Markitup: Crowdsourced Collaborative Reading

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Abstract
People enjoy the sensual and physiological properties of physical books as well as the ease of creating bookmarks and annotations. However, an abundance of annotations can be distracting from the reading experience. With the introduction of e-books, sharing annotations has enabled reading to have a social context, which research has shown to benefit learning and understanding.

Using a research through design approach we developed Markitup: a crowdsourced reading tool that enables individuals to read and annotate in a collaborative environment and benefit from the knowledge of the crowd. We found that participants appreciated the combined advantages of the physical artefact, the flexible digital annotations and the social learning context.

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Crowdsourcing; Collaborative Reading; Information Visualization; Interactive Projections.

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Introduction
People are drawn to the sensual aspects of physical books such as sight and smell, and enjoy tangibly interacting with them: holding, creasing or flipping through pages. Additionally, there are physiological benefits such as reduced eyestrain while reading a physical paper [1] in comparison to e-books. Our research shows that making annotations is considered to be easier in the physical space as compared to the digital platform. However, an abundance of annotations would ruin physical artifacts and detract from users’ reading experience (Figure 1). Furthermore, the individualistic nature of physical books limits the social and collaborative possibilities of learning and understanding.

In comparison, digital media is durable and accessible on different devices. Furthermore, the creation of annotations is an interactive process that allows more control over annotations improving legibility without affecting the original document. The collaboration of notes and sharing of ideas can be done with ease.

We have looked into the opportunity space that lies at the intersection of the physical and digital books. Our goal is to retain the benefits of physical documents [2] while adding interactive digital features such as social collaboration, and building an ecosystem of interlinked documents through crowdsourcing [3,4].

Background and Market Research
Our background research focused on collaborative reading systems, where we identified that shared content can increase reading speed and comprehension. According to Rezon et al [5], studying in a social context helps enhance content conceptualization. Furthermore, providing a summary to individuals about a document improves comprehension [6]. Through user research, we found that people prefer sharing their notes digitally because they are easier to write and more legible. However, they wanted to retain key functions of paper-based resources such as highlighting and note-making [7].

While annotations and comments are useful, we found that hypermedia annotations in digital media were a distraction, suggesting that a simplified comment format would be appropriate [8]. Furthermore, the design would have to enable a way of filtering highlights and comments due to the fact that inappropriate highlighting interferes with reading comprehension [9].

Our market research indicates that the most plausible application of Markitup will be in institutional libraries. This is because students often use same text books and could benefit from a collaborative reading environment.

Our Solution: Markitup
We have come up with a collaborative reading solution that leverages the power of the crowd to build a large ecosystem of linked documents. Markitup merges the social and collaborative nature of the digital medium while retaining the benefits of a physical document.

The idea is to have a workspace where individuals can place a book under an Interactive Projection Interface (IPI). This allows them to create and view annotations, comments and references by a large number of individuals. Through the use of a dedicated physical pen, digital annotations can be created on a physical document, reflecting how people normally mark-up

Figure 1. Abundant Annotations

All respondent’s names have been changed.

“I liked the fact that it enhances the reading experience of a book by adding digital capabilities that increase functionality”
- George

“It doesn’t ruin the book and you can see other people’s views”
- Sarah

“I like the fact that you can highlight as you’re reading, even on library books”
- Rachel

“[I liked the fact that it] enhances the reading experience of a book by adding digital capabilities that increase functionality”
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“I like the fact that you can highlight as you’re reading, even on library books”
- Rachel
physical books. This was central to the design and the basis of the conceptual model adopted. Digital annotations are augmented projections that are created through the use of the physical pen. This means that no marks are made on the physical book.

Due to the potential multicultural and multi-contextual use of the system, the vast range of comments and annotations may vary in relevance and will need to be filtered and moderated. Through the use of a voting mechanism that is propagated by the crowd, annotations can be ranked and filtered.

Since the success of the system pivots on contributions, it is important to encourage user participation. Through gamification [10], user engagement can be incentivized: promoting annotations, comments and references. System abuse is tackled by rewarding constructive contributors with experience points they can then use to unlock content in Markitup.

The system enables individuals to read in a socially collaborative environment, commenting and building on each other's contributions. Based on these contributions generated by the crowd, documents are interlinked. The strength of each link is based on a number of factors in the filtering system such as the number of references and the contributor's ranking. The result is a crowdsourced ecosystem of documents that will lay the groundwork to an advanced recommendation system. This will allow users to find related documents and explore closely linked topics.

Each user will have a Markitup account that will store their highlights, comments and references in an online space, making them available at their convenience, or when access to the Markitup terminal or the book is not possible.

Markitup has varied uses as individuals seek to achieve different purposes such as collaborating and exchanging opinions on a global scale. As found in user research, Markitup can also be installed at institutional libraries as walk-up-and-use terminals. While the tool will perform best through crowdsourcing, it can also be used in situations where access to the internet is limited. Multiple devices in a close proximity will create an ad-hoc network to allow individuals to work collaboratively.

**User Research**

Following a process that was based on Verplank's spiral model [11], we had a concept in mind that was iteratively developed through user research.

We ran a focus group that consisted of 13 people - 9 students and 4 working individuals. Potential benefits and limitations of the concept were discussed and the idea was refined. Requested features included use of different colors for each contributor (Figure 2) as well as the ability to vote on the relevance of annotations.

We then conducted an online survey to obtain information on a wider range of reading and note-making habits. Of our 117 respondents, 81% were students at an undergraduate or masters level and 19% were working. Our results suggest that sharing discussions and notes would be a useful resource for text comprehension. 78% of respondents stated that they consult other sources to better understand a topic. Respondents also indicated that other people's comments would be useful when reading text books.
Over half of our respondents said they still use paper-based resources frequently but almost 75% at some point had access issues such as unavailability of books in the library.

When presented with a storyboard as part of our survey, 20% appreciated the flexibility of creating annotations without marking the physical document. 24% anticipated improved reading comprehension with the additional capabilities of Markitup. Moreover, 50% of our respondents explained that they liked the concept of collaborating and sharing of ideas.

The survey also identified some concerns with the system. For example, a common concern was the context of annotations since highlights and comments are relative to a reader’s purpose. Additionally, users’ comments would possibly not be up to standard or simply irrelevant. Respondents were also wary of the number of highlights displayed, especially since some users tend to highlight considerably more than others.

Our survey results indicated that our product has a solid market in the education and work community. 21% of our respondents said they would buy the product, and 60% said they might. On the other hand, 80% said that they would use the product if provided as a resource in an institution.

**Design and User Testing**

Personas were constructed from the above research, this allowed us to create storyboards that led to the conceptualisation of design ideas. Design refinement was carried out through sketches and a paper prototype was then constructed (Figure 3).

User testing on a paper prototype was then carried out with 5 students who averaged 10 hours of reading every week (Figure 4). Each individual was given a set of tasks including highlighting a passage and changing filter settings. The participants were recorded during the test and their performance was evaluated on response time and success rates.

Using a research through design approach [12], four design iterations were performed and decisions were influenced through user feedback. For example, we included a quote categorization feature, which enables users to view information specific to a subject matter. We also redesigned a simpler highlight filter resulting in a better user experience when re-tested.

Conceptual designs were also made for possible future implementations of the tool, including wearable and portable interfaces (Figure 8, Figure 9) based on user research and survey responses.

**Proof of Concept Prototype**

As part of the iterative design process, a proof of concept device was prototyped (Figure 5). The purpose of the prototype was to demonstrate the possibilities of the IPI combined with a physical book.

The prototype works by projecting a computer screen onto any flat surface. An infrared sensor is paired with the computer that tracks the light emitted from an infrared pen being held by the user. Holding down the button on the infrared pen lights up the LED at the nib and sends a set of coordinates to the computer. These coordinates relate to the position of the cursor, allowing interactions to take place through the projected computer screen. The software creates a highlight in
the chosen color on a specific coordinate. Hence, a set of coordinates constructs a highlighted line (Figure 6).

We researched possible technologies that could be used to implement our idea. There are currently challenges in finding suitable components to construct a fully functional high-fidelity prototype, due to technology and form factor limitations.

Reference Ecosystem in the Making
We created an online platform that will enhance the functionality of Markitup by providing users with easy access to annotations, comments and quotes that they gather over time, along with rewards achieved through gamification. A clickable wireframe prototype was produced and evaluated with Nielsen’s Heuristics. The issues identified were resolved and a functional prototype was developed.

Vannevar Bush’s Memex [13], an idea based on associative trails, is a large self-contained library that mimics the associative processes of the human mind.

Inspired by this we envisioned a solution through crowdsourcing that will allow us to map physical books. This will allow us to build an ecosystem of linked documents that would be propagated by the crowd (Figure 7). The data gathered from all users is then visualized as a three dimensional web, that allows them to interactively navigate through documents based on topics and interests. It will show users how documents interlink and how closely they relate. This adds further meaning to the information available allowing users to find relevant and related documents quickly and easily.

Discussion
By combining the benefits of a physical document, such as the tangible interactions and ease of annotating, with the social and collaborative benefits of the digital domain, we have created a novel crowdsourced reading tool - Markitup. It improves comprehension through annotations, highlights and comments. Social collaboration not only helps an individual achieve a better understanding of a document, it also contributes to the creation of an ecosystem of interlinked documents: a compendium of knowledge.

In trying to design for a new experience, the biggest challenge we faced was to not restrict Markitup by current technological limitations. This could limit the implementation of the tool (Figure 8, Figure 9) and could possibly result in an expensive device, limiting its audience. Another issue is the delicate subject of copyrights but there is no easy solution. Dialogue with publishers would need to be brought about as was done in the music industry [14]. Furthermore, a global system such as Markitup will be exposed to the exchange of comments and annotations that might be irrelevant to the context of reading.
Markitup could be implemented as a teaching aid in low resource schools where students are provided access to annotations through the online platform, helping to alleviate the lack of physical books. Possible variations of the system could be made to suit varying institutional purposes and support learning for a wide range of people around the globe.

By implementing Markitup, we enable digital annotations and categorizations of physical books. When propagated through the crowd, this results in a tremendous wealth of interlinked information. Represented visually, this provides insight into the complex nature of knowledge categorization.

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References


