit nudges you to walk after sitting too long.
Conversationalist	Duolingo chatbot helps you practice languages.
Note-Taker	Meeting AI (like Otter.ai) transcribes and organizes notes.*
Predictor	Netflix suggests shows you're likely to enjoy next.

Figure 36. Roles of AI

1. Another limitation was participants' **partial understanding** of certain pain points. For instance, the pain point "goal-irrelevance leads to low motivation" didn't get many votes, possibly because participants did not fully understand its meaning; the term was only clarified in the next phase of the workshop when participants asked for an explanation.
2. Despite conducting a pilot test, some **procedural issues** emerged in the main workshop, including exceeding the planned duration (from 75 to 90 minutes) and unclear instructions for certain steps. This shows that more multiple rounds of pilot testing would have been beneficial.
3. Finally, it is worth noting that co-creation workshops are inherently **dynamic and chaotic**. Even with clear guidance, participants interpreted materials in diverse ways, which generated both creative ideas and occasional misunderstandings. This dual nature is a strength of the method, but also a challenge for ensuring consistent outcomes.

4.2.3 Conclusion of the Ideation

Through my own ideation and the co-creation workshop, I developed seven concepts in total, which were compared and evaluated along two dimensions: impactful and feasible. This comparison revealed several insights into what constitutes an impactful AI-supported tool for reading scientific papers:

- **Purely emotional support was not perceived as impactful**. Participants valued features that provided tangible assistance in reducing cognitive burden.
- At the same time, **rich and diverse forms of interaction** (e.g., podcasts or comic-style visualizations) were considered more motivating than purely functional features, as they encouraged readers to re-engage with papers by making the experience more engaging.
- These findings resonate with prior work on long-form reading support: for instance, dynamic forms of interaction have been shown to help readers quickly grasp article content (Tjärnhage et al., 2023), and multimodal approaches such as integrating videos with text have been found to enhance comprehension (Kim et al., 2023).

In summary, impactful AI tools for scientific paper reading need to acheive a balance: they must offer practical support that reduces cognitive load, while also providing engaging, diverse interactions that sustain motivation and promote re-engagement.

4.3 Final Concept Selection

4.3.1 Final Two Concepts

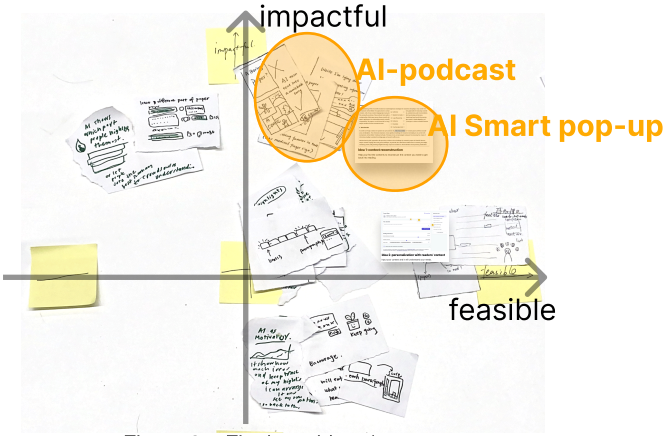


Figure 37. Final two ideas/concepts

From the seven concepts generated during the ideation phase, AI-Podcast and Smart Pop-up emerged as the two strongest candidates. Both were rated highly on the impactful–feasible scale, with their positions being very close. To make a final decision, I applied the Harris Profile method (Van Het Industrieel Ontwerpen, 2014), which allowed for a structured evaluation of their strengths and weaknesses across multiple criteria.

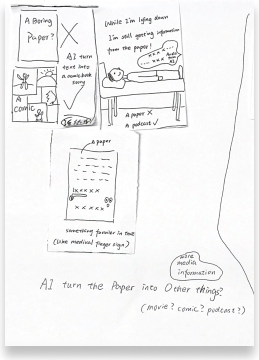


Figure 38. Idea/Concept from co-creation workshop

Concept 1: AI Podcasts

This concept addresses the pain points where readers often find scientific papers unengaging and struggle with re-entering the reading flow due to their diverse contexts (e.g., varying reading levels, knowledge backgrounds, and goals). By transforming the paper into an AI-generated podcast, the system allows readers to listen to a more engaging version of the content. Users can personalize the podcast by specifying their background and reading goals. This approach aims to provide a more motivating and accessible way to reconstruct the context of the paper and ease readers back into the flow.

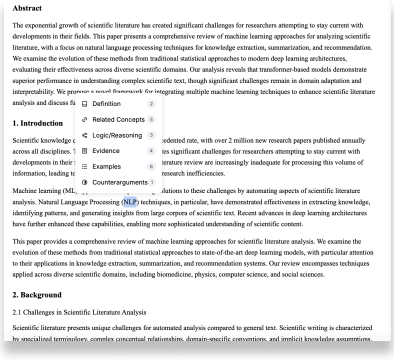


Figure 39. Idea/Concept from my brainstorming

Concept 2: AI Smart Pop-Up

This concept targets the pain point where readers returning to a paper and find themselves lacking critical contextual information, such as the logic chain leading to a statement, or references to time, location, or other key elements. The system allows users to select any word, phrase, or sentence in the text. A smart pop-up appears, offering AI-generated categories (e.g., definitions, related concepts, reasoning, evidence). By selecting a category, users can instantly highlight relevant parts of the document, helping them quickly re-establish understanding of the surrounding context. This interaction is designed to be lightweight and seamlessly integrated into existing reading habits.

4.3.2 Harris Profile Evaluation

Harris Profile is a graphical method for representing the strengths and weaknesses of design concepts. It is particularly useful for evaluating and selecting between design alternatives. The method requires defining a set of criteria that cover all important aspects of the design problem. Each concept is then scored by these criteria using a four-point scale coded as –2, –1, +1, and +2. The resulting profile visualizes the relative performance of each concept across the criteria. When the Harris Profiles of the design alternatives are completed, the profiles can be compared and a judgment can be made as to which alternative has the best overall score. Notably, the Harris Profile is not only for choosing the final alternative, more importantly, it clarifies the pros and cons of different concepts.

For this project, I create the criteria by considering three important aspects of the project: **user experience, interaction, project**.The first two are directly derived from my design goal—"to help readers of scientific papers feel motivated, confident, and supported in getting back to reading by providing clear and engaging assistance...". Accordingly:

- User experience was assessed in terms of being motivational, supportive, and confidence (trust).
- Interaction was assessed in terms of being **engaging** and **clear**.

Together with project feasibility, these formed the six final criteria against which the concepts were evaluated.

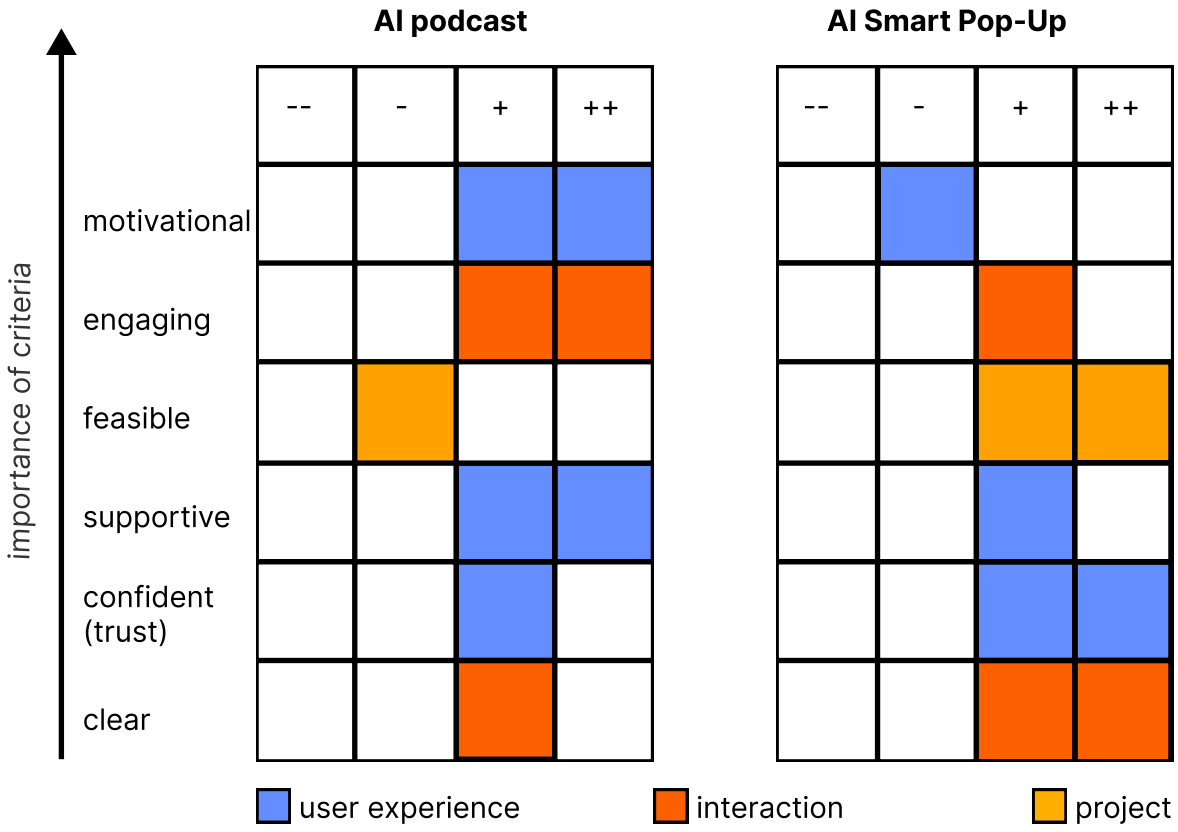


Figure 40. Evaluation with Harris Profile on the final two concepts

4.3.3 Final decision of direction

After evaluating both concepts using the **Harris Profile** and a detailed pros and cons analysis, I decided to go with the **AI Podcast direction while incorporating valuable elements from the AI Smart Pop-up**. This decision was based on findings from both the user study and co-creation workshop, where I observed that students often found the writing style of scientific papers unengaging, leading to frequent internal interruptions and negative emotional responses. In contrast, the podcast format was seen as more engaging and motivational, helping students stay connected to the content and re-enter their reading flow more easily.

Beyond engagement, the podcast format also offers a flexible alternative to screen-based reading, allowing students to continue “reading” when they feel fatigued from screen use or when they must leave the screen—for instance, during commuting or household activities. This adaptability makes it especially suitable for real-world reading scenarios, where interruptions are both inevitable and unpredictable.

Another key advantage of the podcast approach is its potential for personalization. Readers vary widely in terms of prior knowledge, language proficiency, and preferences for content presentation. Unlike the other direction-Smart Pop-up, AI-generated podcasts can be tailored to match individual users’ backgrounds and reading goals—offering different narration styles (e.g., conversational vs. formal), depth of explanation, or even language levels.

The last potential of this direction is that the audio experience could act as a resumption cue and build a more concrete memory for getting back into reading afterwards (based on the participant’s word in user study).

Moreover, by transforming dense academic content into a more conversational and personalized audio format, the AI Podcast lowers cognitive barriers and invites a more relaxed, emotionally positive re-engagement with the material.

However, I acknowledge a key challenge in this approach: trustworthiness. Since AI-generated audio may involve paraphrasing or summarization, users might question the fidelity and accuracy of the content. To mitigate this, I will intergrate the pros from the AI Pop-up idea, which directly links readers back to the original text without paraphrasing and builds trust between reader and AI.

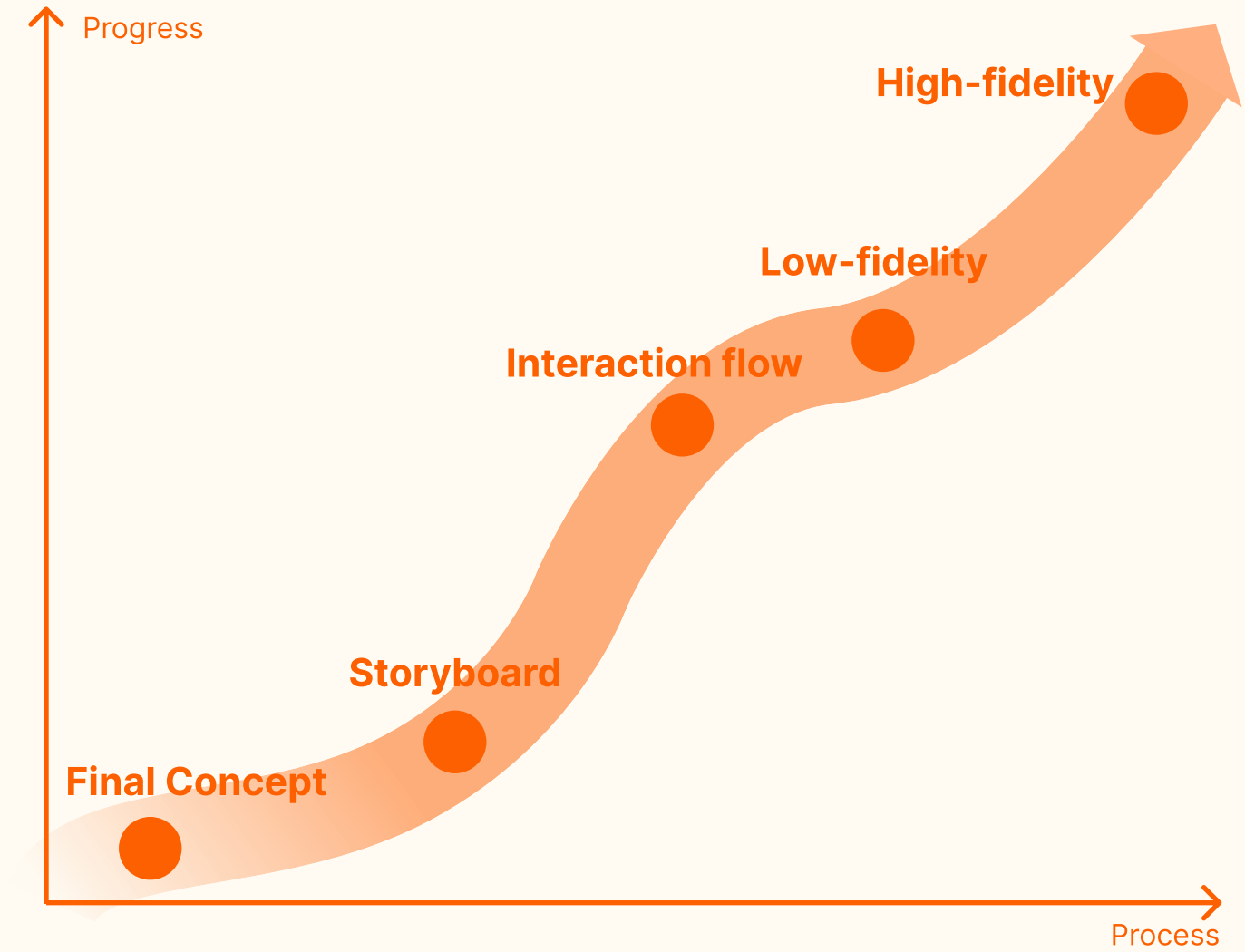
4.4 Summary

This chapter began by applying the C-box method to prioritize pain points and obtain the corresponding design goal. Ideation was then conducted through two approaches: self-brainstorming, which generated two ideas and helped the author gain familiarity with AI prototyping, and a co-creation workshop, which produced five additional ideas. The workshop also revealed a key insight: **engaging and dynamic forms of interaction increase motivation and sustain engagement in reading.**

Using the C-box evaluation, two concepts—AI Podcast and Smart Pop-up—were identified as the most impactful and feasible. To reach the final decision, a Harris Profile was created based on the design goal to systematically compare the two. The final concept integrates the engaging interaction of AI Podcast to motivate readers and support re-entry into reading, while incorporating the text-linking feature of Smart Pop-up to strengthen trust and reliability of AI.

5 Final Concept-The PaperCast

This section further develops the final concept—an AI-podcast combined with pop-up links to the original text—by defining the interaction flow and developing both low-fidelity and high-fidelity prototypes.



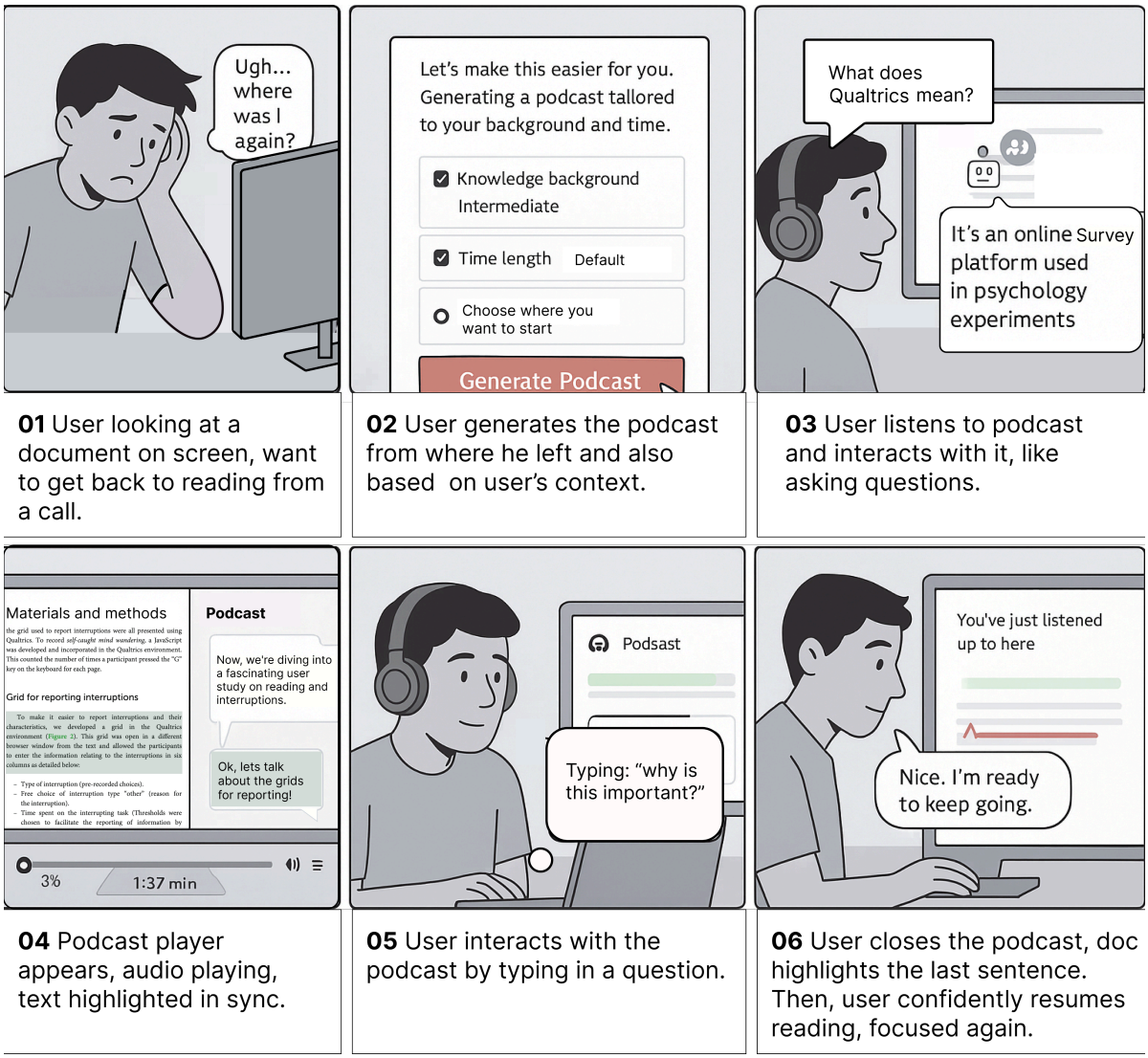
5.1 Design Overview

The target group of this design are students and researchers who read scientific papers on PCs. The design addresses multiple scenarios:

- **Before interruptions**, readers can listen to a podcast version of the text to reduce cognitive load and gain comprehension.
- **During interruptions**, especially when leaving the screen (e.g., commuting or doing household tasks), the podcast allows them to continue “reading” through audio.
- **After interruptions**, the system can generate a quick recap in podcast form, supporting readers in resuming their place and reconstructing the context. A storyboard below illustrates one such post-interruption scenario.

The design is implemented as a **browser extension**, reflecting insights from the co-creation workshop and prior literature (e.g., Srivastava et al., 2025), which emphasize the importance of seamless integration into existing reading practices to lower barriers to adoption.

At its core, the design uses the podcast format to create **engaging, dynamic** interactions that motivate readers. It also allows direct questioning of the podcast, making the interaction **supportive** and interactive. To ensure trust, original text passages are referenced throughout the audio, maintaining fidelity to the source. In addition, users can customize the podcast content according to their preferences and background knowledge, enhancing both a sense of control and trust. Finally, when returning to the paper after listening, visual resumption cues are provided in the original text to guide re-engagement.



01 User looking at a document on screen, want to get back to reading from a call.

02 User generates the podcast from where he left and also based on user’s context.

03 User listens to podcast and interacts with it, like asking questions.

04 Podcast player appears, audio playing, text highlighted in sync.

05 User interacts with the podcast by typing in a question.

06 User closes the podcast, doc highlights the last sentence. Then, user confidently resumes reading, focused again.

Figure 41. Storyboard of the Concept

5.2 Interaction Flow

This figure illustrates the overview of the interaction process between user and this design, which also highlights the important features.
This interaction flow not only structures the design around its most important features but also serves as the foundation for developing both the low-fidelity and high-fidelity prototypes in the following sections.

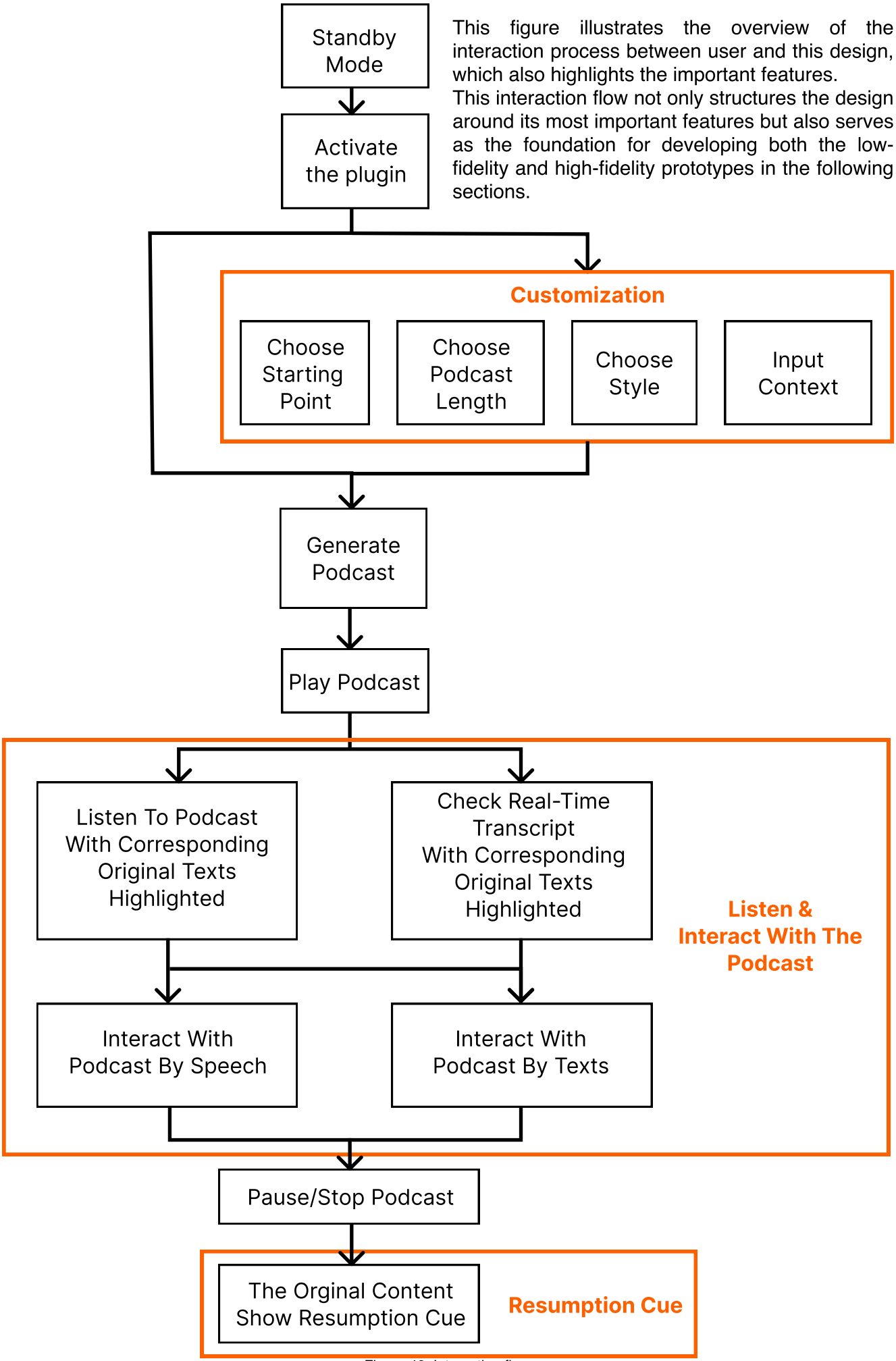


Figure 42. Interaction flow

5.3 Prototyping

5.3.1 Low-Fi Prototype

The figure below presents the low-fidelity prototypes of the final design. These sketches illustrate the expected interfaces, focusing on the overall layout, button placement, and navigation flow between pages.

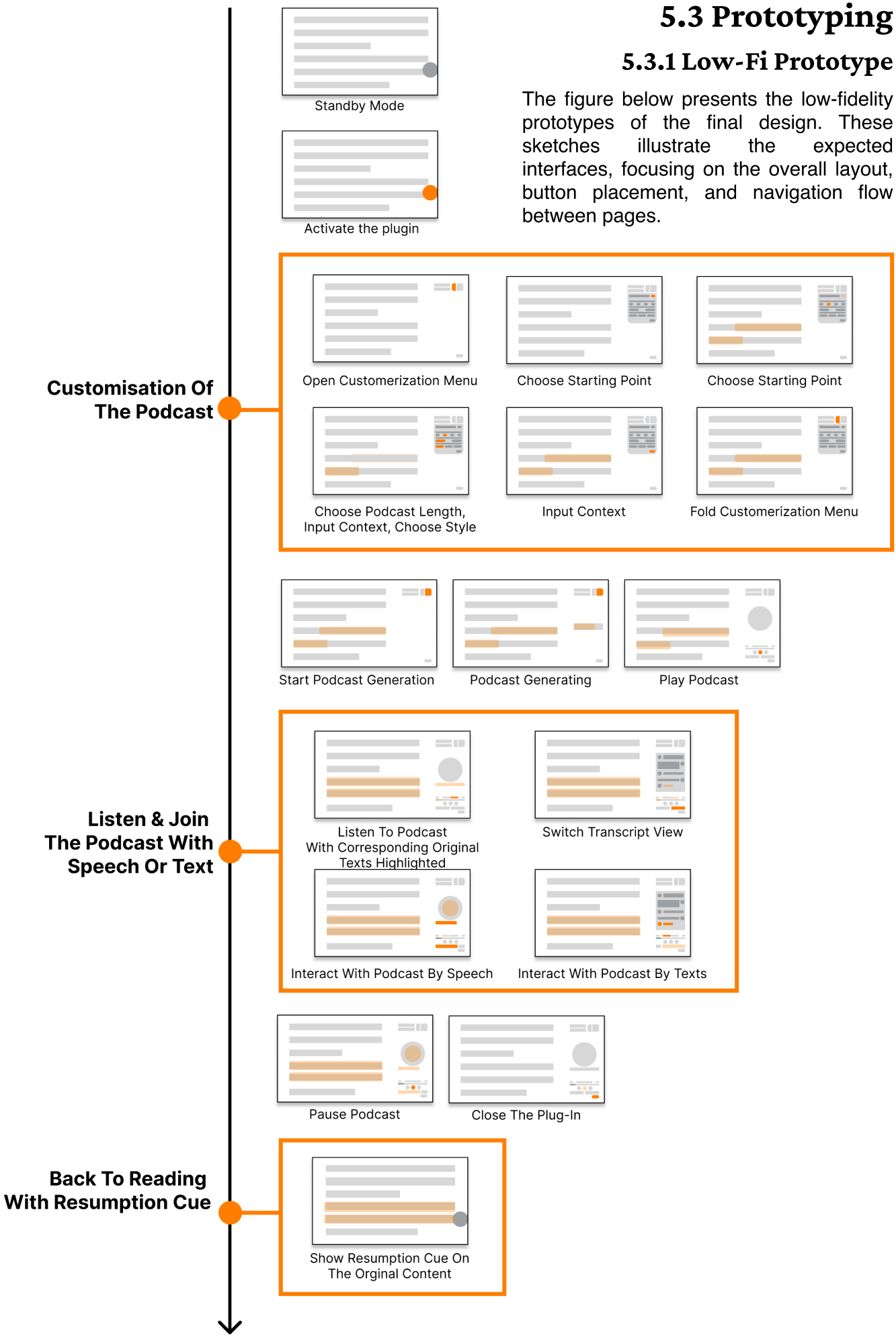


Figure 43. Low-fi prototype

5.3.2 High-Fi Prototype

The figure below presents the high-fidelity prototypes of the design. On the left side is the original reading interface, while on the right side is the main interaction panel of the product, integrated as a browser extension.

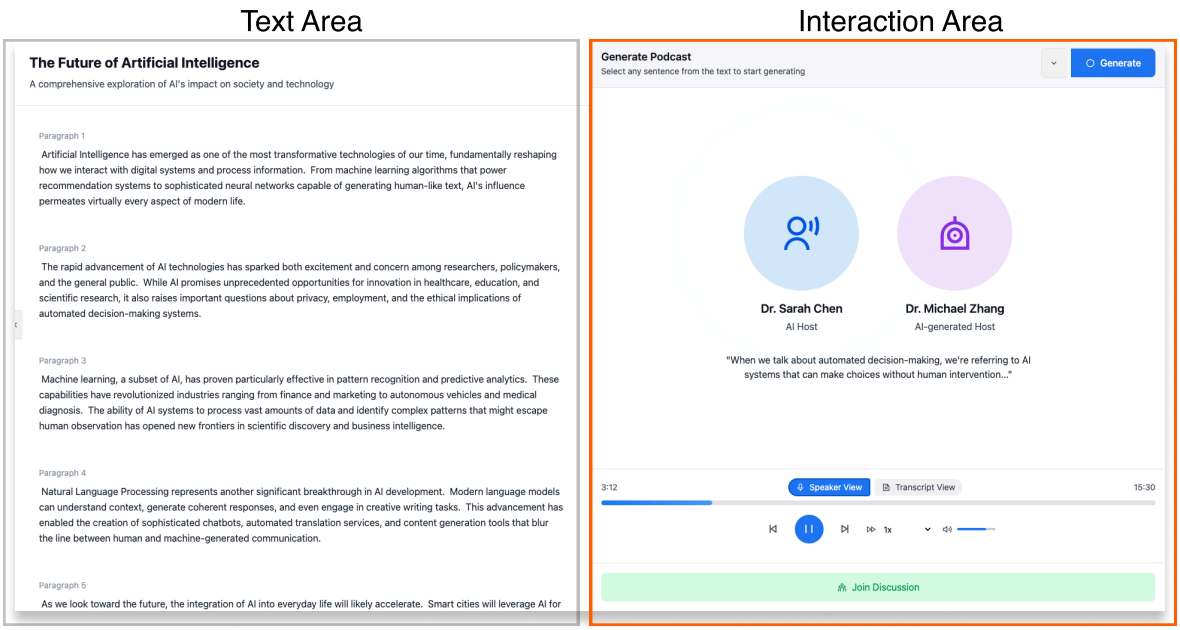


Figure 44. Core interface of the high-fidelity prototype.

The right-hand interaction panel has several key components, as illustrated in the figure below. These components include customization options, and resumption cues.

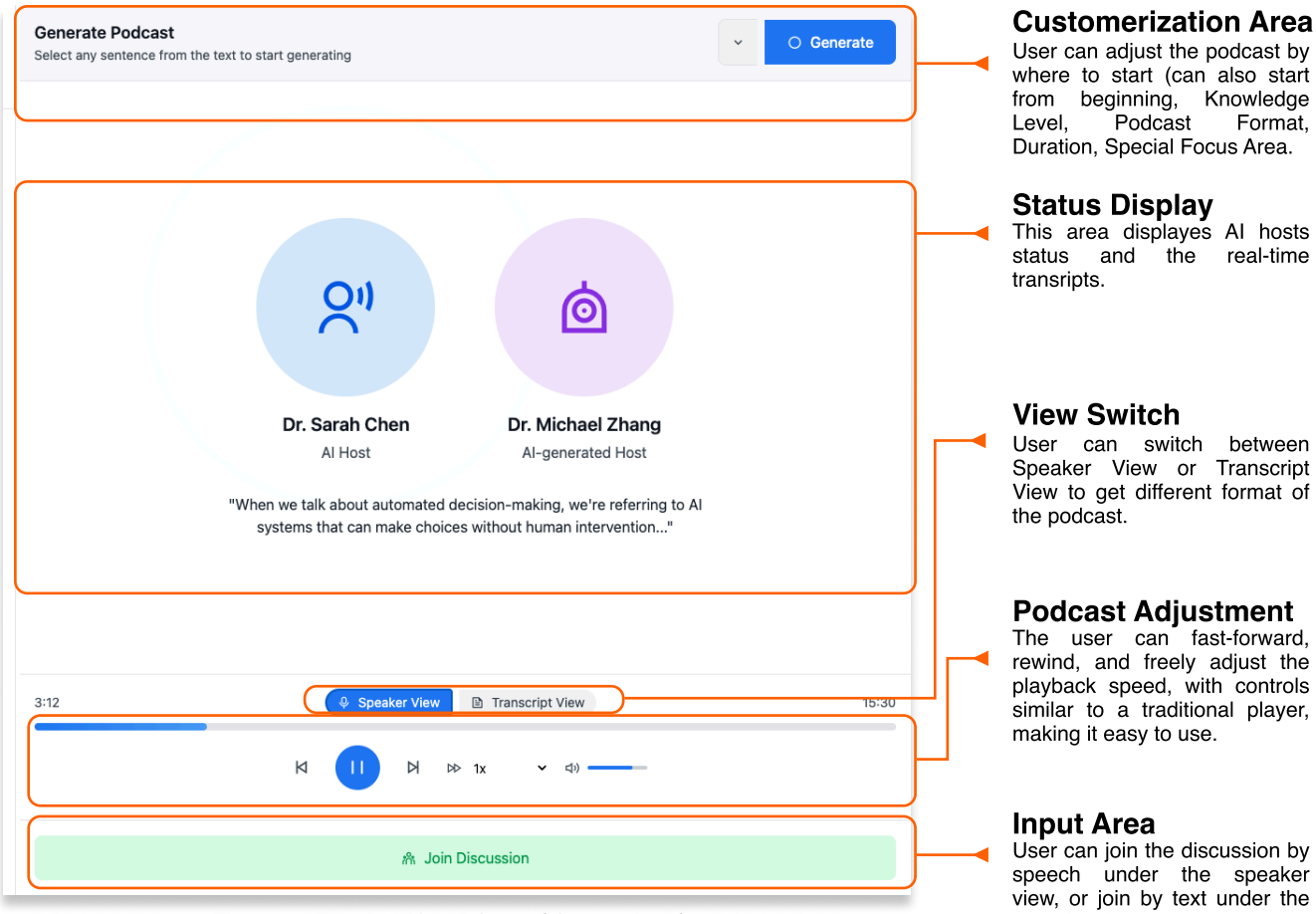


Figure 45. Functional breakdown of the core interface.

5.4 Key features Walk-through

5.4.1 Listen & Join The Podcast With Speech Or Text

Listen & Join The Podcast

Users can listen to the podcast or actively join the discussion with the AI host, using speech or text input.

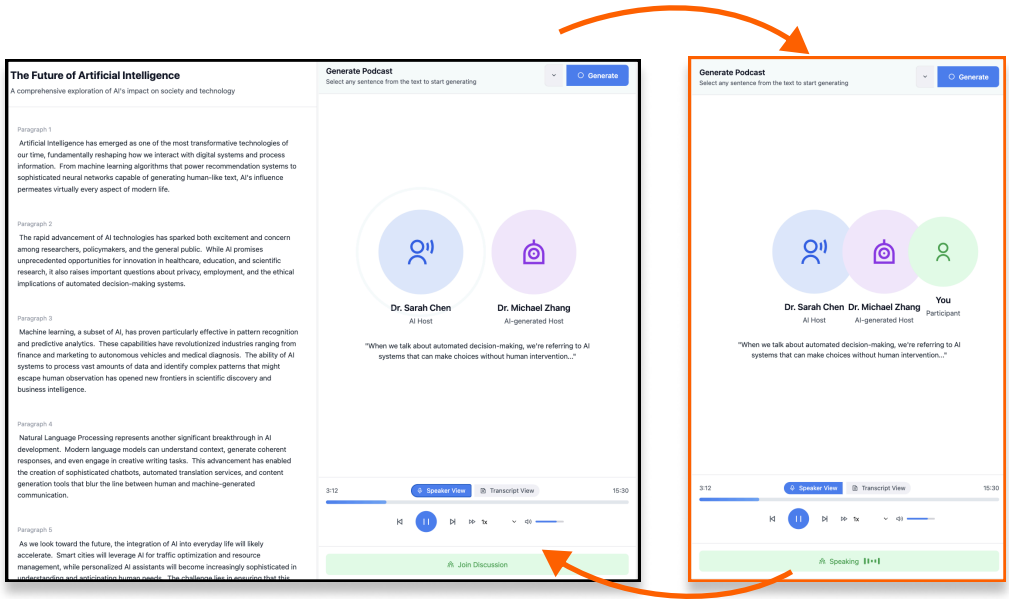


Figure 46. The interfaces of listening to or joining the podcast

Why

Unlike visual reading, the podcast format engages the auditory channel, enriching the reading experience and supporting stronger memory retention (User Test Quali-15). Allowing readers to join the podcast discussion makes the interaction more active and participatory rather than passive. This encourages readers to process the content in their own words, fostering deeper understanding.

To enhance trust, any references made by the AI host during the conversation are simultaneously highlighted in the original text, ensuring transparency and alignment with the source material.

The Detailed Interaction

When the AI host is speaking, its avatar displays animated sound waves around it.

To participate, the user presses and holds the “Join Discussion” button located at the bottom of the panel. Once activated, the button label changes to “Speaking”, and a second circle appears around the user’s icon—indicating that their input is being recognized. During this time, a live transcript box displays the ongoing dialogue in real time, showing the user’s contributions.

When the user releases the button, the label reverts to “Join Discussion”, and the system returns to listening mode. Throughout the exchange, any passages from the paper that the AI host refers to are highlighted directly in the original text, building trust between user and the design

Figure 47. Detail differences in the interface for listening vs. joining.

Switch Between Speech And Text View

Users can freely switch between the speech view and the transcript view.

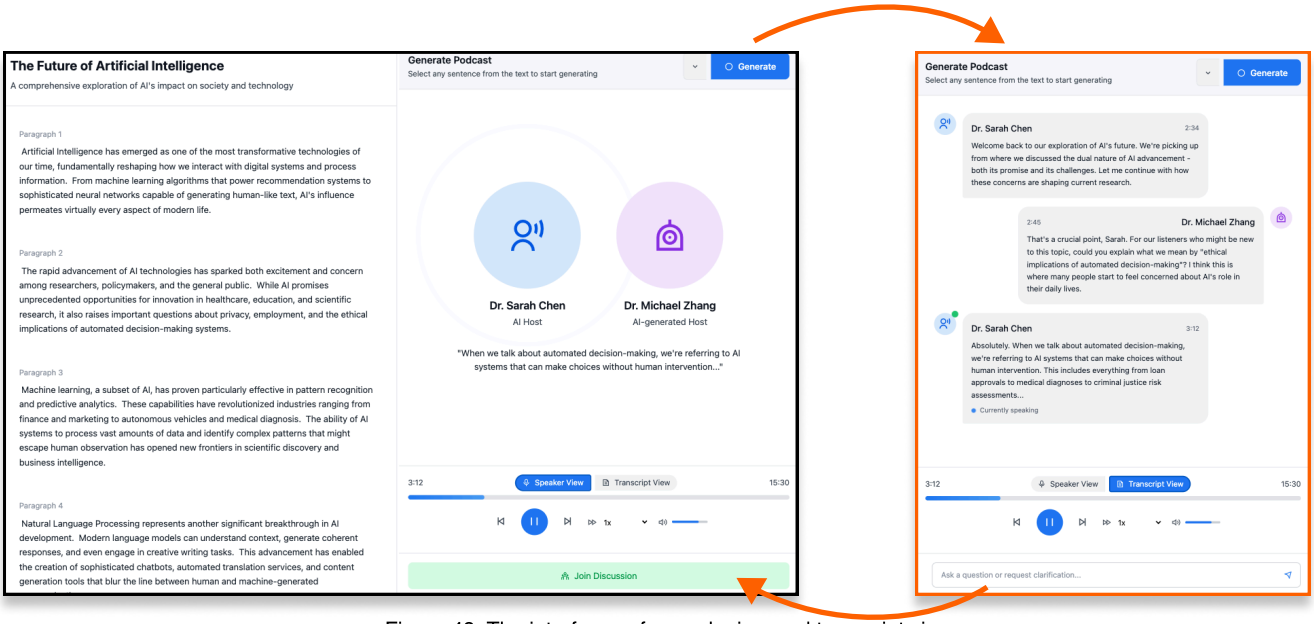


Figure 48. The interfaces of speech view and transcript view

Why

While voice interaction enhances engagement and motivation, it can sometimes reduce traceability and transparency of the content. In the context of reading scientific papers, such transparency is essential for building trust (from Co-creation workshop). The transcript view allows readers to review the conversation in text form, making it easier to verify details. Its chat-like interface also feels familiar to users and expands the interaction to text input, which is particularly useful when speaking is inconvenient—for instance, in public spaces or when listening to audio is not possible.

The Detailed Interaction

During podcast playback, users can switch from the Speaker view to the Transcript view. In this mode, the AI host's avatar is marked with a green dot and a "Currently speaking" status appears at the bottom of the transcript box. The input method changes from the "Speak" button to a text input field, prefilled with prompts such as "Ask a question or request clarification" to guide user.

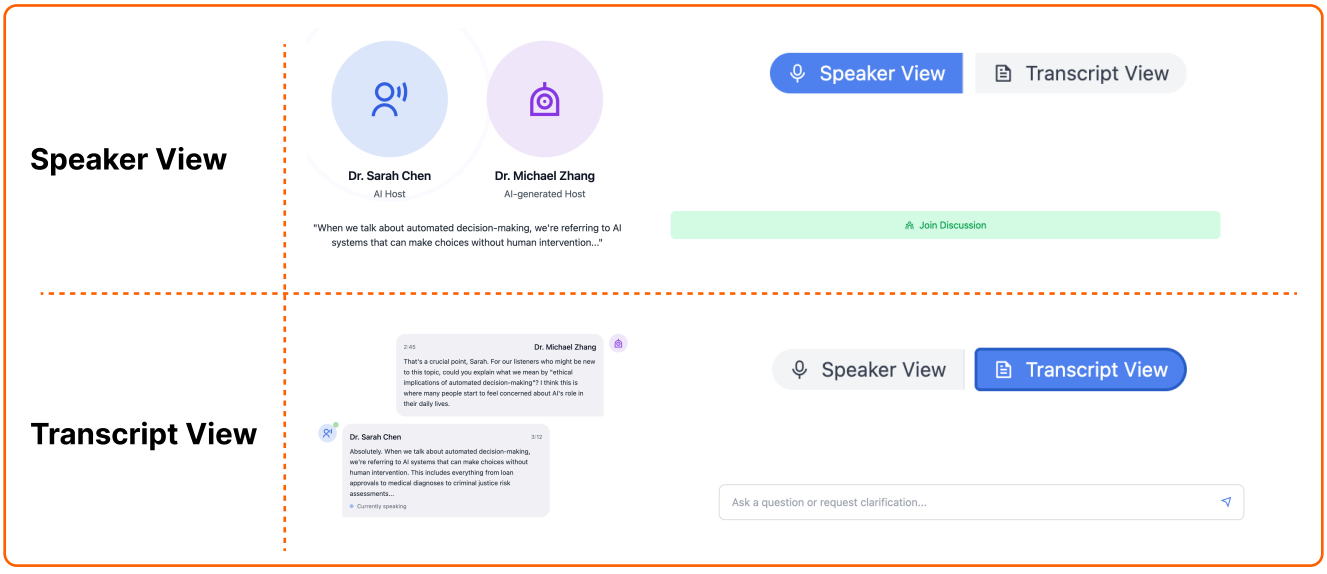


Figure 49. Detail differences in the interface for speech view vs. transcript view

5.4.2 Custermization

Before generating a podcast, users can tailor the podcast with their background and preferences.

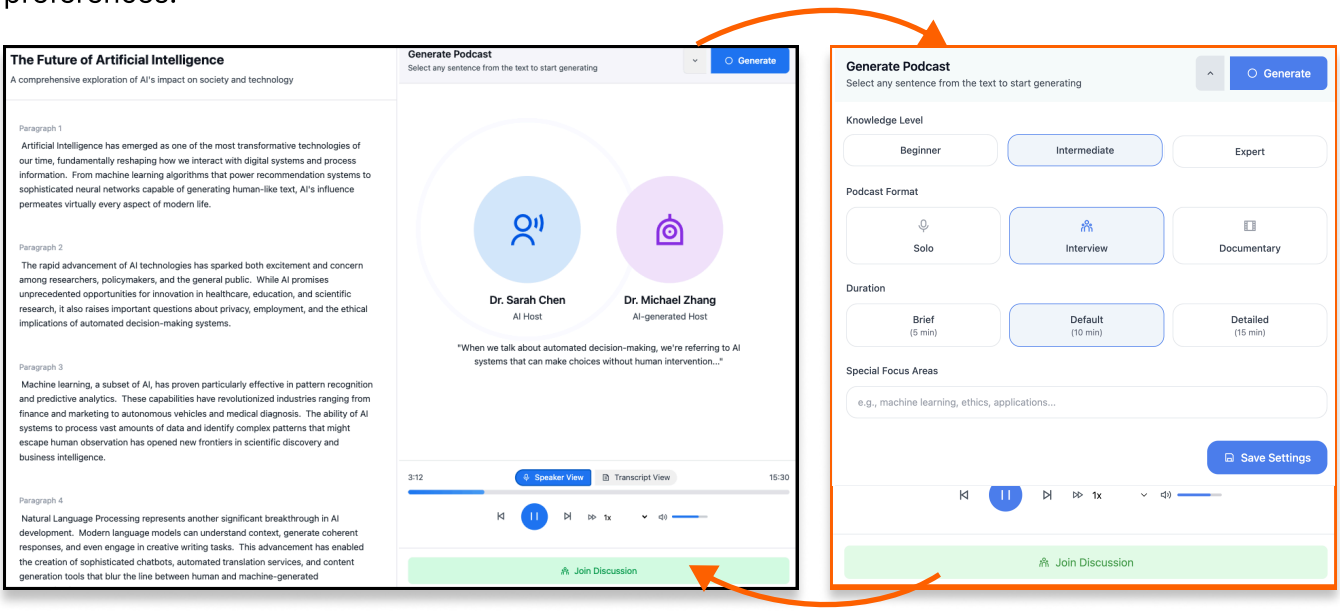


Figure 50. Customization interface of the high-fidelity prototype

Why

The experience of reading scientific papers is closely related to individual differences in preferences, knowledge level, and reading goals (User Study, Quali-04, also identified as a core pain point). It may also be shaped by contextual factors such as time pressure. By allowing customization, the podcast can better adapt to user needs while leveraging the full potential of AI. Users can also choose to generate a podcast starting from where they last stopped reading, instead of restarting from the beginning.

Pre-set options lower the input burden on users by offering guided choices instead of free-form input. This improves usability and ensures more consistent prompts, which helps maintain controllability and stability in the generated output.

The Detailed Interaction

To customize the podcast, users click the settings button in the upper-right corner of the interface. This opens a menu where they can adjust podcast parameters by either selecting from pre-set options or entering text. The customization currently includes four categories:Knowledge Level, Podcast Format, Duration,Special Focus Areas.

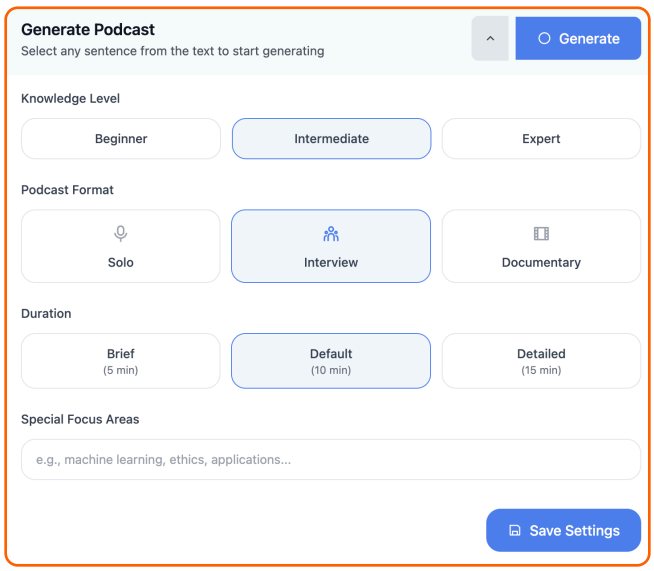


Figure 51. Detailed customization interface

5.4.3 Resumption Cue

When users exit the plugin or finish listening to a podcast, a visual resumption cue is shown in the original text, indicating where they should continue reading.

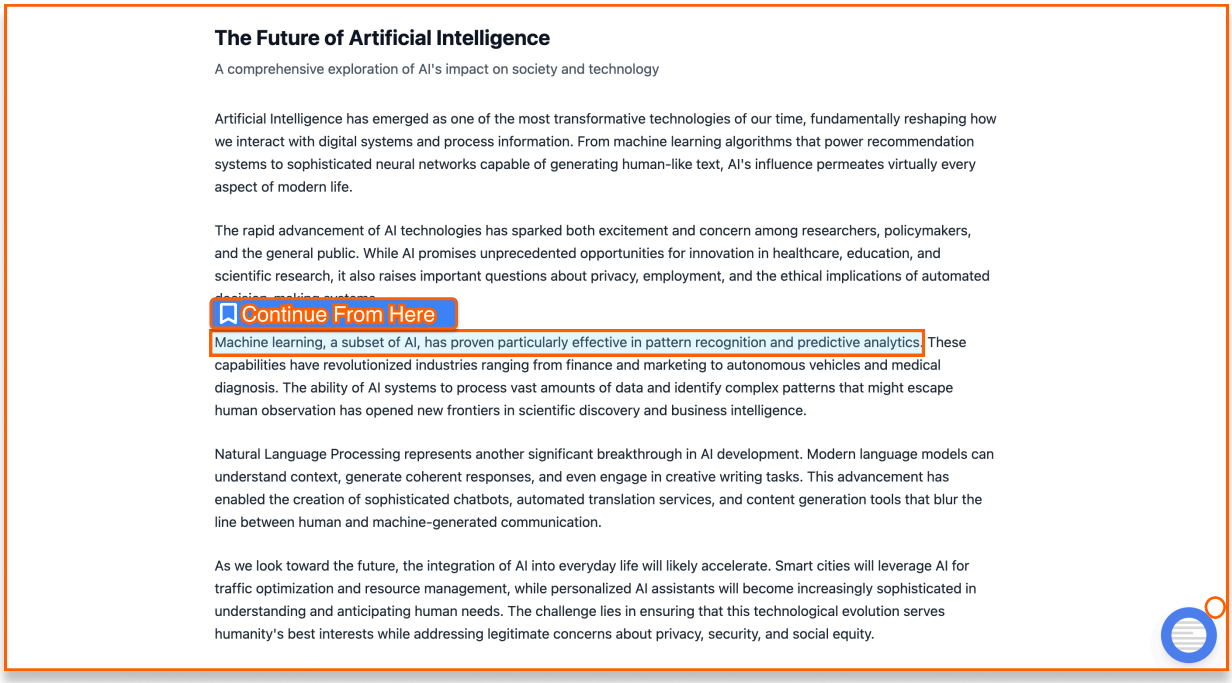


Figure 52. Detailed resumption cue of the interface

Why

The resumption cue acts as a simple reminder of where to continue, saving users the effort of scanning back through paragraphs. It also makes it easier to switch between listening and reading, since users know exactly where to restart.

The Detailed Interaction

When users return to the paper, the next unread section is briefly highlighted. Once they start scrolling, the highlight fades out automatically, so it doesn't get in the way of normal reading.

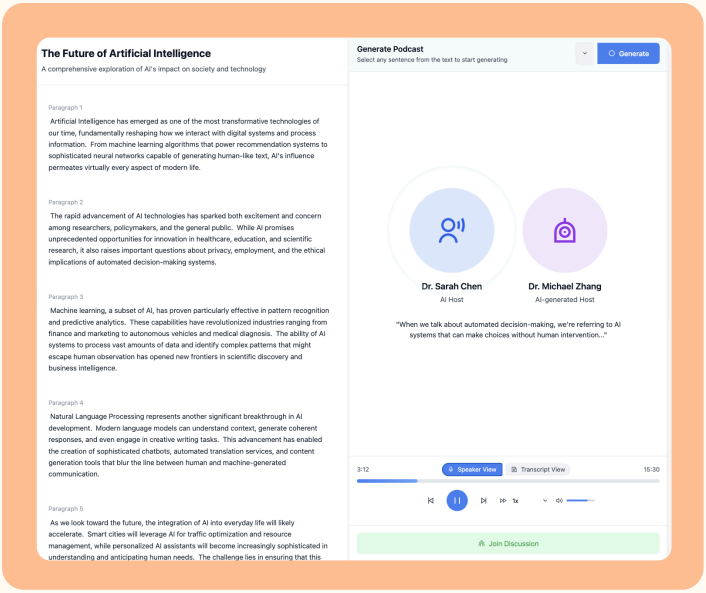
5.5 Summary

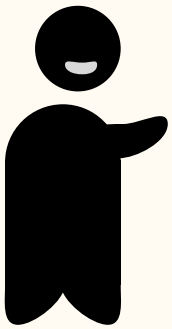
In this chapter, I transformed user feedback into the design of my interface. Starting from the interaction flow, I moved from low-fidelity sketches to high-fidelity prototypes, gradually refining the concept. The design clarified the interaction of the key feature—listening to and joining the podcast through speech or text—while also emphasizing transparency by introducing a transcript view. Besides, I added customization options and visual resumption cues to better support different user needs and contexts.

Through these features, **the design aims to help readers feel motivated, supported, and confident**, while ensuring interactions remain clear and engaging.

6 Concept Evaluation

In this chapter, a swift user test was conducted to evaluate whether my design achieved my design goal.





Participant1,2,3

6.1 Goal
6.2 Methodology
6.3 Discussion
6.4 Limitation
6.5 Conclusion

6.1 Goal

The purpose of this user test was twofold: first, to quickly verify whether the design goal was achieved through the prototype; and second, to assess the usability of the design. In addition, the test further explored the broader research question: "How could we design AI-powered interactions to mitigate the effects of interruptions in long-form reading?"

6.2 Methodology

6.2.1 Participant

Three participants were recruited from the IDE faculty at TU Delft. All reported that they regularly read scientific papers as part of their university projects.

6.2.2 Material

The materials used in this study included four components:

1. A scientific paper: An AI-Resilient Text Rendering Technique for Reading and Skimming Documents (Gu et al., 2024).
2. The interactive high-fidelity prototype developed in the previous chapter (without AI integration).
3. An AI-generated podcast audio file created via NotebookLM.google.com, based on the paper, simulating the AI component of the design.
4. A System Usability Scale (SUS) questionnaire (Lewis, 2018).

6.2.3 Procedure

Participants were first introduced to the project and signed the consent form. They then read the scientific paper on a PC for five minutes without any reading support, to simulate a paper reading experience. Afterward, they interacted with the high-fidelity prototype (without AI) while using think-aloud protocol. To simulate the AI component, I provided them with the NotebookLM-generated podcast.

Following the interaction, participants completed a five-item Likert scale derived from the design goal (motivated, confident, supported, clear, engaging), again while thinking aloud. Finally, they completed the SUS questionnaire, after which I conducted follow-up questions to clarify their reasoning behind the ratings.

6.2.4 Result

6.2.4.1 Quantitative data

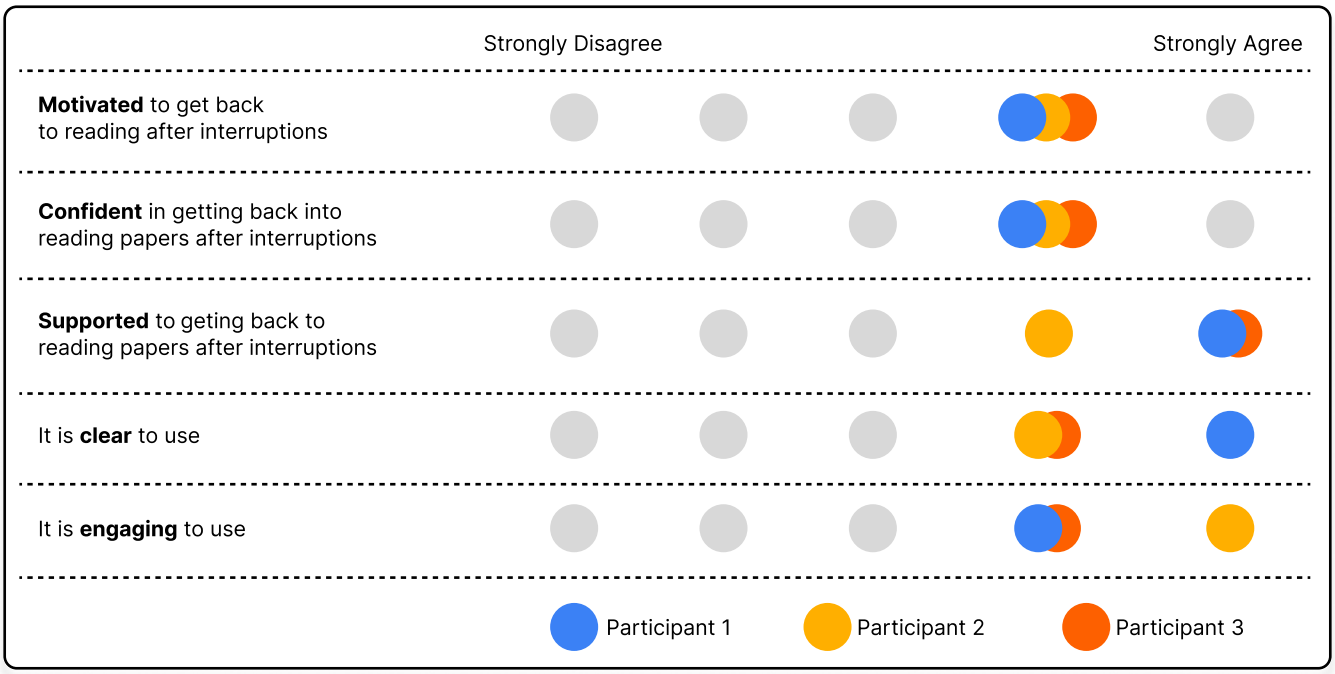


Figure 53. Participants' ratings on motivation, confidence, support, clarity, and engagement after using the prototype.

The SUS scores were as follows: Participant 1 scored 95, Participant 2 scored 77.5, and Participant 3 scored 82.5. The average score was 85, indicating good overall usability of the design.

6.2.4.2 Qualitative data

Participant 1

Comments on interface: Clear to use; found the idea of interacting with AI in audio directly on a paper "surprising" and innovative.
Concerns:
- Podcast quality is decisive for motivation and confidence—should be easy to understand, slightly humorous, and information-dense (ideally via customization).
- AI output can be unstable: would need longer use to judge real usability.
- Transcript view: would not use it continuously while listening (too much workload), but considers it necessary for quickly checking sources when important points arise.

Participant 2

Ideal use case: After a few days' break, use the podcast to recall content and re-establish context; asking questions helps refine scope and goals.
Concerns:
- If podcast structure differs from the article, mapping content back feels difficult.
- Switching between listening and reading may affect comprehension.
- Uncertainty about AI quality undermines confidence.

Positive feedback: Linking podcast content to the original text increases trust.
Suggestions: Integrate user notes into podcasts; log Q&A for future reference; reduce customization input by letting AI infer context from goals.

Participant 3

Ideal use case: Helpful when approaching an unfamiliar paper or returning after forgetting much of the content.
Concerns:
- Reading support may not build genuine confidence—only reading papers directly can.
- Unsure if context options are useful without testing multiple podcasts.

Positive feedback: Dialogue format improves engagement.
Suggestions: Clarify how asking questions interacts with ongoing narration; make "set reading context" more prominent, as reading state varies across sessions.

Figure 54. Qualitative feedback from participants on the prototype interface

6.3 Discussion

Overall, the interaction was perceived as clear and usable, as validated by the SUS results and participants' feedback. The experience was also generally described as motivating, confident, and supportive. However, several uncertainties and potential issues were raised.

First, **the quality of AI-generated podcasts** was seen as critical. Quality here refers to alignment with users' goals, stability across sessions, and consistency across different users. Even with customization functions, participants emphasized that they might need to generate multiple podcasts before building trust in the system.

Second, the issue of **information transparency** emerged. Participants valued the link between podcasts and the original text but were concerned about content navigation in long podcasts and the clarity of their relation to the paper. A balance is needed: providing enough cues to ensure transparency without causing information overload. One potential solution is a tiered information display—highlighting only key arguments, concepts, or figures by default, while allowing users to actively reveal more detailed mappings when needed.

Third, the **shift between auditory and visual modalities** raised questions. While podcasts add engagement and flexibility, it remains uncertain whether alternating between listening and reading ultimately strengthens or weakens comprehension. Given the importance of reliability and precision in academic reading, this remains a key area for further exploration.

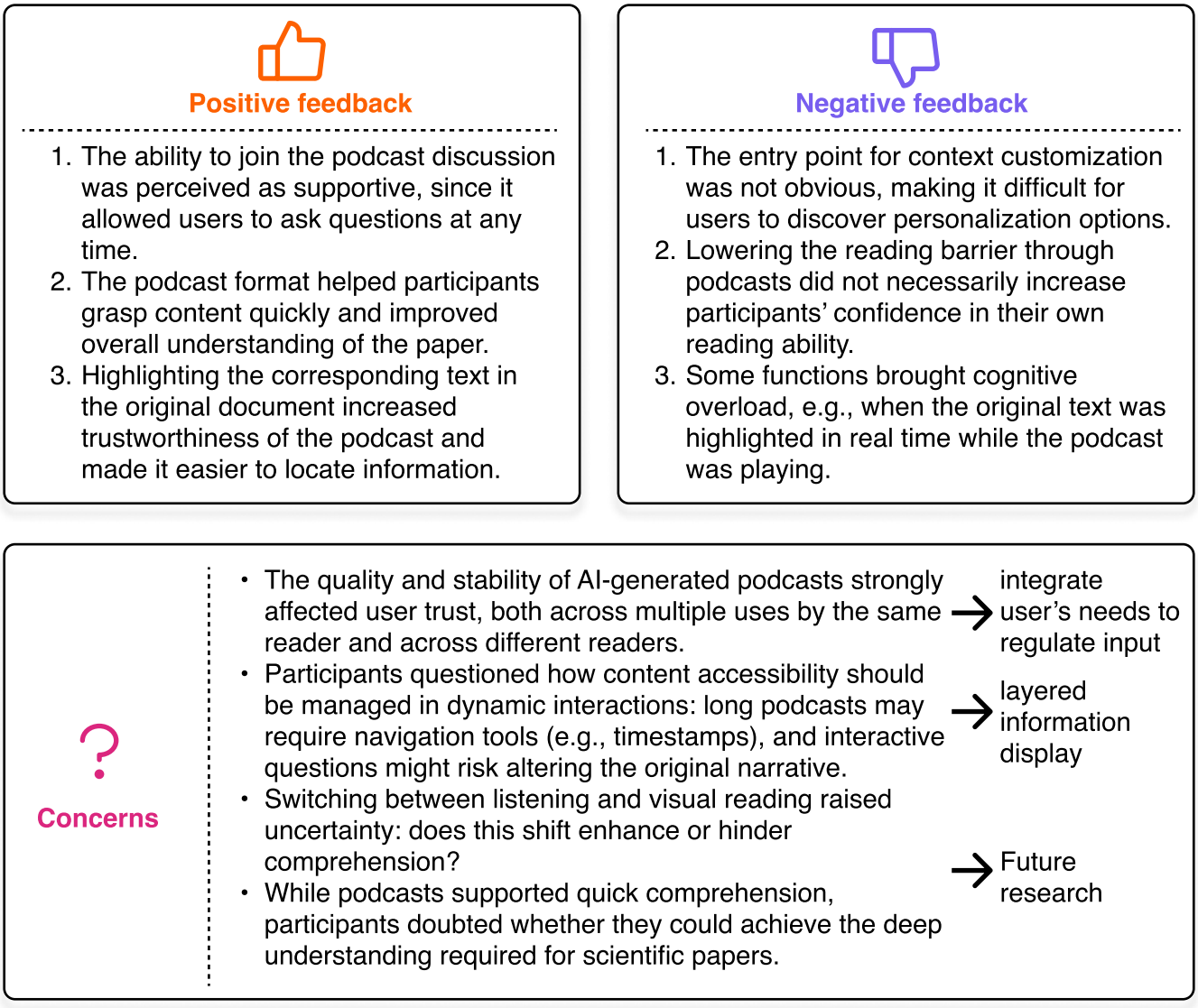


Figure 55. Summary of participants' feedback, concerns

1. Generate summaries or notes from podcast interactions and user questions to support later reference.
2. Integrate previous notes or personal information into podcast generation to make the experience more personalized.

Figure 56. Summary of participants' suggested future work.

6.4 Limitations

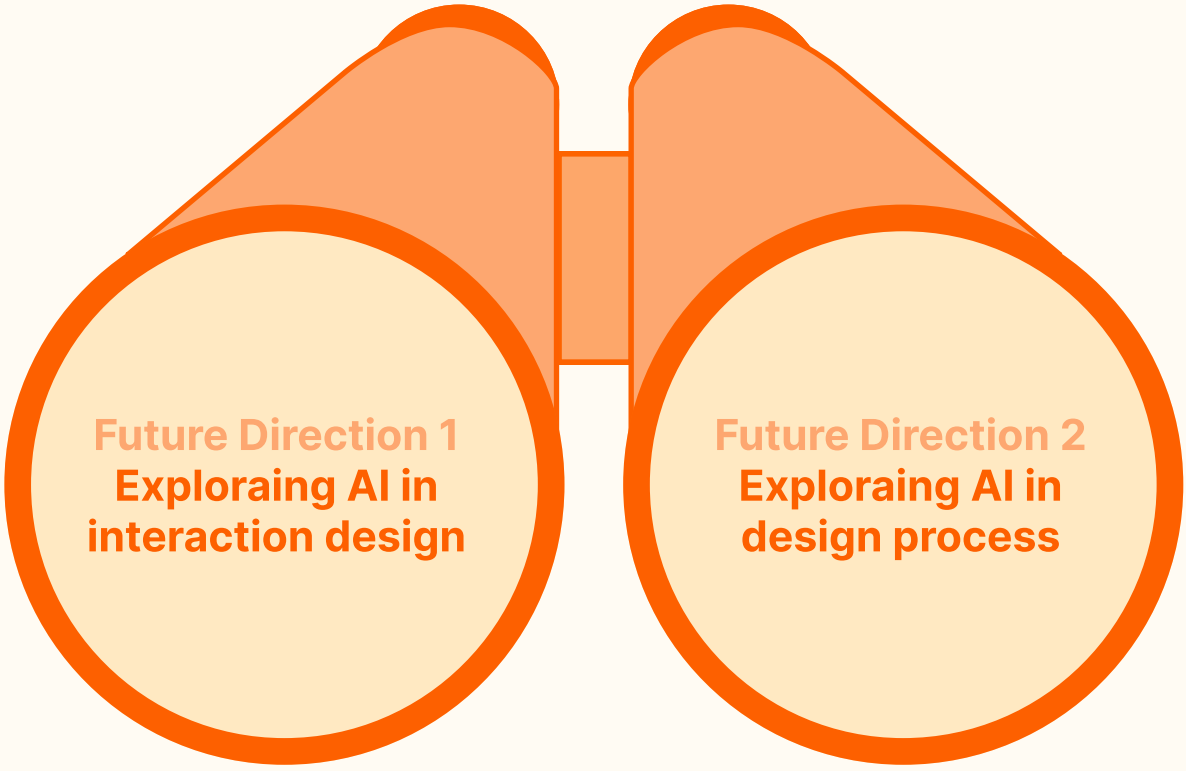
This user test has several limitations. First, the sample size was small: only three participants, all of whom were TU Delft students, which may limit the reliability and generalisability of the results. Second, the selection of reading materials was not strictly controlled. Although all participants confirmed that they had not previously read the chosen paper, their varying levels of background knowledge may still have influenced the outcomes. Also it may not be presentative enough for all the papers. Third, the short testing period prevented exploration of long-term effects. The impact of using the product over multiple days or in extended real-world use scenarios remains unknown. Finally, the testing method itself presented limitations: the evaluation combined static prototypes with AI-generated podcast audio from NotebookLM, which does not fully reflect the experience of interacting with a fully integrated dynamic prototype.

6.5 Conclusion / Summary

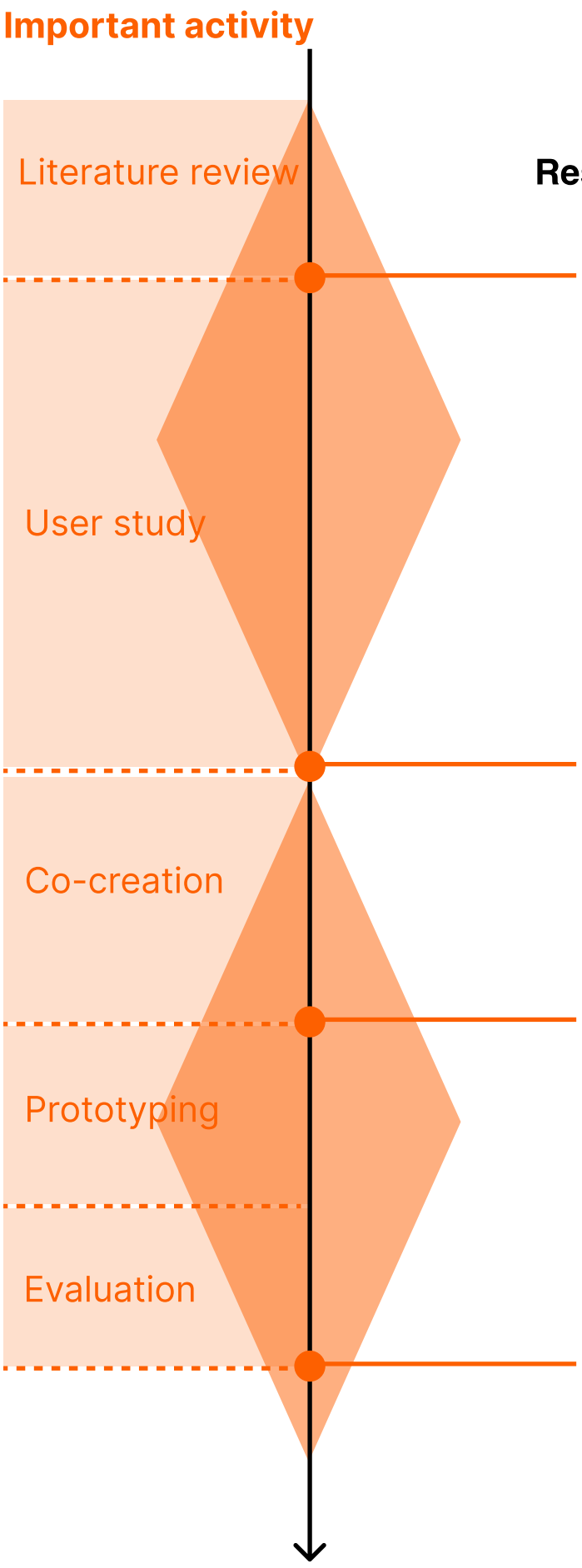
This chapter reported a quick user test of the final design, combining quantitative and qualitative methods. The results suggest that the design generally met the intended design goals: participants described the experience as motivating, confident, and supportive, and found the interaction clear and engaging. However, the overall experience was strongly shaped by the quality of AI-generated content, raising concerns about stability, goal-alignment, and consistency across users. In addition, the presentation of the link between podcast content and the original text emerged as a crucial issue: **it must be designed in a way that builds trust without overwhelming the reader**. Finally, the shift between auditory and visual modes of reading raises open questions about its effect on comprehension. These issues will be revisited and further elaborated in the following Discussion chapter.

7 Discussion

This chapter begins with a reflection on the project process and outcomes, then discusses key insights at both the interaction design and design process levels. It concludes by outlining the project's limitations and suggesting directions for future work.



7.1 Recap on the process



Research Question from literature review:

"How can we design interactions that leverage AI to better support readers in managing interruptions during long-form reading?"

My design goal *is to help readers of scientific papers feel* ***motivated, confident, and supported*** *in getting back to reading by providing* ***clear and engaging*** *assistance that helps them locate their position, reconstruct the context—especially the logic chain—and connect the content to their goals across different scenarios.*

Insights from Co-creation:
Engaging and dynamic forms of interaction increase motivation and sustain engagement in reading. While for the scenario of scientific paper reading, trustworthiness is especially valued.

Insights from Evaluation:
The interaction interface, as a container for AI, already provides a certain degree of experience. However, the quality of AI's output ultimately determines the actual experience of use, and such experience can only be fully understood after multiple rounds of usage...

Figure 57. Overview of the research process and key insights

Through the literature review in the first phase, I explored four areas—long-form reading, interruptions, reading support, and AI as a design material. This made clear the importance of addressing interruptions in long-form reading, while also revealing that existing reading support for this scenario is limited. At the same time, AI offers new possibilities through richer forms of interaction and more personalized, adaptive experiences. This led to my research question:

"How can we design interactions that leverage AI to better support readers in managing interruptions during long-form reading?"

To address this question, I adopted a User-Centered Design approach and followed the Double Diamond process. In the Discover phase, I focused on identifying user pain points and needs, and narrowed the scenario. From this, I defined the design goal across two dimensions—user experience and interaction:

"To help readers of scientific papers feel **motivated, confident, and supported** in getting back to reading by providing **clear and engaging** assistance that helps them locate their position, reconstruct the context—especially the logic chain—and connect the content to their goals across different scenarios."

In the Development phase, I conducted a co-creation workshop, introducing AI as a design material to encourage participants to explore how AI could be integrated into solutions. Using the design goal as evaluation criteria, I selected the most promising AI-powered interaction concept and developed it into a prototype. Finally, in the Deliver phase, I conducted a round of user testing, combining a static prototype with AI-generated audio to simulate the dynamic interaction.

Through this process, I answered my initial research question, and my insights lie in two areas:

1. **At the interaction level**: What kind of interaction best supports readers in managing interruptions? The findings suggest that engaging and dynamic forms of interaction increase motivation and sustain engagement, while in the case of scientific paper reading, trustworthiness is especially valued.
2. **At the design process level:** How can AI be introduced as a design material when addressing this problem? Specifically, how can AI's uncertainty, generative ability, and adaptiveness be treated as "material" in the design process?
   - In ideation, AI was introduced through co-creation to explore its potential as a design material.
   - In prototyping, I applied user-centered constraints to guide AI's dynamic output, ensuring it stayed consistent and controllable.
   - In evaluation, the final prototype combined static interaction flows with dynamic, AI-simulated audio to approximate the intended AI-powered design.

In the following sub-chapters, I will further elaborate on these two aspects, which will be laborated in 7.2 and 7.3.

7.2 Engaging interaction motivates reader

From literature: Prior research has shown that dynamic and multimodal interactions can reduce cognitive load and enhance comprehension. For instance, Tjärnhage et al. (2023) demonstrated how scrollytelling—a combination of storytelling and scrolling—can evoke emotional responses, thereby increasing engagement and fostering a broader understanding of long-form news. Similarly, Kim et al. (2023) proposed Papeos, an interface that augments research papers with localized video segments, enabling a multimodal reading experience that scaffolds navigation, reduces mental load, and supports deeper comprehension.

From user study: Current experiences of reading scientific papers are often described as monotonous and cognitively demanding. Readers come from diverse backgrounds with varying goals and proficiencies, while interruptions are frequent and multifaceted, further compounding the burden.

From co-creation: Participants highlighted that engaging and dynamic interactions could act as powerful motivators, helping them sustain attention and return to reading. They also emphasized the shift from passive reading to active participation (e.g., discussing or co-creating narratives) as a meaningful difference in how knowledge is absorbed.

From market trends/ existing solutions: Recent tools further prove the potential of AI in creating engaging interactions. Google's NotebookLM already transforms user-uploaded documents into mind maps, video overviews, and audio summaries. Particles lets users listen to AI-generated news podcasts, while Snipt enables users to save insights and directly converse with podcast content. Beyond audio, participants in the workshop even imagined transforming long texts into comic books, or gamifying learning—an idea now increasingly possible thanks to advances like Google's Genie 3 world model.

Challenges: However, engaging AI-driven interactions also bring challenges, especially in the context of scientific reading:

1. Output stability – AI's generative nature means the same input may yield different outputs, across sessions or users. This instability reduces trust. Two solutions emerged: improving the underlying model, and constraining input through guided context-setting (e.g., asking for reading goals and knowledge level), which makes the output more predictable and aligned with user needs.
2. Transparency and traceability – For paper reading, accuracy and logic are critical. Users need to see where the AI's content comes from. Linking AI-generated outputs (e.g., podcast excerpts) directly back to the original text helps maintain trust. Post-interaction artifacts (like transcripts or notes) also reinforce credibility.
3. Depth of understanding – While dynamic formats boost motivation, it remains unclear how well they support deep comprehension. In our evaluation, participants often used podcasts for broad overviews rather than deep understanding. The key challenge is how to combine modalities—like linking papers with videos in Papeos—to balance engagement with depth.

Summary: Engaging interactions motivate readers, especially in the demanding context of scientific papers. However, their success depends on balancing motivation with trust and depth of understanding. AI offers exciting new forms, yet careful design is required to ensure outputs are stable, transparent, and genuinely supportive of comprehension.

Figure 58. Overview of evidence, key insight, and design challenges.

7.3 Introducing AI as design material

7.3.1 AI affects design processes

In AI-powered interactions, the interface acts like a container for AI: if we think of AI as electricity, then designing the interface is like building the wiring system—how to deliver power without loss, while amplifying and making the most of it. This raises the key question: how can we treat **AI's uncertainty, generative capacity, and adaptability as "materials"** in the design process—and what challenges come with it?

One major challenge lies in the **uncertainty of AI's capabilities**. AI evolves rapidly, and its underlying technologies are complex, often described by designers as "black magic" (Dove et al., 2017). This makes it hard for designers to truly understand what AI can (and cannot) do at any given moment. As a result, they often rely on existing models or examples from other products for inspiration, which can limit creativity and prevent the use of cutting-edge capabilities in early ideation and development (Yu, 2025).

Another challenge is the **complexity of AI's outputs**, which complicates prototyping. Prototyping is a core activity in evaluating design concepts, but AI's unpredictability makes it difficult to simulate. Traditional methods like the Wizard-of-Oz technique—where human operators mimic system behavior—cannot fully capture the technical limitations or variability of real AI systems. This gap makes it harder to test and refine AI-driven prototypes.

To address these challenges, I adjusted the double diamond process for this project:

- **Discover phase**: kept unchanged, using a diary study to investigate user needs. This revealed issues such as varying knowledge backgrounds, goals, and motivations that affect re-engagement with reading.
- **Develop phase**: integrated co-creation workshops. To help participants ideate with AI, I introduced potential roles AI could take in the design/ the product. This encouraged them to think beyond existing products and explore imaginative, user-centered interactions that could carry their needs.
- **Deliver phase**: combined static prototypes with simulated AI outputs. By blending interactive interface mockups with AI-generated audio (via NotebookLM), I tried to approach the dynamics of an AI-powered product as closely as possible

In this way, AI was not just "added on" to the design but treated as a material,which required adjustments in method and mindset to manage its uncertainty and harnessing its potential at the same time.

7.3.2 AI play as a consultant in my design

In my design, users act as prompters to generate and interact with AI-powered podcasts. They can not only listen to the podcast but also join the discussion and ask questions. This essentially positions AI as a consultant—a design material that provides analysis and support. To achieve such an interaction, the AI needs a broad and comprehensive knowledge base, along with several core capabilities:

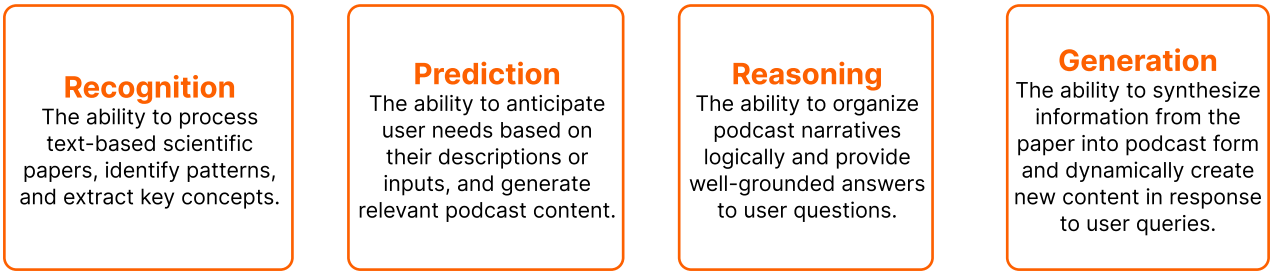


Figure 59. Capabilities required for my design

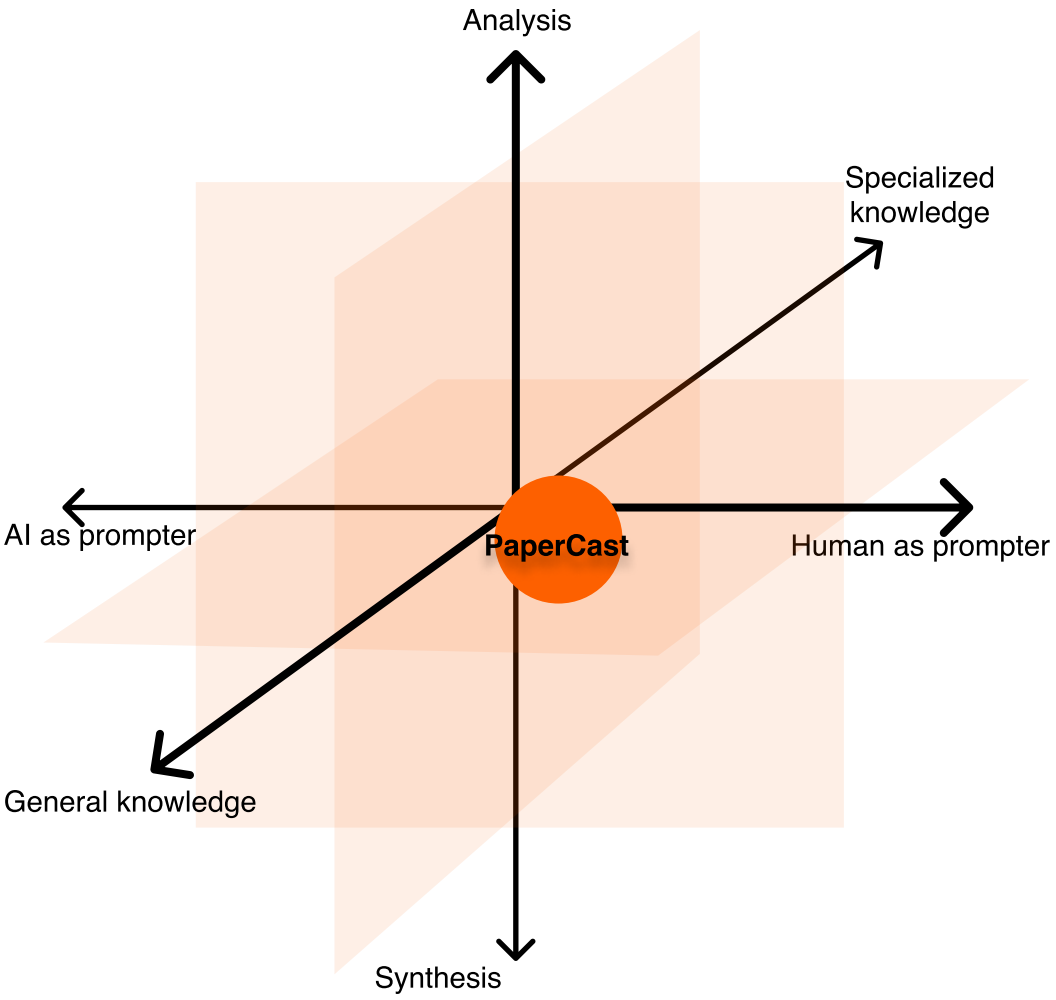


Figure 60. Positioning of the design within the AI role framework (Song et al.2024)

7.3.3 Design recommendations

Layered Information: Balancing Accessibility and Overload

In the context of scientific paper reading, the accessibility of AI-generated information is critical for building user trust. However, too much information overwhelming users could be overwhelming to users. A layered information approach—where key information is presented proactively while secondary details remain accessible to users on demand—balances usability and trust.

Seamless Switching Across Modalities

Since the podcast introduces an auditory channel alongside traditional visual reading, it is essential to design smooth transitions between modalities, such as the visual resumption cue. Leveraging the strengths of each while reducing friction ensures users can switch between listening and reading with ease.

Shift from Passive to Active Interaction

The interactive AI-generated podcast enables users to move from passive consumption to active engagement. By allowing readers to ask questions or join discussions in real time, the interaction not only supports learning but also fosters a stronger sense of being supported, which can improve comprehension.

User-Need–Based Input Customization

My previous user studies show that tailoring input to reflect readers' needs—such as their background knowledge, goals, or proficiency—can both simplify the input process and ensure more stable, predictable AI outputs. This helps maintain a consistent and reliable user experience.

7.4 Limitations and future work

7.4.1 Limitations

Author's capabilities

- My limited knowledge of AI technologies may have constrained the innovativeness of the final concept.
- For designers in the age of AI, building "AI literacy" is essential if we want to integrate AI effectively into design processes.

Methodological limitations

- **Co-creation workshop:** All participants were students from the same faculty, which means their understanding of AI was limited. This may have restricted the originality of the ideas. My own lack of experience with co-creation also meant some guidance was unclear, potentially influencing the outcomes.
- **Diary study**: With limited experience in both quantitative and qualitative analysis, I may have overlooked important insights. The small sample size also reduces the reliability of certain findings.
- **Evaluation**:
  - Only three participants were involved, which weakens the robustness of the results.
  - The prototype's AI component was simulated using NotebookLM audio, which differs from how a fully integrated prototype would behave.
  - Because AI outputs are inherently variable, short-term tests cannot capture a stable picture of user experience. More longitudinal studies are needed, as perceptions only stabilize after repeated use.
  - The test scenario was limited to paper reading. Short trials cannot fully represent the long-term challenges of engaging with scientific papers.
  - The evaluation only examined user experience, not reading comprehension—especially the deeper forms of understanding.
  - Finally, as all participants were students from TU Delft IDE, this sample may not represent the broader population of readers.

- **Concept limitations**
  - Since the podcasts are generated by AI, users may worry about the accuracy and reliability of the information—especially in the context of scientific papers, where precision is essential. Even with the feature of linking back to the original text, summaries or paraphrasing by AI may still distort details, potentially undermining trust and limiting its using scenario.
  - The concept was developed with students and researchers in mind, but readers from different domains (e.g., literature, law, or medicine) may have very different expectations for style, level of detail, or interaction.
  - Some readers may perceive reliance on AI-powered podcasts as harming their own reading ability. And some readers may actually become over-relying on this tool, which may undermine their reading ability.

7.4.2 Future work

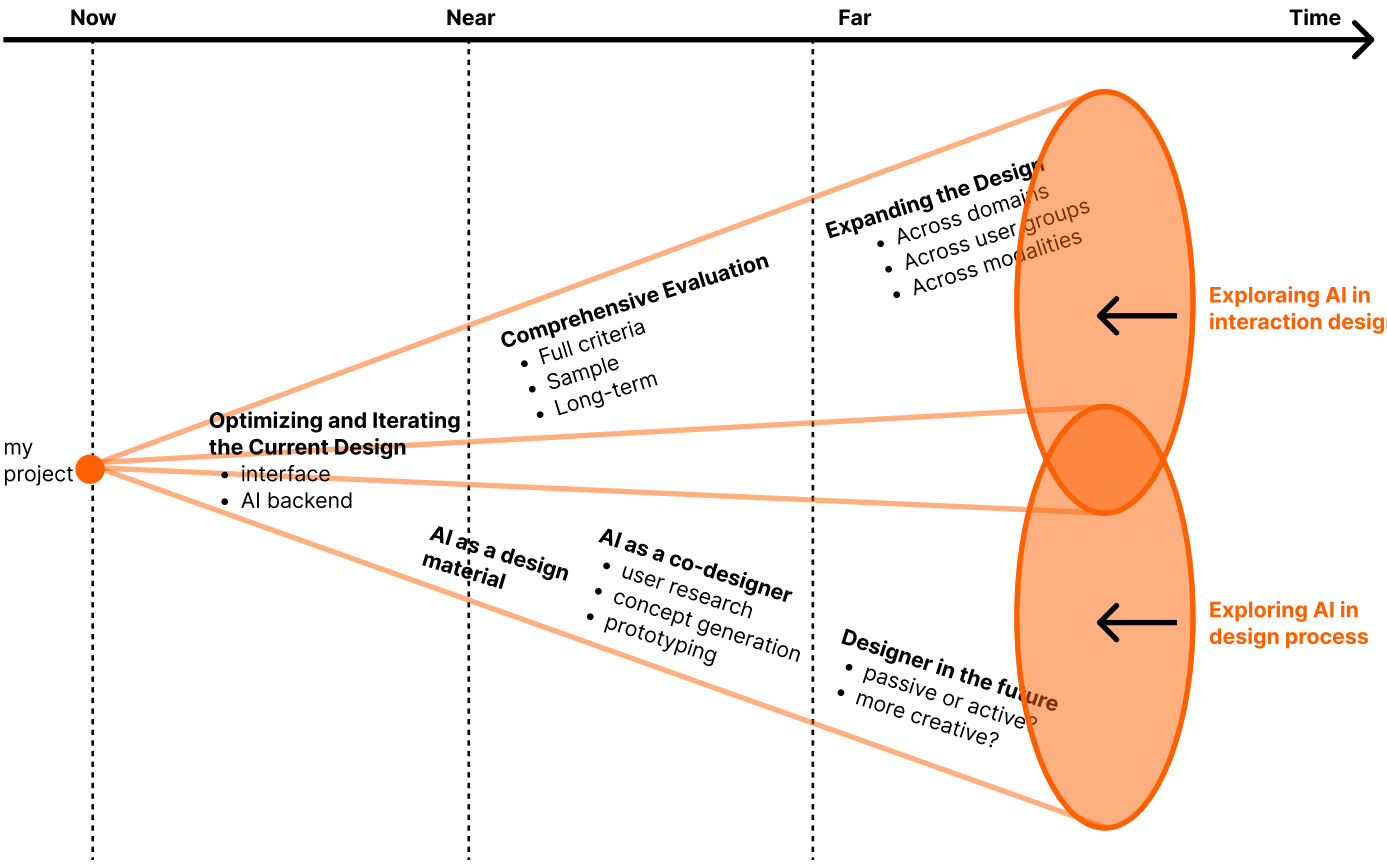


Figure 61. Twofold future work

The future work can follow three steps:

1. **Optimizing and Iterating the Current Design**
   - Interface: Based on initial testing, refine the UI, such as introducing layered information displays to balance accessibility and avoid overload.
   - AI Backend: Build a full prototype with AI integrated at the backend. Development should follow a step-by-step approach, starting with core functions (e.g., generating a podcast from the paper beginning at the point of interruption). Then gradually add other features: personalization based on context (preferences, goals), synchronized transcript with the original text, and interactive podcast participation (asking questions).

2. **Comprehensive Evaluation**
   - Full criteria: Move beyond experience testing to include reading performance, especially deep comprehension. This should examine how media switching (text ↔ audio) and AI-generated dialogue affect understanding.Test effectiveness under different types of interruptions (e.g., short vs. long gaps, complexity of the interrupted content, external vs. internal).
   - Sample: Expand participant sample size and diversity to increase reliability.
   - Long-term studies:
     - paper reading often spans extended periods
     - AI's variable outputs require repeated trials to assess overall stability and user trust.

3. **Expanding the Design**
   - Across domains: Apply the podcast concept to other forms of long-form reading, such as long-form journalism, biographies, or history texts.
   - Across user groups: Extend beyond students to researchers, professionals, patients who need to read medical literature (cf. Paper Plain, August et al., 2023), or populations with specific needs such as ADHD or reading difficulties.
   - Across modalities: Explore AI-generated alternatives beyond podcasts—such as comic books or game-like experiences—that could make scientific paper reading more engaging and comprehensible.

And Exploring AI's Role in the Design Process

- AI as a design material: While frameworks like Windl et al. (2022) describe four approaches, these may need revision as AI evolves rapidly.
- AI as a co-designer: With growing intelligence, AI may not only support but actively collaborate in design—helping in user research (e.g., simulating users or analyzing large datasets, Cohen & Amble, 2025), generating creative concepts (Guo et al., 2023), or accelerating prototyping (e.g., Claude's artefacts, Readdy.ai, or Figma's Make). Current prototyping tools still struggle to simulate dynamic AI outputs effectively. Future work should explore methods to prototype such interactions more realistically.

Finally, the broader question remains: will AI make designers more passive, relying on automation, or will it inspire new forms of creativity and critical thinking? This requires continued exploration in future design practice.

7.5 Summary

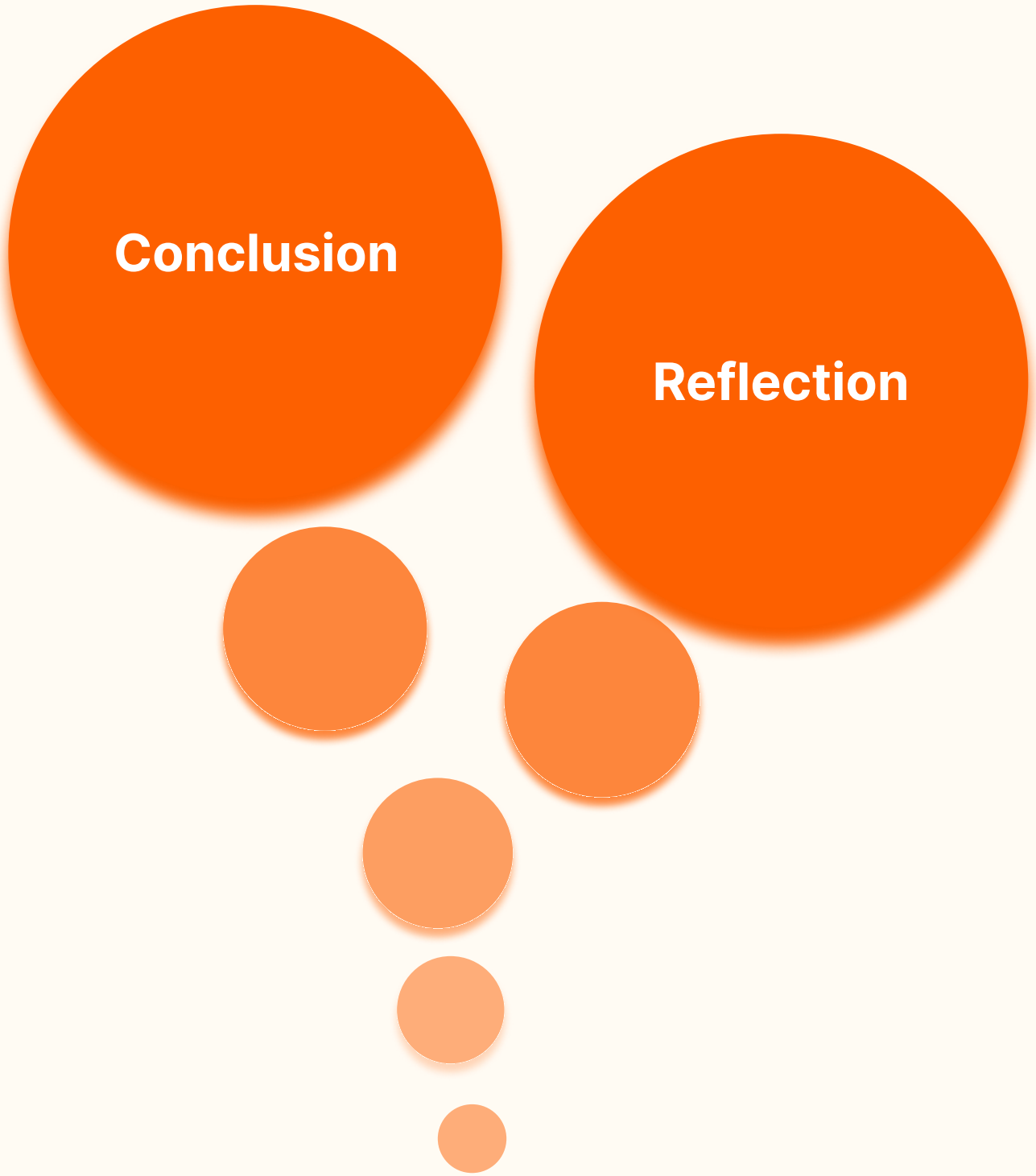
This chapter reviewed the overall process and key milestones of the project, highlighting its main contributions.

At the interaction level, the study showed that AI-generated podcasts—an engaging and dynamic form of interaction—can motivate readers to return to their texts after interruptions and sustain engagement. In the context of scientific paper reading, however, trustworthiness proved to be especially critical, leading to concrete design recommendations.

At the design process level, the chapter reflected on the challenges of introducing AI as a design material and described how this project integrated AI into the design workflow. Naturally, the project has limitations due to scope and the author's expertise. Building on these, the chapter outlined directions for future work: iterating the current design and conducting more comprehensive evaluations, as well as extending AI-generated interactive content to broader reading scenarios and user groups.

8. Conclusion and Reflection

At the end of this project, I reflect on the journey, summarize key insights, and outline the main contributions and takeaways.



8.1 Reflection
8.2 Conclusion

8.1 Reflection

Project-related Reflection

This project explored the innovative use of AI as a design material, embedding it into both the design outcomes and the design process. In doing so, it highlighted several challenges that AI introduces for design and, more broadly, for designers themselves. In the age of AI, designers need to build AI literacy—not only to leverage AI's capabilities in creating products that truly align with user values, but also to accelerate stages of the design process such as ideation and prototyping. At the same time, this project reaffirmed the continuing relevance and power of user-centered and participatory design. These methods remain effective in uncovering user needs and in co-creating interfaces and interactions that reflect what users actually want.

Personal Reflection

- **What I enjoyed the most**
  I felt most excited when prototyping and building the product, and especially during user testing—seeing participants engage with my design and hearing positive feedback made me proud and motivated.
- **What challenged me the most**
  The hardest parts were time and project management. I was often too ambitious, underestimating the complexity of tasks and overloading my schedule, which caused delays. My perfectionist tendencies also made it hard to move forward without polishing every detail. Writing and structuring my report was another pain point—I underestimated how much time clear communication would require. I focused too much on design activities early on and left too little time for writing, which I now realize should have been more evenly balanced. Conducting an AI-driven design project also introduced new uncertainties compared to traditional design processes. And as a solo project, it sometimes felt isolating—I needed time to adjust to the feeling of being "lost" or alone at certain stages.
- **What I learned**
  - Completion over perfection. Knowing when to stop is just as important as striving for quality.
  - Seek support through communication. More frequent discussions with my mentors and peers could have given me both practical insights and emotional reassurance—I realized I don't have to carry everything alone.
  - Stepping outside my comfort zone. I experimented with new methods such as diary studies and co-creation workshops, whereas I was more used to in-depth interviews. Incorporating quantitative data alongside qualitative insights brought both challenges and learning opportunities—especially in planning, since I had little idea initially about how long diary studies would take or how best to design the materials. But these challenges ultimately gave me valuable experience in balancing methods and managing unpredictability.

8.2 Conclusion

This thesis began with the research question:
“How can we design interactions that leverage AI to better support readers in managing interruptions during long-form reading?”

The question was grounded in a literature review across four domains: long-form reading, interruptions, reading support, and AI as a design material. To explore it, I adopted a user-centred design approach within the Double Diamond framework, integrating co-design methods. I conducted a diary study, a co-creation workshop, and a user test—altogether following a design research approach.

The outcomes of this project are threefold:

1. **Design outcome**
   I developed a high-fidelity prototype based on the final concept. The evaluation showed that AI-generated podcasts, as an engaging and dynamic interaction, can increase motivation and help readers re-enter and sustain engagement in scientific paper reading. However, trustworthiness is crucial in this context. AI-generated content must remain traceable to the original text without overwhelming the user, striking a balance between accessibility and information overload.
2. **Process contribution**
   The project demonstrated how AI’s uncertainty, generative ability, and adaptability can be treated as a design material. The final interaction form emerged from the co-creation workshop, while user needs identified in the diary study and co-creation were translated into interface constraints and guidance. These ensured that AI’s dynamic outputs remained consistent, predictable, and controllable, shaping a trustworthy user experience.
3. **Research insights**
   From the diary study, I identified key pain points of long-form reading interruptions and developed a framework linking reading experience and interruption dynamics. This provides a foundation for understanding the challenges of resumption in complex reading tasks.

Despite these contributions, the project faces limitations in testing and user research—for instance, the small sample size, simulated AI components, and the short-term scope of evaluation. Future work should involve more comprehensive testing, long-term studies, and exploration of other AI-generated interaction formats (e.g., comics, gamified learning). Extending the podcast approach beyond scientific papers to broader long-form reading contexts also holds potential.

In sum, this thesis shows that AI-powered, engaging interactions can meaningfully support readers in managing interruptions during long-form reading. At the same time, it highlights the importance of trust, personalization, and careful integration of AI as a design material—both for enhancing the reading experience and for shaping the changing roles of AI in design practice.

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Appendix

1.Project brief

2.User study

2.1 Consent form
2.2 Introduction script
2.3 Interruption log from
2.4 Demographic data collection
2.5 Experience Feedback Questionnaire
2.6 Semi-structure interview

3.Co-creation workshop

3.1 Consent form
3.2 Miro board contents
3.3 Ideas from participants

4.User test

4.1 Consent form
4.2 Evaluation form

1. Project brief

DESIGN FOR our future

TU Delft

Personal Project Brief – IDE Master Graduation Project

Name student _____ **Student number** _____

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT
Complete all fields, keep information clear, specific and concise

Project title Exploring Interaction for LLM-Powered Breadcrumbs to Support Re-entry into Long-Form Reading

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

Not everyone finds reading long-form texts easy. Long-form content typically includes complex information such as intricate concepts, multiple characters, detailed events, and extensive data, requiring sustained attention and placing heavy demands on working memory (Kraal et al., 2017). Readers frequently struggle to retain previously encountered references or details, leading to comprehension gaps. To overcome these obstacles, readers often employ strategies like re-reading previous sections, deliberately interrupting their sequential reading to regain clarity and reconstruct context (Inhoff et al., 2019). However, such interruptions impose a significant resumption cost, increasing cognitive workload and further taxing working memory, especially when external distractions like notifications or phone calls are involved (Foroughi et al., 2015).

Cognitive theories, including Long-Distance Coherence and Scene Perception and Event Comprehension, highlight that context is not inherently encoded during initial reading but reconstructed at the moment of recollection (Easton et al., 2024). This reconstruction often requires significant cognitive resources, especially in complex or information-rich environments. While traditional strategies such as taking notes or manually searching through previously read content exist, these methods interrupt the reader's immersion and flow, often breaking engagement and further complicating the resumption of reading.

With rapid advancements in Large Language Models (LLMs), their performance and capabilities—including natural language understanding, context-sensitive responses, and information extraction—have become reliable and powerful. These features have already demonstrated significant potential in diverse fields, including customer service and software development. Recently, researchers have started exploring the application of LLMs in supporting reading activities. This project specifically focuses on readers engaging with long-form texts.

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1. Project brief

introduction (continued): space for images

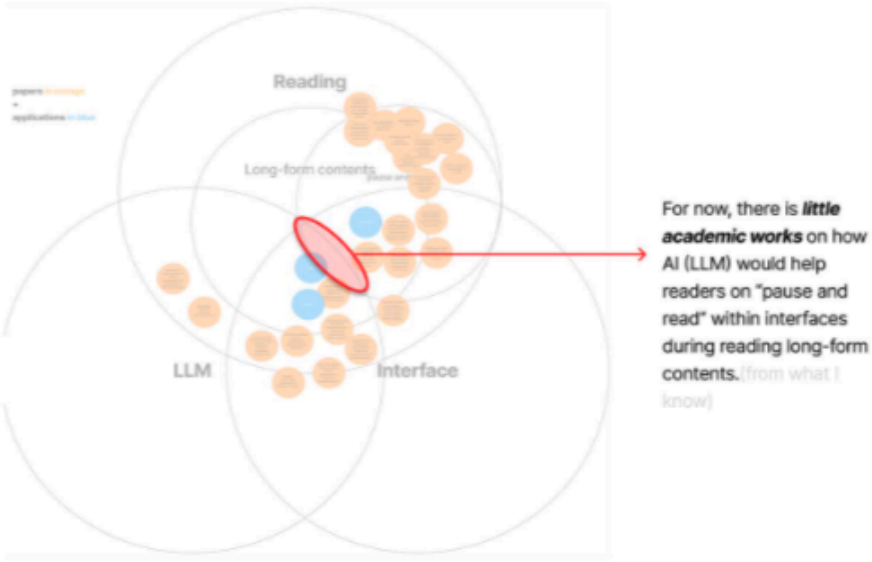


image / figure 1 Focus area after literary study

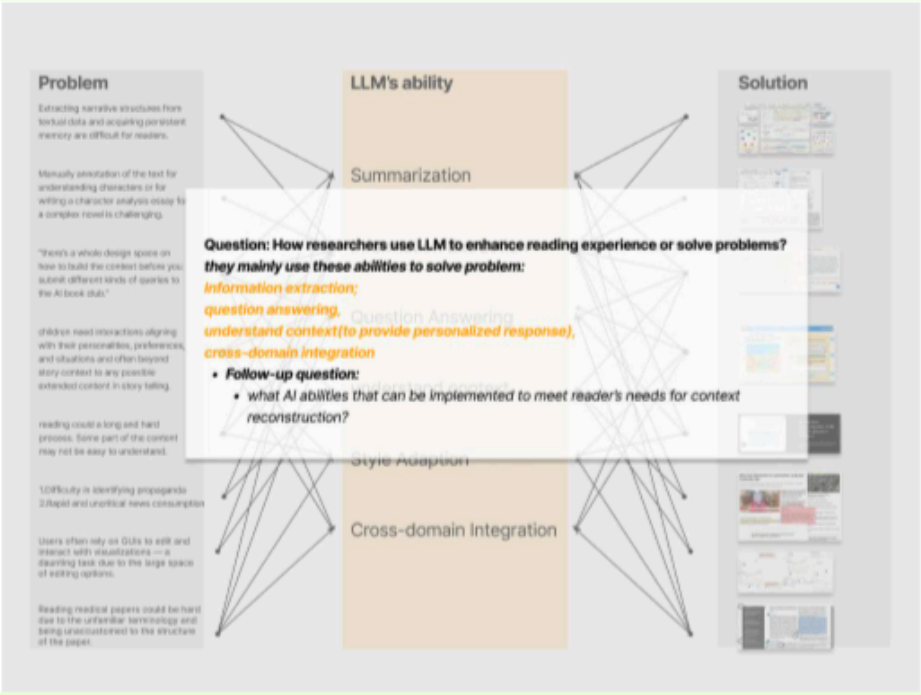


image / figure 2 How researchers use LLMs to facilitate users in reading

1. Project brief

DESIGN FOR our future

TU Delft

Personal Project Brief – IDE Master Graduation Project

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

Interruptions are a common occurrence during everyday reading activities—phone calls as you are deeply engaged, urgent messages from a supervisor or teammate, or external distractions often disrupt reading flow. Resuming reading requires retrieving contextual information, placing additional cognitive load on readers and hindering comprehension (Altmann, 2002). Due to the inherent complexity of long-form texts, retrieving relevant context is particularly challenging, frequently overwhelming readers' working memory. Moreover, since readers typically do not complete long-form content in a single sitting, effectively providing contextual retrieval can significantly support comprehension.

Although recent research has identified potential uses of LLMs to facilitate reading—such as StoryExplorer by Ye et al. (2024), which visualizes narrative structures—little research has investigated how LLMs might provide dynamic, context-aware retrieval of information tailored to readers' immediate uncertainties, seamlessly integrated within reading interfaces.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Explore and develop interaction paradigms that reconstruct contextual information in real-time for readers of long-form texts, guided by research into readers' preferences for interacting with LLM-generated contextual retrieval "breadcrumbs."

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

Research-through-Design
Part 1: Reader Preferences & LLM Capabilities
- Investigate reader preferences and needs for contextual retrieval through surveys, interviews, and literature review.
- Create low-fidelity prototypes leveraging LLM capabilities, testing them with readers to deepen understanding of user preferences and LLM potential.
Part 2: High-Fidelity Prototyping & Interaction Paradigm Exploration
- Develop high-fidelity prototypes integrating LLMs based on insights from Part 1.
- Conduct tests with readers, iterating interaction paradigms for user preferences, cognitive workload, and overall user experience.
Part 3: Evaluation & Finalization
- Discuss findings and into reader preferences regarding contextual breadcrumbs and interaction paradigms.
- Deliver a finalized interface featuring LLM-powered breadcrumbs to effectively support readers in reconstructing context.

2. User Study

2.1 Consent form

Opening Statement and Informed Consent – Exploring Interaction for LLM-Powered Breadcrumbs to Support Re-entry into Long-Form Reading

Opening Statement

You are being invited to participate in a research study titled "Exploring Interaction for LLM-Powered Breadcrumbs to Support Re-entry into Long-Form Reading" This study is being conducted by Yonghao Hu (MSc student) at the TU Delft's Faculty of Industrial Design Engineering as a part of his Master Graduation project, which is expected to end by Ocotober 2025.

This research study session is to understand how interruptions—like phone notifications, external distractions, or internal thoughts—affect your ability to stay focused and resume reading long-form content. The data may be used for scientific publications in anonymized form.

In this study, your involvement will include three parts: Introduction session(10 minutes) – Diary study(5days, 10-15 minutes/per day) – Follow-up interview(around 10–15 minutes). About the dairy study, you'll be asked to

- Select one mentally demanding reading session (e.g., academic texts, serious journalism).
- Record the type and timing of any interruptions using sticky notes during the reading session.
- Complete a short online form after each reading session, ideally within 3 hours.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. I will minimize any risks by collecting only the necessary personal data and storing that data safely on local university servers in compliance with the General Data Protection Regulation. For further processing, the data will be fully anonymized, i.e., the collected data cannot be related to the respective participant.

Your participation in this study and the processing of your data is entirely voluntary. The survey can be cancelled by you at any time without mentioning reasons and without causing any disadvantages. In the event of cancellation, all data recorded of you will be irrevocably deleted.

Please contact the corresponding researcher for any questions.
Contact information:
Corresponding researcher:

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated [*DD/MM/YYYY*], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	☐	☐
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	☐	☐
3. I understand that taking part in the study involves three parts: introduction session– diary study– follow-up interview. During the interview session, the process will be audio-recorded, and the recording will be deleted after the interview is transcribed by the researcher. All identifying information (e.g., name, email, workplace, etc.) will be removed upon transcription. You may be further asked to fill in a survey form asking for demographic information, which will be treated confidential and fully anonymized and cannot be associated with your person.	☐	☐
4. I understand that the study will take 45-90 minutes in total.		
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
5. I understand that taking part in the study involves the following risks: If I am a student or employee at TU Delft, I may feel a sense of obligation to take part in this research or feel uncomfortable sharing personal views with the researcher. I understand that these concerns will be addressed by clearly emphasizing that participation is entirely voluntary and that I may withdraw at any time without giving a reason and without facing any negative consequences. All data collected will be handled anonymously. In cases where full anonymity cannot be guaranteed (e.g., during interviews), I understand that I am only expected to share information that I feel comfortable disclosing.	☐	☐
6. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) [job, age, gender, expert domain] and associated personally identifiable research data (PIRD) [e.g., public reputation] with the potential risk of my identity being revealed.	☐	☐
7. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach. • Data will be collected anonymized using a randomly assigned identifier. • PII such as consent forms and email addresses will be stored separately and only locally and will be deleted at the end of the study. • Raw data such as audio-recordings from the interviews will be only stored locally and deleted after transcription. • The data published open access for re-use and for publication will be aggregated and any PII will be carefully removed.	☐	☐
8. I understand that personal information collected about me that can identify me, such name and email address, will not be shared beyond the study.	☐	☐
9. I understand that the (identifiable) personal data I provide will be destroyed after the study is complete but no later than 6 months after my participation.	☐	☐
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
10. I understand that after the research study the de-identified information I provide will be used for scientific publication and for reuse through open access publication of the data set. The data is for the purpose of scientific publications only, direct quotes of interview statements might be cited.	☐	☐
11. I agree that my responses, views or other input can be quoted anonymously in research outputs.	☐	☐
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
12. I give permission for the de-identified data (i.e., survey responses excl. demographic information, transcripts) that I provide to be archived on the in a TU Delft onedrive so it can be used for future research and learning.	☐	☐
13. I understand that access to this repository is restricted to research purposes only, ensured through mandatory access requests. All PII will be removed to ensure full anonymity. The data will be available for 10 years and deleted afterwards.	☐	☐

Signatures

Name of participant [printed]	Signature	Date

I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Yonghao HU		
Researcher name [printed]	Signature	Date

Study contact details for further information:

2.2 Introduction script

Hi! Thank you for agreeing to participate in my study.
I'm Yonghao, a master's student at TU Delft. This research is part of my graduation project, where I explore how AI can support and improve reading experience—especially when people get interrupted while reading.
What's This Study About?
This study investigates:

- What kinds of interruptions people experience while reading
- How interruptions affect reading flow and the ability to resume reading
- Which reading situations are more vulnerable to disruption

By long-form content, I mean things like:
Literary fiction (e.g., One Hundred Years of Solitude)
Scientific papers
Narrative non-fiction (e.g., long-form journalism, essays, books)
These materials are usually longer and require ongoing engagement.
The goal is to understand real-world reading behavior and use that insight to design AI tools that support readers, especially when they get interrupted.
Demographic Data Collection
At the start of the study, I'll also ask you to fill in a few basic demographic questions, such as:

- Your age group
- Educational background

This information helps me understand the diversity of reading habits and ensures the results are interpreted in context.
All data will be anonymized.
How the Study Works
This is a 5-day diary study. Each day, you'll track only one reading session — but it should be one that you consider substantial.
By "substantial," we mean a reading session that felt meaningful, complete, or worth reflecting on. This could be because of its length, focus, or relevance to you.

- Before and During Your Chosen Reading Session:

Before you begin, decide:
"Is this a substantial session I want to log today?"

- If yes, please keep the interruption log nearby(digital or physical) during the session.
- Log any interruptions that:
- Last between 1 and 10 minutes
- Require some effort to get back into reading afterward
- For each interruption, note:
- Estimated duration
- Cause/type of interruption (e.g., external, internal, intentional)

If there are multiple interruptions, clearly mark the one that had the biggest impact on your reading flow.
After Your Reading Session (or later the same day):

- Complete a short online questionnaire (~10 minutes).
- Please try to fill it out within 3 hours of finishing your reading session, while the experience is still fresh.

After 5 Days: Short Interview
Once you've completed the 5-day diary:I'll invite you to a brief follow-up interview (~15 minutes). This will help: clarify your diary entries; Reflect on your overall reading and interruption experience
Please bring your sticky note logs with you to the interview.
Consent & Privacy
this is the content form (hand the consent form)

- Your input will be anonymized and used only for academic research.
- You can withdraw at any time, without any consequences.
- If you have questions or concerns during the study, feel free to contact me.

Final Note
Thank you again for participating!
Your insights will directly contribute to designing smarter and more supportive AI tools that help people read more smoothly—even when life gets in the way.
Let me know if you'd like me to clarify anything—or if you're ready to begin!

2.3 Interruption log form

Day1 Reading Session

? Before you begin, decide: "Is this a substantial session I want to log today?"

Starting time: DD-MM HH:MM (e.g., 24-05 14:15) _____

1st Interruption[1]
Duration[2]: _____minute Type[3]: ☐External ☐Internal
What interrupted you? _____

2nd Interruption
Duration: _____minute Type: ☐External ☐Internal
What interrupted you? _____

3rd Interruption
Duration: _____minute Type: ☐External ☐Internal
What interrupted you? _____

4th Interruption
Duration: _____minute Type: ☐External ☐Internal
What interrupted you? _____

5th Interruption
Duration: _____minute Type: ☐External ☐Internal
What interrupted you? _____

6th Interruption
Duration: _____minute Type: ☐External ☐Internal
What interrupted you? _____

7th Interruption[3]

Finishing time: DD-MM HH:MM (e.g., 24-05 14:15) _____

Experience Feedback Questionnaire
(Please try to fill it out within 3 hours of finishing your reading session)

Important information

1. Interruption: please only log interruptions that lasted *between 1 and 10 minutes*.
   a. Examples of interruptions to include:
      i. Someone called or talked to you and you lost focus.
      ii. You checked your phone and stayed off-task for a few minutes.
      iii. You got up to do something (e.g., get water, answer the door), then had to re-read to catch up.
   b. Do not log interruptions like:
      i. Briefly adjusting your posture or chair.
      ii. Momentary mind-wandering that you recovered from instantly.
2. Type:
   - External - "I was distracted by something external to myself or the phone (e.g., doorbell, other people, having to get off of train, etc.)
   - Internal - "I was distracted internally (e.g., tiredness, could not concentrate, thinking of something else, mind-wandering, etc.)"
3. If this page is not enough, please see the other side.

Interruption form-Day 1 as an example

2.4 Demographic Data Collection Form

This short section helps us understand general characteristics of participants, which will help us analyze patterns across different groups.
When you submit this form, it will not automatically collect your details like name and email address unless you provide it yourself.
Required
1.Your participant code
To help us keep your responses anonymous yet consistent across multiple days, please create a simple participant code. Use:
First 3 letters of your mother's first name + letters in your zip code
Example: Emily + 2624HL → EMIHL
Please remember to use the same code every time you fill in the questionnaire.
2.What is your age?
Under 18
18-24
25-34
35-44
45-54
Over 55
3.What is your gender?
Female
Male
Non-binary
Prefer not to say
4.What is your native language?
5.What is your highest completed level of education?
High school or equivalent
Vocational/technical training
Bachelor's degree
Master's degree
Doctorate or higher
6.What is your current occupation?
Student
Researcher
Teacher / Educator
Designer
Engineer / Developer
Healthcare professional
Administrative / Office worker
Between jobs
7.How often do you read long-form content?
Long-form content = texts longer than 800 words, requiring focus—like novels, scientific papers, or in-depth articles.
Daily
Several times a week
Once a week
A few times a month
Rarely

2.5 Experience Feedback Questionnaire

Hi! Thank you for taking part in this study.
This questionnaire is part of a research project exploring how people read long-form content—such as novels, scientific papers, or in-depth journalism—and how they experience and respond to interruptions during reading.
Estimated time to complete: approximately 10 minutes.
What This Questionnaire Covers
- The context of your reading session
- How you resumed reading if there was a break (e.g., hours or days since last reading)
- Whether you experienced any interruptions during reading, and how you felt about them

Before You Begin
Please choose one reading session from today that you consider substantial—one that felt meaningful, complete, or worth reflecting on. If you didn't read any long-form content today, feel free to skip this questionnaire.
If you meet any questions, please feel free to contact me through WhatsApp (XXXXX) or Email (XXXXXX).
Section 1 – Contextual Questions
Think about the last reading session that you were having. In this section, we'd like to get a quick picture of your reading setup—what and where you were reading and on which device or format (e.g., phone, tablet, or physical book). This helps us understand how reading context might relate to your experience.
1. Your participant code (Required)

To help us keep your responses anonymous yet consistent across multiple days, please create a simple participant code.
Use: First 3 letters of your mother's first name + letters in your zip code.
Example: Emily + 2624HL → EMIHL
Please remember to use the same code every time you fill in the questionnaire.
Answer: _____

1. What platform are you reading on in the last reading session? (Required)

- ☐ PC
- ☐ Smartphone
- ☐ Tablet (e.g., iPad)
- ☐ E-Ink
- ☐ On paper (e.g., physical book)
- ☐ Other: _____

1. What type of long-form content are you reading? (Required)

Definition of long-form contents: more than 800 words and mentally demanding.

- ☐ Scientific Paper
- ☐ Literary Fiction
- ☐ Narrative Non-fiction (biography, history, serious journalism …)
- ☐ Other: _____

1. What language is the content you're reading in? (Required)

Answer: _____

1. Where were you physically located during the reading session? (Required)

- ☐ At home
- ☐ At work
- ☐ At school/university
- ☐ On public transport (e.g., train, bus)
- ☐ In a café or public place
- ☐ Outdoors (e.g., park)
- ☐ Other: _____

1. How would you describe your reading environment? (Required)

- ☐ Very quiet
- ☐ Some background noise
- ☐ Quite distracting / hard to focus
- ☐ I didn't notice my reading environment

Section 2 – Getting Back into Reading After a While
This part is about how you started your reading session after not reading the material for a while—this could be hours, days, or even weeks since your last session with the same content.
Imagine when you started your last reading session: you were picking up this material you started reading a while ago and you're trying to continue from where you left off.
1. How long has it been since you last read this material? (Required)

- ☐ I never read this before
- ☐ < 12 hours
- ☐ 12 hours – 1 day
- ☐ 1 – 2 days
- ☐ 3 – 5 days
- ☐ 5 days – 1 month
- ☐ > 1 month

1. Please think back to the last time you read this material. How did that reading session end? (Required)

- ☐ I finished the session as planned (e.g., reached the end of a chapter or section)
- ☐ I stopped because I was interrupted
- ☐ I'm not sure / It ended in an unclear way

1. What did you do to get back into the reading? (Required)

Answer (e.g., re-read earlier sections, scrolled up, took notes, just started where you left off):

_____

_____

1. How difficult was it to get back into the reading? (Required)

1 2 3 4 5 (Very easy → Very difficult)

1. What made it difficult to get back into the reading (if anything)? (Required)

Answer (if not difficult, write "n.a."):

_____

_____

2.6 demographic data collection

Section 3 – Interruptions During a Reading Session
This section is about shorter interruptions (usually lasting between 1 and 10 minutes) that happened during your current reading session.
If you had more than one interruption, please think about the one that affected you the most.

1. Think of the most impactful interruption that happened during this reading session. What type of interruption was it? (Required)
   - ☐ External – I was distracted by something external (e.g., doorbell, other people)
   - ☐ Internal – I was distracted internally (e.g., tiredness, mind-wandering)
1. What did you do to get back into reading after the most impactful interruption? (Required)

Answer:

_____
_____

1. How difficult was it to get back into the reading after the most impactful interruption? (Required)

1 2 3 4 5 (Very easy → Very difficult)

1. What made it difficult to get back into the reading after the most impactful interruption (if anything)? (Required)

Answer (if not difficult, write “n.a.”):

_____
_____

1. What was your overall reading experience? (Required)

1 2 3 4 5 (Very unpleasant → Very pleasant)

1. If your experience was especially unpleasant or pleasant, what made it feel that way? (Required)

Answer (if not applicable, write “n.a.”):

_____
_____

1. Upload your diary (optional if digital diary already provided)

File upload: _____

2.7 Semi-structure interview

1. What platform do you use for reading and why?
   → Hypothesis: more complex content (e.g., scientific papers) may require richer platform support(PC).
2. How do you usually read long-form content?- understanding reading habits
3. How do you handle interruptions and resume reading?
   (L2 Scenario)
   → Do different types of interruption affect resumption differently?
   a. long VS short
   b. external VS internal
4. Is there an ocassion that you find it really hard to get back to reading again?
5. What is a good reading experience for you?
   a. What would an ideal reading experience look like?
   b. worst reading experience
6. What factors influence your reading experience?(L3 Goal)
   a. Is interruption(&resumption) an important factor?
7. What is your goal when reading long-form contents?

3. Co-creation workshop

3.1 Consent form

Opening Statement and Informed Consent

Opening Statement

You are being invited to participate in a research study titled "Building LLM-powered Breadcrumbs for resuming reading", This study is being conducted by Yonghao Hu (MSc student) at the Faculty of Industrial Design Engineering, TU Delft, under the supervision of Dr. Tilman Dingler.

The purpose of this research is to understand how people resume reading after interruption and what interventions may improve their resumption experience. It will take you approximately 45 minutes to complete. The data may be used for scientific publications in anonymized form.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by collecting only the necessary personal data and storing that data safely on local university servers in compliance with the General Data Protection Regulation. For further processing, the data will be fully anonymized, i.e., the collected data cannot be related to the respective participant.

Your participation in this study and the processing of your data is entirely voluntary. The survey can be cancelled by you at any time without mentioning reasons and without causing any disadvantages. In the event of cancellation, all data recorded of you will be irrevocably deleted.

Please contact the corresponding or responsible researcher for any questions.

Contact information:
Corresponding researcher:

Responsible researcher:

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated *dd/mm/yy*, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	□	□
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	□	□
3. I understand that taking part in the study involves participating in testing prototypes for reading and interviews. The process will be audio-recorded, and the recording will be deleted after the recordng is transcribed by the researcher. All identifying information (e.g., name, email, workplace, etc.) will be removed upon transcription. It will also include picture taking, which will be treated confidential and fully anonymized and cannot be associated with your person.	□	□
4. I understand that the study will end after 45 minutes.	□	
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
5. I understand that taking part in the study involves the following risks: If I am a student or employee at TU Delft, I may feel a sense of obligation to take part in this research or feel uncomfortable sharing personal views with the researcher. I understand that these concerns will be addressed by clearly emphasizing that participation is entirely voluntary and that I may withdraw at any time without giving a reason and without facing any negative consequences. All data collected will be handled anonymously. In cases where full anonymity cannot be guaranteed (e.g., during interviews), I understand that I am only expected to share information that I feel comfortable disclosing.	□	□
6. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) [job, age, gender, expert domain] and associated personally identifiable research data (PIRD) [e.g., public reputation] with the potential risk of my identity being revealed.	□	□
7. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach. • Data will be collected anonymized using a randomly assigned identifier. • PII such as consent forms and email addresses will be stored separately and only locally and will be deleted at the end of the study. • Raw data such as audio-recordings from the interviews will be only stored locally and deleted after transcription.	□	□

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
• The data published open access for re-use and for publication will be aggregated and any PII will be carefully removed.		
8. I understand that personal information collected about me that can identify me, such name and email address, will not be shared beyond the study team.	□	□
9. I understand that the (identifiable) personal data I provide will be destroyed after the study is complete but no later than 6 months after my participation.	□	□
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
10. I understand that after the research study the de-identified information I provide will be used for scientific publication and for reuse through open access publication of the data set. The data is for the purpose of scientific publications only, direct quotes of interview statements might be cited.	□	□
11. I agree that my responses, views or other input can be quoted anonymously in research outputs.	□	□
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
12. I give permission for the de-identified data (i.e., survey responses excl. demographic information, transcripts) that I provide to be archived on the in a TU Delft onedrive so it can be used for future research and learning.	□	□
13. I understand that access to this repository is restricted to research purposes only, ensured through mandatory access requests. All PII will be removed to ensure full anonymity. The data will be available for 10 years and deleted afterwards.	□	□

Signatures

Name of participant [printed]	Signature	Date

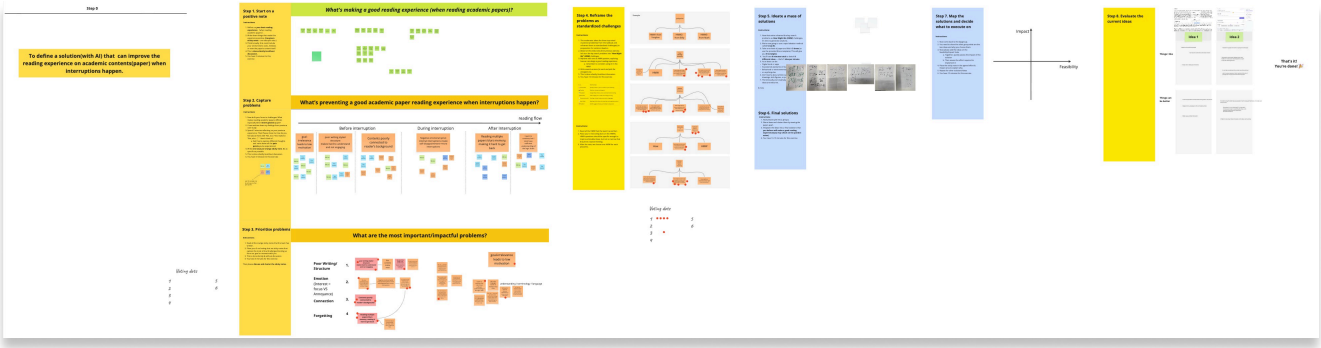
I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Yonghao HU

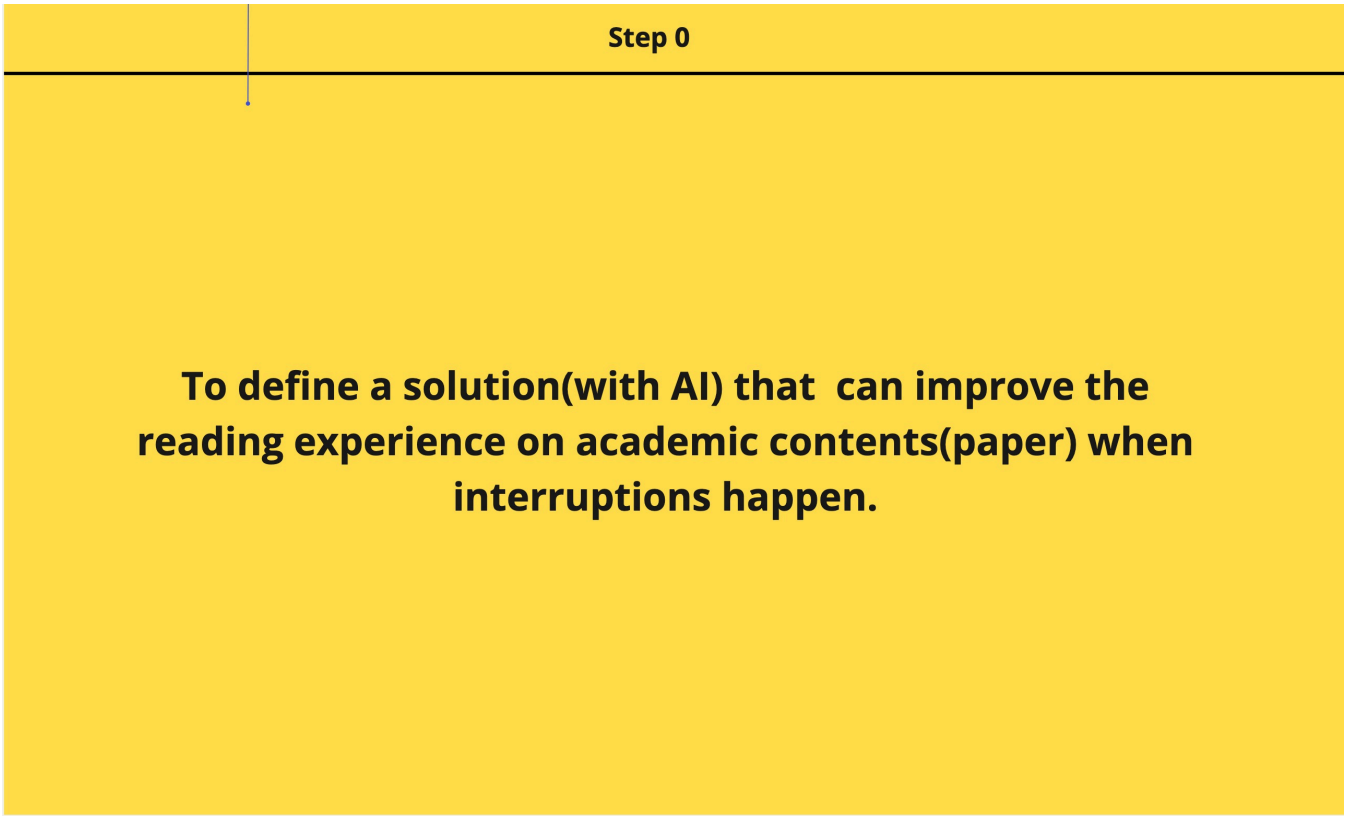
Researcher name [printed]	Signature	Date

Study contact details for further information:

3.2 Miro board

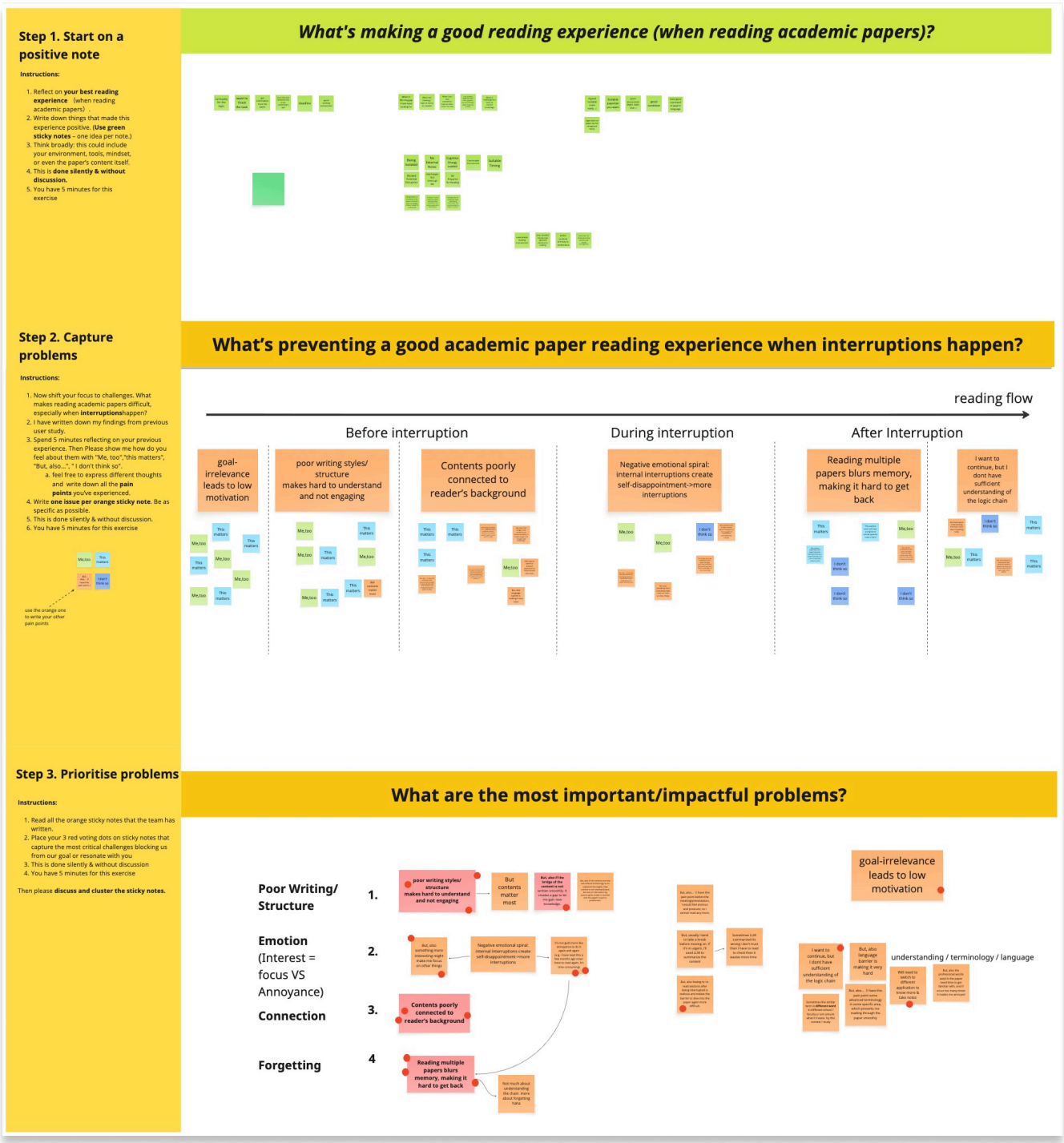


overview of the Miro borad



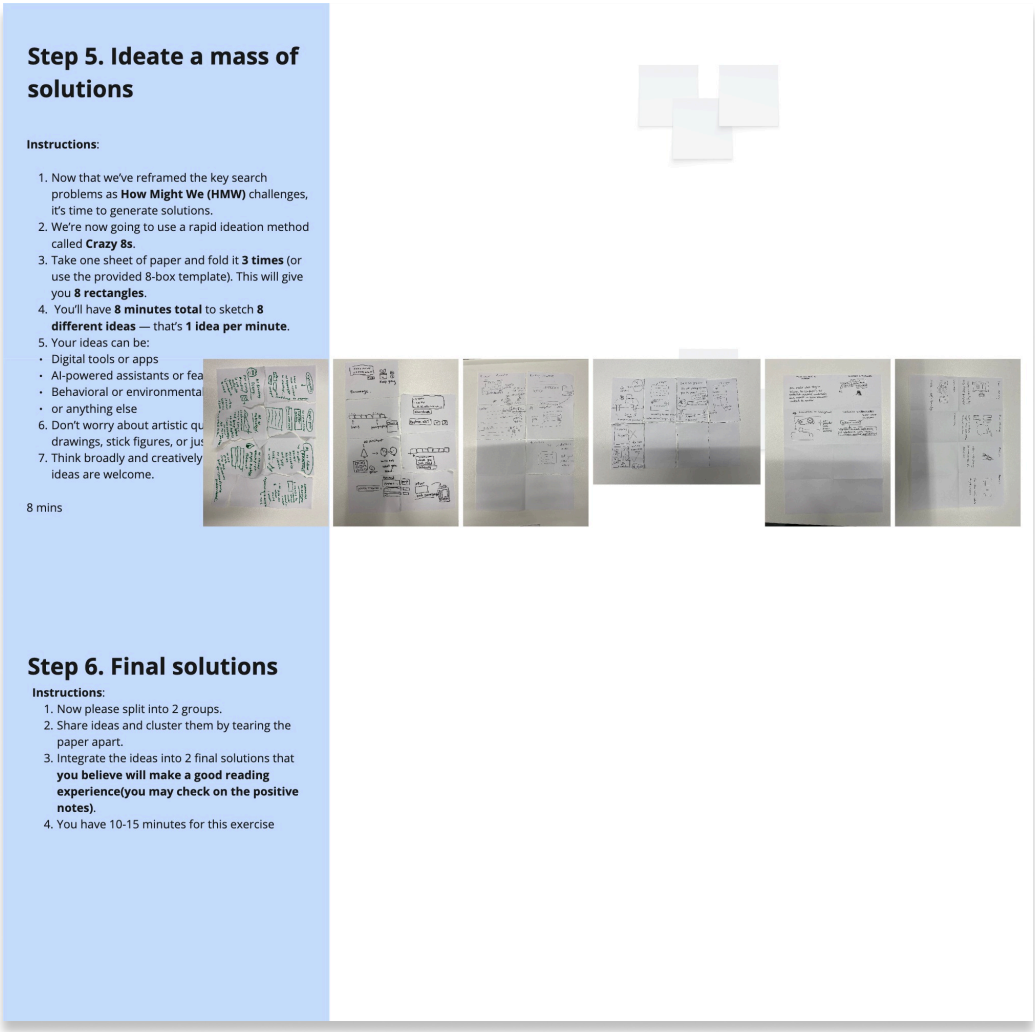
Step 0

3.2 Miro board

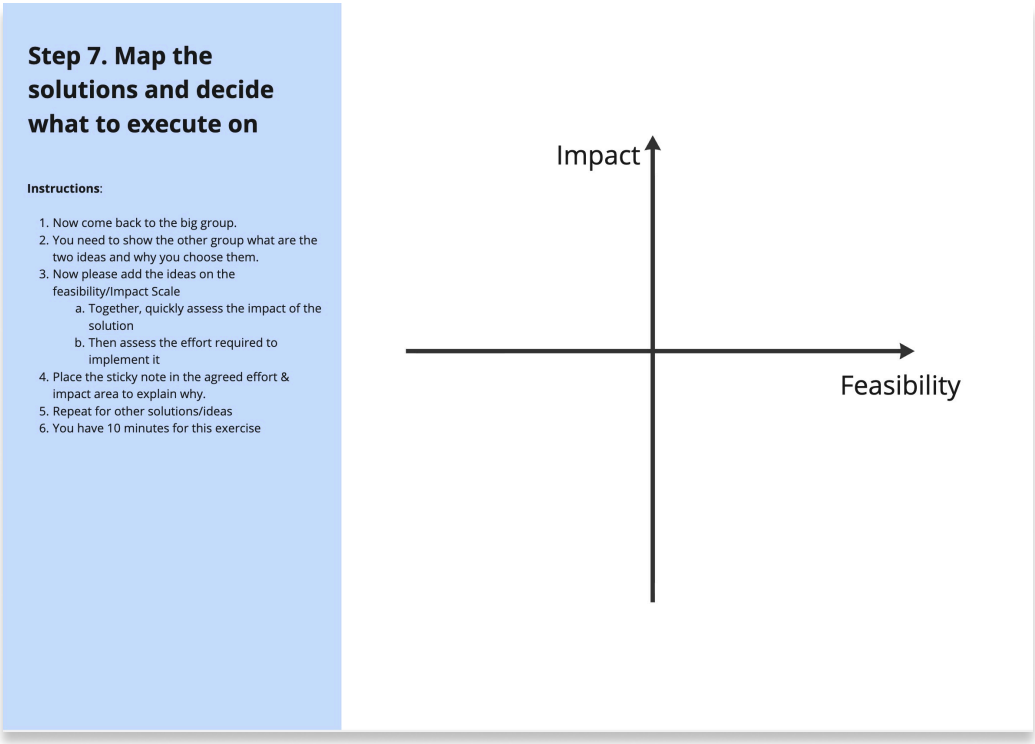


Step 1-3

3.2 Miro board



Step 5, 6



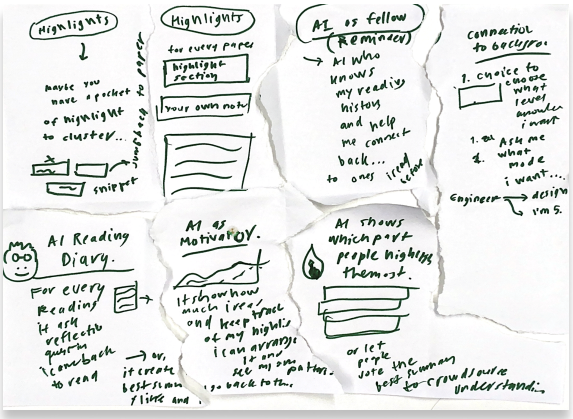
Step 7

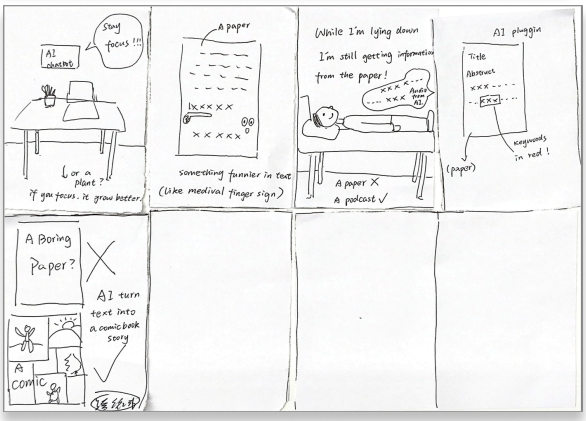
3.2 Miro board

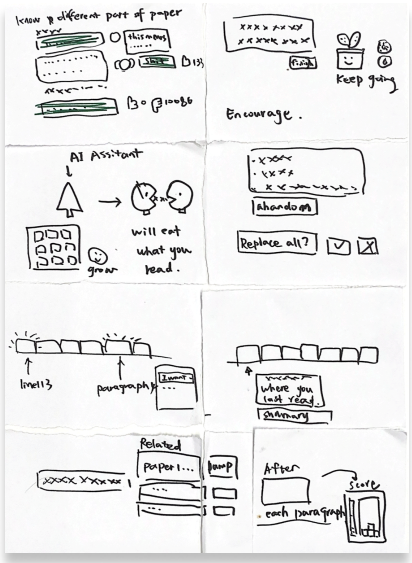
Step 8

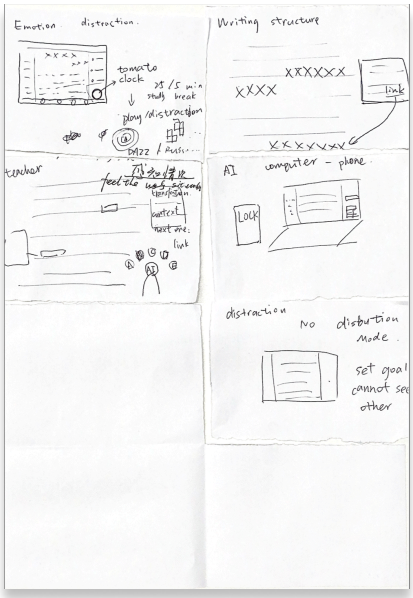
3.3 Ideas from participants

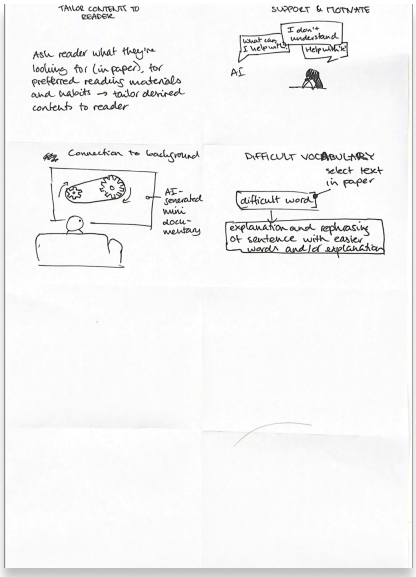
3.3.1 Ideas



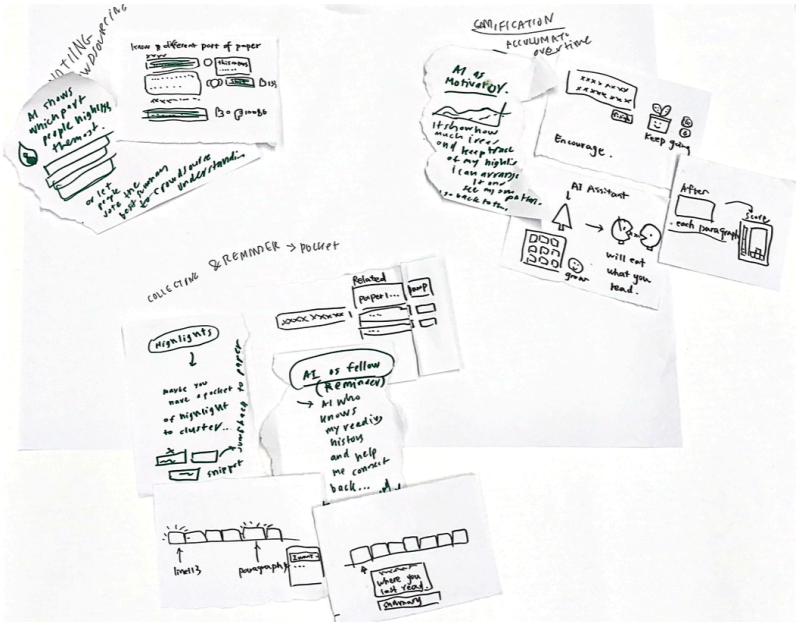


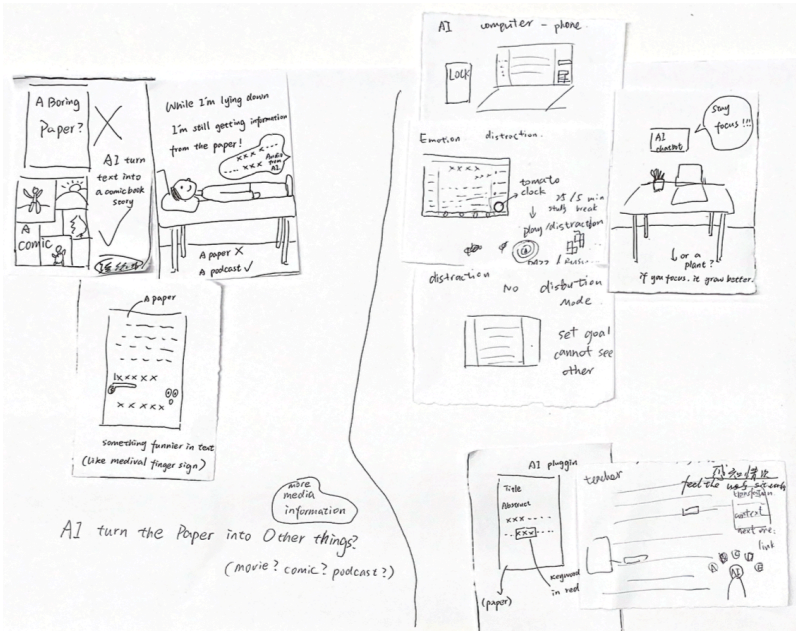






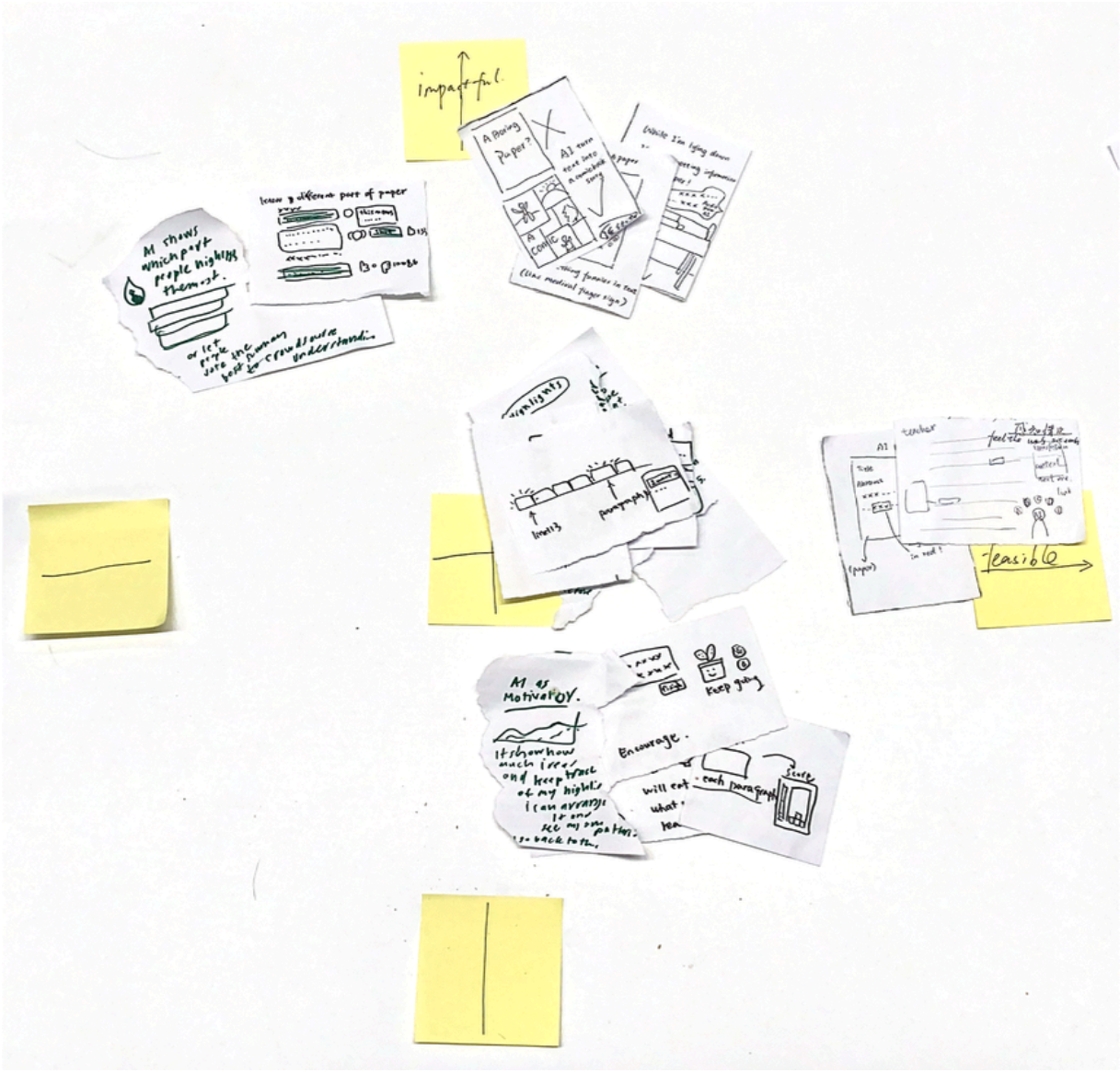
3.3.2 Ideas clustered in groups





Ideas in Group A and B

3.3.3 Ideas mapped in scale



Ideas mapped in scale

4. User test

4.1 Consent form

Opening Statement and Informed Consent

Opening Statement

You are being invited to participate in a research study titled "Building LLM-powered Breadcrumbs for resuming reading", This study is being conducted by Yonghao Hu (MSc student) at the Faculty of Industrial Design Engineering, TU Delft, under the supervision of Dr. Tilman Dingler.

The purpose of this research is to understand how people resume reading after interruption and what interventions may improve their resumption experience. It will take you approximately 45 minutes to complete. The data may be used for scientific publications in anonymized form.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by collecting only the necessary personal data and storing that data safely on local university servers in compliance with the General Data Protection Regulation. For further processing, the data will be fully anonymized, i.e., the collected data cannot be related to the respective participant.

Your participation in this study and the processing of your data is entirely voluntary. The survey can be cancelled by you at any time without mentioning reasons and without causing any disadvantages. In the event of cancellation, all data recorded of you will be irrevocably deleted.

Please contact the corresponding or responsible researcher for any questions.

Contact information:
Corresponding researcher:

Responsible researcher:

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICPANT TASKS AND VOLUNTARY PARTICIPATION		
1. I have read and understood the study information dated *dd/mm/yy*, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	□	□
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	□	□
3. I understand that taking part in the study involves participating in testing prototypes for reading and interviews. The process will be audio-recorded, and the recording will be deleted after the recordng is transcribed by the researcher. All identifying information (e.g., name, email, workplace, etc.) will be removed upon transcription. It will also include picture taking, which will be treated confidential and fully anonymized and cannot be associated with your person.	□	□
4. I understand that the study will end after 45 minutes.	□	
B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)		
5. I understand that taking part in the study involves the following risks: If I am a student or employee at TU Delft, I may feel a sense of obligation to take part in this research or feel uncomfortable sharing personal views with the researcher. I understand that these concerns will be addressed by clearly emphasizing that participation is entirely voluntary and that I may withdraw at any time without giving a reason and without facing any negative consequences. All data collected will be handled anonymously. In cases where full anonymity cannot be guaranteed (e.g., during interviews), I understand that I am only expected to share information that I feel comfortable disclosing.	□	□
6. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) [job, age, gender, expert domain] and associated personally identifiable research data (PIRD) [e.g., public reputation] with the potential risk of my identity being revealed.	□	□
7. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach. • Data will be collected anonymized using a randomly assigned identifier. • PII such as consent forms and email addresses will be stored separately and only locally and will be deleted at the end of the study. • Raw data such as audio-recordings from the interviews will be only stored locally and deleted after transcription.	□	□

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
• The data published open access for re-use and for publication will be aggregated and any PII will be carefully removed.		
8. I understand that personal information collected about me that can identify me, such name and email address, will not be shared beyond the study team.	□	□
9. I understand that the (identifiable) personal data I provide will be destroyed after the study is complete but no later than 6 months after my participation.	□	□
C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION		
10. I understand that after the research study the de-identified information I provide will be used for scientific publication and for reuse through open access publication of the data set. The data is for the purpose of scientific publications only, direct quotes of interview statements might be cited.	□	□
11. I agree that my responses, views or other input can be quoted anonymously in research outputs.	□	□
D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE		
12. I give permission for the de-identified data (i.e., survey responses excl. demographic information, transcripts) that I provide to be archived on the in a TU Delft onedrive so it can be used for future research and learning.	□	□
13. I understand that access to this repository is restricted to research purposes only, ensured through mandatory access requests. All PII will be removed to ensure full anonymity. The data will be available for 10 years and deleted afterwards.	□	□

Signatures

_____ _____ _____

Name of participant [printed] Signature Date

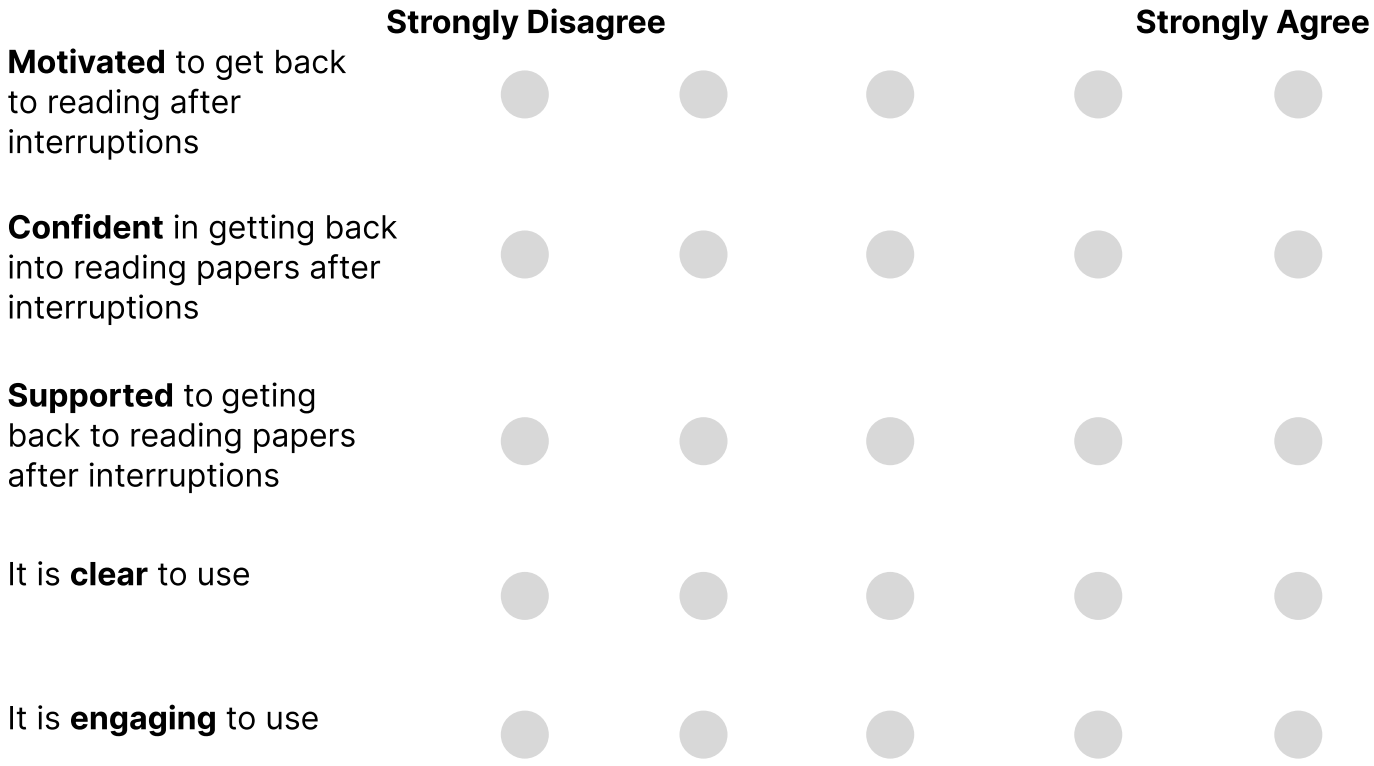
I, as researcher, have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Yonghao HU

Researcher name [printed] Signature Date

Study contact details for further information:

4.2 evaluation form



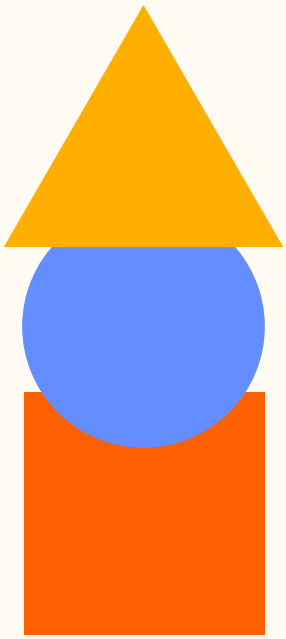
Evaluation form_part 1

4.2 evaluation form

System Usability Scale (SUS)

	Strongly Disagree				Strongly Agree
I think that I would like to use this product frequently.	1	2	3	4	5
I found the product unnecessarily complex.	1	2	3	4	5
I thought this product was easy to use.	1	2	3	4	5
I think that I would need the support of a technical person to be able to use this product.	1	2	3	4	5
I found the various functions in this product were well integrated.	1	2	3	4	5
I thought there was too much inconsistency in this product.	1	2	3	4	5
I would imagine that most people would learn to use this product very quickly.	1	2	3	4	5
I found this product very awkward to use.	1	2	3	4	5
I felt very confident using this product.	1	2	3	4	5
I needed to learn a lot of things before I could get going with this product.	1	2	3	4	5

Evaluation form_part 2: SUS test



Yonghao Hu

MSc Design for Interaction
Faculty of Industrial Design Engineering
Delft University of Technology

September 2025