

Complementary Note-taking

*Designing a Digital Interface specifically
for the Note-taking Activity*

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This work is dedicated to my late Father, John Dennis Patrick Aloysius Norton, who passed after my first year of graduate school in June of 2018. You had no idea why I wanted to do this, what I was going to do, or how it would end up. Thank you for providing motivation through the good times and the bad times.
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CONTENTS

	<i>Abstract</i>	
<i>CHAPTER 1</i>	<i>Introduction</i>	<i>9</i>
<i>2</i>	<i>Problem Statement & Justification</i>	<i>11</i>
<i>3</i>	<i>Assumptions & Limitations</i>	<i>13</i>
<i>4</i>	<i>Annotated Bibliography</i>	<i>15</i>
<i>5</i>	<i>Conceptual Framework & Research Questions</i>	<i>21</i>
	5.1 Conceptual Framework	21
	5.2 Research Questions	27
<i>6</i>	<i>Methods</i>	<i>31</i>
<i>7</i>	<i>Results</i>	<i>33</i>
	7.1 Precedents	33
	7.2 Studies	39
	7.2.1 Adapting Linear Organization	43
	7.2.2 Limiting Unnecessary Distractions	55
	7.2.3 Enhancing Annotation Capabilities	67
<i>8</i>	<i>Discussion</i>	<i>81</i>
	8.1 Design Principles	81
	8.2 Future Work	83
	8.3 Conclusion	85
<i>9</i>	<i>References</i>	<i>87</i>

ABSTRACT

This research examines how features of a digital note-taking application can be designed specifically for the note-taking activity. Digital note-taking applications are increasingly common as students continue to use personal computing devices in classrooms. These applications enhance note-taking with technological benefits, however, they are not designed to complement the cognitive goals of the student. I develop a conceptual framework, based on activity theory, to break down the note-taking activity and identify individual characteristics to be designed for. This investigation establishes opportunities for a note-taking interface to focus on the intentions of the student while continuing to employ technological features.

CHAPTER 1

INTRODUCTION

Note-taking is recording information. We take notes to remember that information. It happens in all aspects of life— from class notes to quick reminders or grocery lists. Note-taking occurs in various formats. We can take notes by hand; countless kinds of notebooks and journals are available for every type of person and note-taking style. We can also take notes digitally; every computer, tablet, and smartphone offer multiple note-taking applications for download.

But there is a juxtaposition between handwritten note-taking and digital note-taking. While they are similar activities yielding comparable results— the experiences are vastly different. Handwritten note-taking requires an individual to write by hand, which is a rather complex activity. It requires the individual to spell from memory and spatially organize as they physically write their thoughts and ideas (Karavanidou, 2017). Furthermore, it is a time-consuming process which forces the individual to summarize the information being recorded. Digital note-taking requires typing on a keyboard. This is a less time-consuming, repetitive activity that capitalizes on digital affordances like spell-check and copy-and-paste (Karavanidou, 2017). Digital note-takers can take a higher quantity of notes

that are closer to verbatim; however, they might not be processing the information as thoroughly (Mueller et al., 2014).

Both Mueller et al. (ibid) and Bui et al. (2013), respectively, argue that handwritten note-taking and digital note-taking can be beneficial activities for students. While I do not argue that handwritten note-taking will be replaced, it is difficult to disregard the enhancements digital applications provide to the note-taking experience. With that, I see an opportunity for the design of digital note-taking applications specifically for the note-taking activity. This investigation focuses on how the format and features of a digital interface is designed to complement the note-taking experience.

CHAPTER 2

**PROBLEM STATEMENT
& JUSTIFICATION**

Note-taking is a common activity in college classrooms across all disciplines. Students rely on their notes to learn content and succeed in their coursework (Morehead et al., 2019). Handwritten note-taking remains a common practice, however digital methods are becoming more popular as new technologies emerge, including Evernote and Pen+ Ellipse. Students are flexible with their approach to note-taking, alternating between longhand and digital methods depending on the content or situation (Morehead et al., 2019).

Digital note-taking applications provide specific enhancements to the activity of note-taking. Typing allows students to record more information and achieve more accurate transcription (Bui et al., 2013). Students capitalize on basic word-processing tools such as copy-and-paste and the backspace button. Applications automatically save notes to cloud-storage and sync them across personal devices for archiving. Students can quickly share their notes with classmates or edit them later to add missing information.

Current note-taking applications are not designed with the experience of note-taking in mind. Note-taking benefits the student through two

different forms: encoding and external storage (Bui et al., 2013; Mueller et al., 2014). Encoding refers to the actions of processing, transcribing, and organizing the given information. External storage is defined as creating an archive in order to study and review notes. Currently, the functionalities of digital note-taking applications focus on the external storage benefit of note-taking. These systems promote their efficiency of archiving notes and searching for content. While effective, the encoding aspect of note-taking is forgotten. Overall, the design of note-taking applications is not conducive to the actual experience of taking notes. These applications mimic word-processing programs rather than being designed for note-taking specifically.

If designers understand how people think and remember, they can design features and tools to promote interactions that complement those actions. Craik and Lockart’s (1974) Levels of Processing provide a framework for assessing how stimulus of information affects depth of processing. Increasing engagement with the information, regardless of the medium, results in deeper analysis and moves the information through the levels of processing (Craik & Lockhart, 1972). In conjunction, Activity Theory allows an individual activity to be dissected to understand the relationships between motives, actors, and objects throughout the given activity (Kaptelinin & Nardi, 2012).

There is an opportunity to create note-taking applications that are specific to the note-taking experience. Manipulating the format and function of the interface creates opportunities to stimulate deeper engagement between the student and their notes. Focusing on note-taking as the primary activity for the interface allows us to design with the specific characteristics of note-taking in mind. Throughout this investigation, I will design individual aspects of a note-taking application that best complement a student’s encoding process while taking digital notes.

CHAPTER 3

ASSUMPTIONS & LIMITATIONS

ASSUMPTIONS

For the purposes of my investigation, I assume that students are willing to download and participate with note-taking applications across their various personal devices. Furthermore, I assume that students want to take notes digitally and archive information using such an application compared to other formats. It is unlikely that all students can afford personal devices. For my investigation I assume students have access to these technologies. While the technological affordances embedded in the interface are achievable, I assume that it is feasible to adapt such an interface. Finally, I assume that students are interested in the subject matter in which they will be actively note-taking, as well as motivated to study the information throughout the term of the course.

LIMITATIONS

Through my investigation, I design specific software features within a note-taking application. While note-taking may also involve a variety of visual forms, such as images or diagrams, I focus on text-based note-taking. While note-taking can occur across multiple personal devices, such as tablets or

smartphones, I design the interface specifically for laptop computers. I do not create a full working prototype of a note-taking application; instead, I focus on specific features that embody the research points I address.

It should be mentioned that note-taking is subjective to each individual student. Students develop their own style of note-taking that provides the most success. While I attempt to create an interface that can benefit all students, there may be potential objections to certain benefits, depending on the individual student. Due to these issues of customization and preference, I try to provide customization options where applicable.

CHAPTER 4

**ANNOTATED
BIBLIOGRAPHY**

NOTE-TAKING TECHNIQUES

Bui, Myerson, & Hale, 2013

Using a computer alters the balance of quality and quantity of notes taken. Results indicate greater quantity and immediate recall for digital note-takers compared to longhand. Note-taking using organizational strategies is most effective for recalling information past 24-hours.

Morehead et al., 2019

Understanding how and where students take notes is critical since notes are a key method a student learns and comprehends throughout their education. Students are flexible in their note-taking techniques; adapting different strategies to information recorded across different subject matters.

Kim et al., 2009

Digital note-taking interfaces inherently make note-taking more difficult due to the software and hardware limitations.

Mueller & Oppenheimer, 2014

Handwritten note-taking involves greater mental and physical activity, compared to digital techniques, which increases recall of the recorded information. Digital note-takers tend to transcribe information verbatim which results in shallow processing.

Karavanidou, 2017

Handwriting and typing are very different activities and affect transcribing and processing abilities in specific ways.

Roam, 2012

Visualizing information helps us discover and comprehend our own ideas while also serving as an explanation for others to understand the information in their own way.

van Wyck & van Ryneveld, 2018

Students welcome the utilization of mobile devices in classrooms for educational purposes, however, they are not willing to rely upon their functionalities or consistent adaptation.

Simpson & Nist, 1990

Annotations facilitate active learning through the processes of paraphrasing, synthesizing concepts, deliberating with information, and selecting key phrases.

DIGITAL INTERFACES

Sutherland, Luxton-Reilly, & Plimmer, 2016

Terms regarding digital annotations within applications need to be used consistently across studies for optimal interpretation.

Sage et al., 2019

Digital and physical flashcard systems yield similar results. This begins to question how applications can use their digital affordances to offer features that will entice interaction.

Morgan et al. 2008

Mediating artifacts and its features affect how a user will interact with the information and, therefore, how the information is cognitively processed.

MEMORY & RECALL

Craik & Lockhart, 1972

Memory trace can be interpreted through the levels of processing framework where greater depth refers to greater analysis and recall ability.

Baddeley, 2012

Short term memory is explained as the temporary storage of information, while working memory refers to a combination of manipulation and storage.

Kaptelinin & Nardi, 2012

Activity theory provides a framework to understand the relationship between a subject and object and the motives and factors that inform those actions.

Manoli & Papadopoulou, 2012

Graphic organizers provide a framework to visually represent and organize information. This can increase comprehension of the subject matter by depicting relationships throughout the content.

MACHINE LEARNING

Balci, Saadati, & Shiferaw, 2017
People still choose to write using pen and paper regardless of cumbersome archiving abilities and sharing difficulties. This research explains two methods of handwriting recognition: word classification and character classification.

Allahyari et al.,2017
Text mining is the process of a computer scanning large amounts of text and discovering patterns using various methods of clustering and classification.

Yan et al., 2013
A hybrid of supervised learning and unsupervised learning allows the machine learning algorithm to be trained with user input while continuing to recognize patterns in the data uninterrupted.

NOTE-TAKING TECHNIQUES	
The Pen Is Mightier Than the Keyboard: Advantages of Longhand Over Laptop Note Taking	Mueller & Oppenheimer, 2014
Note-Taking with Computers: Exploring Alternative Strategies for Improved Recall	Bui, Myerson, & Hale, 2013
Note-taking Habits of 21st Century College Students: Implications for Student Learning, Memory, and Achievement	Morehead et al., 2019
Requirements for Electronic Note Taking Systems: A Field Study of Note Taking in University Classrooms	Kim et al., 2009
Is Handwriting Relevant in the Digital Era?	Karavanidou, 2017
Back of the Napkin: Solving Problems and Selling Ideas with Pictures	Roam, 2012
Affordances of Mobile Devices and Note-taking Apps to Support Cognitively Demanding Note-taking	Van Wyck & van Ryneveld, 2018
Textbook Annotation: An Effective and Efficient Study Strategy for College Students	Simpson & Nist, 1990
DIGITAL INTERFACES	
Freeform Digital Ink Annotations in Electronic Documents: A Systematic Mapping Study	Sutherland, Luxton-Reilly, & Plimmer, 2016
Flip, Slide, or Swipe? Learning Outcomes from Paper, Computer, and Tablet Flashcards	Sage et al., 2019
Applying Distributed Cognition Theory to the Redesign of the ‘Copy and Paste’ Function in order to Promote Appropriate Learning Outcomes	Morgan et al., 2008

MEMORY AND RECALL	
Levels of Processing - Framework for Memory Research	Craik & Lockhart, 1972
Working Memory: Theories, Models, and Controversies	Baddeley, 2012
Synthesis Lectures on Human-Centered Informatics: Activity Theory in HCI: Fundamentals and Reflections	Kaptelinin & Nardi, 2012
Graphic Organizers as a Reading Strategy: Research Findings and Issues	Manoli & Papadopoulou, 2012
MACHINE LEARNING	
Handwritten Text Recognition using Deep Learning	Balci et al., 2017
A Brief Survey of Text Mining: Classification, Clustering and Extraction Techniques	Allahyari et al., 2017
Fuzzy Semi-supervised Co-clustering for Text Documents	Yan et al., 2013

Table 4.1. Bibliography

CHAPTER 5

CONCEPTUAL FRAMEWORK & RESEARCH QUESTIONS

5.1

CONCEPTUAL FRAMEWORK

The framework for this investigation (see Figure 5.1) is based on (a) Craik and Lockhart’s (1972) Levels of Processing, (b) Activity Theory, and (c) five characteristics of note-taking derived from pertinent research studies.

LEVELS OF PROCESSING

Craik and Lockhart outline a framework for human memory in which they describe memory trace in terms of levels of processing (1972). The framework describes three levels related to verbal memory: preattentive (shallow), phonemic (intermediate), and semantic (deep). Each level progressively demands deeper analysis and greater interaction with the information (Craik et al., 1972). The framework describes features found across the levels which can be adapted to pertain to other forms of memory and information processing. I applied concepts from Levels of Processing to the individual actions performed while note-taking to understand their effects on the activity. The three levels of processing as they pertain to my project are summarized in Table 5.1.

<i>Level of Processing</i>	<i>Definition</i>
Shallow Processing	Preattentive. Information is quickly overwritten. Written in verbatim.
Intermediate Processing	Phonemic. Requires conscious attention. Rewording and paraphrasing.
Deep Processing	Semantic. Connections across knowledge. Writing through call and response.

Table 5.1. *Three Levels of Processing (Craik et al., 1972)*

<i>Characteristic</i>	<i>Description and Example</i>
Artifacts	Tools or a combination of tools used throughout the activity of note-taking. Includes both hardware (i.e. tablet) and software (i.e. digital application).
Encoding	The action of receiving information and then processing it before it is recorded. Involves rewording, paraphrasing, remembering verbatim when necessary, and thinking through thoughts.
Transcribing	The action of transcribing the encoded information into an archivable format using the given artifacts. Involves spelling, wording, grammar, and putting thoughts into real words.
Organizing	Methods and strategies (or lack thereof) that are used to create order during the activity of note-taking. Involves understanding information to find similarities and differences, spatially orienting content as needed, and using methods to arrange content being transcribed.
Studying	Transcribing and organizing notes creates a record of information for the student to review at a later time. Notes are reread, annotated, and edited in order to increase comprehension.

Table 5.2. *Five characteristics of note-taking*

ACTIVITY THEORY

Activity Theory provides a framework to understand the relationships of actors and objects during a specific activity (Kaptelinin & Nardi, 2012). The framework dissects the concurrent relationships occurring within activity by considering the actor’s needs, motives, social demands, and situational factors. I adapted structural concepts from Engeström’s activity system model (Kaptelinin, 2012) and Davis’ activity theory diagram (2012) to apply Activity Theory to note-taking processes.

CHARACTERISTICS OF NOTE-TAKING

Case studies revealed common characteristics across both digital and handwritten note-taking experiences. Characteristics are micro-actions, which serve as individual functions within the larger activity. I identified five main characteristics (artifacts, encoding, transcribing, organizing, and studying) within the comprehensive activity of taking notes. These characteristics serve as touchpoints for note-taking that were applied to Levels of Processing and Activity Theory. Aspects of each characteristic are summarized in Table 5.2.

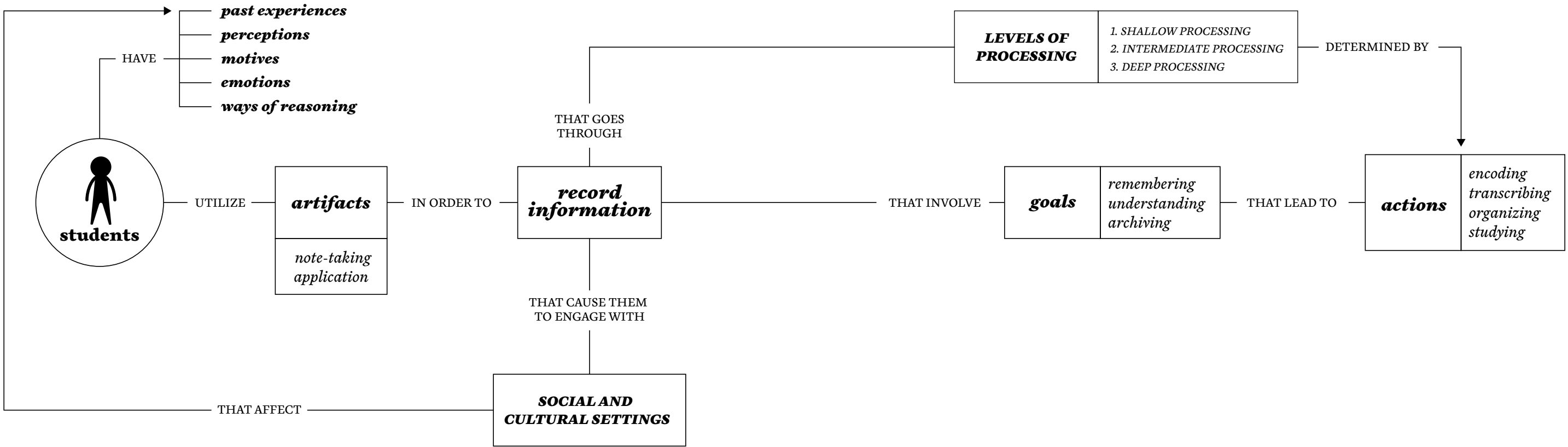


Figure 5.1. Conceptual Framework combining levels of processing (Craig et al., 1972), activity theory (Kaptelinin, 2012; Davis, 2012), and characteristics of note-taking.

5.2

RESEARCH QUESTIONS

PRIMARY RESEARCH QUESTION

How can the design of a digital interface promote purposeful interactions during note-taking to strengthen a college student’s encoding capabilities while engaging with lecture-based coursework?

SECONDARY RESEARCH QUESTIONS

- SQ1** In what ways can an interface design adapt organizational strategies to invoke students to actively organize and manipulate the recorded information?
- SQ2** How can word-processing features be customized to limit unnecessary distractions to enable efficient encoding and transcribing techniques?
- SQ3** How can annotation tools help students make connections across information when organizing and reviewing their notes?

Sub-question Focus		Encoding	Transcribing	Organizing	Studying
SQ1	Interface design to adapt organizational strategies	1A		1C	1D
SQ2	Customize word-processing features to limit unnecessary distractions	2A	2B		
SQ3	Annotation tools to help make connections across notes		3B	3C	3D

Table 5.3. Investigational Framework

INVESTIGATIONAL FRAMEWORK

I designed this investigational framework (Table 5.3) in conjunction with my conceptual framework to guide my research throughout the project. Focusing on individual characteristics of note-taking (encoding, transcribing, organizing, and studying) allowed me to design for specific moments, rather than note-taking as a whole (“artifacts” has been disregarded since I determine a digital interface on a laptop computer as the artifact for this project.) Each sub-question addresses the characteristics that are relatable to the contents of a question, thereby allowing me to narrow the focus when designing for the sub-questions. The framework also ensured that I acknowledged all aspects of note-taking throughout the research.

Term	Definition
Annotation	A comment, note, or marking added to a document.
Digital Note-taking	Recording information using a digital device, interface, or platform typically through a computer or mobile device.
Formatting	Refers to the process of applying styles to text. For example, bold, underline, or italic.
Formatting Command	The individual icons located on the formatting toolbar that are used to create formatting.
Formatting Toolbar	A collection of icons, tools, and commands in a word-processing application. Typically located along the top of the screen.
Graphic Organizer	A visual organizational structure that spatially arranges information, typically using text, to depict relationships across the represented content (Manoli & Papadopoulou, 2012).
Handwritten Note-taking	Recording information using a writing utensil (pen, pencil, etc.) to physically mark a writing surface (paper, notebook, etc.)
Linear Organization	The concept of content being organized and arranged in a specific sequence.
Memory Trace	The concept of information being committed to a certain level of memory and subsequently the ability to recall said information when necessary.
Note-taking	The activity of recording information originally from an outside source.
Note-taking Application	A digital interface intended for users to record, organize, and archive notes across their personal devices.
Page Structure	A framework applied to a page to determine where different types of information will be recorded.

Table 5.4. Definition of Terms

CHAPTER 6

METHODS

Case Studies & Design Precedents

Case studies were performed on current digital note-taking applications to analyze user benefits and design features. A variety of precedents were found in research papers and provided detailed analysis of comparable systems and concepts.

Interviews & Observations

Interviews were conducted with six North Carolina State University graduate students. These discussions provided insights regarding current note-taking habits and organizational strategies. Observations included analyzing students’ physical and digital notes to understand how notes were organized and stylized.

Literature Review

The literature review provided a foundational understanding regarding the problem areas and the participants. Literature is organized into the categories of note-taking techniques, digital interfaces, memory & recall, and machine learning.

Personas

A persona was created using information from the literature review and interviews. Developing a persona allowed for the design studies to be in context to a specific student’s journey.

Research Through Design

Research Through Design utilizes all aspects of the design process to gain knowledge which enhances the design practice (Martin & Hanington, 2012). This method provided insight on the forms and features to be interacted with throughout note-taking digitally.

User Journey Map

A user journey map describes the narrative of the persona’s actions and feelings over a specific period (Martin & Hanington, 2012). Creating a user journey map assisted with identifying areas to design for throughout the student’s note-taking experience.

CHAPTER 7

RESULTS

7.1

PRECEDENTS

TECHNOLOGICAL DEVICES

Apple iPad & Apple Pencil

Apple Pencil (Figure 7.1) gives users the ability to intuitively write, draw, and interact with content directly on the iPad screen. This allows handwritten forms to be created in digital platforms very similar to the experience of pen and paper. Apple Pencil uses physical gestures to change modes while writing for an efficient workflow, for example, double-tapping your finger to switch to eraser. The combination of Apple Pencil and the iPad interface provides users a wide range of possibilities and outcomes regarding handwritten forms. However, the physical feeling of writing on the tablet is not the same as writing in a notebook. For example, writing with a plastic tip on glass compared to a felt tip on paper.



Figure 7.1. Apple Pencil allows users to write and draw directly on the digital content.

Pen+ Ellipse

Pen+ Ellipse (Figure 7.2) is a smart pen and notebook combination that provides the natural experience of writing in a notebook along with some digital affordances. The smart pen is used with a compatible Moleskine notebook to digitize what is written on the paper. Users can access and manipulate the digital records through Moleskine Notes app. Pen+ Ellipse has multiple features which integrate the physical notebook and the Moleskine Notes app, such as physically writing in the calendar records events in your digital calendar. Pen+ Ellipse creates a unique combination between the physical and digital experiences of note-taking.



Figure 7.2. Pen+ Ellipse smart pen and notebook converts content from the page to the digital application.

NiCEBook

NiCEBook (Figure 7.3) is a “paper notebook that supports taking, structuring and reusing notes.” Researchers used observations from a previous study regarding note-taking habits to produce a notebook that supports the actions of note-taking and studying. The notebook itself requires the user to make deliberate moves that will then digitally archive the given information. For example, users can categorize a note by checking the corresponding box and then making the selection on the page. Notes are digitally accessible through the NiCEBook system and archived using the smart pen’s internal memory. With NiCEBook, researchers “present a solution that combines the flexibility and simplicity of taking notes on paper with the benefits of a digital representation” (Brandl et al., 2010).



Figure 7.3. NiCEBook uses page notations and markings to digitally archive handwritten notes.

DIGITAL APPLICATIONS

Evernote

Evernote’s note-taking interface (Figure 7.4) provides users the ability to collect and organize various kinds of information that syncs across all personal computer devices. Evernote offers many other features that go along with the note-taking experience. Document scanning allows users to use a smartphone camera to import handwritten notes, business cards, or any other physical documents into their collection. Notes, including handwriting, are searchable to quickly access information. Notes can be organized with tags and collections designated by the user. Evernote’s key take-aways are its seamless interface across devices and the features provided that enhance the note-taking experience.

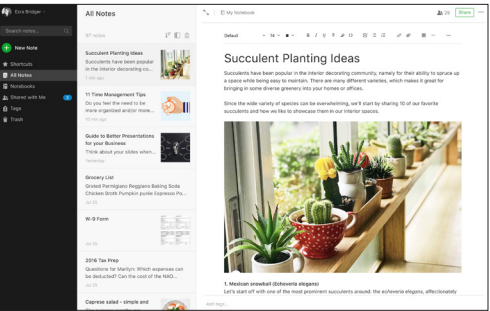


Figure 7.4. Evernote’s interface is like a word-processing application but provides increased organization through tags and folders.

OneNote

OneNote (Figure 7.5) is a detailed digital note-taking system by Microsoft. The interface offers users in-depth organization through tagging, sections, and pages. The Content can be shared for viewing and collaboration. Notes and documents can be annotated with handwriting by physically writing on the screen with your finger or stylus. OneNote is adaptable to educational programs for teachers and students to engage information with these technological capabilities.

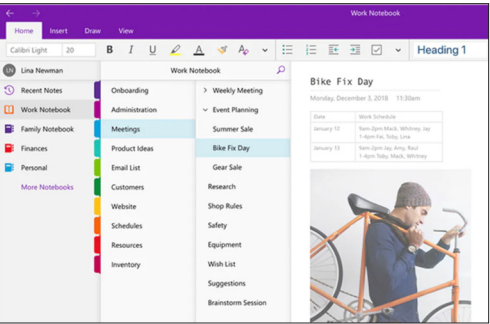


Figure 7.5. OneNote’s interface is like Microsoft Word; however, notes are organized using notebooks and color-coding.

Pen to Print

Pen to Print (Figure 7.6) removes the need for users to copy handwritten notes via their keyboard. The app uses optical character recognition (OCR) to scan and convert handwritten notes into text that can be edited or saved in various digital platforms. Users can simply take a photo using their smartphone and then export the text to their notes app.

Simplenote

Simplenote (Figure 7.7) is a “light, clean, and free” (Simplenote, 2020) note-taking application available for all devices and operating systems. The app sync notes across devices and organizes with tags and quick searching. Users can view previous versions of a note by dragging a slider to move backwards and forwards. While Simplenote doesn’t offer any unique features compared to competitors, the interface’s consistent and clean design is refreshing and almost reminiscent of blank paper.

Apple OSX Mission Control

Mission Control (Figure 7.8) provides Apple users an interface to utilize multiple desktops on a single computer screen. Users operate Mission Control with trackpad gestures or key commands to reveal a bar at the top of the screen showing thumbnails of desktops. This allows the user to organize desktops in a specific order, move active applications to different desktops, or open more desktops.



Figure 7.6. Pen to Print converts handwritten text using a smartphone.

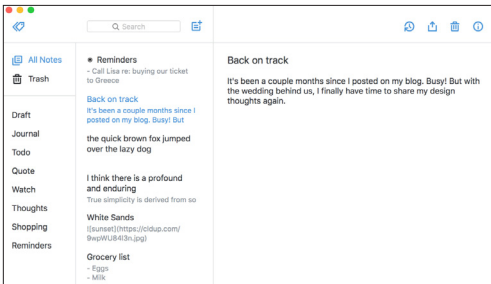


Figure 7.7. Simplenote uses a clean interface design to limit distractions while note-taking.

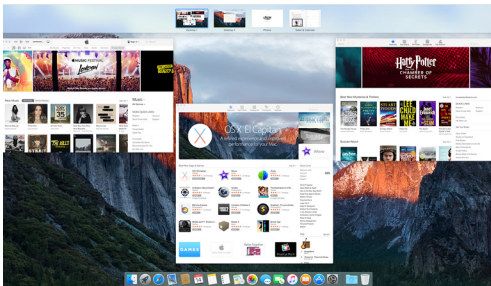


Figure 7.8. Mission Control allows users to organize open applications across multiple desktops and reveals the hidden desktops in the top bar when prompted.

PHYSICAL NOTE-TAKING DEVICES

Notebook

Notebooks are simply bounded sheets of blank paper, usually with some sort of cover. Notebooks require physical engagement with the object and therefore the content, like flipping through the pages in order to move throughout the recorded information. The experience of writing in a physical notebook is unique due to the tangibility of the object along with the feelings people develop and then associate with writing or drawing.

Writing Utensil

A writing utensil (pen, pencil, marker, etc.) is a physical mark making instrument used to write or draw. There are a variety of forms, sizes, and styles; all slightly change the experience of writing or drawing. Writing utensils allow for accuracy and consistency when transcribing a message or image by hand. With that, using a writing utensil becomes habitual over time.

7.2

STUDIES

Note-taking is subjective; every student will transcribe, organize, and review their notes as they deem necessary and beneficial to them. Thus, I research and design my studies with a generalist mindset. However, I use a persona and scenario of a student to show the concepts from each study and explain how the interface will act and be experienced. At the end of each study, I discuss how the persona interacts with the features described in the given study. Throughout the studies, I design individual features within a note-taking application referred to as “NoteMode.”

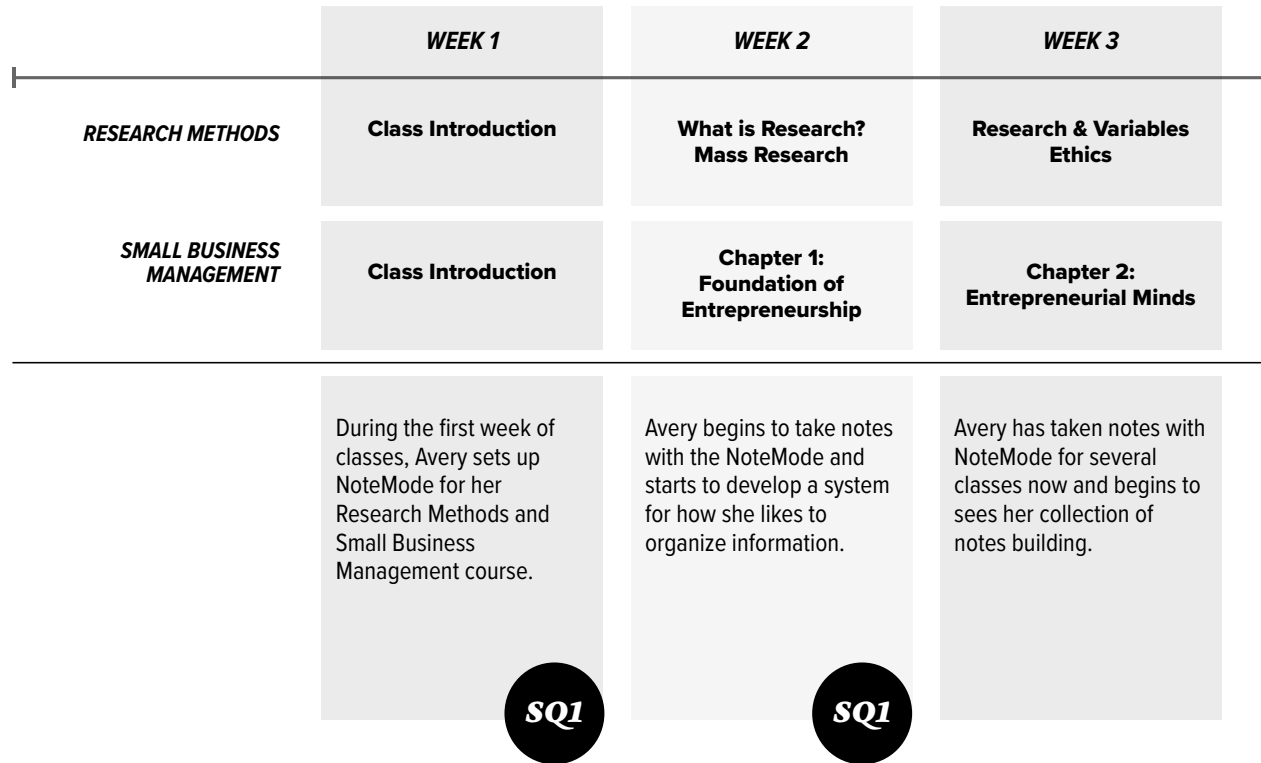
PERSONA

Avery Barnett is a second-semester freshman at North Carolina State University. She is currently enrolled in the Exploratory Studies program and will be choosing a major after this semester. Avery is still acclimating to varying demands of college coursework. While she passed her classes last semester, she feels she did not perform to her best abilities and believes her note-taking habits and in-class attention is a key factor of those results. Last semester, Avery took notes in varying forms, sometimes in a notebook and other times in Google Docs; typically choosing based on her mood or focus-level on the given day. Avery knows she needs to be more consistent with her note-taking habits and feels she is more proficient taking notes digitally.

SCENARIO

The following scenario focuses on Avery’s spring semester of her freshman year. The events within the scenario occur throughout the first eight weeks of the semester (Figure 7.9).

At the beginning of the spring semester, Avery commits to taking notes digitally for her lecture-based courses. She installs NoteMode onto her laptop as her primary note-taking application. Avery is taking four courses



this semester and two are heavily lecture based— those being Research Methods and Small Business Management. Before classes begin, Avery sets up individual “notebooks” within the application for each class.

The Research Methods course involves lectures discussing the various kinds of research methods that are common across many disciplines. The first half of the course is dedicated to learning about the methods. The students will then move into writing a research proposal during the second half. The Small Business Management course contains two exams throughout the semester, with the first exam occurring during the seventh week of class. The exam consists of content primarily discussed during the

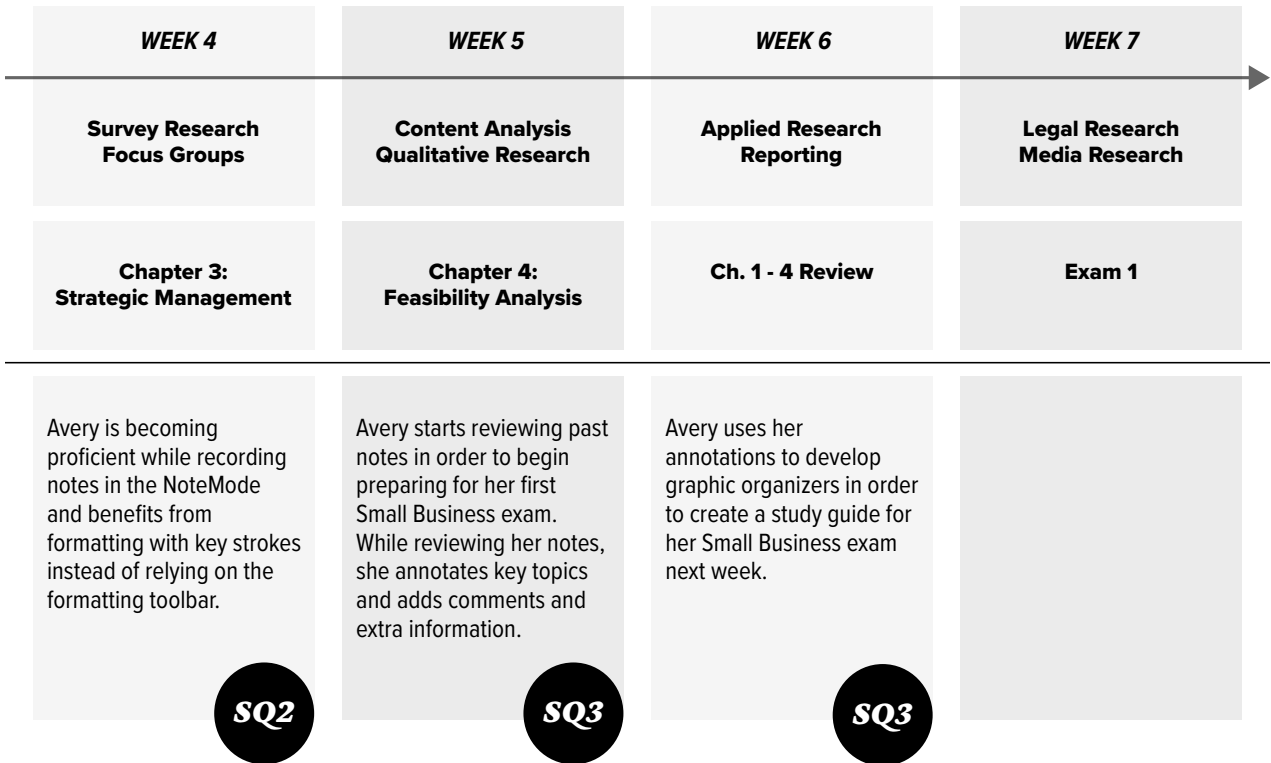


Figure 7.9. User Journey Map detailing how Avery uses NoteMode in relation to the two courses found in the studies.

lectures. The lectures are segmented by chapters based on the textbook for the course.

During the first two weeks of class, Avery is acclimating to the interface and begins to develop a hierarchy system that works best for her note-taking style. After a few weeks, Avery begins to enact her note-taking hierarchy using key commands during the process of taking notes. Her notes in both classes begin to accumulate. As the mid-term approaches, Avery begins to review her notes for her first Small Business Management exam. She decides to use the graphic organizer feature while studying to better understand the information.

7.2.1

ADAPTING LINEAR ORGANIZATION

This study focuses on the possible organizational strategies within a note-taking interface, including how the interface itself is formatted, as well as organization features, to guide the user when taking notes.

Note-taking throughout a college course is a linear process— notes are taken in sequence alongside the progression of coursework and class meetings. Physical notebooks excel with this linearity. Students take notes one page after another, sequentially adding to the larger collection of information. I began thinking about how this concept of linear organization could be implemented into a note-taking interface. First, I examined existing ways that digital content is presented, including note-taking and word-processing (as with Google Docs or Evernote), as well as other software, such as Apple’s Mission Control and internet browsers. Then, I consolidated these precedents into three common methods in which information is organized linearly (Figure 7.10).

Front-to-Back: Content is placed one on top of another. For example, an internet browser with multiple tabs or a desktop with numerous applications opened.

Top-to-Bottom: Content is organized from top to bottom. The user scrolls down as they move through the content. For example, the progression of pages in Google Docs as you add more content.

Side-to-Side: Content is displayed moving from side to side. For example, a slideshow or carousel of images that the user swipes or clicks through.

Studying these types of linear organization provided me insight regarding how a collection of notes could be digitally organized and experienced. While each is successful at moving a user sequentially through content,

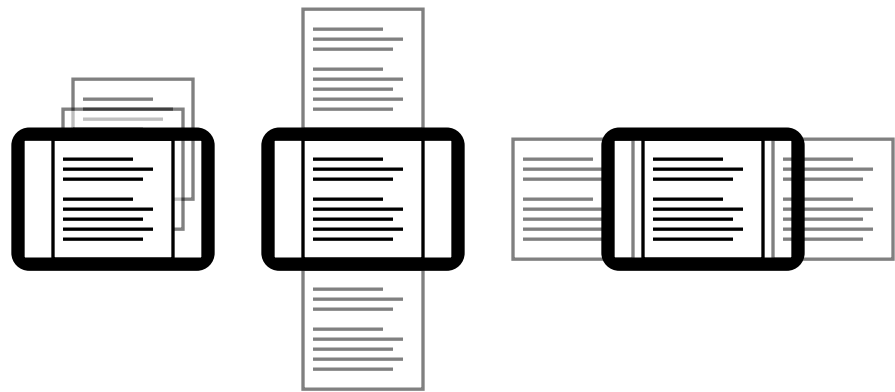


Figure 7.10. Digital content is commonly organized in a linear fashion such as front to back, top to bottom, or side to side. Each provides limitations for how content can be experienced.

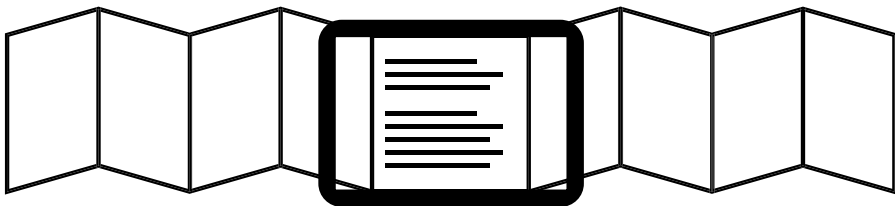


Figure 7.11. The accordion concept organizes content linearly while providing the user an ability to collapse and expand depending on the student's needs.



Figure 7.12. The accordion concept translated into modes within the note-taking application: Edit Mode (left), Browse Mode (middle), and Visualize Mode (right).

they limit the user's ability to browse and understand the relationships between information. With this limitation in mind, I created a form of linear organization that would directly apply to the activity of note-taking.

I developed the accordion format (Figure 7.11) where information is organized from side-to-side and can be collapsed and expanded depending on the task at hand. I found side-to-side to be the most natural form of linear organization since it is like the page sequencing of a physical notebook as well as comparable to the orientation of a timeline. Furthermore, organizing the notes side-to-side allows the student to intuitively move throughout their notes by sliding pages left or right. This sliding motion is utilized across many different interfaces. For example, Apple's OSX software offers a "Cover Flow" option in the Finder which lets the user browse the files and folders before opening a given file. The accordion format offers a similar experience, but with more adaptability using the different modes.

To implement the collapsing and expanding of the accordion format within the interface, a collection of notes can be viewed in various modes—zooming in and out depending on the task at hand (Figure 7.12). Edit Mode enlarges two pages where the student transcribes new notes, makes edits, or studies specific material. Browse Mode is where four pages are shown at once, allowing the student to glance at past notes or find a specific topic. Finally, Visualize Mode is where the entire collection can be seen in a timeline format, providing a macro-view of the notes within the selected collection. Visualize Mode lets the student hover on a specific note to glance at the topic and content as well as search for keywords across the collection.

A consistent page structure is necessary to stimulate effective note-taking strategies within the overall concept of organizing the collection of notes. The page structure needs to be flexible for multiple subject matters, while providing a consistent format to promote proficient transcribing techniques. With a page structure, the student can focus on the information, increase memory trace of the material, and have a consistent

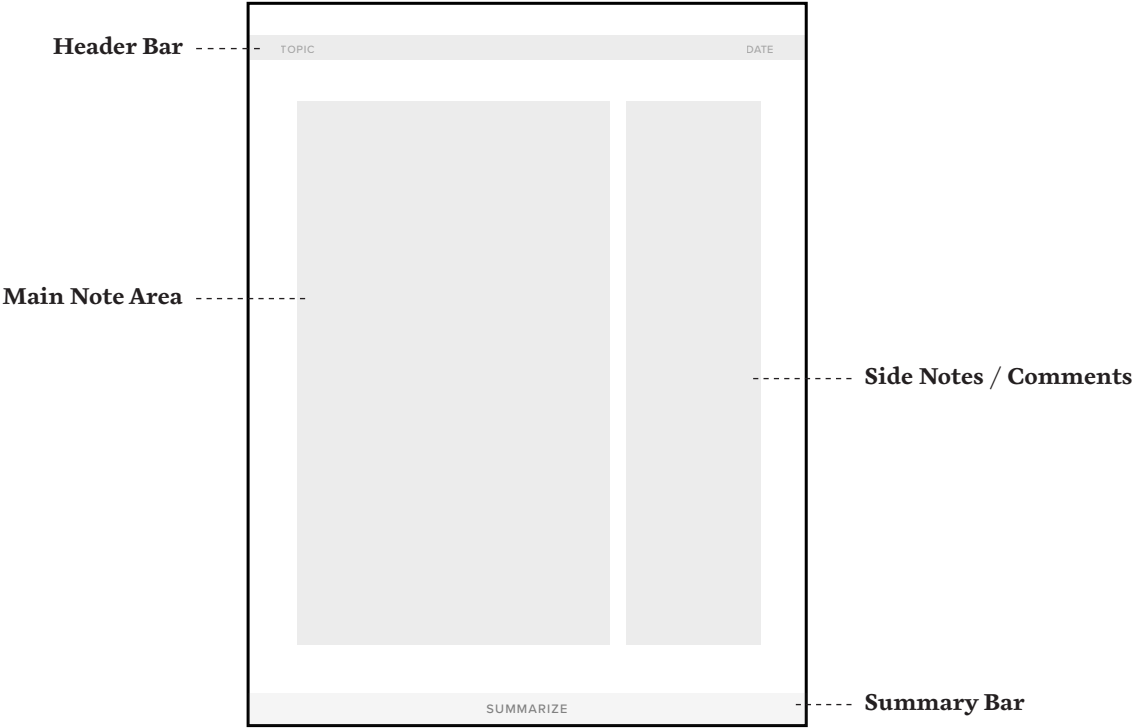


Figure 7.13. The page structure provides the student with a framework to record information. This displays pertinent information as necessary and guides the student to transcribe in a consistent format.

archive of their notes (Pauk, 1993). The Cornell System, developed by Walter Pauk in the 1940s, is one of the most commonly taught structures for taking notes. By dividing the page into sections, it provides a flexible format for the student to record thoughts and information as well as providing space to reflect on the material. I use the Cornell System as a foundation to create a page structure within the note-taking application (Figure 7.13).

The top of each page has a “header bar,” where the topic and date are displayed. The larger area on the left side of the page is the main note-taking section, where the student transcribes the bulk of their notes. The smaller section on the right side is dedicated to side comments, thoughts, or reminders, depending on the needs of the student at a given time. Finally, there is a “summary bar” at the bottom of each page, which allows the student to summarize the information discussed on each page. The information displayed in the header bar and summary bar is utilized within the visualize mode as well.

STUDY SCENARIO

Avery begins using NoteMode at the beginning of the semester for her Research Methods course. Like any kind of notebook, the interface starts out blank and slowly fills as notes are transcribed and the semester progresses. Once a few classes have passed, Avery starts noticing how the interface is reminiscent of a physical notebook. She also begins to see how the different modes are beneficial in certain circumstances. The following figures (7.14-7.19) show Avery moving through her notes and the different modes of the interface.

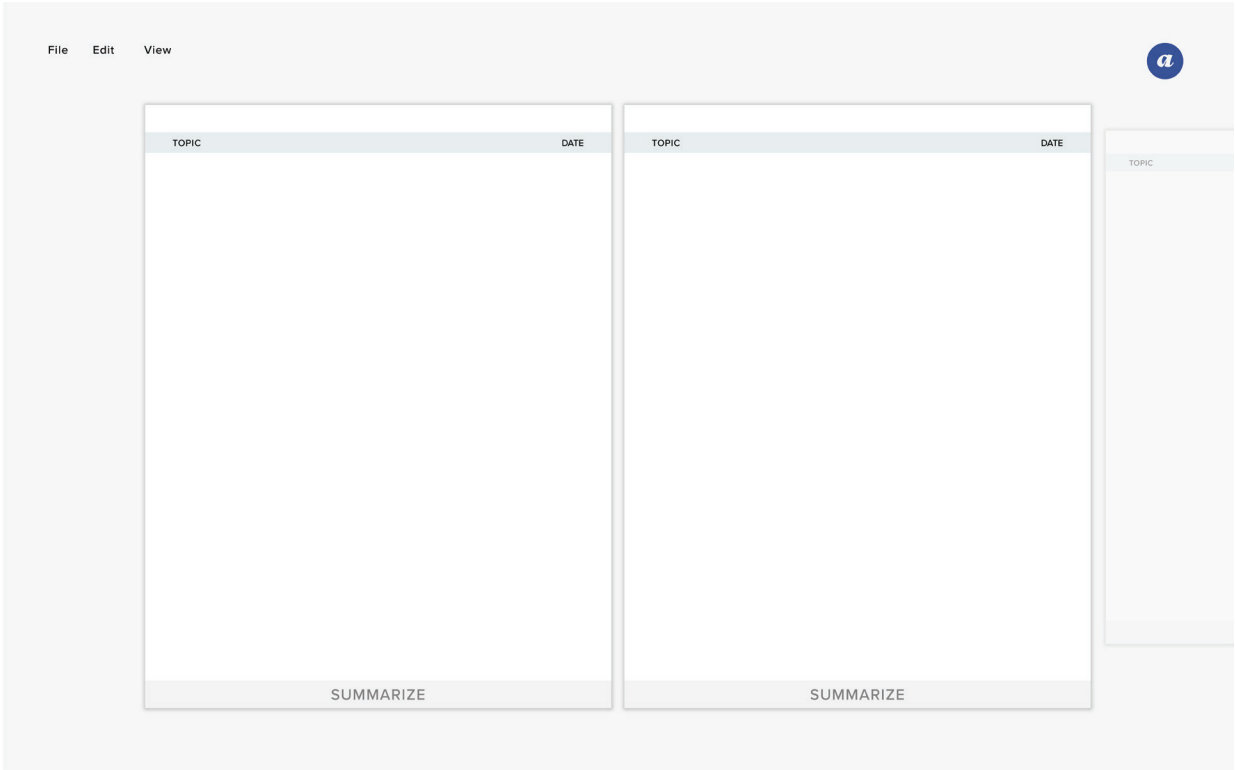


Figure 7.14. Avery begins her semester using NoteMode for note-taking in her Research Methods course. On the first day of class, she opens the application to start note-taking on the lecture.

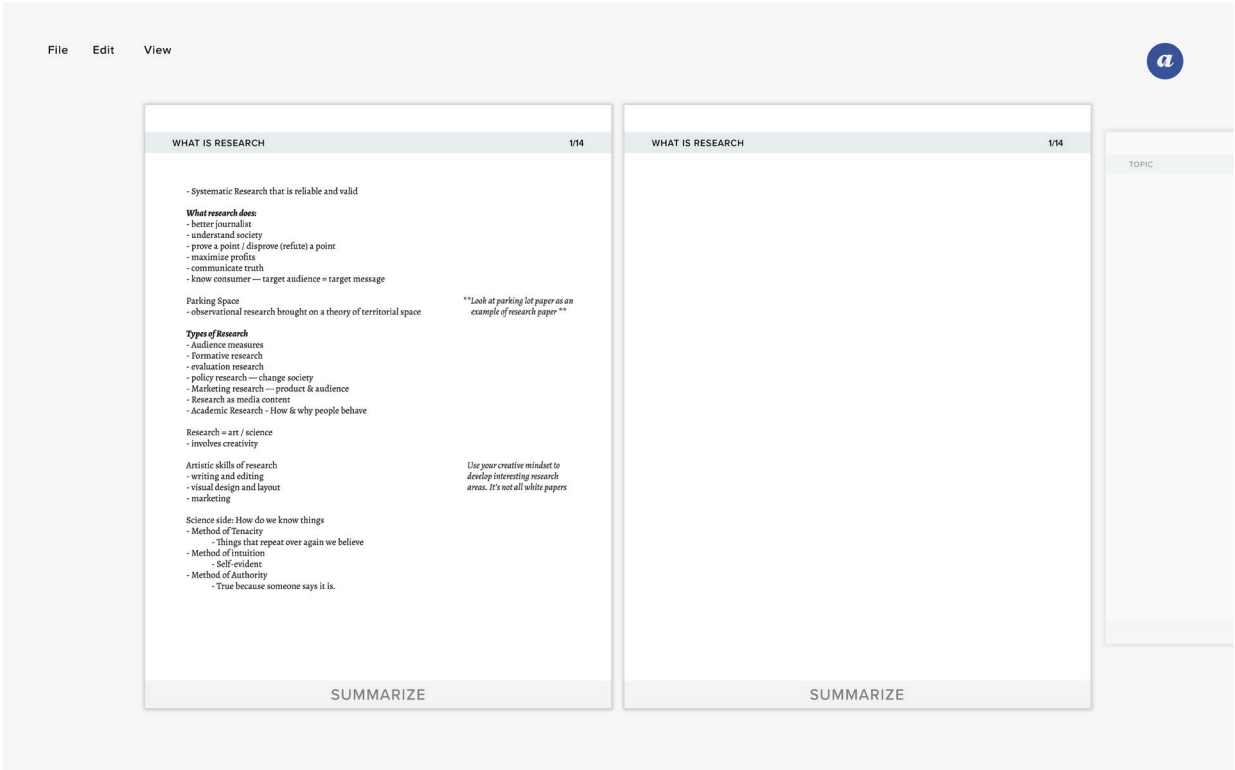


Figure 7.15. Avery follows the page structure within the interface throughout the lecture. The header bar displays “What Is Research” as the topic and automatically fills in the date. Main notes are taken on the left side of the page and comments are on the right side.

See a video of this study scenario at:
https://college.design.ncsu.edu/thenfinally/norton/study_one.mp4

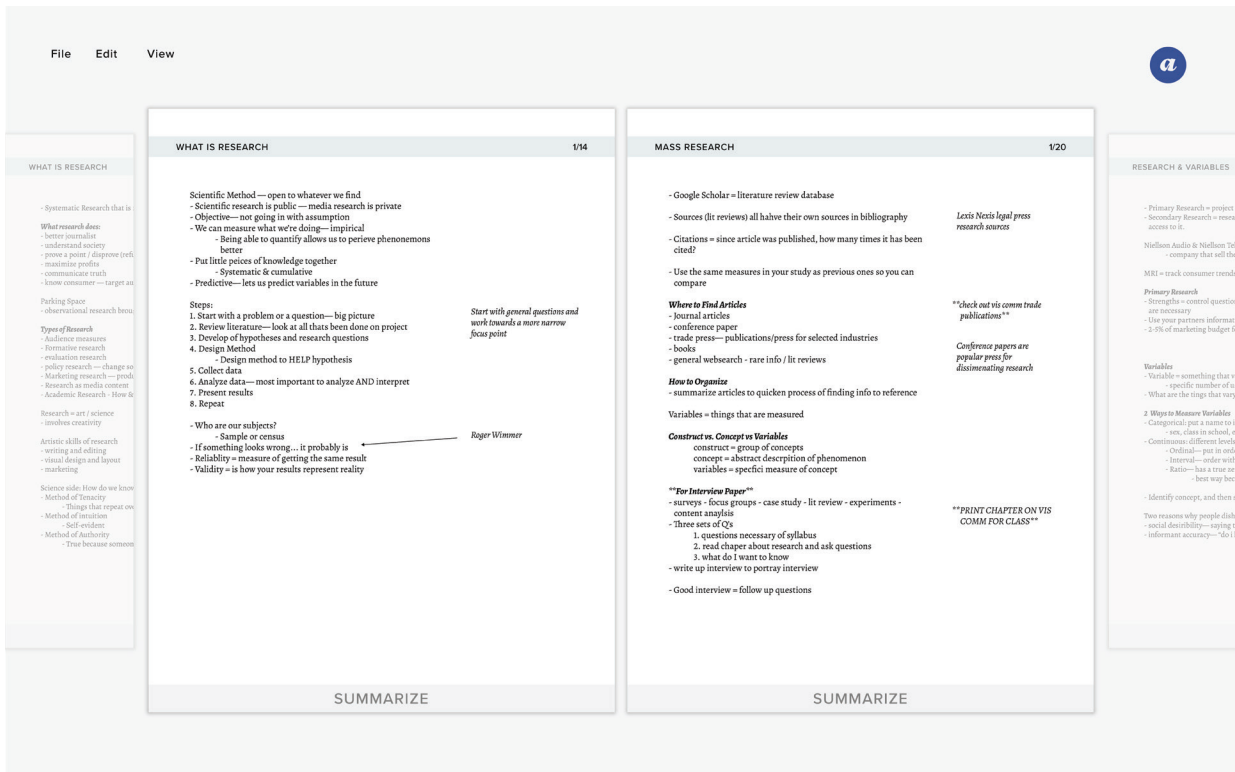


Figure 7.16. Avery’s collection begins to accumulate as classes continue during the semester. When in Edit Mode, Avery can read and edit two full pages of notes. On the sides of the two full pages, she can see the pages before and after shown in a lower opacity. This allows her to get an idea of where these notes are in relation to other pages.

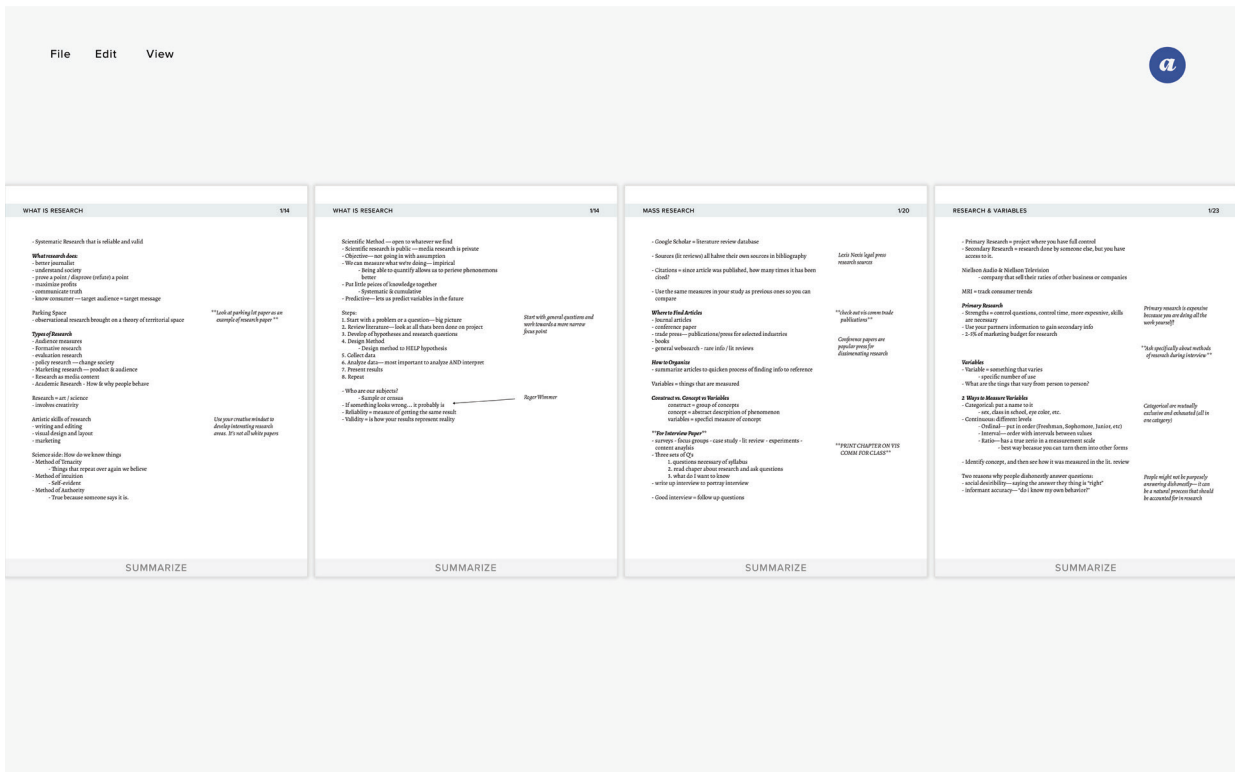


Figure 7.17. Using a quick gesture on the trackpad, Avery can move into the Browse Mode of the NoteMode. This lets Avery glance her notes to find specific pages or quickly scan the information.

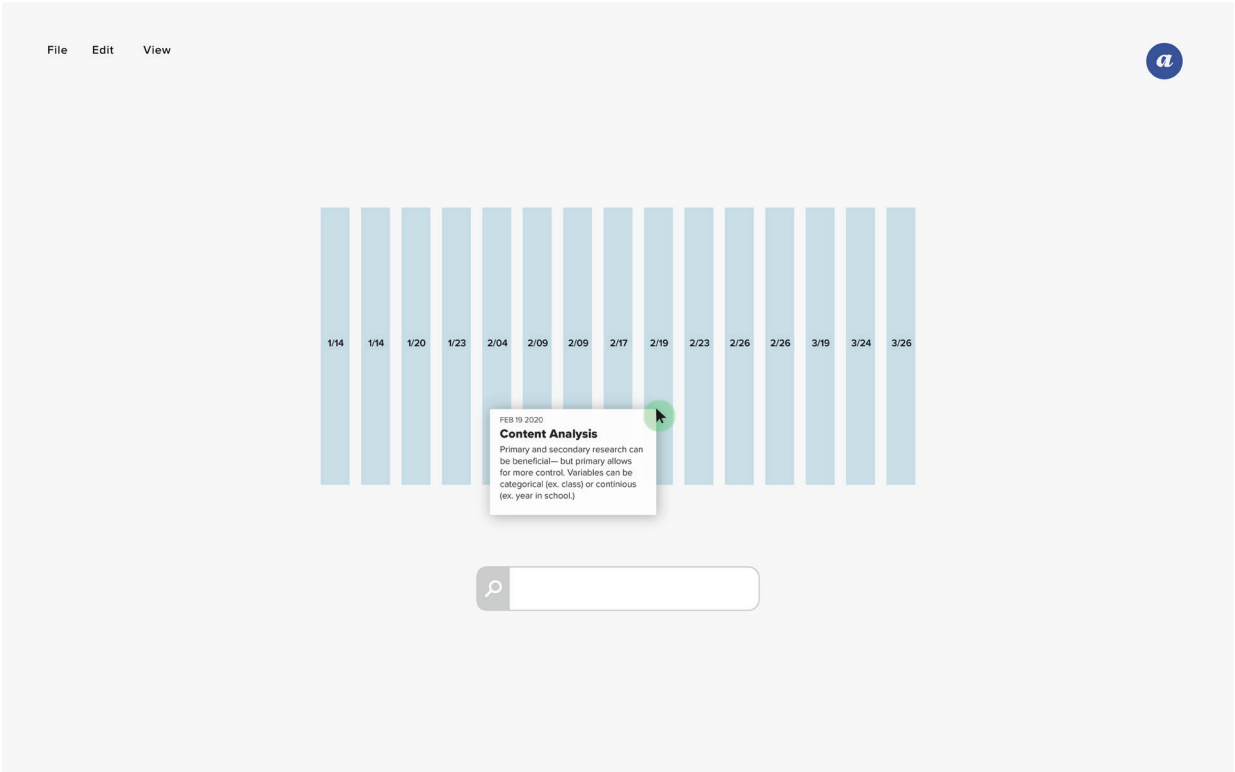


Figure 7.18. Another gesture on the trackpad brings Avery to the Visualize Mode. This mode shows each page of notes represented as a single “note bar.” Avery can hover over bars to see the topic, date, and summary of that individual page of notes. She is also able to search her notes in this mode.

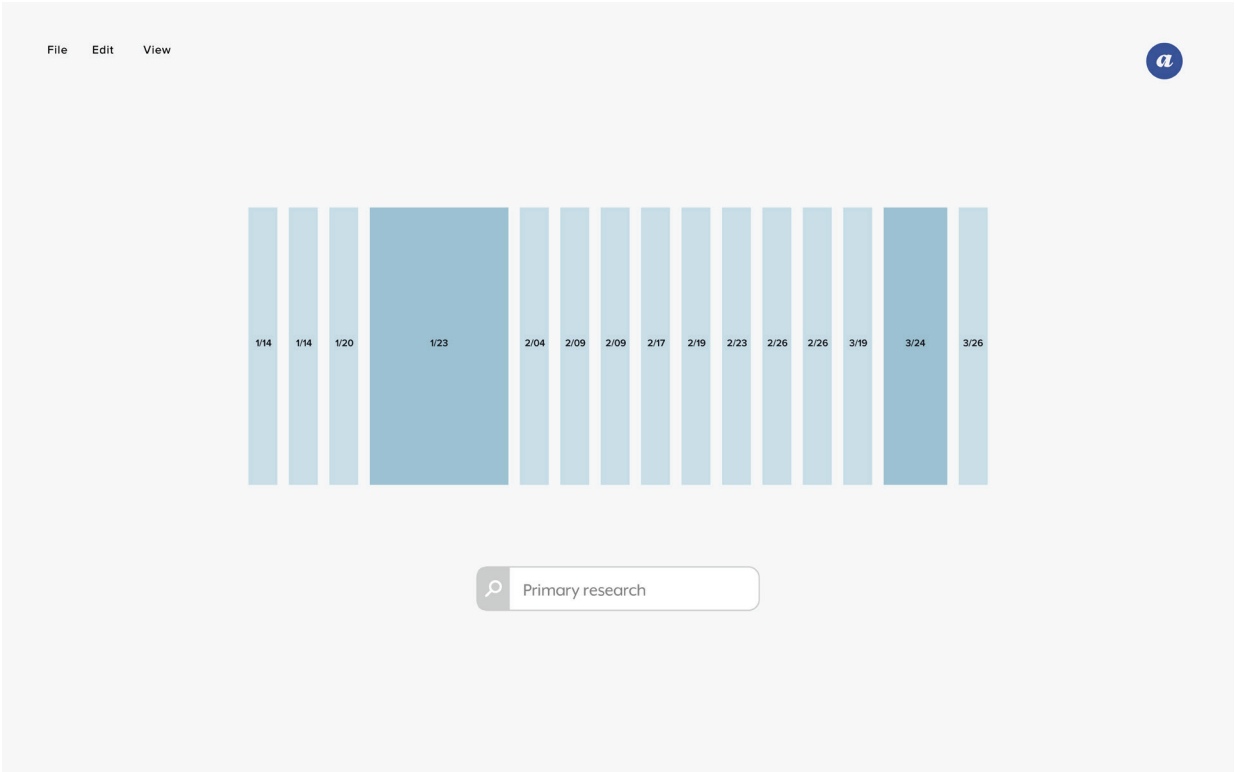


Figure 7.19. When Avery searches for a term, for example “primary research,” the note bars darken and expand if the keyword is found on that page. The more the keyword is found, the more the bar expands. This feature allows Avery to get an idea if a keyword is simply mentioned or if it is a common theme throughout the page.

7.2.2

***LIMITING UNNECESSARY
DISTRACTIONS***

This study focuses on adjusting common word-processing features to limit distractions while note-taking. I primarily analyzed how these features are presented and embedded within the formatting toolbar as well as implementing keystrokes to apply those formatting functions.

I began this study by analyzing formatting methods within digital notes and handwritten notes. Formatting methods refers to how the student is stylizing and organizing their notes to create hierarchy. Digital notes are formatted using commands located primarily in the formatting toolbar. This feature provides the student a wide variety of styling possibilities; however, the overt amount of options can make it difficult to navigate. In contrast, handwritten notes limit the formatting decisions of the student since they must create styles using their writing utensil. I also conducted short in-person interviews with students regarding their decision-making when note-taking. I found that most students, consciously or not, limit their formatting options throughout their notes. For example, a student might capitalize titles and subtitles, list information using bullet points, and underline key words. It became apparent that consistently repeating formatting decisions simplifies the student’s decision-making when transcribing information. Furthermore, it helps when reviewing notes as it creates a consistent hierarchy structure.

I needed to determine the possible formatting commands that could be selected. This includes formatting options native to word-processing applications as well as those that are found when note-taking by hand. I developed a taxonomy of formatting options in order to create a collection of possible commands to offer (Figure 7.20). The taxonomy organizes formatting options into four levels of ways to create hierarchy. All are inherently unique, but each level achieves a common hierarchical task. For example, bold and underline are both text styles. While visually different,

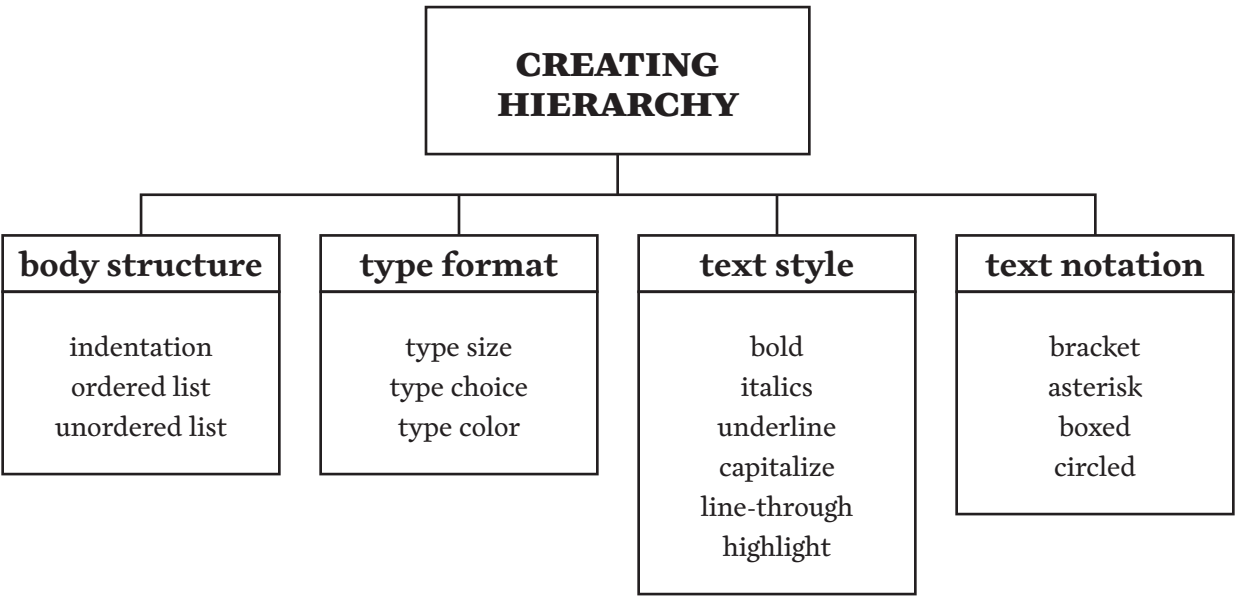


Figure 7.20. Taxonomy describing the different levels of hierarchy created through formatting commands.

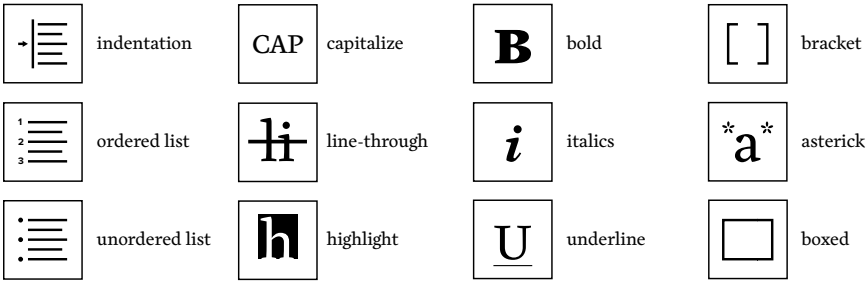


Figure 7.21. Customizable formatting toolbar showing master styles, formatting commands, and spelling and grammar show/hide button.

they act similarly within an organizational structure, and choosing between the two is dependent upon the preference of the student. If using both, the student is making a distinction as to why both styles are necessary, and therefore, the information is formatted as such. For example, bold might be designated to key phrases from the lecture and underline would be for definitions.

The formatting toolbar is a common interface feature within word-processing and note-taking applications. It allows the student to quickly select formatting commands via small icons rather than searching through drop-down menus. However, many commands within the toolbar are unnecessary while note-taking, and notably, they can be distracting. Furthermore, the excessive amount of options can force the student into unnecessary decision-making. To create more efficiency, I implement a simplified, customizable toolbar (Figure 7.21). This feature allows the student to add or remove formatting commands and customize the toolbar to their note-taking method. Creating a customizable formatting toolbar is beneficial for multiple reasons. First, it lets the student designate their primary formatting options and place them in an easy-to-find location. As well as hiding options that are rarely used. Second, displaying icons for every option lets the student quickly browse commands without being distracted by non-formatting tools. Lastly, the student can quickly select the command while text is selected or before they begin typing and then continue with their note-taking.

The customizable formatting toolbar consists of three sections (Figure 7.22). First, master styles, which the student makes by combining individual formatting commands to create paragraph or character styles. This feature is common within many word-processing applications; however, they are not as prominently displayed. Listing them as individual buttons via a drop-down menu allows the student to quickly change the style of a word or phrase. Second, formatting commands, which are individual commands from the creating hierarchy taxonomy. In this section, the student can designate the formatting commands that they consistently use. The student’s primary commands are constantly

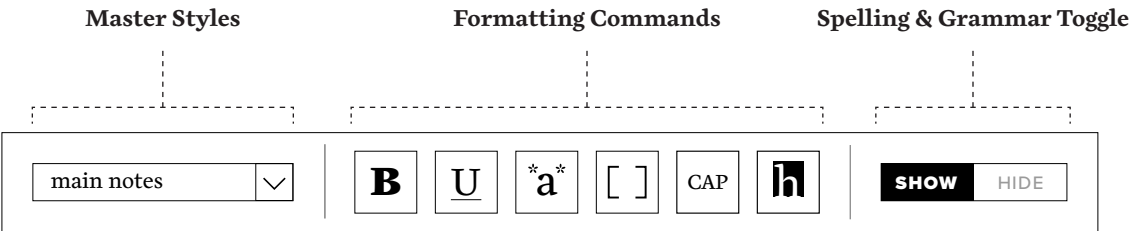


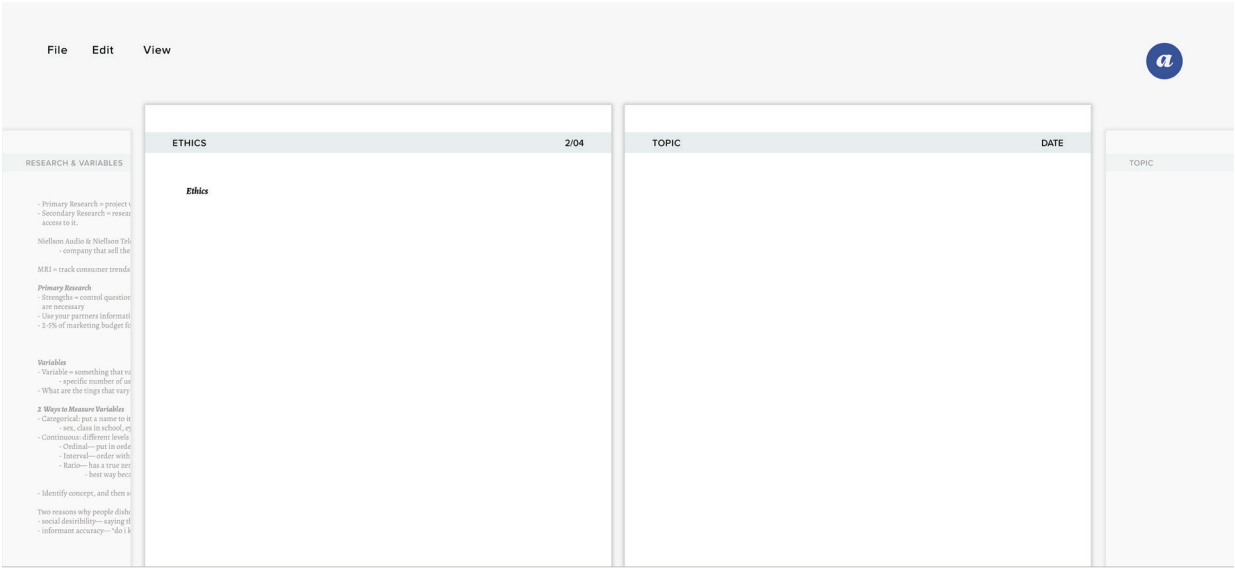
Figure 7.22. The formatting toolbar is simplified into three sections: master styles (left), formatting commands (middle), and spelling and grammar toggle (right).

displayed; however, all options can be accessed by sliding the icons to the left. Third, a spelling and grammar “show/hide” button which gives the student the ability to toggle the spelling and grammar annotations and corrections on-and-off.

As stated previously, creating hierarchy throughout note-taking is imperative for the student to retain information, develop organization, and find specific content when reviewing. However, it can be difficult to keep a consistent formatting system when trying to quickly transcribe notes. The student must move back-and-forth between typing on their keyboard and select commands with their mouse or trackpad. However, developing a system of formatting hierarchy that can be implemented via keystrokes removes that back-and-forth. These keystrokes are determined by the student and applied to all the pages of the interface. The student can assign keystrokes to specific formatting and paragraph styles so they can be created without removing hands from the keyboard. For example, if the student is typing a subtitle, they can hit “option-1” in order to declare that this line will be formatted in that manner. Hitting enter, going to the next line, tells the system to return to the main note-taking format. Detailed prototypes showing various states of use are shown in Figures 7.23 – 7.26.

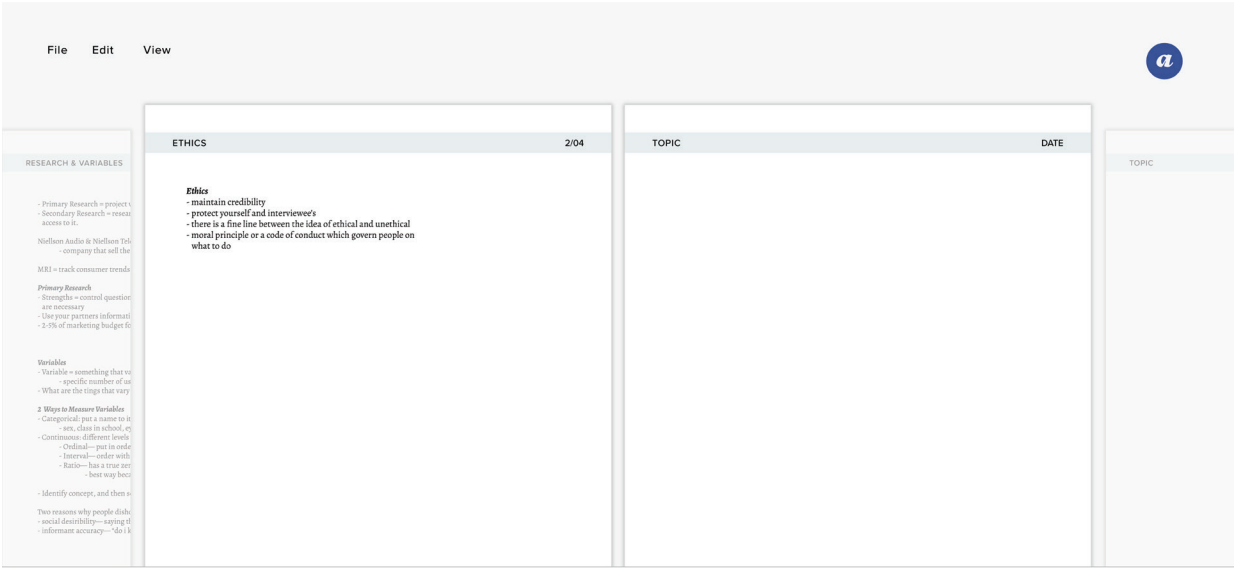
STUDY SCENARIO

This part of the scenario focuses on Avery taking notes for a single class period during her Research Methods course. Avery uses key commands to structure her notes with her master styles and formatting options. This allows her to create subtitles, make bullet points, and add side-comments without using the formatting toolbar. While she’s typing, the formatting toolbar remains hidden unless Avery moves her cursor to its location to reveal it if necessary.



option + 1

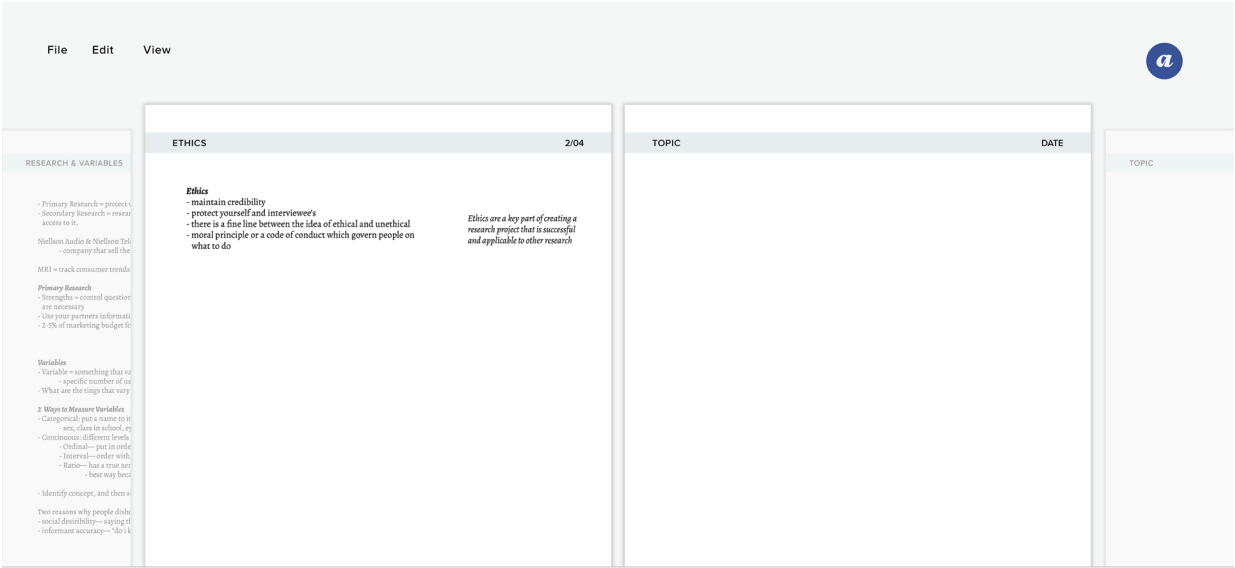
Figure 7.23. Avery begins by making a title for this section of her notes. She hits “option + 1” in order to tell the system to assign the subtitle master style to the first line.



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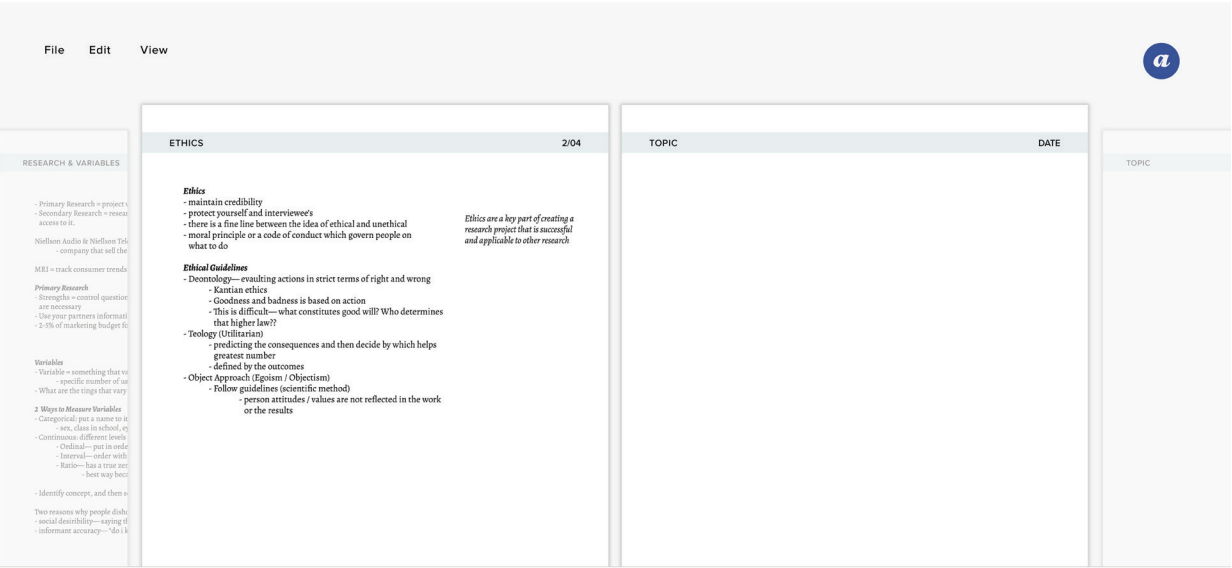
Figure 7.24. Avery hits “enter” after typing the title to move to the next line. She then uses the “dash” key to make bullet points as she types her notes.

See a video of this study scenario at:
https://college.design.ncsu.edu/thenfinally/norton/study_two.mp4



option + (DRAG)

Figure 7.25. Avery can add side-comments on the right of her main notes. She holds “option” and drags her cursor to make a text box and type her comment. The system automatically italicizes these side-comments.



tab OR tab + shift

Figure 7.26. As Avery continues to take notes throughout class, she can use “tab” to move the bullet points to the next level of indentation. Pressing “shift + tab” will move the bullet point back one level.

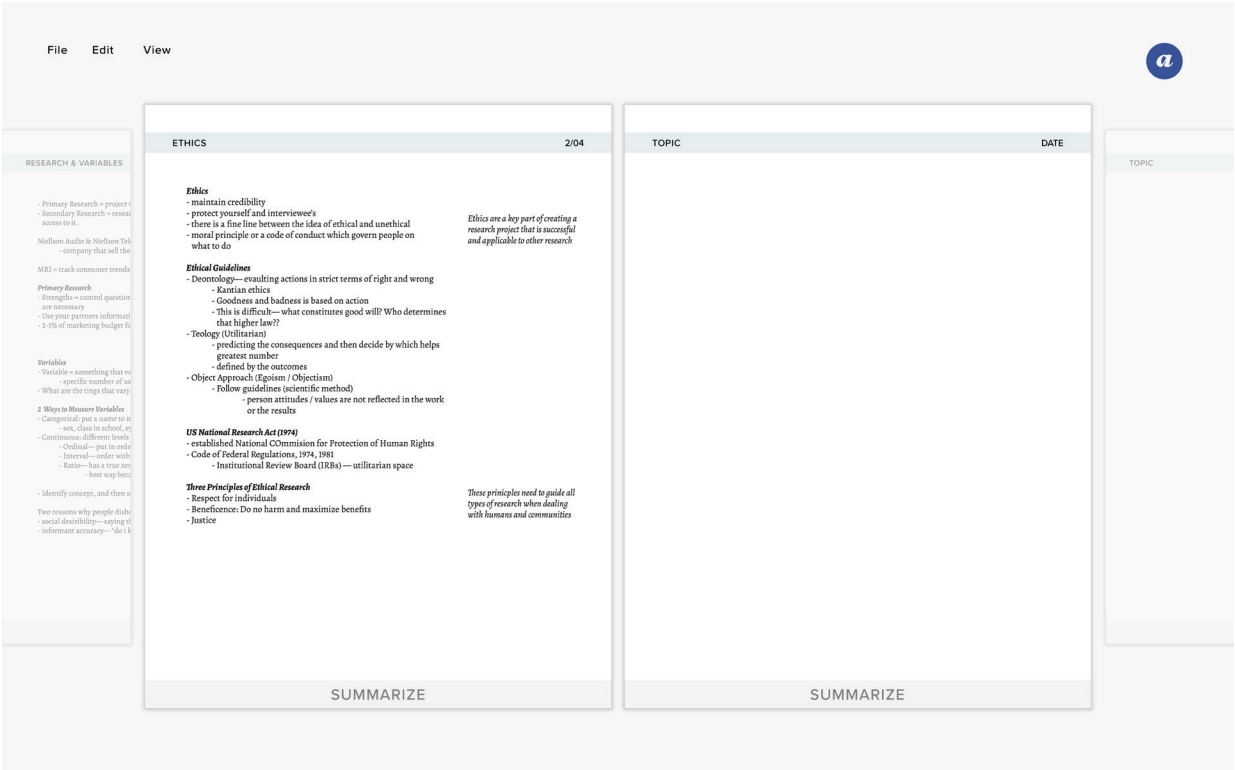


Figure 7.27. The formatting toolbar is hidden while Avery is typing her notes. This lets Avery focus on transcribing the information.

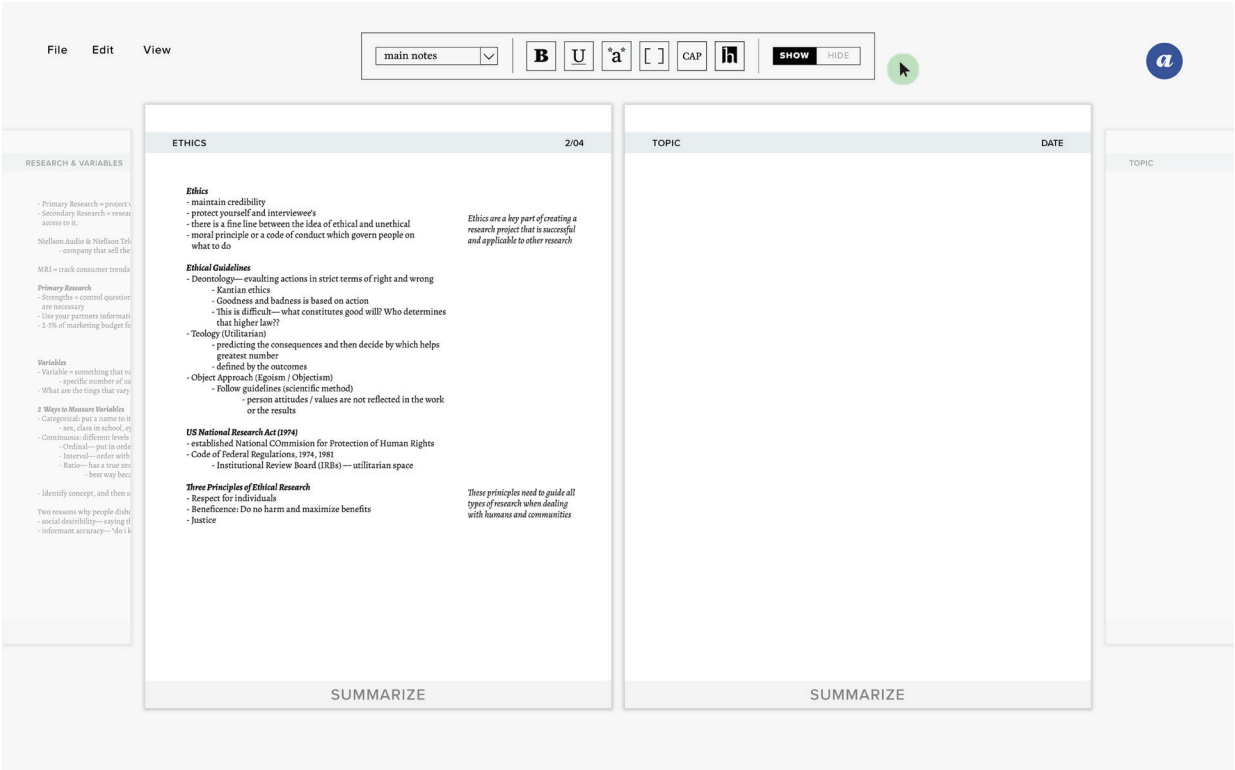


Figure 7.28. If Avery needs to use the formatting toolbar, she can easily reveal it by moving her cursor to the top of the screen (the area where the toolbar is located.)

7.2.3

ENHANCING ANNOTATION CAPABILITIES

This study combines student annotations with machine learning algorithms to identify relationships across a collection of notes. The data generated from the process is then used to populate graphic organizers, providing the student a visual and spatial depiction of the selected notes.

Annotation holds a variety of meanings. Simpson and Nist (1990) breakdown seven actions that can be described as annotating. (1) Writing brief summaries in the text margins using their own words; (2) combining multiple ideas in an organized fashion; (3) noting examples of concepts in the margin; (4) adding key information on graphs and charts with the text when appropriate; (5) writing down possible test questions; (6) noting puzzling or confusing ideas with a question mark in the margin; and (7) selectively underlining key words or phrases (Simpson & Nist, 1990). In the context of note-taking, these could take place at two different moments. First, when the student is transcribing the information; and second, when the student is reviewing their notes. In both circumstances, annotating increases student performance and comprehension since they are actively constructing ideas, facilitating questions, and drawing relationships across the recorded information.

There is an opportunity to further increase interaction with the information by using machine learning algorithms to identify patterns across a selection of notes. This process is described as semi-supervised machine learning— a hybrid of supervised and unsupervised machine learning. In semi-supervised machine learning, the algorithm uses both labeled and unlabeled data to train the system and then recognize patterns that create clusters of common data (Yan et al., 2013). Clustering is the task in which the system finds similarities and patterns across the data and organizes those data points into specific groups called clusters (Allahyari et al., 2017, Yan et al., 2013). Clusters can be created in various degrees

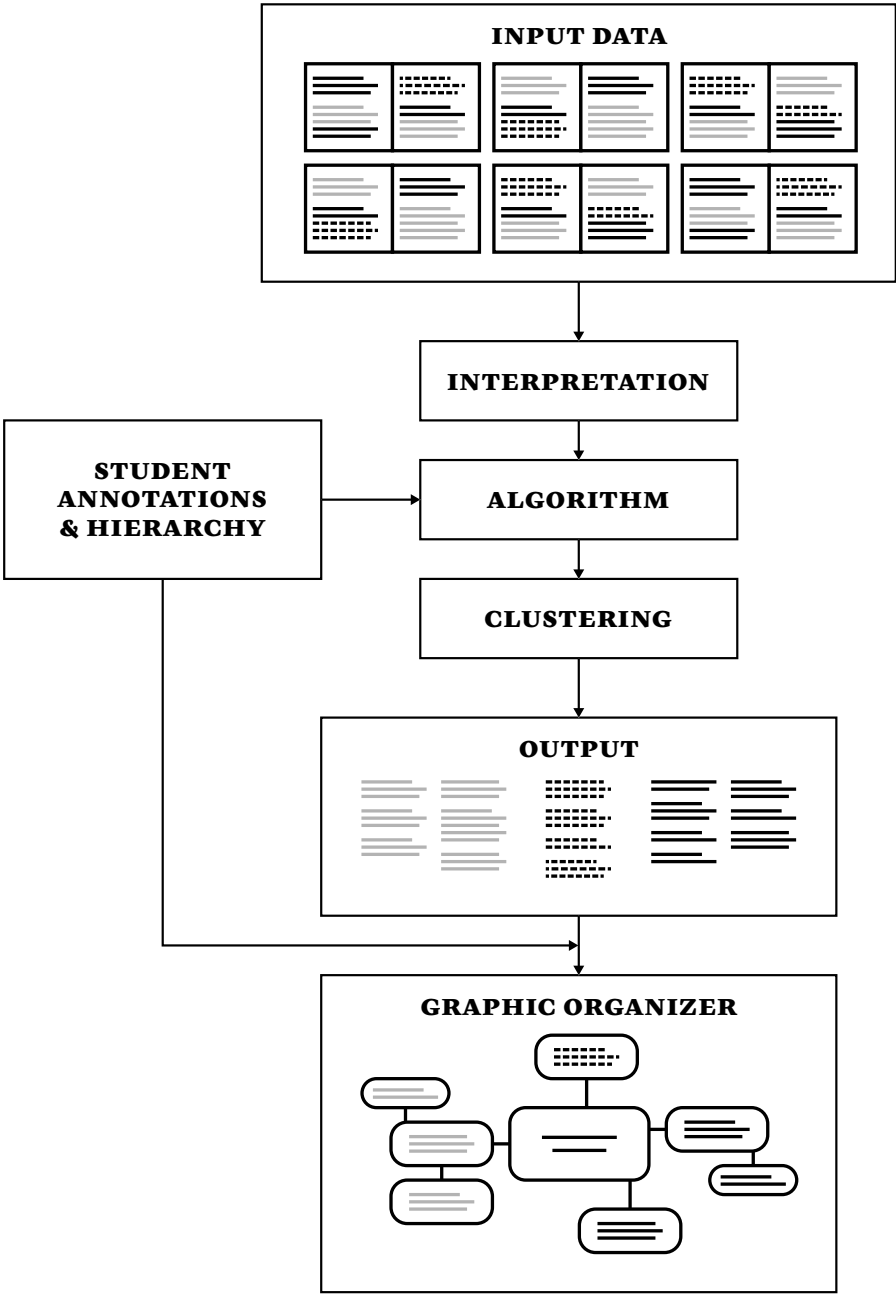


Figure 7.29. Framework visualizing a semi-supervised machine learning system in context to the note-taking interface and resulting in a graphic organizer.

of specificity, such as documents, paragraphs, or terms (Allahyari et al., 2017). In the context of a note-taking interface, a semi-supervised learning method allows for two notions to occur. First, unsupervised learning identifies patterns and relationships across the collection of notes. Second, supervised learning uses the students’ annotations and hierarchical structure as a labeled data to train the system. This allows the connections created by the student to remain an integral part of the notes during the process.

Figure 7.29 visualizes the process of the semi-supervised machine learning system in context to the note-taking interface. First, a selection of notes is used as input data for the system. The system interprets the text for the system to employ an algorithm using that data. This allows the system to identify patterns, create clusters of the information, and output those clusters in the form of text. The students’ annotations and hierarchical structure are implemented in the algorithm as training data to be included in the output. Finally, the output is then reorganized into the form of a graphic organizer, which also uses the student’s annotations and hierarchical structure as means to filter and populate a graphic organizer.

A graphic organizer is a visual organizational structure that spatially arranges information, typically using text, to depict relationships across the represented content (Manoli & Papadopoulou, 2012). The format or layout of a graphic organizer varies depending on the subject matter or intended purpose. This strategy works well from a students’ perspective since a specific type of graphic organizer can be created depending on the task at hand. For example, knowledge maps excel in explaining the relationship between concepts across a larger topic and studying them promotes increased recall of the overall ideas presented (Manoli et al., 2012). With that, creating a knowledge map would be beneficial when studying for an exam.

The generated graphic organizer is a combination of the student’s annotation input and the algorithm’s process of recognizing patterns in the data. This feature gives the student an interesting transformation of their

notes by showing connections across multiple pages of notes. Figures 7.35-7.37 show an example of how a graphic organizer, specifically a knowledge map, is displayed in the interface. The knowledge map is color coded to delineate whether the content is from a student annotation or determined by the algorithm. The student can click on individual contents of the knowledge to learn more details about where that information originates from. Finally, the knowledge map can be easily archived alongside the rest of the notes.

STUDY SCENARIO

Avery is getting ready for her first Small Business Management exam. First, she reviews her notes by highlighting key topics and important information discussed during the review session. Avery then decides to use the graphic organizer feature to develop a visual study guide to increase her understanding of the subject matter before the exam.

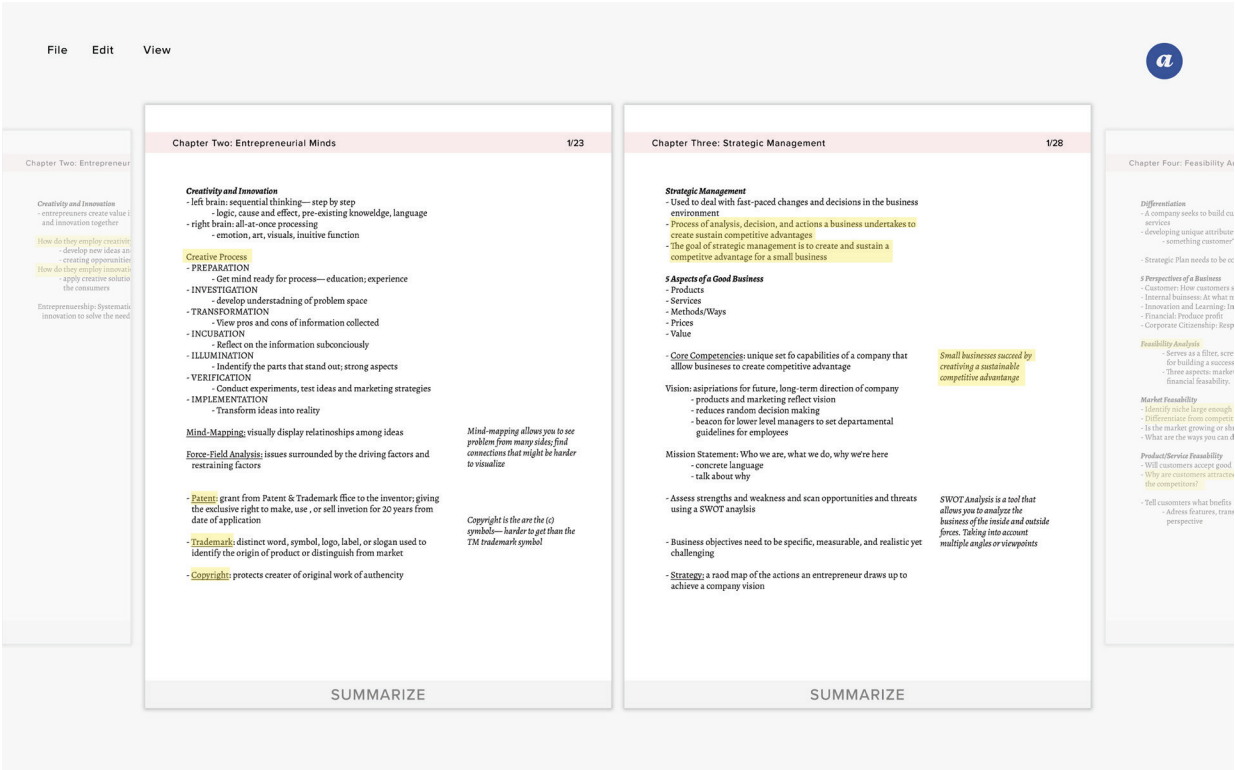


Figure 7.30. Avery has started reviewing for the exam by highlighting key topics and concepts throughout her notes.

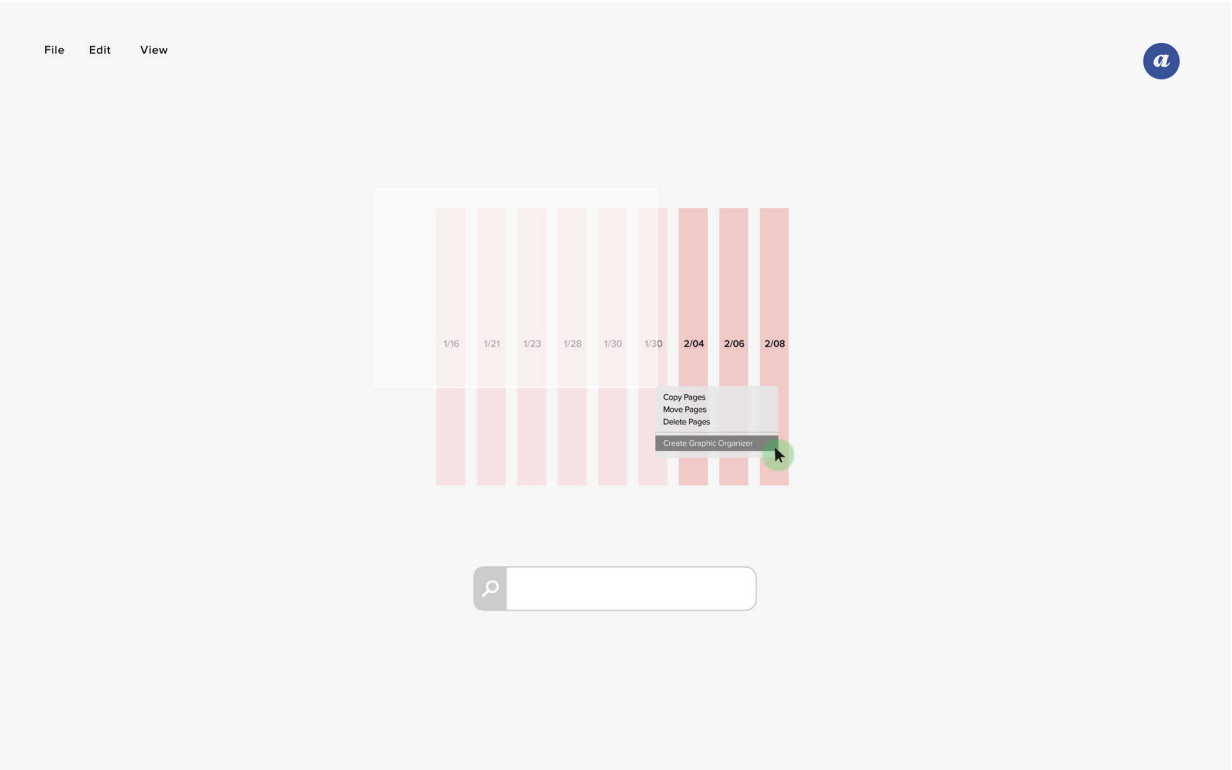


Figure 7.31. To create a graphic organizer, Avery moves into Visualize Mode and selects the note bars from chapters 1-4. Avery then right clicks and selects “create graphic organizer.”

See a video of this study scenario at:
https://college.design.ncsu.edu/thenfinally/norton/study_three.mp4

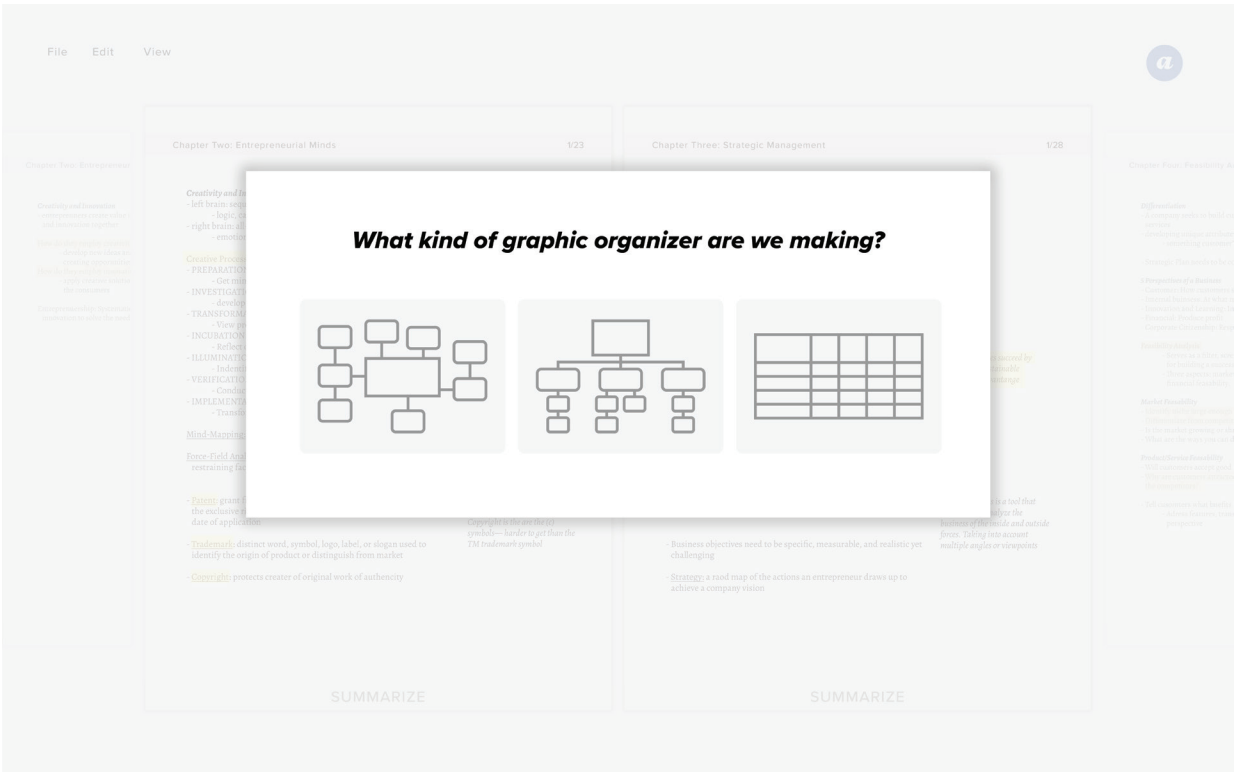


Figure 7.32. When prompted, the system asks Avery what kind of graphic organizer she would like to make using the selection of notes.

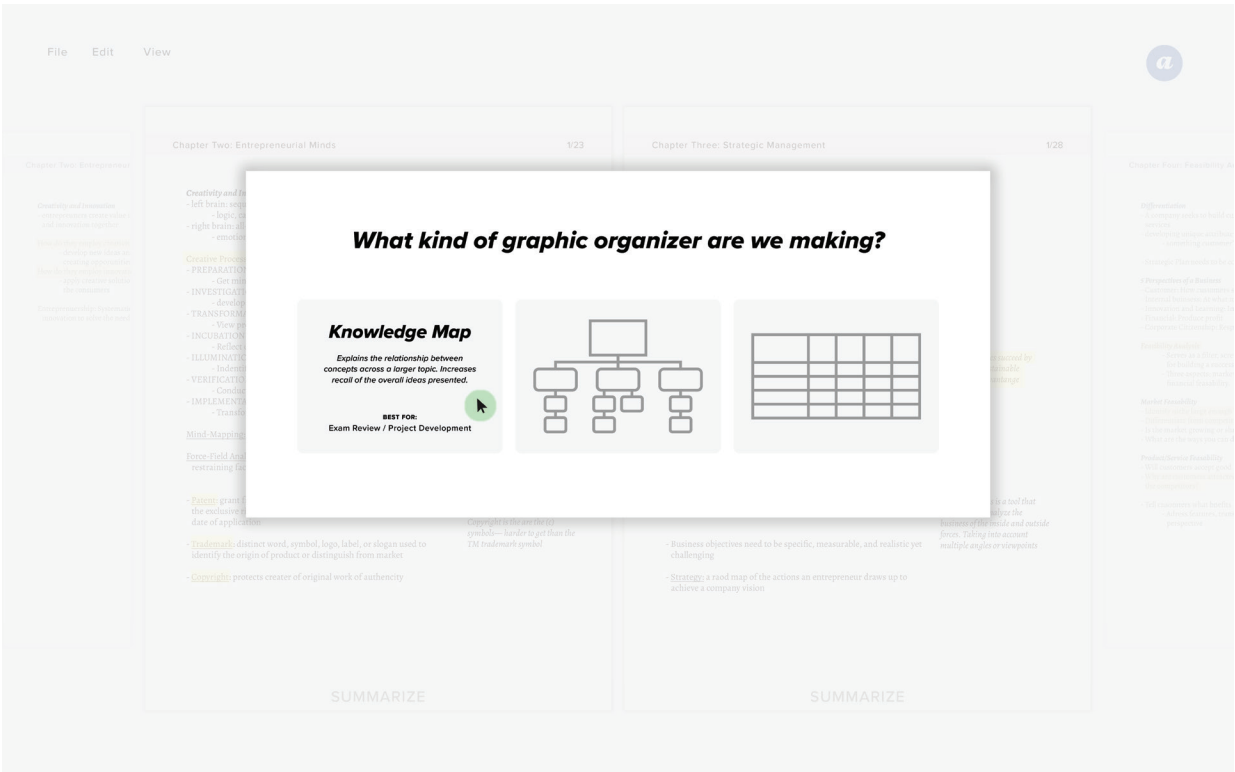
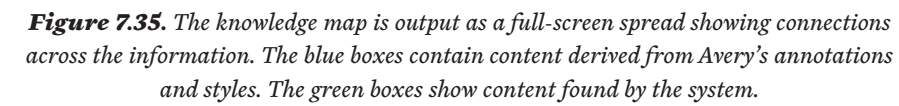
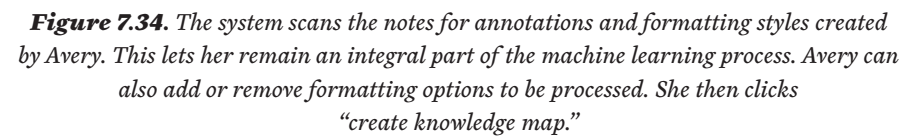


Figure 7.33. Avery can hover over the illustrations to read descriptions of each type of graphic organizer. This also tells Avery what each is best used for. Avery selects the Knowledge Map since it is recommended for exam review.



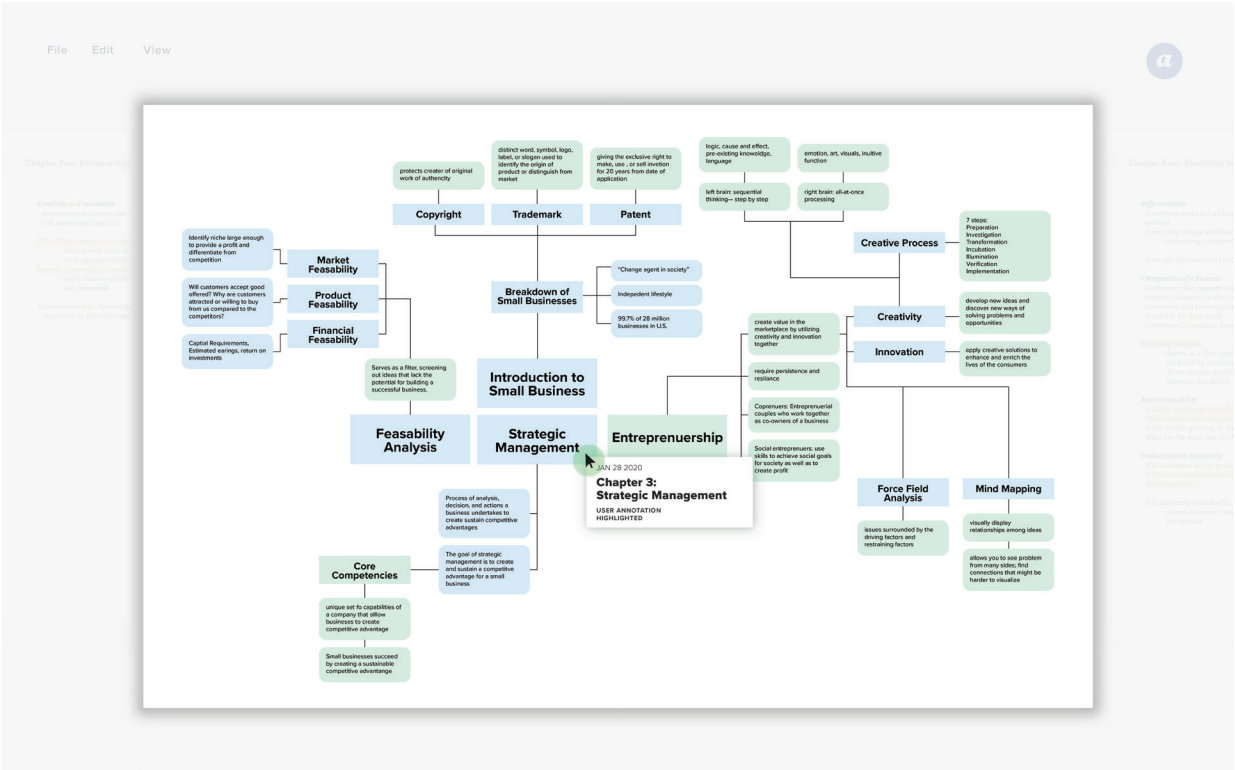


Figure 7.36. Avery can click on any section of the knowledge map to show the origin of that specific point. This shows the date and topic of the source note as well as how the content was processed.

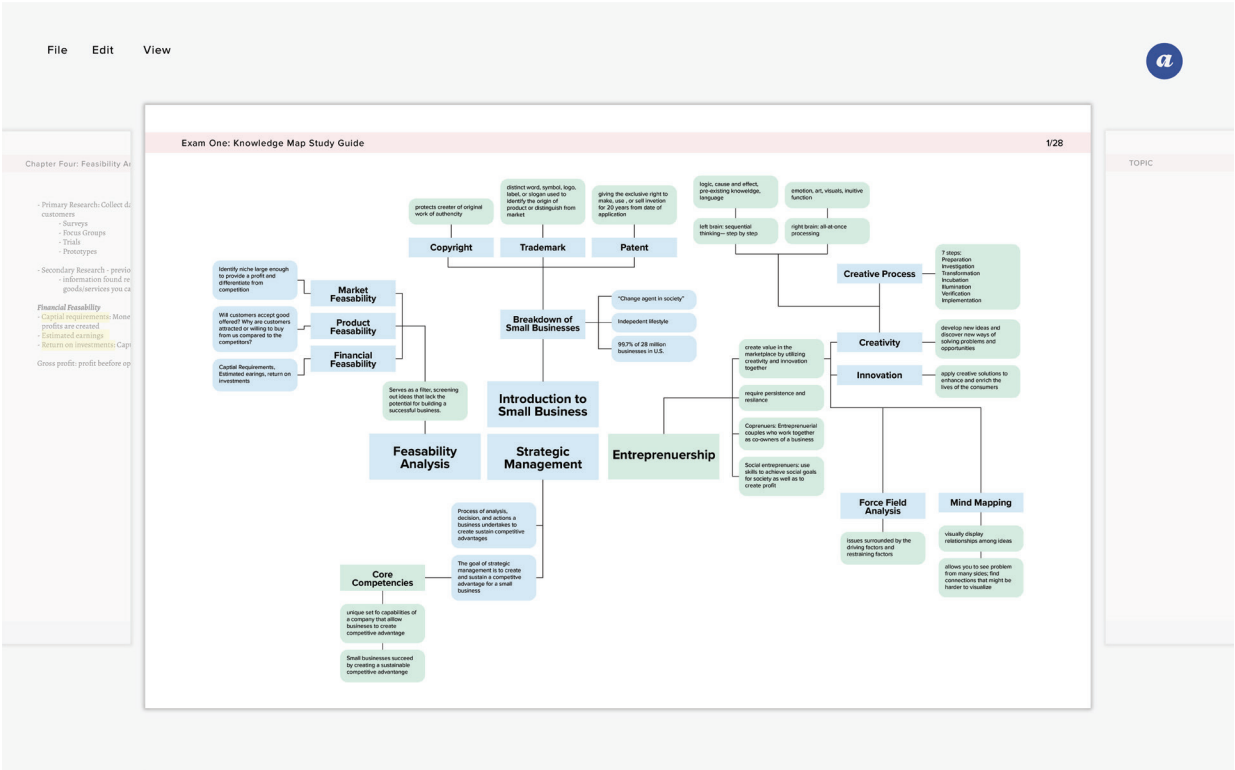


Figure 7.37. Avery can save the knowledge map, or any type of graphic organizer, directly into her notes for the specific class.

CHAPTER 8

DISCUSSION

8.1

DESIGN PRINCIPLES

During this investigation, I designed specific features for a digital note-taking interface intended to strengthen a college student’s encoding capabilities while engaging with lecture-based coursework. This process of research and making revealed specific principles that I believe are applicable to designers designing for digital environments.

Allow the physical to inform the digital

Through personal experiences and my research, it has become apparent that digital precedents heavily influence their future counterparts. Designers should be reminded that physical objects can greatly impact the design of the digital. Not simply mimicking the physical objects, but drawing from the tangibility and rhetoric within those objects.

Linearity is a simple form of organization

The linear form of a physical notebook excels in organizing notes. The oldest notes are at the front and newer notes progress towards the back. This creates a simple form of organization without the need for detailed

filing systems or naming conventions. Digital interfaces can use linear organization as a foundation for adaptable systems to be built.

Digital structures allow for adaptability

Developing a page structure when note-taking is a fundamental method to propel students to improve note-taking skills and increase retention of the subject matter. This idea is proven through scholarly note-taking systems like the Cornell Method. Digital forms of page structures can only increase the adaptability of the systems while still providing those same benefits to the students.

Hierarchy is more than format and style

Note-taking is increasingly beneficial when a consistent hierarchy structure is implemented. Hierarchy provides more than a format for organization; it accelerates the transcription process, decreases decision-making, and expedites the task of finding information. However, there is a point where too much hierarchy is distracting and confusing. Designers need to be aware of how and to what purpose a user is navigating content to decide how much the content needs to be organized.

Relatable content teaches the impact of machine learning

Using machine learning in the context of student note-taking creates an opportunity for students to understand how these algorithms read and process information. Since the algorithm is reading their notes as input data, students will have a better idea of what is being manipulated. This can then be extrapolated to more complex situations regarding machine learning.

8.2

FUTURE WORK

One of the key concepts I began with during the project was the idea of collapsing and expanding a collection of notes. This concept creates an experience closer to the physicality of flipping through the pages of a physical notebook. I am interested in expanding upon the possibilities of the “Visualize Mode” as referred to in my first visual study (Chapter 7.2.1.). Digital file storage limits the ability to view the collection. This feature can be compared to a collection of books— where you can look at the bookcase, a single bookshelf, the book, and finally moves into the individual pages. File storage currently feels like individual books or pages neatly (or not) organized into groups (known as folders.) I am interested in discovering ways to represent the concepts of the bookcase and bookshelf digitally.

My visual studies focused primarily on the theories and concepts driving the features I developed. I would like to test the features with user-testing in order to gain insight regarding how different students move through and interact with the interface. Also, I want to complete focus groups regarding digital note-taking to understand the specifics of a student’s engagement with the interfaces. Both research methods would provide valuable feedback regarding the features of the interface and the experience of taking notes digitally.

Text was the main form of notes used throughout my studies. I found text-based notes to be most common through observations and research. However, text is not the only form found when note-taking. Images, diagrams, and other visuals provide great benefits when attempting to understand and remember information. In future work, I would like to explore how these visual forms would be archived and experienced using the features developed during this investigation. I would also be interested in expanding the possibilities of machine learning to find relationships between text-based notes and the visual forms.

I implemented machine learning within the note-taking application in order to identify patterns across the student’s notes. Those patterns are then combined with the hierarchy created by the student to populate graphic organizers. Within this concept, it’s important for the algorithm to understand the student’s note-taking habits so the student’s input is not overruled by the unsupervised learning system. I would like to pursue the development of this collaboration between the student and the machine learning algorithm. There are opportunities for more intricate visual output, like graphic organizers, created by the algorithm. There is also the possibility of utilizing the algorithm as a suggestive system during the encoding and transcribing of note-taking.

8.3

CONCLUSION

In this investigation, I focused on designing features of an interface for the activity of note-taking. Breaking down the activity into individual characteristics allows for features to be designed for specific characteristics rather than note-taking in general. The concepts developed in the studies are not brand new. Rather, they repurpose and reinvent existing ideas found within physical and digital precedents and apply them directly to the experience of note-taking. I believe designing features, tools, and visuals that are familiar to the student would propel more successful note-taking compared to an interface design that is foreign.

Digital note-taking applications will continue to be developed as personal devices become more prevalent and powerful. The principles discussed in this research provide methods of designing a different, yet familiar, note-taking interface. With technology updating so quickly, it is becoming increasingly difficult to consider a specific device to remain present for an extended period. While the exact details of those future personal devices are unknown, the intentions of note-taking will remain the same— that is what we should be designing for.

CHAPTER 9

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COMPLEMENTARY NOTE-TAKING