



READERQUIZZER: Augmenting Research Papers with Just-In-Time Learning Questions to Facilitate Deeper Understanding

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ABSTRACT

Academic reading is a key component of higher education, and serves as a basis for critical thinking, knowledge acquisition and effective communication. Research shows many students struggle with comprehension and analysis tasks with academic texts, despite the central importance of academic reading to success in higher education. Undergraduates and researchers need to internalize dense literature to scaffold their own work upon it. This reading task is time-consuming and difficult to do. Oftentimes, students struggle to actively and critically engage and as a result attain merely a cursory understanding of a paper’s contents, or worse, incorrectly interpret the text. How, then, can we provide a means to more easily digest a text while also facilitating meaningful, critical engagement and understanding? This paper locates itself within the broader field of augmented reading interfaces to implement an augmented reading interface that leverages the power of large language models (LLM) to intelligently generate and co-locate comprehension and analysis questions in an academic paper, thereby making the paper more digestible with the end goal of facilitating deeper understanding, and developing critical reading skills.

CCS CONCEPTS

• **Human-centered computing** → *Interactive systems and tools.*

KEYWORDS

augmented reading interfaces, academic papers, reading comprehension

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1 INTRODUCTION

Academic reading is integral to success at higher education institutions, in part because reading academic papers is a daily task for

researchers, graduate and undergraduate students alike. Literature surrounding academic reading emphasizes reading’s importance and centrality to the college curriculum [4, 7, 11]. The text has to be actively and critically engaged with, as both are a crucial part of the learning process and for gaining the benefits of reading [7]. Academic reading is important not only because failure to complete required readings is associated with declining exam performance and research performance [13], but also because strong reading capabilities foster effective participation in scholarly conversations [16], ultimately furthering academic research progress on the whole.

Despite the central importance of academic reading to successful learning in higher education, struggles with academic reading comprehension are widespread, especially at the undergraduate level. While academic reading struggles are multi-faceted in nature, being influenced by a multitude of factors including “proficiency in the material’s printed language, motivation, self-regulation, academic background, self efficacy and students’ academic life adjustment” [3], these struggles are largely due to both student and institutional shortcomings [7, 13].

It remains critical, then, that readers’ comprehension skills are stimulated and developed as much as possible to promote ‘deep’ understanding. We strive to develop a method to intelligently generate and co-locate comprehension and critical thinking questions in an academic paper. Secondly, we aim to further stimulate readers’ critical engagement with a text. Hence, in the pursuit of fulfilling these goals, we are motivated by the following question: *Can a novel reading interface provide readers with an easier means to extract knowledge from and intellectually engage with a paper, especially those that prove to be prohibitively difficult to comprehend?*

Our proposed solution is an augmented reading interface intended for use primarily by undergraduates that incorporates just-in-time positioned learning questions in order to better facilitate deeper understanding of the text. We present *READERQUIZZER*, a software tool designed to support students in their comprehension of academic texts.

2 RELATED WORK

Challenges with College Reading Comprehension. Undergraduate academic reading skills are negatively impacted by both comprehension and analysis difficulties. College instructors observed that even when provided with study guides, college students typically read without an emphasis on comprehension [14]. Regarding difficulties with the texts themselves, studies such as [18, 19] determined that many students struggle with understanding vocabulary, identifying main and global ideas in text, composing summaries, and synthesizing information from multiple academic texts

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to produce academic writing. Perhaps most importantly, the undergraduate academic context is characterized by low compliance with reading assignments. Studies show only 20–30% of undergraduate students complete required readings [13], and their academic performance suffers as a result [3]. Undergraduates merely give a cursory and superficial reading of their assigned material [2], and subsequently do not take the proper time and effort to truly engage with and understand the readings, which research shows would simultaneously develop their reading skills. Reading skills are not necessarily improved at college, either; one study of 848 undergraduates found only minimal gains in reading abilities as students progressed toward college graduation [9]. Learning opportunities are being lost, and consequently threatening the quality of higher education. This suggests better practices are needed to help undergraduates read and develop their comprehension abilities, by making reading assignments easier to digest, giving students who are less proficient more opportunities to practice and scaffold, and providing direct feedback to students' reading processes to foster engagement.

How to Motivate Readers: Strategies to Support Reading Practices. Given the undergraduate sphere is generally characterized by a lack of active and critical engagement with academic texts, fueled by a lack of time, motivation and inadequate support in teaching undergraduates how to read, how do we motivate readers to engage with academic texts and facilitate deeper understanding? Research shows a positive relationship between self-monitoring reading, the ability of a reader to remain aware of their own understanding and comprehension of the text, allowing students to identify areas that need clarification and engage with complex texts in a thoughtful and reflective manner, and learning effectiveness: "when students are taught to ask each other a series of comprehension-monitoring questions during reading, they learn to self-monitor more often and hence learn more from what they read" [1]. This is where our tool, *READERQUIZZER*, fits in: integrating a self-monitored comprehension-question-based reading interface into a higher education setting for students could prove beneficial for overall active and critical engagement with texts, and may even help increase compliance in completing required readings.

Existing Augmented Reading Interfaces. A handful of tools have been developed in the domain of improving and augmenting the process of academic reading. These tools include digital annotation tools [5], augmented reality [6, 8, 12], and augmented reading interfaces. Our tool took inspiration from the work and design principles involved in three main works: *ScholarPhi*, developed by Andrew Head et al. [10], an interactive hypertext interface that supports the comprehension of scientific papers, including helping readers understand nonce words (unique technical terms and symbols defined within scientific papers) through automatically generated, position-sensitive definitions; *CiteRead* by Rachatasumrit et al [20], a reading interface built upon the *ScholarPhi* reader that integrates information about follow-up and citing works directly into a given paper, facilitating connections to related works and reducing the amount of context switching between papers; and *ReadingQuizMaker* by Xinyi Lu et al [15], which incorporates Natural Language Processing (NLP) models into a document-viewing

interface to support instructors in their design of high-quality reading comprehension question for students. Regarding the last tool, just as *ReadingQuizMaker* sets out to achieve, we too aim to support reading comprehension in higher education contexts. However, our tool *READERQUIZZER* differs from *ReadingQuizMaker* in several key aspects. First, our tool focuses more on supporting students rather than instructors, allowing students themselves to generate learning questions in varying types and quantities as they see fit. Our student-driven approach gives students more autonomy and practice with self-monitoring their own learning, with the end goal of helping students' conceptual understanding of the text. Secondly, our tool is compatible with PDF articles, thus broadening the scope of compatible papers beyond merely publications since 2018 [15]. Lastly, our tool aligns with the American Association of Colleges and Universities (AACU)'s VALUE rubric that evaluates student reading comprehension capabilities, as later outlined in Section 3. Ultimately, these reading interfaces demonstrate a world of new "readers" is coming and a need for academia and pedagogy to adjust. Learning is changing.

3 BRIEF OVERVIEW OF *READERQUIZZER*

READERQUIZZER is implemented as a web application with a *Node.js* back-end that utilizes an LLM, in our case, the ChatGPT-3.5 model is used via the OpenAI API [17], to automatically generate learning questions. Figure 1 shows the user interface. When a PDF is opened in *READERQUIZZER*, the text is extracted and subsequently rendered as input to ChatGPT with the prompt "generate [X] [question type] questions followed by answers based on the following research article: [text]". As the paper's text is given as context to ChatGPT, the generated questions and answers are often verbatim quotes, thus effectively connecting them to the text.

Regarding question types, we drew upon the American Association of Colleges and Universities (AACU)'s Reading VALUE Rubric to help quantify reading comprehension, as the AACU proves an authoritative source on comprehensively assessing and discussing student learning at higher education institutions [4]. Within the rubric, they define reading as "the process of simultaneously extracting and constructing meaning through interaction and involvement with written language." Drawing upon this, we focus on incorporating two main facets of undergraduate reading for formulating questions within *READERQUIZZER*: **comprehension** and **analysis**. We chose these two categories as we felt they reflected the two principal components of effective reading, comprehension representing the process of extracting meaning from the text and analysis reflecting the process of constructing meaning beyond the scope of the text. As such, *READERQUIZZER* generates comprehension and analysis questions, and we provide ChatGPT with definitions of each in our prompt to properly generate each question type.

4 EVALUATION

We performed an evaluation study to understand the overall usability of *READERQUIZZER*, and collected feedback from participants on the current design, potential improvements for the system, and overall perceived usefulness as a study tool for undergraduates. We recruited participants through offline correspondences on our university campus. 16 undergraduate students (9 male, 7 female)



Figure 1: READERQUIZZER’s User Interface. Learning questions are generated based on the text of each page in a paper to further stimulate reflection, knowledge acquisition and deeper engagement with the text. Guiding questions are found in the margin and are distributed throughout the text. Questions are generated by clicking the 'generate questions' icon in the toolbar. A drop-down is presented, allowing the user to select the type of question and number of questions per page, and after which the questions can be generated (A). Once generated, each page contains a question box with questions pertaining to that page’s text. Answers are found below each question, and can be toggled (B).

participated in the study of varying class years. All participants had taken college-level courses that require readings. They were from disciplines such as computer science, mechanical engineering, economics, political science, physics, and social research and public policy.

During the study sessions, participants each selected a course-related reading text of their choice to upload to and use with READERQUIZZER. The text types included academic publications, textbook chapters, and their own research papers. Participants completed three tasks: first, to interact with READERQUIZZER, use the tool generate a set of both analysis and comprehension questions, and then share their thoughts on the experience; second, to better evaluate the questions themselves, we had participants comment on the quality of each question individually, rating the usefulness of each question for aiding comprehension of the text on a 5 point Likert scale; finally, we conducted a nine-question exit survey to further assess READERQUIZZER’s overall perceived usability. The study sessions lasted for approximately 30-40 minutes.

4.1 Results

We found that participants were satisfied with the quality of the learning questions, with a resulting increased motivation to read, comprehension of a text, and self-reported information retention. Participants found our tool helpful for facilitating active and critical engagement with a text, as compared to their usual reading practices. Students looked forward to incorporating it into their studies to assist with classroom discussions and exam preparation, with 85% of participants strongly agreeing that “READERQUIZZER would be helpful in preparing for exams”. According to one participant,

“READERQUIZZER helped me complete my reading assignment quicker and with improved comprehension. This tool made my assignment feel more approachable and helped motivate me to get it done.”, and to another, “With READERQUIZZER I’m more actively thinking about what I’m reading, and found I’m zoning out less. I’m getting more out of the texts than I was before.” Several participants commented on the time-saving aspect of the tool as opposed to their typical reading habits. For instance, one described “When I was pressed for time with a long reading assignment, READERQUIZZER helped direct me to the most salient points, then allowed me to quiz myself on my comprehension.”

Our study highlights READERQUIZZER’s relevance for its application as a design intervention in large learning environments. For instance, we can envision READERQUIZZER being used in large on-line classes, with a high ratio of students to instructors, where it is difficult for instructors to individually assess readers on their understanding. READERQUIZZER is student-facing and facilitates a self-monitored learning approach to reading with its question and answer format, and we believe READERQUIZZER is an excellent showcase of the ways augmented reading interfaces can be meaningfully intervened in high education learning environments to enrich the learning experience.

One limitation of our study is its small sample size. In the future, ideally we would run a larger, longitudinal study to better understand how undergraduates use tools like READERQUIZZER to hone their reading comprehension skills, to understand how students may develop trust with the system. Longitudinal access to READERQUIZZER would shed insight into assessing how readings might truly use the tool “in the wild.” A more comprehensive qualitative

study is needed to fully investigate the time-saving and reading efficiency aspect of `READERQUIZZER`.

5 FUTURE WORK

Make `READERQUIZZER` a fully-online web app to promote wide-spread use and adoption. One of the biggest drawbacks of `READERQUIZZER` in its current state that would prevent widespread adoption in higher education contexts is the installation process. As `READERQUIZZER` is run by hosting a local Node.js server on the user's PC, Node had to be installed and environment variables declared in order for `READERQUIZZER` to run properly. The proposed alternative is hosting `READERQUIZZER` on a server and making it available online.

Enhanced personalization of the reading experience. In addition to improving the overall speed of the interface and reduce waiting time, future reading interfaces could be better tailored to individual readers' characteristics and preferences. `READERQUIZZER` currently supports two question types and a dynamic number of questions per page, yet future iterations could encompass multi-pass reading workflows, position questions differently based on the text type (for instance, questions solely about the introduction at large, methodology, results, and so on rather than generate questions by page). One could also tailor the experience to users of different fields, and evaluate their goals in reading the paper and the number of times the paper has been read previously.

6 CONCLUSION

We presented `READERQUIZZER`, an augmented reading interface that automatically generates two types of learning questions, comprehension and analysis, based on the AACU Reading rubric [4], to support students in their reading comprehension of academic texts. In an evaluation study with 16 participants, we found that participants were satisfied with the quality of the learning questions, with a resulting increased motivation to read, comprehension of a text, and self-reported information retention, and was reported as helpful for facilitating active and critical engagement with a text. Students looked forward to incorporating tools such as `READERQUIZZER` into their studies to assist with classroom discussions and exam preparation. With the advent of interactive reading interfaces such as `READERQUIZZER`, the way reading is being conducted in academia is rapidly evolving and the learning experience is being reshaped. Based on the qualitative insights from our study, we recognize the potential of augmented reading interfaces for improved motivation in self-monitored learning, personalized learning, and increased meaningful engagement.

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