noteSpace: Applying direct manipulation in note-making

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Abstract

Our project explores a new approach to note-making. It is based on direct manipulation of text which, in context of this project, means that the selected and highlighted text of a given text document gets automatically copied to a workspace for the users to see the change immediately. Through this project, we also propose that this approach to note-making has more benefits in terms of efficiency, focus, retention and effectiveness of the notes and can be advantageous when it comes to electronic note taking. Since traditional handwritten notes are the most efficient as has been proven time and again, we have tried to incorporate such features into our system as well. We have created a GUI-based desktop application that has a concurrent view for both the imported document and the workspace. Highlighting the selected text from the text document will reflect the selected text directly into the workspace. This makes the process of note-making quicker. To evaluate this system, we conducted a between-subject study where participants were divided into two groups. One group was given the Microsoft Word-Adobe Acrobat Reader combination for note-making and the second group was given our system: noteSpace. While conducting the study, we observed the participants and after the study, we asked them to fill out a questionnaire that helped us in comparing the two methods. Our results showed that the participants who used our system performed better and completed the task in less time. We have concluded by discussing the results in detail, their implications, the limitations and the future scope of our system.

CCS Concepts: • **Human-Computer Interaction**; • **Direct Manipulation**; • **Digital Note-making**;

Keywords: Note-making, Direct manipulation, System Usability Scale (SUS), Effectiveness, Usability

1 Introduction

We are dependent on technology for all our tasks but there are certain tasks that are better done manually, by humans, rather than by computers. Handwritten notes are one example that falls under this category. Various experiments conducted have proven that note-making is most efficient and effective when written on paper. In the paper [2], the advantages of paper over screen and screen over paper are discussed extensively. Note-making is an iterative process and it engages the user in turn improving the user's productivity. The goal of a user, while making notes, is to summarize information in a concise manner by jotting down the important and crucial points. It is fairly easy to achieve this when a user is making notes on paper. However, using electronic means, this entire process involves either typing or copy-pasting, which is not natural to human psych. This process of making notes on an electronic medium is very different from making notes using paper.

The main advantage of note-making by writing on paper is that the important points register better with the user since this type of note-making uses embodied action. This embodied action lacks when the user creates notes on an electronic medium. While dealing with this problem, it is important to focus on the end goal of the task involved. The result of making notes must be to improve the retentivity of the important points, concepts and to be able to refer to those points easily for a quick recap in the future. Keeping these end goals in focus, we decided to adopt an approach that tackles this problem of electronic note-making and helps to achieve these end goals.

As a concept, direct manipulation has been around for many years. Direct manipulation's popularity can especially be attributed to the pioneering invention of Sketchpad [3]. Direct manipulation has been portrayed in three points in [4], two of which that are relevant to our project are:

1. Continuous representation of the objects and actions of interest.
2. Rapid incremental reversible operations whose effect on the object of interest is immediately visible.

Using the above points, we have designed a system for note-making that allows the continuous and real-time representation of the text from the imported text documents while the user is making notes.

2 Related Work

A related work of note-making using a digital reading [2] was performed where the interaction patterns of physical

tools like the desk or paper for note-making was mimicked. They addressed the problems of the physical world like a limited supply of paper as well as of the digital world like menu bars and tool overload. In order to overcome these, they presented a novel idea of digital drag-and-drop Post-it system which supported active reading. By using the same interaction component for multiple tasks, the system incorporated the benefits of the physical world. An extended workspace was also provided to the users to minimize the interactive effort for attentive reading. Their study concluded that this additional workspace is a beneficial component for the creation of notes and summaries. We decided to explore this idea in the design of our system.

InkSeine [1], an application developed by Microsoft Research, supported active note-making in a tablet using a customized pen. It also provided a unique feature to search in the handwritten notes and the object combined with the handwritten notes. The authors leveraged the in-situ search properties to design this feature. They conducted two studies on iterated prototypes to confirm their goals of in-situ search, optimum workflow, and minimizing search screen real estate. They found out that users can easily switch between taking notes and searching. The main feature of this application was that it could combine and annotate content from multiple applications.

In [5], the authors have discussed how the techniques of note-making have evolved over the years with the introduction of technology, how it affects the cognitive understanding of the students and how mobile devices help in note-making, increase the learning gains and to promote collaborative learning. Their user-study elaborated on how students can take notes in different forms like text-based, image-based, audio, or video recordings using mobile devices and the way in which the state of the art applications cater to the needs of the users.

In [4], the author has outlined some important points regarding the concepts of direct manipulation and how it helps the user. The author has described direct manipulation as a concept that depends on visual representation of actions of interest and rapid incremental reversible operations whose effect is immediately visible to the users. In his paper, he has also mentioned that direct manipulation interfaces instil confidence among users and gives them a feeling of control. He has summarized that using the principles of direct manipulation, one can design an easy to learn system for beginners, tasks can be made more versatile, retention of operational concepts becomes much easier, user experiences less anxiety and more confidence while using the system, and the user feels more in control of the system. Using such direct manipulation interfaces, the users feel responsibility towards the tasks that they perform and hence experience a feeling of accomplishment. The author concludes the paper by addressing these points and ascertains a huge scope for this concept attributing it to these observations and reasons.

3 System Description

The requirements of the system included that the users should be able to first, create notes without having to switch multiple times between screens and/or applications and second, the cognitive load of copying a few lines of text from the document to a different text editor should be eliminated. To address the first requirement, we implemented a concurrent view of the document to be viewed and the notes file. Employing the functionality of auto-copying the selected text into the notes section helped us in meeting the second requirement.

We decided to design a GUI based desktop application for our final system implementation (Figure 2). The screen was divided into two sections: the left section to view and access the PDF file and the right section was designated to be a workspace which the user can utilize for note-making. According to our research, individuals prefer multicolor highlighting and we decided to incorporate it into our system. Upon selecting certain text, the text is highlighted and gets copied into the workspace as a bullet point simultaneously. The user can choose to copy text into the workspace without highlighting as well. The bullet point structure was chosen because it is most popularly used for note making. The user also has an option to delete the generated bullet point by simply double clicking on it. Upon the completion of notes, the user can also export the content of workspace into a document which he/she can save on their personal device.

As for the technology stack involved in developing the application, we used HTML/CSS for developing the interface of the application. JavaScript, in combination with the Electron framework, was used to implement highlighting and auto-copying of text as well as to develop the concurrent view of the document and work space. Lastly, dynamic file selection and exporting of workspace content was implemented using the Python programming language.

3.1 Design Process

Our design process for designing and developing noteSpace was as following:

1. Designing high-fidelity prototypes that reflect the final interface of the system (Figure 1): This included designing a complete application for note-making including the functionalities which the state-of-the-art application provide.
2. Developing an initial system prototype: This which was a website that we had used for quick and dirty pilot study.
3. Pilot study: It emphasized on some flaws of our design. The website required uploading a document to the cloud for viewing. Also, there were too many features or creeps for a focused study.
4. Post pilot study: After the pilot study, we reached the conclusion to develop a desktop application which can

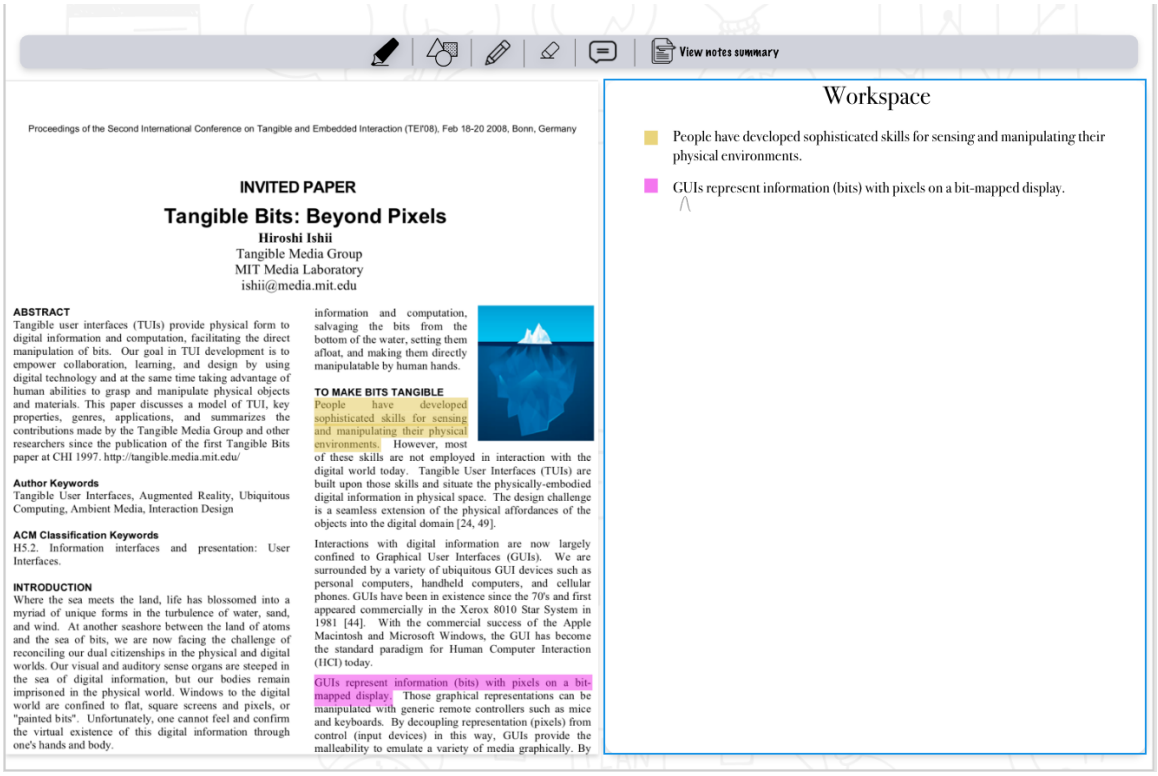

Figure 1. High Fidelity Prototype: included all the state-of-the-art functionalities for note-making

access files directly from the file system. Instead of developing all the features of note-making, we decided to focus on auto-copying as it was the novel feature of our application and was directly related to our seed idea. To support this feature, we also included highlighting of selected piece of text in the document.

5. Final system: This system was used in the study against a control method which is explained later.

4 Study design and Implementation

We adopted a Research-Oriented Design (ROD) approach to implement the system and then conducted a study to observe and analyze the usability and effectiveness of the system and response of the participants.

We took the different methods of note-making as the independent variable for the study and the dependent variables for the same are as follows:

1. Effectiveness: This can be measured through -
   - Time taken to make notes
   - Number of colors used for highlighting text
   - Questionnaire
2. Usability: This can be measured through -
   - Cognitive load on the user
3. Retention Capability: This can be measured through -
   - Questionnaire

4.1 Participant Details

A total of 16 participants took part in the user study and among these people, there were 8 males and 8 females. We tried to maintain the balance between the male and the female participants to avoid any impact of gender on the results. All of them were graduate students who belonged to diverse majors like Computer Science, Industrial Engineering, Mechanical Engineering, Business Intelligence, and Philosophy. Their age ranged between 22 to 25 years. To keep the identity of the participants anonymous, each participant was assigned a unique identification number. A between-subject user study was conducted and therefore the 16 participants were divided into two groups, namely Group A and Group B. Each group consisted of 8 people with 4 males and 4 females.

4.2 Study Design

Firstly, before starting with their respective sessions, all participants were asked to fill out a questionnaire that asked for their following details: age, gender, major, frequency of using applications like Adobe Acrobat Reader DC and Microsoft Word, and how they prefer to make notes: collated points or paragraphs.

Participants of each group were explained our research topic, and the tasks that they were required to perform during their session. The participants who were not familiar with the required applications, especially noteSpace, were

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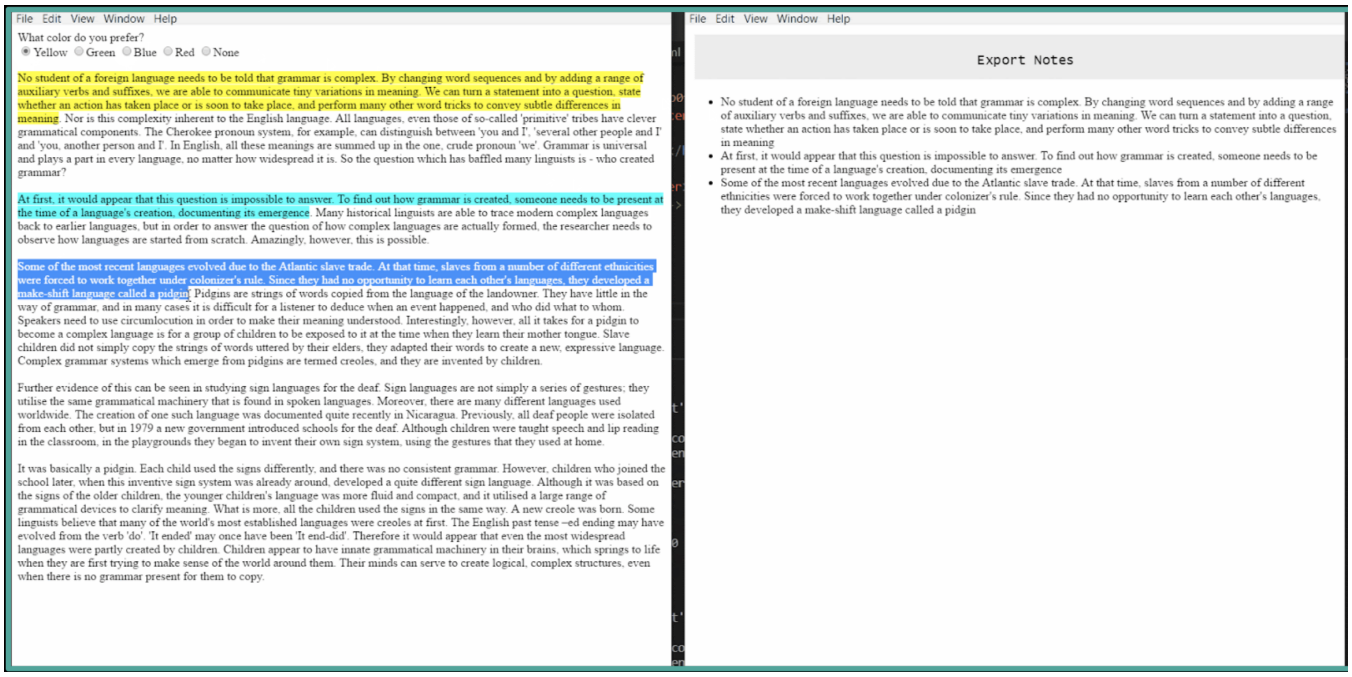

Figure 2. User Interface of the final system

adequately informed and trained to execute the different required functionalities.

Group A participants were asked to make notes using the control method, copying the highlighted text from a PDF file and then pasting the copied content into a text editor. Adobe Acrobat Reader DC was used to view the PDF file and Microsoft Word was used as a text editor to make notes. To make notes, the users had to subsequently handle and switch between these two applications.

Group B participants were asked to make notes using our application, noteSpace. Unlike, the previous condition, here the participants did not have to switch between two applications. They were able to open the PDF file, highlight the important text as well as make and export notes in the same application.

The PDF file contained a passage that was randomly selected from a pool of TOEFL reading comprehensions. It had 700 words and was 2 pages long. Since all the participants were international students and had attempted the TOEFL entrance exam in the past two years, we believed that it will be a fair baseline for all. According to the TOEFL guidelines, the all the participants were given utmost 10 minutes to read the entire passage and take notes.

During the session, for both the groups, the following points were noted:

- Time taken to read the passage and make notes
- Length of the notes with respect to bullet-points

In addition to these two parameters, for Group A we measured the number of times users switched between the two applications whereas for Group B, we also measured the number of colors they used to highlight the text.

After the completion of note-making for the given passage, the participants of both the conditions were asked to answer a set of five questions based on the passage provided to them. All these questions had four multiple choices with a single correct answer. The objective of conducting this test was to check and analyze the impact of the note-making techniques on the comprehensibility and retention capability of the users.

The participants of both the groups were also asked to fill out a post-session questionnaire. Group A's questionnaire included a System Usability Scale (SUS) test to be used a control attribute against the noteSpace SUS scores. The questionnaire given to Group B included the SUS test as well as questions concerning the features of Note-Space that the users found useful, the ones which could be improved and other new functionalities that can be incorporated in the future.

All the questionnaires, except the Retentivity Test were published using Qualtrics. The retentivity test was published using Google Forms.

Table 1. Time allocated to the participants to perform the tasks

Task	Time alloted
Provide participant details	02 mins
Introduce and explain tasks	05 mins
Read and make notes	10 mins (max limit)
Answer retentivity Questions	05 mins (max limit)
Post-session Questionnaire	02 mins

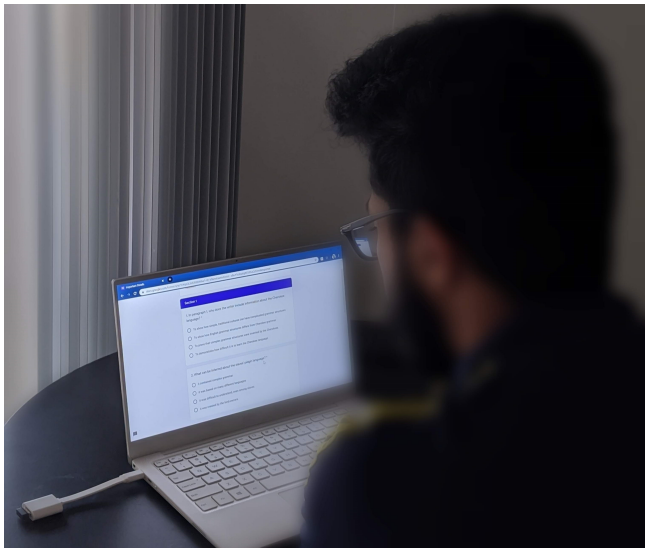

Figure 3. Group A participant during user study

Figure 4. Group B participant during user study

5 Data analysis

5.1 Quantitative analysis

For quantitative analysis of the two conditions, we performed a t-test on the usability and effectiveness measures of our system i.e, the dependent variables. Usability was assessed using System Usability Scale (SUS) test through the post-session questionnaire. Effectiveness of the system was assessed based on how the participants were performing during the sessions. Each of the dependent variables was taken into consideration: time taken to read the passage, number of bullet points made and retentivity. Retentivity was measured using the score obtained by the participants in the retentivity questionnaire.

5.2 Qualitative analysis

The qualitative data for noteSpace was obtained from the post-session questionnaire responses of Group B participants. It included a combination of open-ended and close-ended questions. The open-ended questions asked were as follows:'Which system features did you find useful?','Which system features did you find frustrating?' and 'What new features can be added in the future?'. The close-ended questions asked were based on the current features of our system and they were as follows:'Were you able to export the notes generated in the workspace?', 'Did you find the concurrent view of your document and notes file advantageous?', 'Did you use the multi-color text-highlighting feature?'. All possible alternatives (Yes, No and Maybe) were presented for the close-ended questions. The results are discussed in the following section.

6 Results

6.1 Results of quantitative analysis

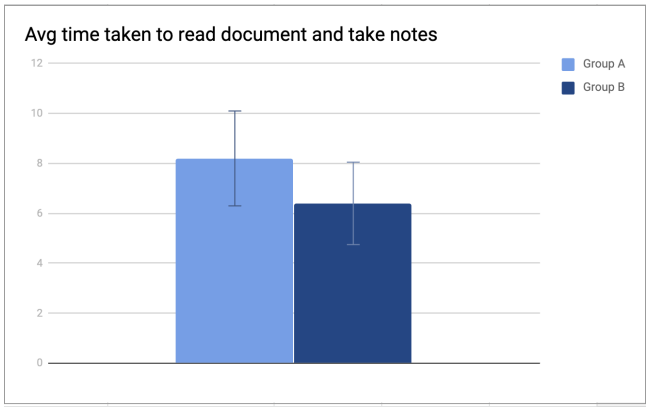

Figure 5. Average time taken to read document and prepare notes

There was significant difference between the time taken by the participants of Group A (Mean= 8.2, SD=1.9) and Group B (Mean=6.4,SD=1.65); t= -1.88,p= 0.04. Mean of Group A was higher than group B (Figure 5).

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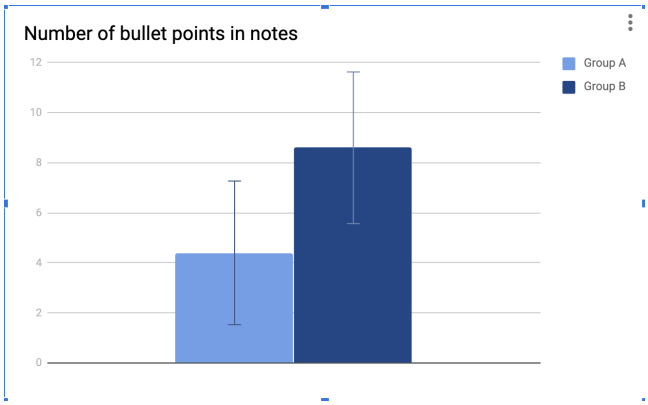

Figure 6. Avg of bullet points for the notes

Significant difference was observed for number of bullet points in the notes between participants of Group A (Mean= 4.4, SD=2.87) and Group B (Mean=8.6,SD=3.03); t= -2.7,p= 0.008. Group B participants consistently took higher amount of notes than Group A, which is implied through the notes that they made. (Figure 6).

Figure 7. System Usability Scale(SUS) scores

Usability was measured using System Usability Scale (SUS) test. There was significant difference in the SUS scores for Group A (Mean= 75.6, SD=9.34) and Group B (Mean=82.1,SD=6.54); t= -1.81,p= 0.045, though there is not much difference between the means of the two groups.

Effectiveness was captured using Retentiveness Test i.e. a set of 5 questions based on the document. There was no significant difference in the retentivity test score for Group A (Mean= 2.6, SD=0.85) and Group B (Mean=3.3,SD=1.29); t= -1.06,p= 0.15, though higher mean was observed for the scores for Group 2 (Figure 8).

6.2 Results of qualitative analysis

For the close-ended questions of the post-session questionnaire, all 8 participants of Group B found the concurrent view of the document and the notes file advantageous and were able to export the notes generated by noteSpace. 6 out of 8 participants used the multi-color text highlighting feature. For the open-ended questions, majority of the participants favored the auto-copying feature of the system whereas the inability to format the notes file was listed as the frustrating point of the system.

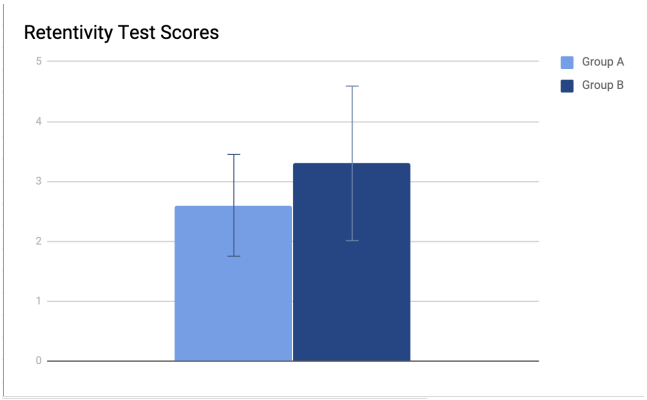

Figure 8. Retentivity scores

7 Discussion

From the results of the user study, we observed that the average time taken by the participants of Group A to read the PDF file and make notes was higher than that of the Group B participants. This can be attributed to the fact that the users of Group A had to switch between the applications and also spend some time in formatting the Word file according to their need. Whereas, the participants of group B, did not have to face such issues and this resulted in lesser time.

Secondly, the retention of both groups was tested by a retention questionnaire where we made comparison between the correct answers. Although the mean value of both comparison were comparatively similar, the t-test done on these values determined that the difference was not statistically significant. This can be due to the subjective nature of retention capabilities of different individuals. Adding more parameters in the questionnaire might provide better results in the future.

We also compared the number of bullet points made in both the conditions which showed a significant difference among the given conditions. Participants of condition 2 were more inclined towards making notes in comparison to those of condition 1. This clearly shows that if the concentration of an user is retained by minimizing the switching of application, he/she can focus more on making more notes. This can also be attributed to the fact that user might get lose their interest in making notes if they have to repeatedly switch between the applications.

Also, from the responses of the post-session questionnaire, users generally prefer multiple colors to highlight text while making notes as the color-coding of text helps them to

distinguish multiple aspects of the content like definitions, examples, etc.

From the obtained SUS scores, it can be stated the usability of noteSpace had an edge over the traditional note-making method. The instantaneous reflection of the selected text into the workspace and the lesser cognitive load on the part of users are the most probable reasons for this significantly different results.

8 Conclusion and Future Work

Our system successfully implemented the concept of direct manipulation and digital note-making. The system could provide a concurrent view of both the documents and it enabled the automatic copying of highlighted text. The system also allowed users to perform immediate deletion of a point by a simple double click. All of these features imply that the system could provide prompt visual representation of actions of interest and rapid incremental reversible operations.

The user evaluation study showed that the participants who used our system, noteSpace, could perform better, make more efficient notes and focus better. This justifies our claim that the incorporation of concepts of direct manipulation helps in efficient and effective note-making. The results of the evaluation study also showed that the system was fairly easy to learn and use.

The current features in our system have been implemented focusing on our seed idea which is direct manipulation. However, the feedback that we got were in terms of the additional features which we can add in future. From the feedback received from the participants through the post-questionnaire survey, we aggregated the suggestions for the features that can be added to our system in the future scope:

- Make the notes section editable
- Add sub-points in the notes made
- Include images and equations in notes

Further, our system can have the following applications:

1. Natural Language Processing: This system can also be used by an NLP model that summarizes or paraphrases the copied points. This can be a significant progress in this field that can be supported by this system, noteSpace.
2. Researchers: This tool can be utilised by researchers while reading long research papers. They can utilise the functionalities of this tool to jot down important points of a research paper and have an easy reference in the future.
3. Students: School and university students can use this tool to make notes for examinations or personal learning.
4. Presentation Slides: noteSpace can be used to create bullets points for presentation slides from any text document. This can be done very quickly by the user even if the user skims the document for the important points. This system will save a lot of time in preparing slides for a presentation.

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