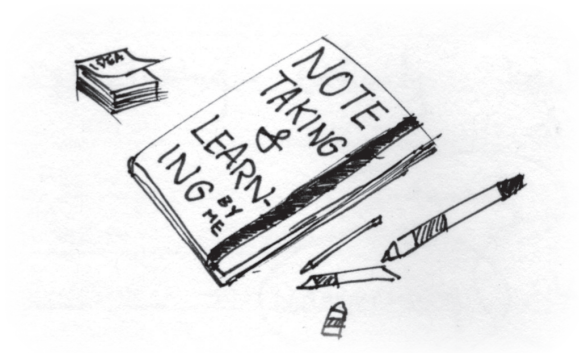


designing note-taking for meaningful learning



THESIS PROJECT DOCUMENTATION

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Master of Design 2012
Interaction Design
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Designing note-taking for meaningful learning

A thesis project submitted for School of Design, Carnegie Mellon University
for the degree of Masters in Design
in Interaction Design

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To my parents, Chloe, and Bebe.

abstract

Technology can have an immense impact on how people perceive, process, and learn new information. Technology-focused research is being conducted in the area of note-taking, as it is an activity most students perform. However, much of this work focuses on improving access, efficiency, and interactivity without emphasis on how technology can support learning. Thus, this project investigates the design of note-taking tools and their contexts of use as a means of helping people perceive, process, and learn information in educational contexts. The outcome of this investigation realizes an opportunity for a new device and software experience that is designed to aid learning in the information era.

Kekulé is a digital notebook for the information era developed as a result of this thesis investigation. It is designed to cater to different learning preferences and help individuals move through the cycle of learning in meaning-making, abstract conceptualization, experimentation, and transforming knowledge to new understanding.

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1 Definition

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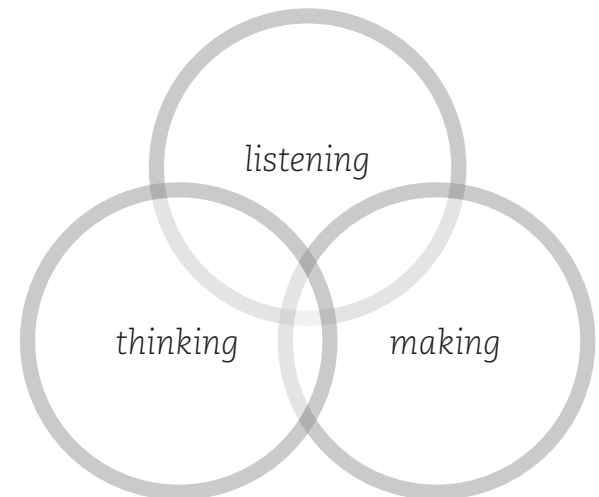
INTRODUCTION

The act of note-taking is a pervasive activity found among students in a learning environment. Studies have shown that as high as 99% of college students take notes in instructor lectures (Palmatier & Bennett, 1974). More recent research reveals that 94% of U.S. college students regard note-taking as essential to assimilating lecture content (Dunkel & Davy, 1989). New technology has expanded the tools for note-taking past pen and paper to the use of digital tools, such as computers and multimedia recording. However, it is questionable whether or not digital note-taking tools aid learning. In fact, note-taking software interfaces have shown to affect both the quantity and quality of notes recorded (Bauer, 2008). Given that the majority of students take notes warrants an investigation to determine the relationship between the use of technology and its benefits to learning. Through understanding students and the implications of new note-taking technology, this research aims to inform the design of new tools that better appropriates technology to facilitate learning

Before investigating technology and ways students learn, it is important to evaluate existing theories that describe the benefits of note-taking. There are four theories that support traditional note-taking as having a positive effect on student learning. First, taking notes facilitates encoding of information for the student. Encoding ideas through the act of note-taking helps the student transfer lecture material to their working memory. Second, the notes function as artifacts, serving as an external storage for memory that facilitates recall when reviewed at a later time. Third, students typically can only capture a small amount of information from a lecture when taking notes. Thus, the process causes them to omit superfluous details and focus on key concepts. Fourth, note-taking allows for elaboration of key concepts that connect to the student's existing knowledge. Elaboration helps in personalizing new knowledge in the student's context he or she can have it available for practice and application (Bauer, 2008).

*Note-taking offers four major learning benefits:
1) Encoding; 2) External storage; 3) Focusing; 4)
Elaboration (Bauer, 2008)*

Ideal note-taking process



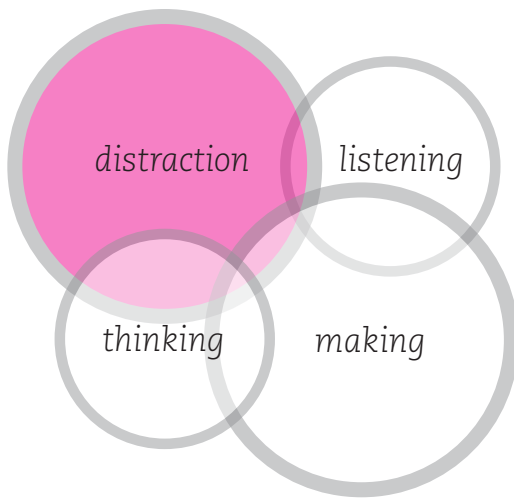
OBSTACLES

Although traditional note-taking has been proven effective in some respects, the process poses numerous obstacles that impede learning for note-takers. First, note-taking is a highly cognitive task that involves the simultaneous performance of listening, processing, and note-taking. On average, students record less than 50% of critical points in lectures (William, 2002). Effective note-takers achieve the balance between attending, storing, and manipulation of notes through the use of their working memory. However, studies have shown that note-taking may be detrimental to students who don't attain a great working memory capacity (Berlinger, 1969, 1971; DiVesta & Gray, 1973). Other related studies have shown that students perform better by simply listening (Hadwin, 1999). Second, note-taking can be tedious, error-prone, and distracting when the instructions contain complex and detailed information. The manual nature of note-taking can cause note-takers to be distracted when a high quantity of information needs to be recorded. Therefore, the quality of notes is also determined by the efficiency of the note-taker.

Technology is being used to address these problems by providing tools to capture notes more efficiently. Software examples such as Evernote, OneNote, AudioNote, Adobe Ideas, Poplets, and PlainText offer different ways to input, visualize, and store notes in mobile and desktop scenarios. However, while smart computing devices are commonplace in the classroom, their presence does not always result in more effective note-taking. The “always-on” technoculture for young adults poses a challenge as they are constantly tempted to multitask while in the classroom.

While technology serves a critical role in a student's college academic career, they can be a large source of distraction in classroom lectures. Multitasking makes note-taking difficult because note-taking is a highly cognitive task. On the other hand, a supporting theory of what makes traditional note-taking effective is that it enhances focus and attention. Traditional note-taking helps the student focus on the concept as it is being recorded. By taking notes, attention will need to be dedicated in order to listen, manipulate, and process the information. Together, focus and attention provides the environment to enable encoding of lecture materials. In order for future note-taking technology to be effective, it must consider the context where note-taking takes place and foster focus in the lecture materials.

Actual note-taking process



SIGNIFICANCE

Our ability to process information is fundamental to living in the 21st century. This is especially critical in the abundance of information driven by the advancement in computing and Internet connectivity. Technology is also transforming our learning environments. A prime motivation for this project is to uncover designs to help people capture, process, and transfer information in more intuitive ways that lead to sustained learning and understanding. Although the focus of this project is seeded in note-taking in the classroom, its results can have significant implications in other settings where information processing, transfer, and learning takes place. Some examples include business meetings, casual conversations, courtroom hearings, and interviews, just to name a few. The goal of this project is to break barriers for people to process information in an information-rich world. The decision to situate the project in the classroom setting aims to suggest that note-taking is not a solitary act, but a social and collaborative one when physical embodiment in the classroom is considered.

OPPORTUNITIES

Note-taking is almost as ubiquitous as language. As a result, an abundance of technological products and concepts have emerged in the marketplace. However, these products fail to demonstrate learning implications, efficiency, and desirability for the process of note-taking. Therefore, appropriating technology for learning is critical for the design of new note-taking tools.

Technology has the ability to influence the quantity and quality of notes we take. Research indicates that the availability of copy-and-paste in text editors will increase the quantity of overall notes as well as the quantity of verbatim notes recorded (Bauer, 2008). While text editors offer more efficient ways to capture notes, the notes captured through text editors have been found to be more verbatim in nature as it was originally presented. Thus, it is uncertain whether or not notes taken through the text editors offer similar encoding benefits as traditional note-taking tools. Also in Bauer's research, software interface interventions have the ability to influence the quantity of notes taken. This is important because a large quantity of notes may suggest less encoding might be happening during note-taking. Conversely, a small quantity of notes may suggest that fewer ideas are being captured. Consequently, desirability of software interfaces in digital note-taking tools must be carefully considered to encourage usage and achieve a balance in the quality and quantity of notes.

In order for new tools to succeed, a greater understanding of how people process, experience, and learn new information is needed. In "About Learning," McCarthy suggests a framework for learning as a cycle of direct experience, reflective observation, abstract conceptualization, active experimentation, eventually leading to renewed experience (McCarthy, 2000). This project encompasses how people perceive and process information to support the development of note-taking tools that aid in learning.

GOALS AND SCOPE

This project focused on bridging the gap between the design of technology and how it affords better learning specifically in the process of note-taking. To accomplish this task, I gathered theories supporting the advantages and disadvantages of traditional note-taking. Exploratory research was conducted with students to better understand them and their needs. Then, an audit and analysis of existing digital note-taking tools were developed for evaluation based on the supporting theories from research. All of these efforts targeted the goals of this project to inform, explore, and suggest speculative future note-taking features that can improve the student's learning experience.

Success was measured by students' impressions of the note-taking tool, their satisfaction of the experience, and the assessment of learning over time. Another indicator of success was determining whether this project served as a framework for developing future products that help people process information.

The scope of this project was note-taking in the classroom limited to classes where lectures were the main source of course instruction. This excluded online classes or discussion groups. The decision to omit these formats of instructions was to dedicate attention to lectures considering the time constraints and the complexities that these formats offer that demand dedicated attention.

Research was conducted on college students and graduate students primarily in subjects where instructions were delivered verbally along with visual aids. However, subjects where performances were involved were out of the scope (i.e. choreography, carpentry) of this project.

The grade levels of students were an important consideration for this project. Typically a student's note-taking technique matures when he or she reach collegiate education. Thus, it was important to investigate students on both end of the spectrum; on one hand, highly developed note-taking technique and the other with unrefined techniques.

The primary learning environment identified for this project was the classroom. However, the project also helped identify other spaces where students interact with their notes.

2 Exploratory Research

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RESEARCH PLAN

A comprehensive design research plan was developed in order to better understand student needs regarding note-taking and learning. The research plan consisted of a literature review on topics including learning theory, visual thinking, teaching, and creativity. Also part of the literature review was a wide range of relevant academic research papers and projects on the subject of digital note-taking and embedding technology in classrooms.

The target audience identified for the research activity was CMU undergraduate freshmen students. The rationale for targeting this group was because students just entering collegiate education have relatively nascent note-taking techniques. Therefore, more diverse results were collected as opposed to higher grade level students who may already have developed strong note-taking preferences.

User research activities began with an online screening survey which was sent to students enrolled in a number of history courses as required courses for incoming freshmen students. Interviews were also conducted with instructors from the Eberly Learning center at CMU. Both students and instructors were asked about learning and technology as they pertain to note-taking. The students also provided and described examples of notes they liked and disliked, which enabled the review of artifacts. In the generative design exercise, students were asked to describe their ideal note-taking tool and its context of use.

Lastly, a tools audit was conducted consisting of relevant note-taking products available in the marketplace today. The audit evaluated each tool based on a set of learning criterion developed as the research progressed.

Project research timeline

AUG	literature review
SEPT	survey interviews generative
OCT	tools audit

REVIEWS

Literature Review

A short list of published works were selected based on their relevance to the subject of learning and note-taking. The following section describes the materials reviewed and their implications to the development of this project.

CONCEPTUAL BLOCKBUSTING

Conceptual Blockbusting describes the ability for human beings to think and organize a number of mental or psychological barriers that prevent us from thinking. John Adams calls these mental barriers conceptual blocks and he organizes the blocks into a few categories. Perceptual blocks are about inspecting the details and the ability to look at problems from a different perspective. Emotional blocks are barriers that suggest natural human tendencies to avoid chaos, risk, and ambiguity. Cultural blocks refer to behaviors that are suggested by the social environment we live in. Environmental blocks address the blocks that are created by our physical and social surroundings. Adams describes each block in detail as well as offers strategies to address them.

Adams' suggestions to overcome conceptual blocks is important in developing future note-taking tools. One such concept is the importance of fluency and flexibility of thought. Fluency refers to the number of concepts one can generate. Imagine solving a particular problem, fluency in concept generation would cover the depth of the problem. On the other hand, flexibility refers to the diversity of the ideas generated. Future note-taking tools need to support fluency and flexibility in developing thought. Another important implication is the supporting theory behind conscious and subconscious thinking. Every thought emerges from the subconscious and passes the ego/superego to the conscious. This process suggests wild or creative ideas sometimes may be filtered and omitted before it reaches conscious thinking.

DESIGN IMPLICATIONS

Adams' suggests that creative thinking must surface from our subconscious. Note-taking tools need to employ techniques that can foster creative thought.

UNDERSTANDING BY DESIGN

Understanding by Design provides a framework for teaching for understanding, rather than what is typically observed in education which is coverage-based

and activity-based teaching. There is a subtle but important difference between understanding and knowing. Understanding of a concept will demonstrate transferability which means the learner will have the ability to abstractly think about the material and make connections with not just the subject matter, but also generalize it his or her existing network of knowledge. Simply knowing the material implies memorization and regurgitation. Understanding means that the learner has acquired meaning from the facts. Understanding by Design emphasizes a learning-focused approach to lesson planning and suggests lesson planners to utilize a design approach to structure learning.

In a deep analysis on understanding, Wiggins and McTighe explain the Six Facets of Understanding which include explanation, interpretation, application, perspective, and empathy. They assert that teaching for understanding should be the goal of educators and these facets are indicators of such. They explain that it is counterproductive to hand students prepackaged “significance”. Learning needs to be more experiential, geared towards making students confront the effects—and affect—of decisions, ideas, theories, and problems.

DESIGN IMPLICATIONS

Wiggins and McTighe suggest organizing material on key concepts or big ideas rather than focusing on facts or details. This is useful in developing future note-taking tools in that note-taking should support the learner in understanding and not simply recording of the facts.

LAPTOP USE IN UNIVERSITY 2006

In this study of laptop use for incoming college students, the researcher found that having laptops influenced how long and where students engaged in school work. Students with laptops preferred to work from home and the location was often chosen for its physical comfort level rather than the support of learning and community. The research suggested that the design of physical spaces must take students’ comfort into consideration. Creating comfortable, functional learning spaces, could also serve to maintain students’ sense of community. The availability of the laptop allowed the students to work whenever they wanted which lead to longer working time on the computer. However, the time working on the computer was not always productive as it was dispersed with other computing activities such as checking email. Also, having a computer resulted in over reliance on technology

which constrained their abilities and thinking. For example, some students relied on the computer to create digital drawings, which resulted in a perceived weakening of their hand-drawing skills.

The implications of this laptop study to the design of note-taking tools is to design with care in appropriating technology. Technology can be a double-edged sword, as this study suggests. Learning and support often comes from a community which is also what is beneficial about the university experience. It is important to recognize technology has the ability to influence the construction of this community.

DESIGN IMPLICATIONS

Designers of note-taking tools and community builders need to recognize that learning is an individual effort but is enhanced and supported by a community.

EXPERIENCES IN VISUAL THINKING

In this book, McKim addresses how visual thinking should be utilized to facilitate thinking and when generating new ideas. He also suggests that thinking should not be a solely verbal activity but also a visual one. This is because verbal thinking techniques result in rationalization and inference whereas visual thinking techniques can lead to discovery. Therefore, visual thinking should be encouraged because it complements abstract language thinking by its power to concretize.

DESIGN IMPLICATIONS

Note-taking needs to afford both modes of thinking: both verbal and visual. The left brain and right brain complement each other and allow us to make meaning, solve problems, and dream.

A NEW CULTURE OF LEARNING

The new culture of learning is the shifting of the learning environment enabled by fast changing technology. Technology has made information more accessible to more people, more places, and more often. Therefore, the new culture of learning is occurring everywhere and not strictly in the classroom. It also suggest that the current model of education is not sustainable to handle the changing environment. In resolution, the book offers a new perspective on the traditional teaching-based approach. It suggests that the new culture of education should be learning-based. The culture of learning should emerge from the environment and learning occurs

when students engage with the world. The learning-based approach embraces inquiry or “what we don’t know” rather than finding answers.

DESIGN IMPLICATIONS

- » *Tools need to encourage learners to stay curious and keep asking questions under a learner-based approach.*
- » *The tool needs to focus on what the learner is passionate about. In support of their passion, tools help connect individuals to collectives, which is a community of similarly minded people who will offer advice and opportunity to actively engage with the process of learning.*
- » *The tool needs to adopt a lifelong learning approach rather than a “Mechanistic View” of learning. A mechanistic view of learning means that learning can be distilled into a series of steps to be mastered with the goal of learning as efficiently as possible. When learning is a lifelong interest, learning is continuous and what we understand keeps being renewed and redefined.*

HOW LEARNING WORKS: 7 RESEARCH-BASED PRINCIPLES FOR SMART TEACHING

In Chapter 2 of this book, the authors discuss how the organization of knowledge affects students learning. The authors use two stories to illustrate that students’ lack of knowledge in the subject matter will often result in a superficial organization of the material. This type of structuring of material encourages the students to memorize individual parts rather than understanding the big picture and the relationships among the individual parts. In contrast, teachers who possess expert domain knowledge will often create more meaningful organization structures which connects the important concepts, facts, procedures, and elements within the domain. The authors conclude that how students organize knowledge influences how they learn and apply what they know.

The principle and research findings covered by this chapter have great implications to the design of note-taking tools. First, they provide the basis that organization of information influences how one can learn and apply knowledge. Second, it suggests that teachers or domain knowledge experts can better recognize patterns in information and create often multiple and more complex organizations. The complexity of organizations suggest that more meaningful connections are being made with other individual knowledge parts which results to understanding. For

designing note-taking tools, the ability to draw connections to similar or divergent concepts is important for understanding.

DESIGN IMPLICATIONS

Note-taking tools must have flexibility in providing and also encouraging note-takers to use different organization structures.

FRAMES OF MIND

In “Frames of Mind,” Gardner describes his multiple intelligence theory as a different way to assess individual’s innate attributes. Therefore, test scores and intelligence tests may not fully describe an individual’s abilities.

“The apparent correlation of these test scores across ages and across different tests corroborates the notion that the general faculty of intelligence, g, does not change much with age or with training or experience. It is an inborn attribute or faculty of the individual.”

— Howard Gardner

Based on the theory, individuals possess intelligence in the following areas: musical, bodily kinesthetic, logical-mathematical, linguistic, spatial, interpersonal, intrapersonal. This theory can be considered as a possible learning model to design note-taking tools to aid learning for individuals that possess excellence in different intelligence areas.

DESIGN IMPLICATIONS

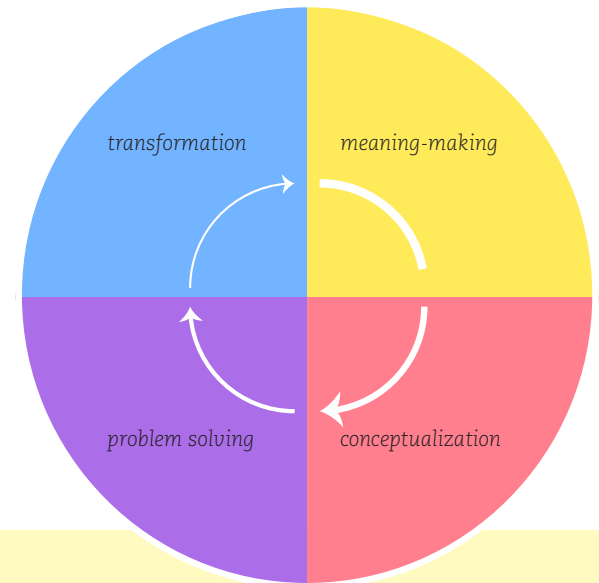
Designers of note-taking tools need to take into consideration the multiple intelligence theory that all individuals possess strengths in different abilities.

ABOUT LEARNING

In “About Learning,” McCarthy describes the 4MAT learning theory as a cycle that brings balance and wholeness to learning. According to McCarthy, learning is a continuous cycle with four core stages. Learning as deep understanding requires movement through the cycle where learners perceive and process information in a variety of ways despite the fact that individuals may identify more closely with one of the four stages based on individual learning preferences. The cycle consists of sequential stages: attend—feeling and sensing in the present environment, reflect—thinking and abstracting the information, understand—create concepts

that can be generalized based on the new information, try—put theory into action, adapt and integrate—transform and experiment based on results of action. She asserts that learning environments should be supportive so individuals can move through phases that may seem uncomfortable. The first quadrant can be described as meaning-making. It is the process where personal truths and subjectivity are honored. The second quadrant is abstract conceptualization. It is about reflection, organization and pattern seeking. The third quadrant is problem solving through application. This is the process where theory is taken into action where learners are tinkering, testing, and trying. The fourth quadrant is concept transformation. It is the process where action is being refined, adapted, and transformed. Individuals are creating new meaning based on their actions, reflections, and creations.

McCarthy's 4MAT learning system is used as a basis for this thesis, providing a framework for learning that informed the design of the digital notebook. The design outcome is a framework that describes ways to design note-taking activities to move students through various stages of learning, and a tool that illustrates the application of the theory.



McCarthy's model of understanding explains the continuous cycle of learning.

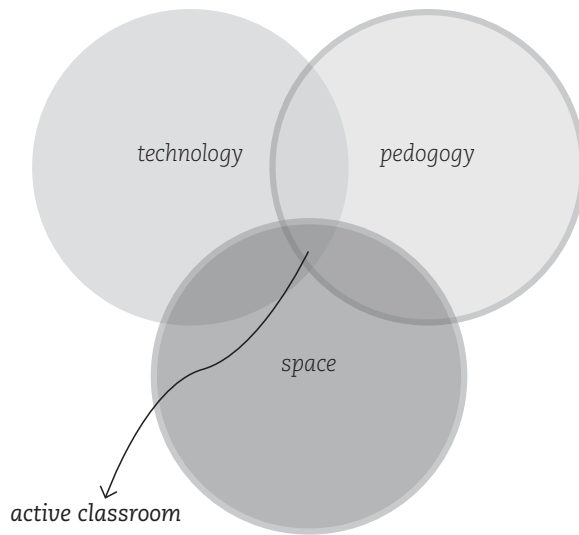
DESIGN IMPLICATIONS

All learners have a preferred way of learning. However, meaningful learning is an outcome from moving through the learning cycle. Therefore, the design of note-taking tools should aim to move learners through the cycle while accomodating different learning preferences.

STEELCASE DESIGN OF FUTURE CLASSROOMS

In Steelcase's future classroom design, pedagogy, technology and space can establish new protocols for advanced learning environment solutions. In this research, there are a number of notable findings:

- » *The classroom is not the only learning space. In fact, learning occurs everywhere. Even within spaces on campus, learning occurs in the cafe, lounge, computer lab, library, and faculty office spaces.*
- » *The next-generation classroom needs to consider pedagogy, technology, and space as equal parts in the design of the classroom learning experience. The interaction of the three equal parts allow active learning to occur.*
- » *The design of the classroom space should support multiple learning styles. Therefore, the classroom space should be adaptable to support different activities.*



In Steelcase's future classroom design, pedagogy, technology and space can establish new protocols for advanced learning environment solutions.

- » *The design of higher-ed institution should encourage collaboration, co-creation, and communication based on the new team-based work environment.*
- » *This work is also suggesting changing the lecture format from a passive experience to a more active one.*
- » *Students often dislike common lecture formats, which frequently encourage them to take a passive role in their learning, leading to inadequate note-taking.*

I gained valuable insights from reviewing the SteelCase design project. While I had thoughts on how space can influence learning, this work is elaborate and backed with research and testing. I look forward to utilizing some of their insights and solutions to advance note-taking strategies.

Steelcase's design of learning spaces also pushes me to think in terms of activities and behaviors that I want my design to facilitate. I came up with the following questions after evaluating this work:

- » *How can student participation(personalization) and engagement(focus) be facilitated by note-taking tools?*
- » *How can learning be bridged from campus spaces to learner's day-to-day life? How can review of notes be encouraged?*
- » *How can the design of note-taking tools encourage collaboration?*
- » *How can the design of note-taking tools make note-taking be active rather than passive?*

DESIGN IMPLICATIONS

While it is obvious that Steelcase's focus is on the design of spaces, they omitted important parts of a successful learning environment which are learners and the supporting community. The design of note-taking tools can aim to integrate individual learners with their communities and physical environments.

OTHER RELEVANT WORK

A number of relevant projects have been evaluated for this project for their use of technology in classrooms, note-taking, or use of novel technology for educational purposes.

The research project eClass, formerly known as Classroom 2000, studies the automation of capturing lecture material. The project seeks to identify opportunities where ubiquitous computing can be applied in the classroom scenario. Automation of notes captured includes video of the lecture, audio, and web pages presented during the lecture. The material is then made available for student access after the lecture.

StuPad is a related project to eClass, which it seeks to address the ability for students to personalize notes captured by the eClass system. This project is important in pointing out the significance for personalization of notes as opposed to an objective view of lecture material.

Livenotes is a project where a networked collaborative whiteboard system is introduced in the classroom. Students and lecturers can collaboratively generate notes based on the lecture presentation and have it available for access after lectures. This project further explores the shared experience of lectures but also taps into the richness of social note-taking and the concept of group intelligence.

Similarly, project HyLighter is a software project which allows highlighting text in a text editor and enables sharing of annotations. The research sheds light on the benefits and drawbacks of sharing and merging annotations in a group setting.

Aaron Bauer from CMU conducted a number of studies involving the use of copy-and-paste and highlighting in a desktop text editor. His research sheds light on how software interface design can influence the quantity and quality of notes taken.

A project by Tom Moher introduces a learning technology framework called “Embedded Phenomena.” It is a simulated scientific phenomena mapped onto the physical space of classrooms. The project explores the principles of situated and experiential learning. It also explores how aspects of experience and play can enhance science education.

DESIGN IMPLICATIONS

Together these research projects forged the direction I took for this project:

- » *The eClass project has shown the benefits of automation, but it also suggested a possible downfall which is students not showing up to class.*
- » *Moher's work on "Embedded Phenomena" showed that technology and physical embodiment should coexist and can enrich learning.*
- » *The Livenotes, HyLighter, and StuPad projects suggest that note-taking tools need to allow group collaboration and individual personalization. Both types of notes, group-generated and personally-generated, offer different learning benefits. Group-generated notes offer a more complete objective view of concepts learned which helps in abstraction and concept generation. Personally-generated notes allow individual meanings to develop and facilitates connection to individual's existing knowledge.*

DESIGNED ACTIVITIES

Survey

The initial screening survey asked basic background questions such as gender, class standing, major of study, whether or not they took notes in class, and if so what tools did they use to take notes. Twenty students participated in this survey.

DESIGN IMPLICATIONS

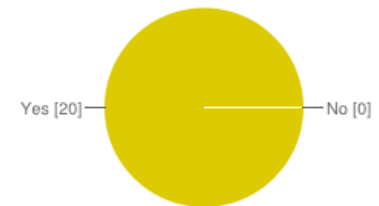
The results of the screening survey show that students from a variety of majors responded and unanimously all take notes and all listed pen and paper as one of the tools they use in class. The use of digital tools in the classroom is very low.

Directed Storytelling

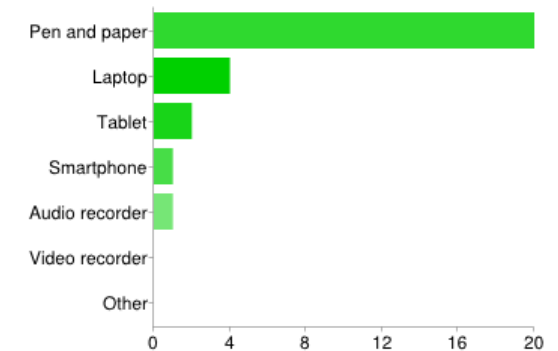
Directed storytelling was conducted with five freshmen CMU students. The questions I prepared for the students were mainly focused on uncovering their attitudes toward note-taking, what they did with their notes, technology, preferences in tools, and how instructors influence the notes they take. During the session, students also brought examples of notes that they liked and disliked. Here are some the questions I asked:

- » Show me an instance of notes you took that you thought was effective for you. Explain why you feel this was particularly effective.
- » Show me an instance of notes you took that you wish could be better. What would you like to be better?
- » Think of a time when you couldn't make it to class. How did you end up catching up with the learning material?
- » What do you do with your notebook after the class ends?
- » What do you do with your notes after the class ends?
- » Would you be comfortable not taking notes during a lecture?
- » Do you use any electronic devices in class? (i.e. laptop, smartphone, tablet, audio recorder, video recorder, eReader)
- » Do you use any electronic devices for taking notes?
- » Can you think of a time when using an electronic device in class helped you take better notes or learned a particular material better?
- » Think of a time when a device distracted you from class. What were you doing?

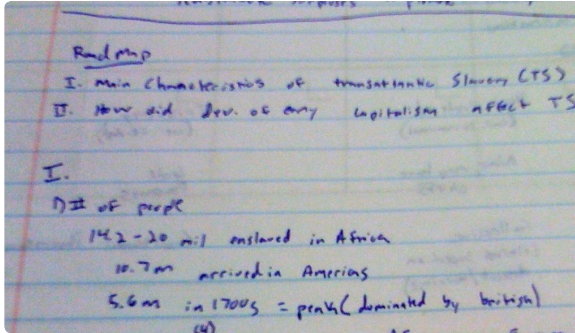
Do you take notes in class?



What tools do you take notes with in class? (Check all applicable)



Here are some of the interesting results from the survey. All participants of the survey reported taking notes in class using pen and paper.



This participant used a roadmap organization system to create an outline for the subsequent blocks of notes.

African before TS	TS slaves
- reproducing system: care, education, enforcement	- no reproducing system: care, education, enforcement
- obtained via warfare, loans	- obtained via capture and sale
- punishment	- became commodities
- members of group even if they eventually freed, or children "freed" from birth	- treated as private property
- NOT racially different/inferior	- children inherited slave status
- used according to demands	- even to "hierarchical" racism which treated Africans as inferior
- tributary systems (in Africa) labor + trade more valuable than land	- increased used according to capitalism

This participant used a table as a visual mechanism to compare two competing theories on capitalism.

- » Do you use any electronic devices for purposes other than taking notes?
- » Do you feel having these electronic devices help you learn better while in class?
- » Have you recorded a lecture using audio or video? Useful? Why?
- » If you weren't able to attend class, what would you prefer to receive to learn the materials from class? Why?
- » Do you review your notes outside of class? Why?
- » Do you rewrite/reorganize your notes? Why?

Interviews were also conducted with Marie Norman and Marsha Lovett from the CMU Eberly Center for Teaching Excellence. They run teaching seminars for graduate students that provide techniques for effective instruction. They are also co-authors of the book "How Learning Works: Seven Research-Based Principles for Smart Teaching" which I covered in my literature review. The interviews were centered around what they thought the benefits of note-taking were and how to improve it. They also provided an instructor's perspective regarding technology in the classroom. Here are some of the questions I asked:

- » How does seeing students take notes affect the way you teach?
- » Do you allow students to record audio/video of your lecture for note-taking purposes? Why or why not?
- » How does the presence of computers in the classroom affect the way you teach?
- » How do you structure your learning/lecture material?
- » What do you think students miss by not attending the lecture?

As part of directed-storytelling, I asked participants to show examples of their personal notes. This activity was very revealing in terms of what students actually do in note-taking. The following themes highlight recurring actions:

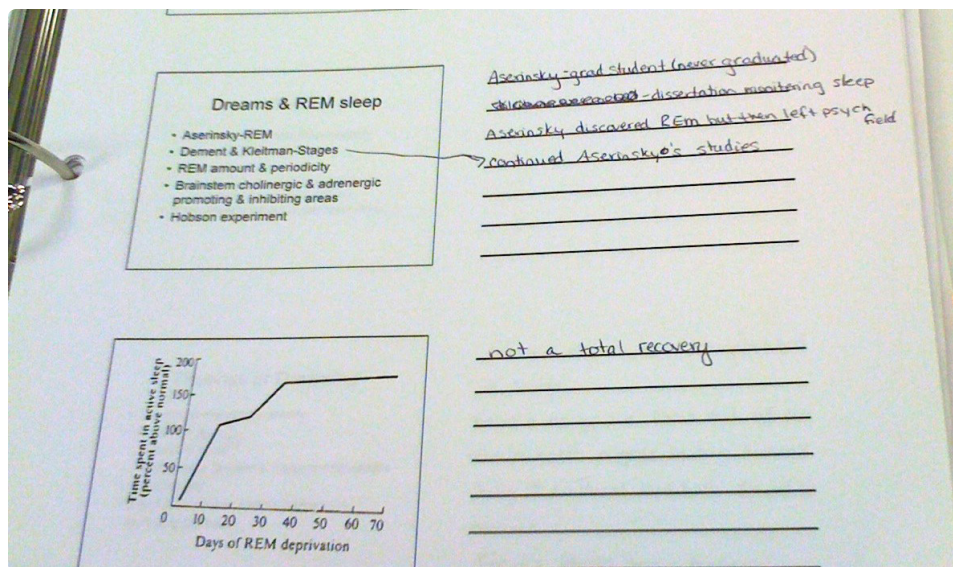
ORGANIZATION

"I need organization. it'll be nice if it organizes [information] in different ways. Part of what annoys me about file organization is that there is only one way to organize. you have to choose one way and go for it."

—Participant

I saw many examples of different organization systems to format lecture notes. For example, the use of the tables is a visual mechanism that allows for comparisons

This participant came up with a note-taking strategy for a class which the instructor makes presentation slides available prior to lectures. This participant printed out the slides with lines adjacent to each slide for additional note-taking during the lecture.



DESIGN IMPLICATIONS

- » Notes can record emotional reaction during lectures.
- » Students typically write down what instructors write on the board.
- » Students typically prefer classes with a lot of notes because it allows them to review.
- » Students typically dislike taking notes in classes where instructors don't provide a formal structure for taking notes, or when the instructor jumps around topics sporadically, making notes seems disorganized and less cohesive.
- » Notation marks and shorthands are developed by more expert note-takers. They also exhibit better information organization.
- » Annotation on instructor-provided slides was a method that was appealing to some students. It alleviated the need to copy down all the information and instead focus on course material.

Tools Audit

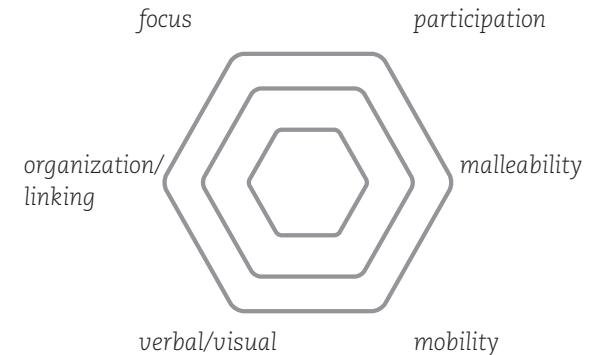
A tools audit was completed as part of this project to understand the current tools that are readily available to students and how they compare to each other. In evaluating these tools, it was important that the evaluation criteria elude to a broad and fundamental need, and stay loosely connected to a particular technology. For example, a post-it note and a smartphone mobile note-taking application can both be evaluated on a broad concept of mobility. The use of the evaluation criteria allows consistent comparison across tool categories. The audits evaluated tools in three major categories:

1. *Traditional*—These are tools that require no technology and are typically used in conjunction with pen and paper.
2. *Software*—These are software note-taking tools that mostly focus input through the computer qwerty keyboard and installable in common personal computers and also existing tablet devices such as the iPad.
3. *Dedicated devices*—These devices are physical electronic devices designed for aiding note-taking and can take different physical forms.

A fourth category of drawing devices was also collected but not evaluated. They served as inspiration for designing note-taking tools geared towards learning. They include Boogie Board, Bamboo Tablet, Wacom Inking, Cintiq.

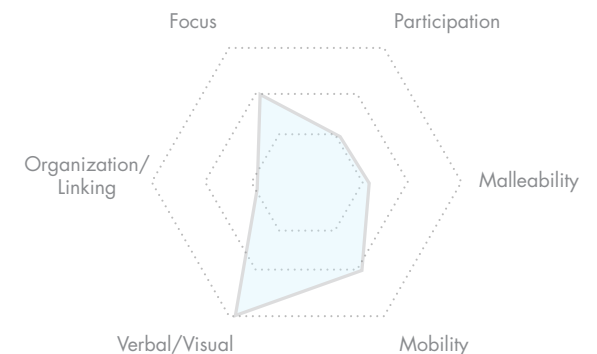
An experience model was created to evaluate the tools. The model consists of these core factors:

- » *Focus*: How well does the tool encourage focus and sustained attention?
- » *Malleability*: Does the tool allow manipulation of content and information?
- » *Mobility*: How portable is the content and information in the everyday usage context?
- » *Organization/linking*: Does the tool offer different ways to organize and link information to draw insights?
- » *Participation*: Does the tool encourage learners to participate in learning or connecting to a community?
- » *Verbal/visual*: Does the tool offer the flexibility of verbal and visual input?

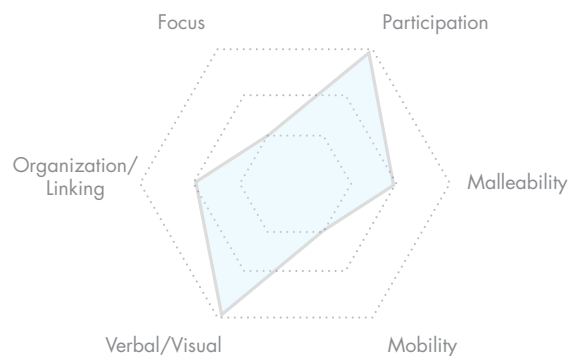


The experience model consists of core factors to consider in designing note-taking tools for learning. The model was used to evaluate current tools and was used to develop the concepts from this project.

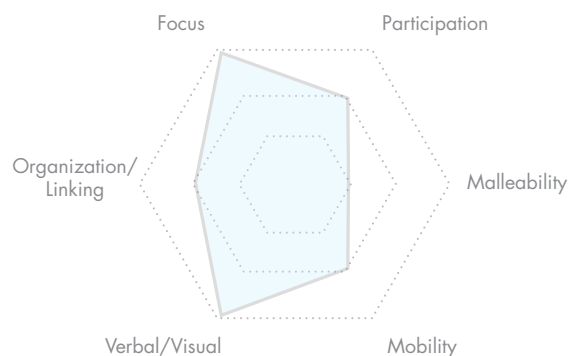
Pen and paper



Whiteboard



Doodling/Sketchnoting



TRADITIONAL

PEN AND PAPER

- » Most accessible and popular tool for note-taking.
- » Many benefits such as accessibility, flexibility of input.
- » The activity of using pen and paper makes students focus.
- » Traditional note-taking is great for input but poor for review because it lacks organization methods other than chronological.
- » Although notebooks can be portable, but it usually consists of a single subject at a time.

WHITEBOARD

- » Ease of input and great for review.
- » Larger space allows and encourages further elaborative thinking.
- » Allows for spatial organization.
- » Allows for collaboration.
- » Whiteboards are often shared in the environment so they are not always accessible.
- » Notes taken on whiteboards are not portable.

DOODLING/SKETCHNOTING

- » Doodling as a technique allows people to get into relaxed attention which is the best state for seeing, imagining, and drawing.
- » Leverages dual modes of thinking: verbal and visual.
- » Attractiveness makes a good entry point and story for any subject.
- » Shareable, can lead to conversations.

SOFTWARE

EVERNOTE/ONENOTE

- » Cross-platform: Mac, Web, Mobile.
- » Flexibility of digital input: pictures, text.
- » Offers different ways of organizing notes: notebooks, tags, chronological.
- » Allows for sharing.
- » Organization is based on physical metaphor but not encouraging other ways of packaging information for learning.

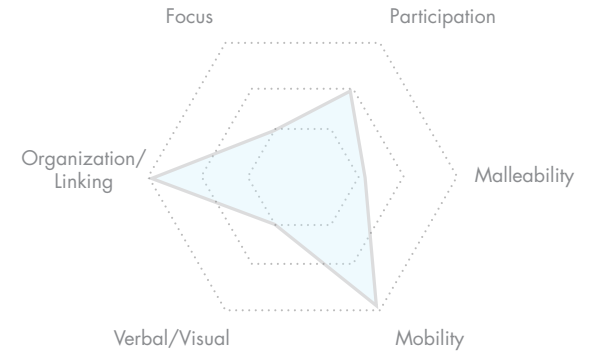
NOTES PLUS/NOTE TAKER HD

- » Uses tablet form factor and optimized to use with a stylus.
- » Allows for various input: text, drawings, pictures.
- » Support for multiple notebooks.
- » Support for annotating over existing digital material.
- » Organization is based on physical metaphor but not encouraging other ways of packaging information for learning.

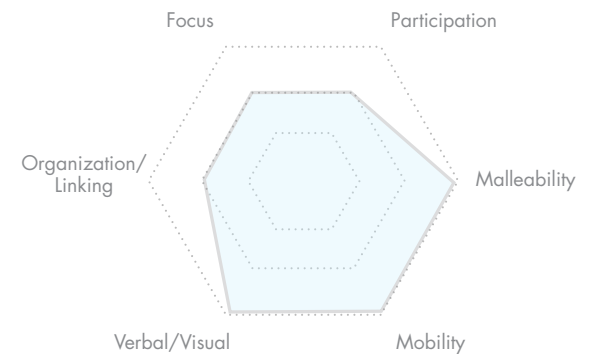
INKLING

- » Integrated digital textbook and note-taking solution: allows for annotations and free-form note-taking.
- » Interactive learning examples are helpful and takes advantage of the digital platform.
- » Allows students to share notes and participate in online discussion centered around the same text.
- » Software addresses the portability and storage problem: however, only Inkling is considering the learning perspective.

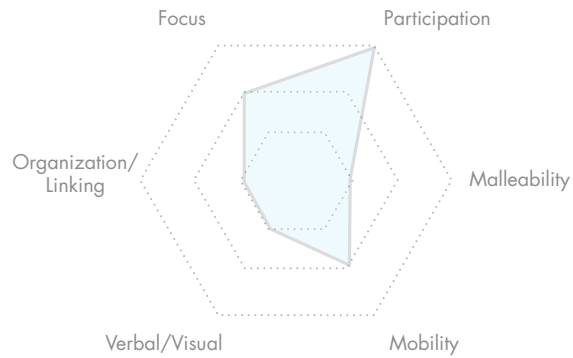
Evernote/Onenote



Notes Plus/Note Taker HD



Inkling



DEDICATED DEVICES

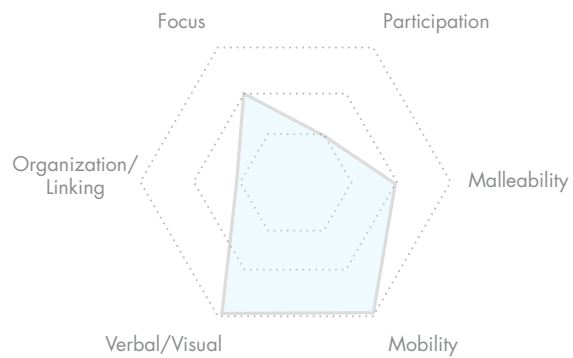
NOTESLATE

- » Low resolution and relatively low priced.
- » Aimed at note-taking and allows for handwritten notes and drawings.
- » Allows for sharing.
- » Noteslate is promising but not many features for learning.

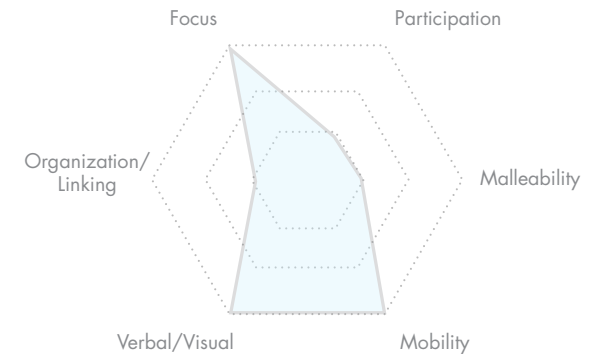
LIVESCRIBE

- » Fluid input using custom pen and paper.
- » Audio recording allows another level of context with handwriting.
- » Audio recording requires additional time to review.

Noteslate



Livescribe



DESIGN IMPLICATIONS

- » *Traditional note-taking tools are very effective for learning, but they lack in features that digital tools afford such as malleability and mobility.*
- » *The software category affords better malleability of user-inputted information and mobility of content, but lack the learning benefits of traditional tools while weak in focus and verbal/visual input.*
- » *The dedicated device category generally improve one particular deficiency but fail to dramatically improve its learning implications.*
- » *The digital note-taking tools reviewed were more focused on efficiency and mobility with no emphasis on learning.*
- » *All categories of tools did not offer different ways to organize and reorganize information.*

INSIGHTS

Concluding the exploratory research activities, I summarized my key findings into the following six insights.

1. Memorization

Note-taking is generally perceived as aiding memorization.

Notes can enable learning instead of encouraging memorization. The process of note-taking can help students sustain focus, and enable the encoding, storing, and elaboration of information.

directed storytelling, literature review, tools audit

2. Verbal Thinking

Education is often biased towards verbal thinking.

Visual ideation aids learning by translating abstract words into concrete visual forms. In fact, visual sketches complements abstract language thinking as another vehicle of thought.

directed storytelling, literature review

3. Information Structure

Students often copy information structure.

Organizing information in various ways encourages a range of connections to be made among words or visual notations. Tools can better support learning if it affords reorganization of information.

directed storytelling, literature review, tools audit

4. Pre-packaged Significance

Pre-packaged significance does not lead to learning.

Note-taking is a personal process where oneself acts as a gateway to new materials worthy of connections to existing understandings. The discovery of personal relevance is critical to learning.

directed storytelling, literature review

5. Stigma around Technology

There is a stigma around technology in the classroom.

Technology is observed to be banned in a number of freshmen seminar courses.

Technology can be more than just a distraction and benefit learning if appropriated with instructor participation.

directed storytelling, literature review

6. Learning occurs everywhere

Learning does not just happen in classrooms.

The learning culture is in a new paradigm because of technology. Learning is no longer exclusively in educational institutions. It occurs continuously and everywhere. People learn through interaction with the real world.

directed storytelling, literature review

3 Generative Research

DESIGN OBJECTIVES	35
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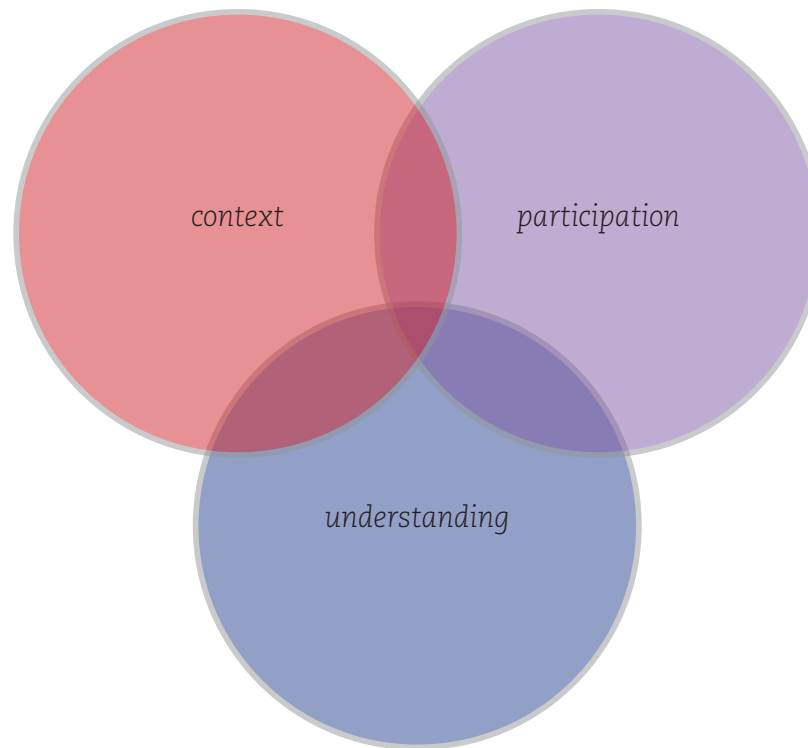
DESIGN OBJECTIVES

Using the key findings from the exploratory research activities, I want to establish a model where I could focus my investigations as I moved forward. Through the analysis of my research findings, I discovered three recurring themes that warranted attention and are described in greater detail on the following pages:

1. *Understanding: Learning is a continuous cycle and it is an experience.*
2. *Context: Learning takes place in physical and virtual contexts.*
3. *Participation: Learning is often collaborative with others who share a common interest.*

For each theme, I formed a design objective incorporating my research findings and started generating ideas about how note-taking can be designed to achieve my design objectives.

This is a model of my design objectives. The design of future note-taking tools should encourage understanding, participation in collectives, and encourage learning in various contexts.



Understanding

SUPPORT LEARNING AS OPPOSED TO MEMORIZATION

How can technology and note-taking be utilized to move people through the learning cycle?

- » *Note-taking should help students focus on organizing and linking information in various ways instead of just transcribing content.*
- » *Note-taking should encourage visual thinking in combination with written words as a better way to conceptualize.*
- » *Note-taking should allow for easy manipulation of information in order to facilitate ideation, conceptualization, and transformation.*

Derived from research insights: Memorization, Information Structure, Verbal Thinking

Context

ENCOURAGE LEARNING IN VARIOUS LEARNING CONTEXTS

How can note-taking be effectively integrated in learning contexts and aid in learning?

- » *The activity of note-taking should be visible and transparent in the environment to enable technology to integrate into the classroom.*
- » *Note-taking should be integrated into the classroom lecture and review experience to better access to its learning benefits.*
- » *Note-taking and the review of notes should be portable and embedded in learning environments such as the home, workplace, or classroom.*

Derived from research insights: Stigma around Technology, Learning occurs Everywhere

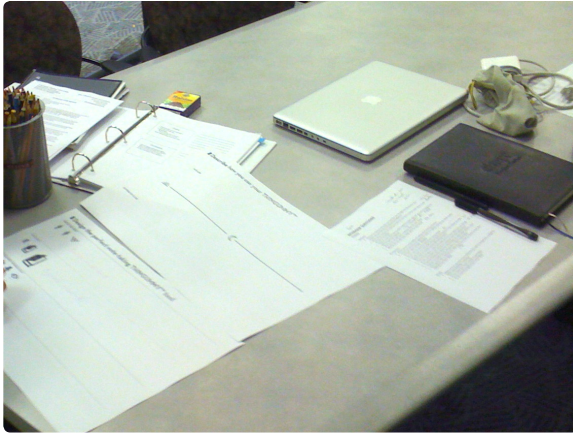
Participation

FACILITATE CONTINUOUS PARTICIPATION IN LEARNING

How can continuous collaboration among people be facilitated by technology and aid learning?

- » *Note-taking tools should support learning as a continuous life-long interest instead of solely in the educational context.*
- » *Note-taking tools should engage learners through personalizing information and connecting to their motivation.*
- » *Note-taking should support the new culture of learning by connecting individuals to a community of learners who shares a common interest.*

Derived from research insights: Pre-packaged Significance, Learning occurs Everywhere



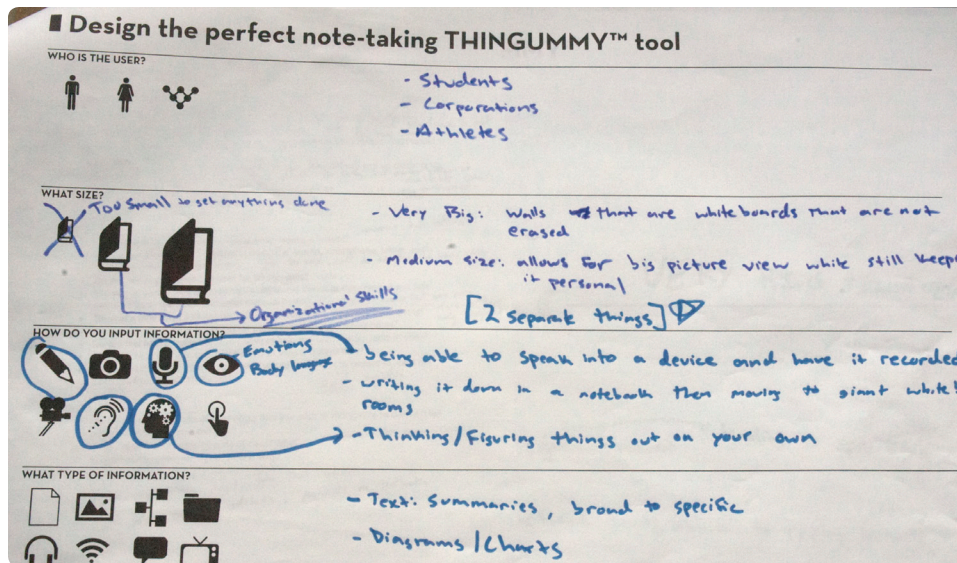
DESIGNED ACTIVITIES

Thingummy

In design research, what people say, do, and make can all reveal interesting insights into a design problem. In directed storytelling, I was able to gather what students say about note-taking. In evaluating their notebooks and examples, I was able to observe what students did in classes. In order to get another level of understanding of students' attitudes toward note-taking, I designed a generative design exercise to solicit hidden desires out of learning, note-taking, and technology through two worksheets.

The goal of this activity was to encourage students to make what they consider the ideal note-taking tool. Aside from defining what the ideal tool could be, I also asked them to think and define what time of day and how they would use it when they are in class and outside of class.

In the following sections, I will showcase three examples of the Thingummy activity I conducted with students. In all instances of this activity, participants were asked to complete the worksheets on their own and immediately after using the worksheets to explain what they drew or wrote. The stories these participants tell after the activity reveal interesting and noteworthy insights.



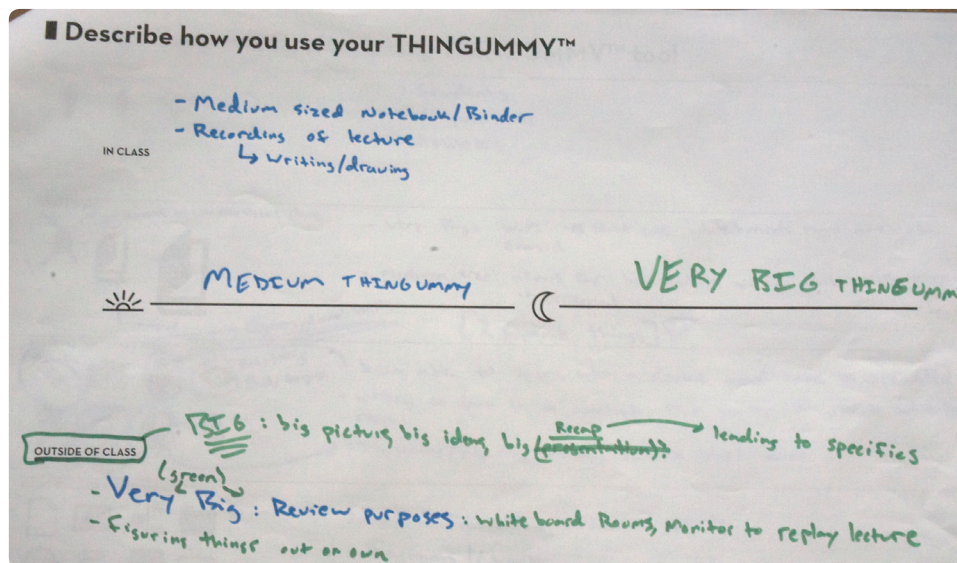
This participant was very specific in the size of the tool. He specified that the tool should come in different sizes because the larger the size, the better it is at facilitating big picture summarization. He wanted the tool to come in a medium size because that is more convenient to carry around just like regular notebooks.

The Thingummy captures all the details of the lecture because instructor body gestures are important. Sometimes based on the instructor's gestures, students can know whether something is important or not (may appear on an upcoming exam).

He explained that the very big Thingummy would primarily be used away from school when reviewing for an exam or preparing to write a paper. It would work in tandem with the medium size Thingummy. He mentioned that the medium size Thingummy would be better at capturing details while the big Thingummy would summarize those details.

"Whiteboards everywhere. put your key stuff from your medium thingy, and put this on a giant whiteboard. Go from there like the map crazy people have arrows stemming everywhere with sub ideas. It doesn't erase and just stays there. Seeing big and seeing it in front of you, sometimes when you see it front of you it jumps out at you. It will help you figure stuff out on your own. you'd be able to decipher yourself: these are my conclusions."

—Participant

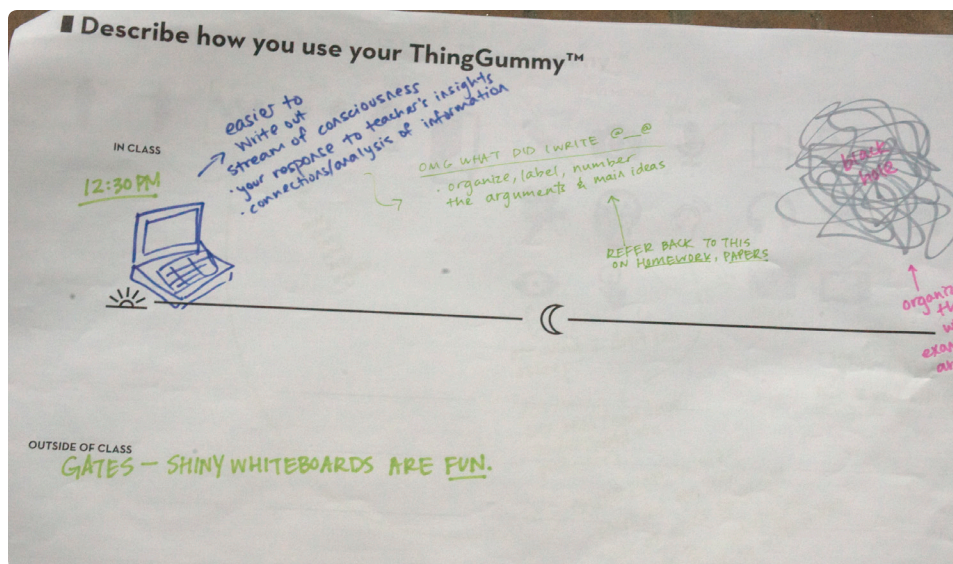
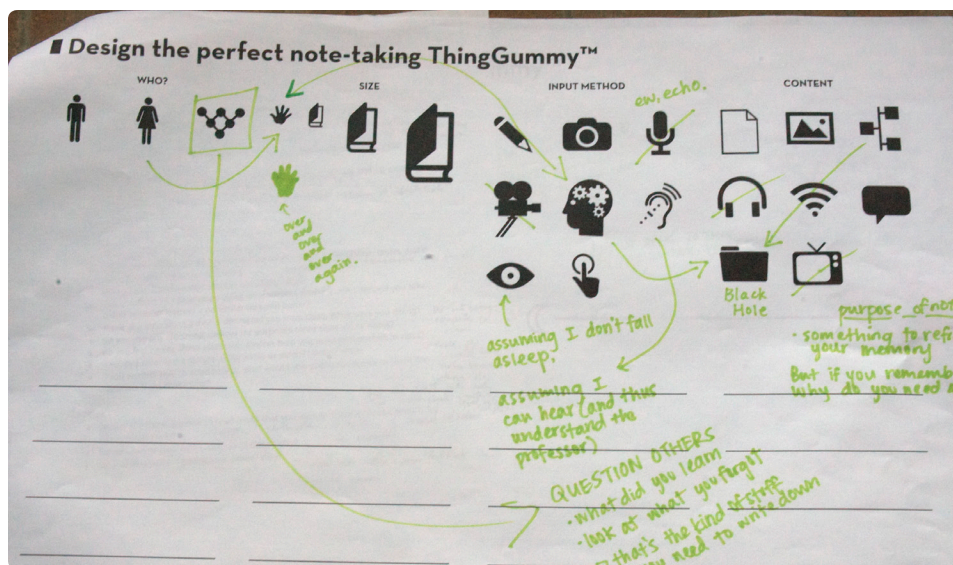


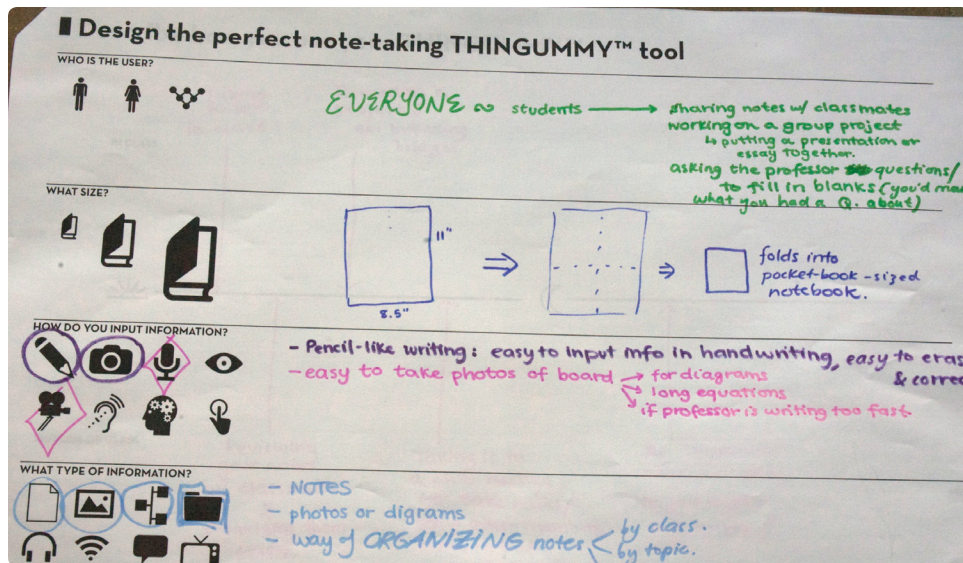
This participant wanted a Thingummy that helps people remember. Her Thingummy was essentially an information “black hole,” where everything is there and never lost. She explained that people will use it once they’ve realized that they’ve forgotten something.

In describing how the Thingummy is used, she referred to the use of a whiteboard to summarize thoughts and perform analysis on contents from the blackhole. Essentially, she wanted her Thingummy during review to make organizations, labels, and summaries of everything that happened during the day.

“If I know this stuff everything should go into this blackhole. every now and then I should go to my blackhole to see if I forgot any of the stuff.”

—Participant



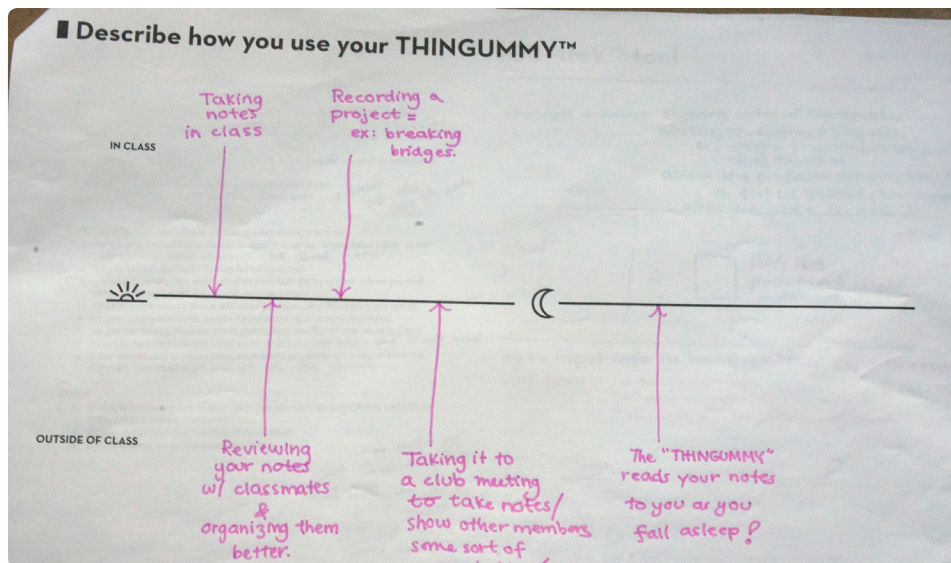


This participant had a clear idea of a Thingummy that allows for collaboration, organizing, and carrying around. She explained that it is typically hard to share notes, so this Thingummy would make working on group projects easy. She wanted the Thingummy to allow her to ask professors questions during review. As for the form-factor, the notebook would be letter-sized in normal operation but could fold into a pocket-sized notebook for ease of carrying around.

The Thingummy would be with her at all times. She would also use it for subjects outside of school such as a club meeting. She wanted the Thingummy to also read the notes back to learners as they fall asleep so they would have more time to review.

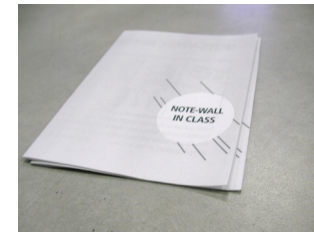
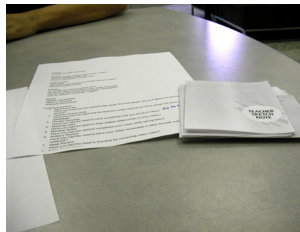
"I have one wish to stick the textbook under the pillow and have the knowledge seep into your head."

— Participant



Speed-dating

As part of the ideation process, a number of concept storyboards were generated based on the design objectives. They were then evaluated by students through a method called speed-dating, a design research method that combines needs validation and user enactment. The storyboards incorporate various note-taking features, contexts, and steps in the learning cycle. A total of 10 concepts were tested. The goals of the activity was to find out if and which any of the concepts resonated with freshmen college students and to reveal uncovered needs.

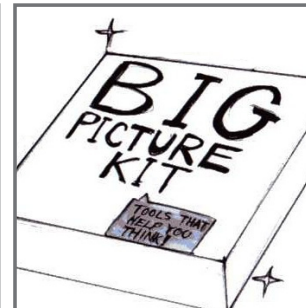


BIG PICTURE KIT (CONCEPT BASED ON DESIGN OBJECTIVE: UNDERSTANDING)

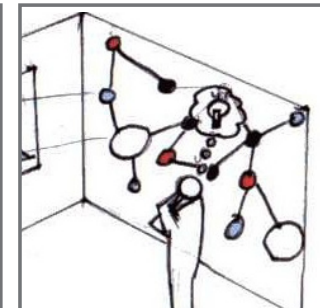
Do you find yourself needing to step away from the details when reviewing notes?



Jamie has a big exam tomorrow and is struggling to memorize everything.



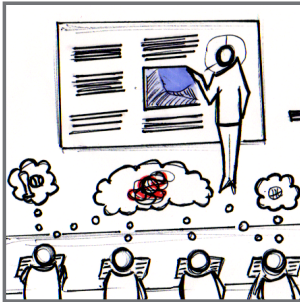
Jamie uses the "Big Picture Kit" which is a set of tools that helps to see the big picture and connect the dots.



Jamie uses the kit and constructs a map that becomes a study aid.

TEACHER SKETCHNOTE (CONCEPT BASED ON DESIGN OBJECTIVE: UNDERSTANDING)

Do you perceive the need for teachers' notes to be more visual? Or more visually appealing?



Everyone is so confused by the things the professor writes on the board. The notes just doesn't make sense!



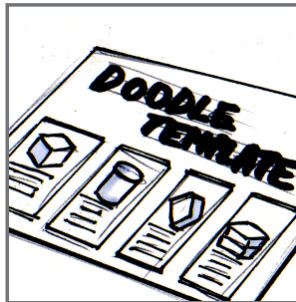
The next day, the professor draws a sketchnote to teach students the concepts and how they connect to each other.

DOODLE TEMPLATE (CONCEPT BASED ON DESIGN OBJECTIVE: PARTICIPATION)

Do you find yourself needing something to help you focus in class?



It's hard to focus and listen to the lecture sometimes. Jamie end up day-dreaming or the mind just wanders.



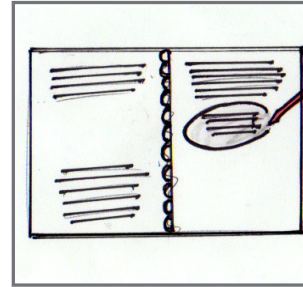
The doodle template keeps Jamie busy so Jamie's mind stays focused in class.

MOVABLE NOTES (CONCEPT BASED ON DESIGN OBJECTIVE: UNDERSTANDING)

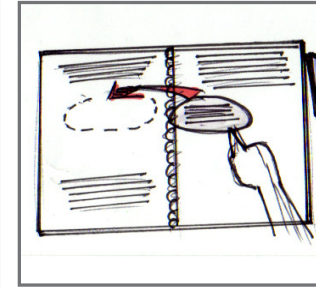
Do you find yourself needing to reorganize your notes while taking them?



Jamie is taking notes in class but realizes that something is out of order.



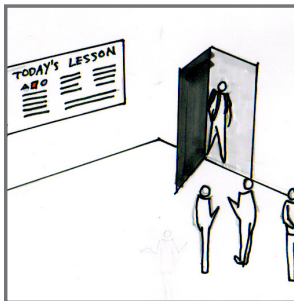
Jamie circles the part that seems out of place.



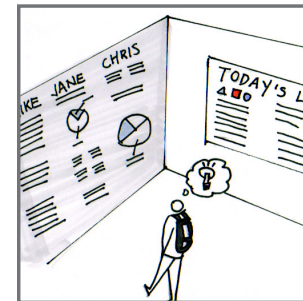
Jamie's noteboard allows Jamie to lift up notes and move freely to any place.

NOTE-WALL IN CLASS (CONCEPT BASED ON DESIGN OBJECTIVE: PARTICIPATION)

Do you find it better to learn from peers and on your own rather than attending to a lecture?



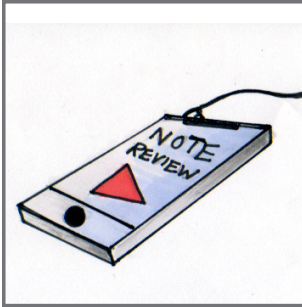
Jamie arrives to class late. Jamie was worried that the lecture has started already and he will miss something important in the lecture.



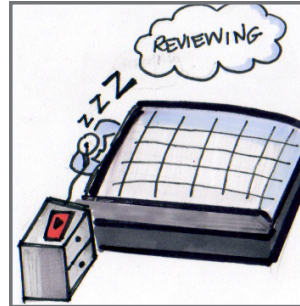
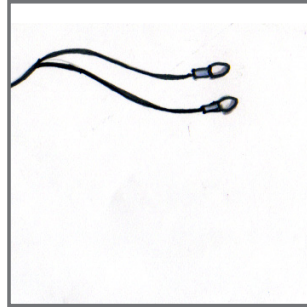
However, Jamie recalls that this is a special course without a lecture. Learning occurs by seeing everyone's notes on the wall.

SLEEP REVIEW (CONCEPT BASED ON DESIGN OBJECTIVE: UNDERSTANDING)

Do you see the need to use sleep to learn?



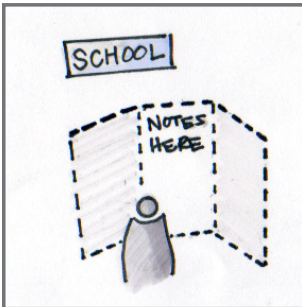
Jamie has notes available anywhere, but struggles to find time to review them. Jamie doesn't find note-taking useful and is thinking about not taking notes at all.



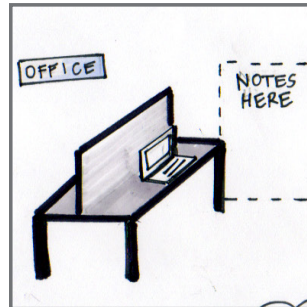
Jamie uses the feature where the notes are being reviewed while Jamie sleeps.

NOTES EVERYWHERE (CONCEPT BASED ON DESIGN OBJECTIVE: CONTEXT)

Do you need access to your notes while you are away from school or where you usually study?



Jamie has notes available at school to study. But Jamie doesn't just study and learn from school.



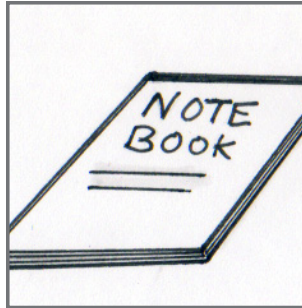
Notes are also available at Jamie's workplace to help Jamie think.



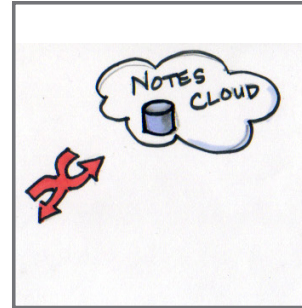
Fortunately, Jamie can access and project notes on any surface anytime and on-the-go to facilitate learning.

AUDITORY REVIEW (CONCEPT BASED ON DESIGN OBJECTIVE: CONTEXT)

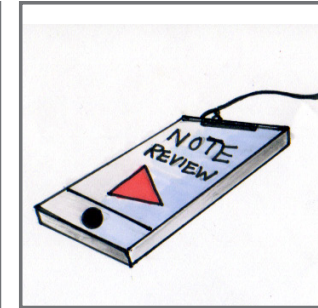
Do you need your notes reviewable in other formats outside of your notebook?



Jamie doesn't carry the notebook everywhere. Especially notes of the past.



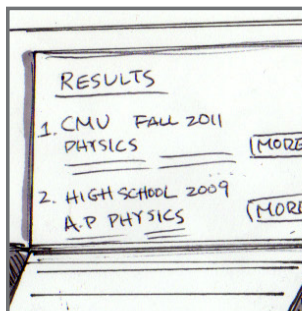
Thankfully, Jamie's notes are saved and available anytime, anywhere.



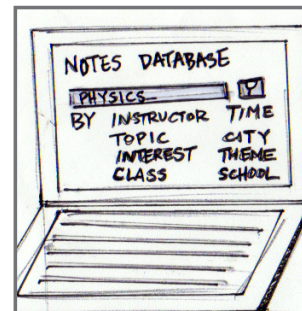
Jamie's favorite feature is how the notes can be read back like a podcast when Jamie's on-the-go.

SEARCH YOUR NOTES (CONCEPT BASED ON DESIGN OBJECTIVE: UNDERSTANDING)

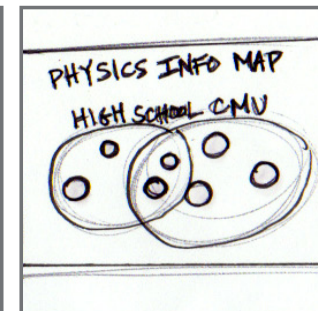
Do you need to find old notes and reflect upon your overall learning?



Jamie is trying to lookup old class notes because he thinks it may help with his hobby project.



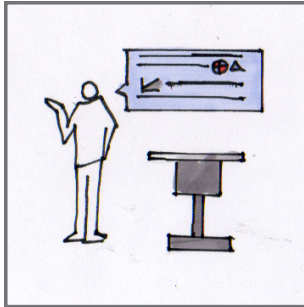
The Notes Database contains all the notes Jamie has ever taken and allows searching by various categories.



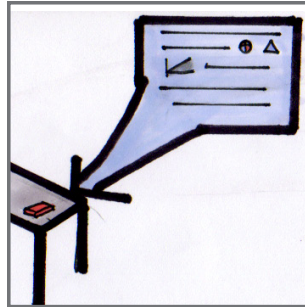
The Notes Database not only finds Jamie's high school Physics notes but also shows how they connect to his notes on the hobby project.

NOTES RECOGNIZER (CONCEPT BASED ON DESIGN OBJECTIVE: UNDERSTANDING)

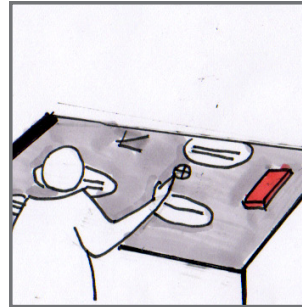
Do you find taking notes distracting and interfering with your ability to focus and learn?



Jamie is in class. Jamie dislikes taking notes because it is hard to keep up with the pace.



The “Notes Recognizer” helps Jamie transcribe class lectures automatically.



Jamie no longer needs to copy things down, but just spends time organizing and annotating as needed.

ANALYSIS

After each storyboard was shown, I asked each participant to fill out a questionnaire to rank the concept. The results showed that some of the ideas I thought would score well like “Notewall in class” or “Notes Everywhere” did not resonate with participants. This finding also points to organization as a key desirable feature lacking in current note-taking tools and the importance of visualizing abstract concepts or big picture ideas. It suggests that students are open to more creative ways to review notes such as audio review or large-scale notes projection in public spaces. At this point of the project, I aimed to incorporate these desirable features into my final solution.

How well does the proposed concept address the challenge?



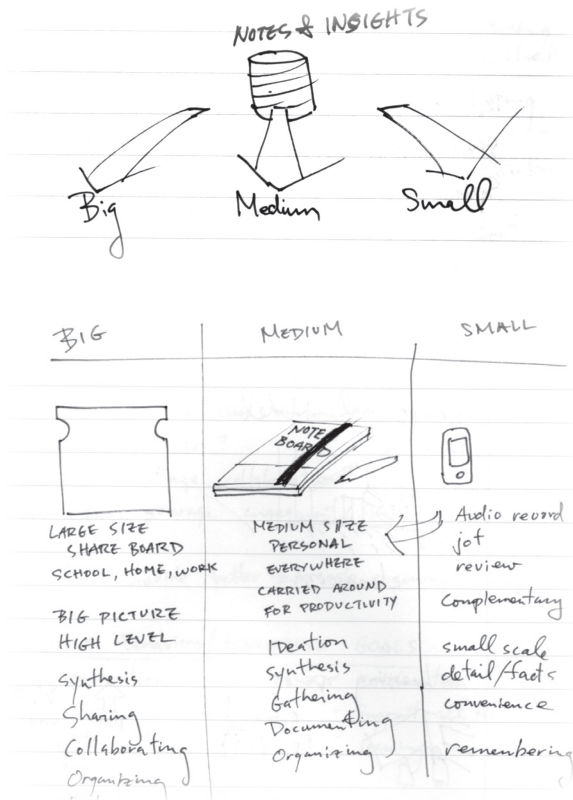
This graphic is a visual summary of the concept test results. Each concept was rated an value between 1–5 by participants where the higher the value the better it was perceived to address the challenge the concept posed by participants.

IDEATION

Early sketches

In the early stages, I tried to integrate the speed-dating concepts based on the test results. The concepts that had the strongest reactions were Big Picture Kit, Teacher Sketch Note, Notes Recognizer, Search your notes, and Movable Notes. I started to think about the physical form since I will use that to inform the software experience. I've learned from my research that the size of the surface will afford different type of thinking activities. See the next subsection for details on the form. Regarding the software, I did quick sketches in my notebook and then made a quick mockup of what I think the Notes Recognizer would look like. See **ROUGH MOCKUP** on the next page for my initial ideas for the interface.

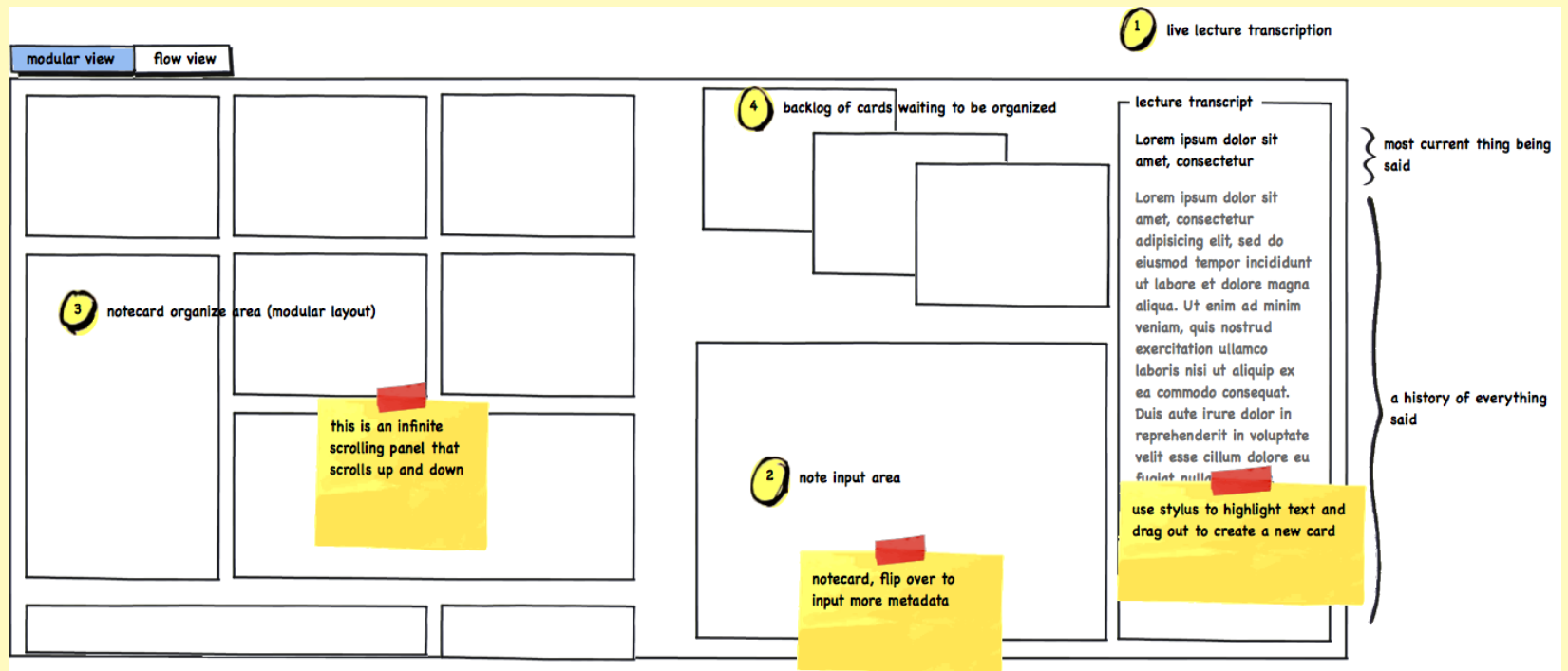
The rough mockup gave me enough feedback to design the software experience in a higher fidelity. After a couple iterations, the wireframes were printed out as a paper prototype for a public poster session along with the experience prototype to get more feedback. See **FIRST ITERATION** and **SECOND ITERATION** for screenshots.



Different physical form affords specific learning activities. I did a quick analysis in this sketch to determine that the note-taking tool should be a medium size tool.

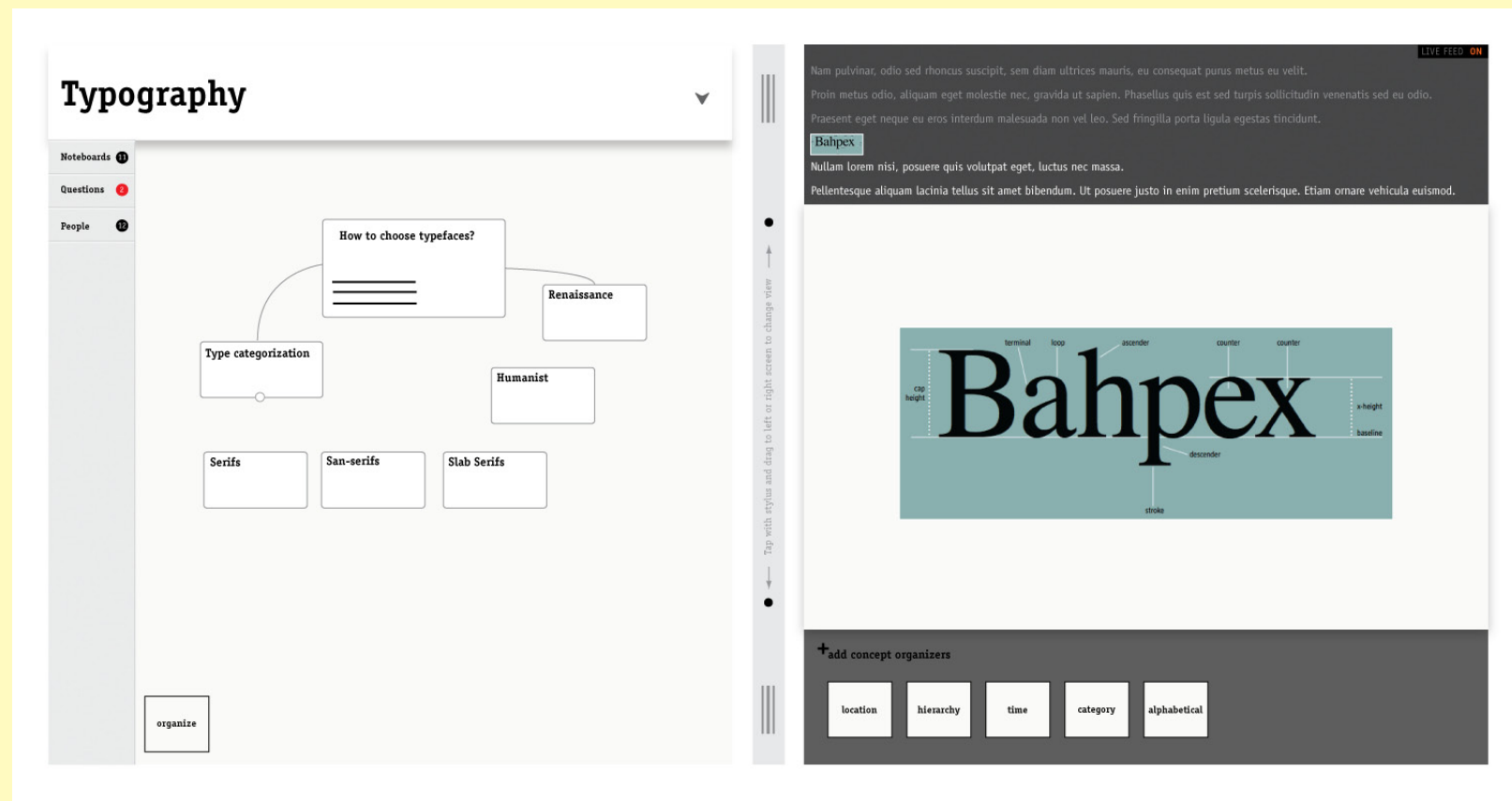
ROUGH MOCKUP

The rough mockup was done really quickly to get a sense of what UI components were needed for the page. With this quick mockup, I was able to get some quick feedback and move to a higher fidelity prototype. One of the key realizations was that multiple views and the “cards” metaphor can be confusing. My goal was to simplify this interface to be as straight-forward as using pen and paper.



FIRST ITERATION

In the first iteration, I played around with a draggable spine that allowed resizing of the two panels. I decided to drop the feature in later iterations since it wasn't crucial to the core scenarios.





Elements of type



In typography, a counter or aperture is an area entirely or partially enclosed by a letter form or a symbol.



RESPONSE FROM Brandon Young

Q: How do I apply Kevin Lynch's theory on design of city to my layout?



I would try to first figure out what are the components, or rather your content before you try to attempt layout. Figure out the logical parts first, and let the inherent relationship inform the layout. To apply Kevin Lynch's theory, start thinking about landmarks, edges, paths. Which parts of your content would categorize under those definitions? Let me know if this doesn't make sense.

Today at 9:20 PM



When combining the heights and characters

The x-height or corpus size is the distance from the baseline to the mean line of the x-height.

COMMUNITY

NOTEBOOKS

DOMAIN

Typography

DISCUSSIONS

PEOPLE

+ START A DISCUSSION

Elements of type

Kevin Lynch

LATCH

Visual vocabulary

Interaction/Experience

Grid/Layout

4

2

9

10

2

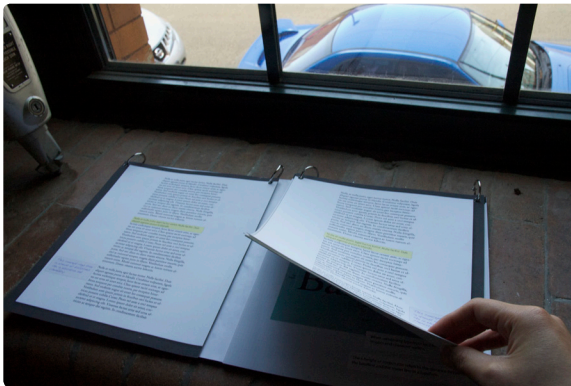
6

SECOND ITERATION

I started to flesh out more of the community aspects of the software experience. At this stage, I realized that storytelling is a powerful way of explaining an approach or asking a question to facilitate learning.



The experience/paper prototype I made using foam core, rings, and printed interface mockups. It successfully confirmed that the physical size works. The spread measured 20 x 11 inches. When folded, the prototype measured 9.5 x 11 inches.



I was able to see how a spread worked as an interface working with a paper prototype. I was able to swap various screens to try out different screen configurations with the clip rings.

EXPERIENCE PROTOTYPE

To enable evaluation, solicit feedback, and refinement, a physical prototype was built. The physical prototype is low in fidelity but enabled evaluation on the physical form. A number of physical forms that were considered. Using the insights from the tools audit, I choose the form for the experience prototype.

LAPTOP/DESKTOP/NETBOOK

A traditional desktop computer with an upright display, keyboard and mouse was considered. However, it is inadequate for many reasons. 1) It is not portable. My research insights suggest that learning occurs everywhere therefore, mobility is very important to allow learning as individuals interact with the world. 2) The traditional desktop software experience encourages multitasking, which may make focusing difficult in class. 3) The upright screen acts as a physical barrier between the student and the instructor. It is easy for students to hide behind the screen and get distracted by the computer. Although laptops and netbooks are portable but their upright screens do not satisfy the focus criteria.

SMARTPHONE/POCKET DEVICE

Smartphones are becoming more ubiquitous among college students. Their widespread popularity may them appealing as new learning tools. Although they offer the best form to mobilize digital experiences, pocket devices such as the smartphone often provide passive experiences (i.e. consuming content) rather than active experiences (i.e. data entry). The screen is too small to afford verbal/visual input, malleability and organization of content.

TABLET

Tablet devices such as the iPad are becoming more popular with schools and students. They afford both great active and passive experiences while being portable. Without an upright screen, the tablet makes the activity of learners transparent to the instructors. However, their small screen size is still a drawback. Although larger than a smartphone, they do not afford an adequate drawing and writing surface for diagramming.

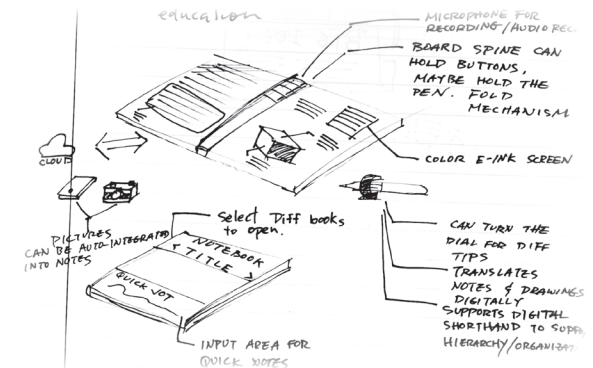
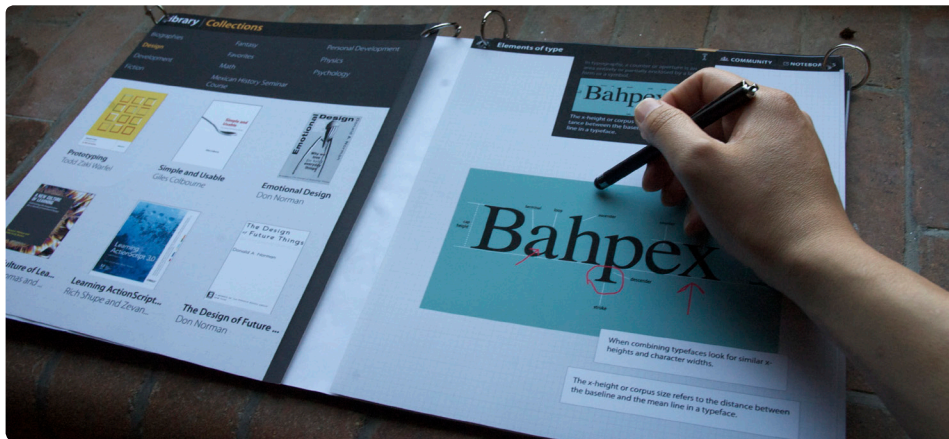
BOOK

I also evaluated traditional forms such as whiteboards or tabletop computers.

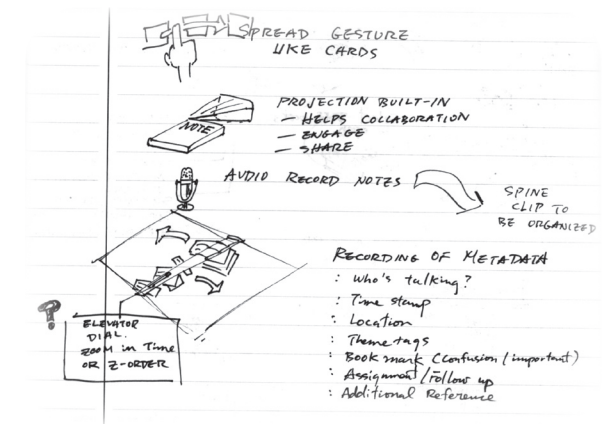
IDEATION

However, I was drawn to the physical form of a book because of the interaction it affords. The form of a book is portable since it fits in a backpack. Obviously books come in many shapes and sizes but a medium-sized notebook offers a comfortable writing and drawing surface.

Working with a new form is definitely more challenging than leveraging a proven platform or hardware. The physical form factor was successfully simulated through the experience prototype. The size of the digital notebook will fit in a backpack and the size of the writing surface is large enough for writing, drawing, and diagramming.



Initial sketching of a device that were inspired by the Microsoft Courier concept.



A number of sketches aided the development of tool features, such as this one that addresses the possibility of portable projection of notes.

INSIGHTS

Many valuable insights were gained from the generative research phase. First, the Thingummy participatory design activity confirmed many of the key findings from the exploratory research phase. It confirmed that note-taking should allow for collaboration and note-taking is not just for memorization. Also, the use of whiteboards or larger surface areas affords more “big picture” thinking.

In speed-dating, I found that participants desired different ways to organize their notes or to be able to quickly arrange notes in real-time. Also, participants found certain levels of automation such as transcription or digital syncing desirable.

Finally, the experience prototype with interface mockups informed key insights about the physical size of the device. The size I came up with is about the size of a file binder. The device can open up as a spread which afforded a large writing and drawing surface.

4 Design Implementation

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DESIGN FRAMING

After speed-dating, I continued to develop concepts that incorporated all of my design objectives that may work together as a cohesive system. To accomplish this, I referenced the 4MAT learning theory as a framework to design for meaningful learning. I then mapped features to the framework to ensure each component had learning benefits and that it addressed a range of the preferences of learner types.

The resulting design proposal, named kekulé, is a tablet device that is designed to enhance learning through note-taking. The artifact resembles a traditional book as a means of preserving the benefits of conventional note-taking. Having the book form factor offers a 2-screen spread that can facilitate both verbal and visual note-taking activities. A digital stylus serves as the primary input method, providing precision and flexibility between verbal and visual input methods similar to traditional pen and paper note-taking. I designed kekulé to excel beyond traditional notebooks by integrating individual learners with their physical learning environments and their respective community of learners.

Design Framework

McCarthy's 4MAT learning framework is used as a basis for this thesis, providing a framework for learning that informed the design of the digital notebook. According to McCarthy, learning is a continuous cycle with four core stages. Learning as deep understanding requires movement through the cycle where learners perceive and process information in a variety of ways despite the fact that individuals may identify more closely with one of the four stages based on individual learning preferences. The solution framework describes how kekulé's features were conceived with consideration to individuals' learning preferences.

For each learner type, I considered students' learning needs and obstacles. Once the needs and obstacles were understood, the learner types were used to develop personas and usage scenarios.

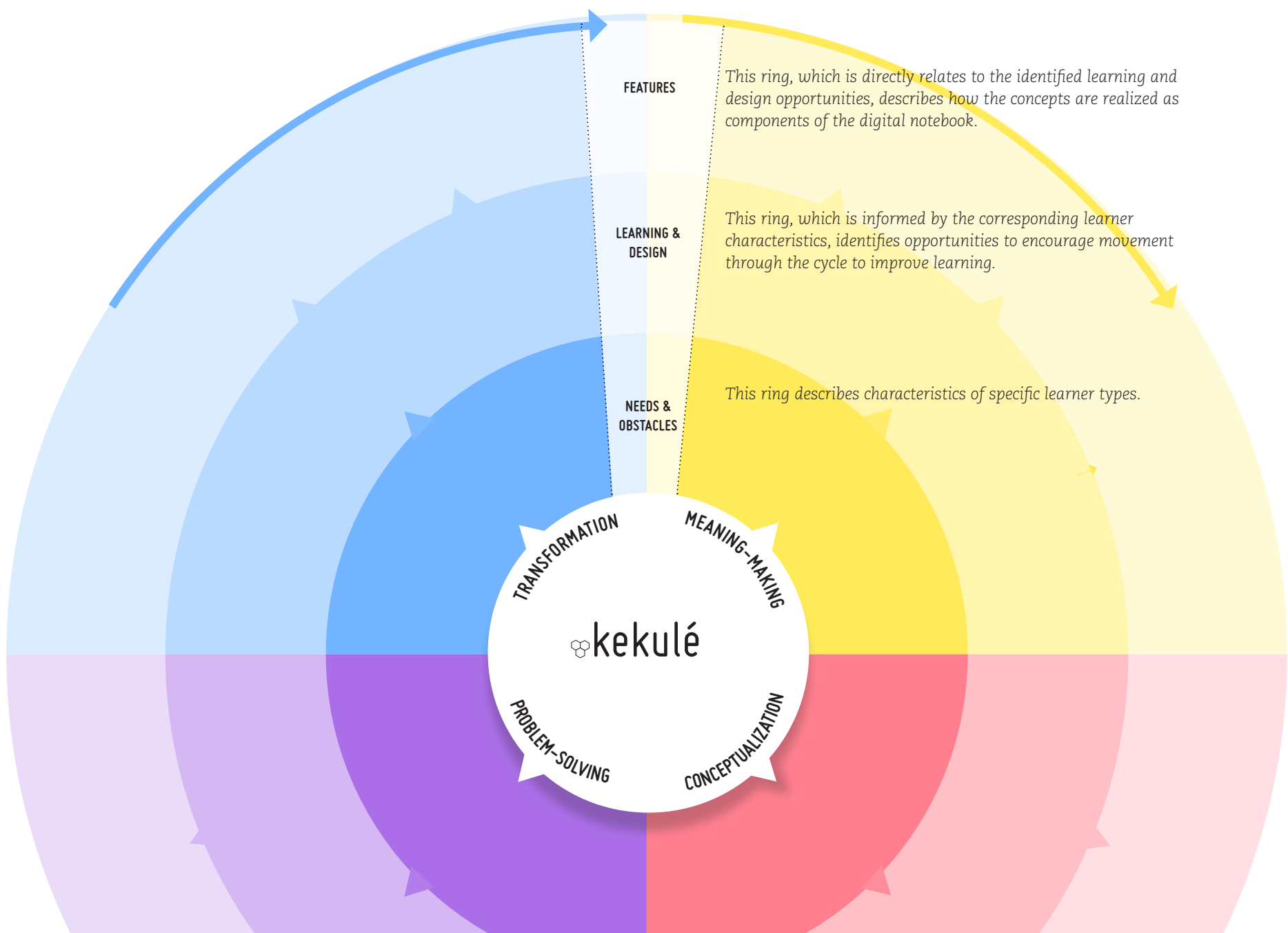
The following page I show a visual diagram of how I developed kekulé based on each of McCarthy's learner types. Reading starts from the center of the diagram and then outwards where the inner rings inform subsequent outer rings.

What is kekulé?

The name that encompasses the entire design concept is a German organic chemist named Friedrich August Kekulé von Stradonitz who discovered the solution to his problem through his dream. He discovered the Benzene structure through a dream of a snake biting its own tail. It's been commonly referred to the most important dream in history. I like the fact that this story hints at learning occurs both subconsciously and consciously, and that creativity and visual thinking occur at the subconscious level. Thus, his names seems fitting as a title for my prototype.



McCarthy's learner types were used as a design framework to conceive kekulé as a system that can move all individuals through the cycle of learning.



NEEDS

Imaginative learners tend to make meaning in nurturing, open environments where subjectivity is honored.

OBSTACLES

Imaginative learners tend to stumble when challenged to learn something quickly because they need to translate information into something they can sense and feel. They also have a tough time experimenting as a means of learning because they often prefer to simply reflect on the information they encounter.

OPPORTUNITIES

- » *The learner should feel that subjectivity is honored and also appreciated. Thus, the tool should support physical and virtual group discussions and brainstorm.*
- » *The learner should feel competent in organizing information in various structures. Therefore, the tool should enable organizing of notes and information through various information structures such as time, location, hierarchy, category.*
- » *The learner should feel learning is personal and integrated into everyday life, not just in academia. Thus, the tool should support any kind of notes scalable to a learner's lifetime.*

FEATURES

- » *Noteboards are digital notes that are capable of containing handwritten notes, drawings, annotations, and other visual aids. Noteboards can be created individually or collaboratively when in the physical context. Noteboards help support the open and nurturing environment where subjectivity is key.*
- » *Organizers are virtual information containers that note-takers can use to display notes in various ways such as chronologically, geographically, hierarchically, or categorically. Multiple organizers can be used on the same set of notes which helps Imaginative learners to encode information.*

IMAGINATIVE LEARNERS

Imaginative learners are sensory thinkers. They rely on their feelings of the present through outstanding observation, and establish personal meaning through deep reflection.

ANALYTICAL LEARNERS

Analytical learners are conceptual thinkers. They are comfortable in dealing with complex information and are able to conceptualize meaning out of content through organization and analysis.

NEEDS

Analytical learners tend to prefer learning environments where facts are given in a formal, structured fashion.

OBSTACLES

Analytic learners tend to focus on details and therefore it is often difficult for them to see the larger picture. Their need for precision and certainty makes it hard for them to understand subjectivity and creative spaces.

OPPORTUNITIES

- » *The learner should feel relieved from copying notes, but focuses on perceiving and processing the information. In support of this, the tool should be able to disassemble lectures into parts (i.e. text, visual aids) that is capable of being annotated or transformed by the learner.*
- » *The learner should feel free from the constraints of technology to input verbal or visual type of notes. Therefore the tool should allow flexibility of input to support verbal and visual thinking modes.*
- » *The learner should feel comfortable and confident in venturing into action or skills development. In aid of this, the tool should integrate resources that represent expert opinions to provide necessary data for move forward in the cycle.*

FEATURES

- » *Livefeed is a feature that is integrated into each Noteboard where live lectures can be transcribed into text and visual aids can be sync to each notebook. This frees up the Analytic learner from copying notes so the focus can be interpreting and processing the information.*
- » *Stylus is a physical pen that allows learners to write, draw, annotate, and highlight in noteboards. It supports precision and flexibility of input and helps learning by exercising both verbal and visual thinking modes.*
- » *Library and web are components of the system to bring external learning materials into Noteboards. Library contains articles, papers, and textbooks in electronic forms. Web allows access for the learner to retrieve any information that exists on the Internet. Library and web are fully integrated with Noteboards so that annotations, highlights, and notes made in textbooks or web pages can be brought into learners' notes.*

NEEDS

Common sense learners tend to prefer experiential learning activities where they can try things out and learn through understanding how things work.

OBSTACLES

Common sense learners are often skills-oriented so they can seem impersonal at times. They are driven by productivity so at times they have trouble honoring the time others need to discover things for themselves.

OPPORTUNITIES

- » *The learner should feel comfortable in experimenting with new variables to simulate different outcomes. Therefore, the tool should encourage collaboration even when away from the classroom.*
- » *The learner should feel productive even when not directly developing skills but in perceiving new information. Thus, the tool should allow kinesthetic interactions when manipulating content.*
- » *The learner should feel supported when encountering an obstacle during skills development. In aid of this, the tool should allow real-time feedback or assessment during skills development.*

FEATURES

- » *The learner can identify other individuals either as an expert or peer within a domain. This helps the Analytical learner by providing timely feedback, assessment, and coaching even when away from the classroom.*
- » *Noteboards follow a canvas-like layout system so notes are organized spatially. Learners can utilize the stylus or touch to manipulate the position of the notes for reorganization. The act of kinesthetic organization allows learners to keep focus even when no writing or copying is needed (via Livefeed).*
- » *Community is a social learning feature that is integrated with physical learning environments. It can create an intimate social learning networks based on any domain of knowledge. The network will connect peers in the same physical context (i.e. classroom) and also allow other individuals to be added virtually.*

COMMON SENSE LEARNERS

Common sense learners are practical thinkers. They are comfortable in applying theory into action. They learn new material by playing, doing, and figuring out how it works.

DYNAMIC LEARNERS

Dynamic learners are sensory tinkerers. They are comfortable in integrating their current experience with action. They learn through trial-and-error and are highly intuitive.

NEEDS

Dynamic learners tend to prefer learning environments which facilitates the ease of experimentation with different variables.

OBSTACLES

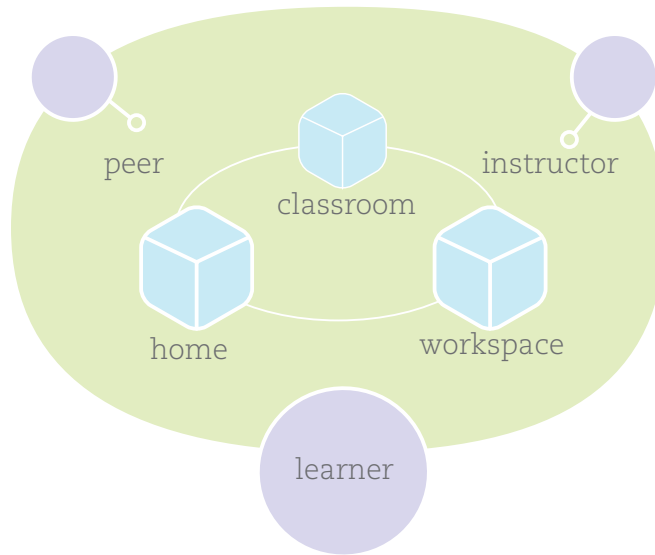
Dynamic learners tend to have challenges developing focus and reflect on their actions because of their preference to experimentation. They also have a difficult time going deeper into subjects because they are driven by what they feel and sense which makes it hard for them to think in the abstract.

OPPORTUNITIES

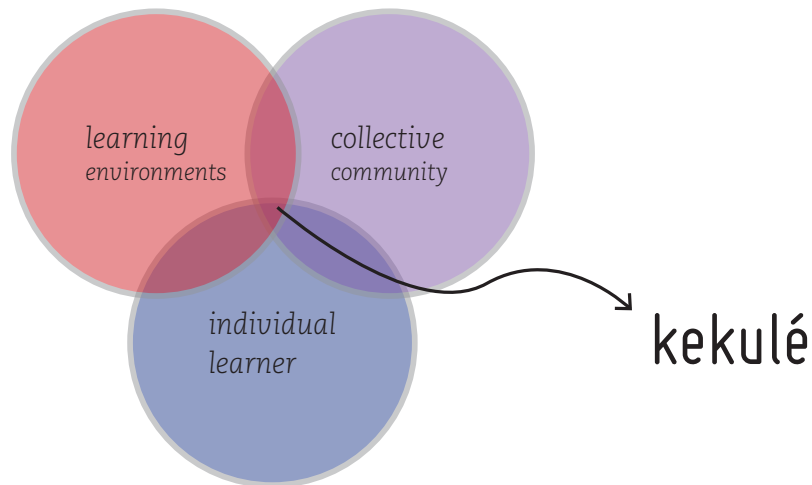
- » *The learner should not feel compelled for immediate action but retain focus in order for more reflection. Therefore, the tool should aid focus and make the act of note-taking visible in classrooms.*
- » *The learner should know when to stop and reflect on his or her actions. Thus, the tool should help the learner gain insight through shared knowledge from a community.*

FEATURES

- » *The form factor of the device resembles a physical book. When opened as a spread, it is a full tablet device. The form factor differs from a laptop because it allows for transparency of student activity which will encourage students to stay focused in learning activities.*
- » *Using the community feature, the Dynamic learner can start discussions and have a conversation space for experimentation. Noteboards and screen capturing can be embedded in discussions allowing learners to articulate their concepts or questions.*



The territory map was developed as a result of my understanding of learning contexts through my research. This model communicates the people and places that inform the design direction of this thesis.



Kekulé aims to aid learning through interaction between the learner and all learning environments while connecting to a group of individuals who share a common learning interest.

DESIGN ARTIFACT

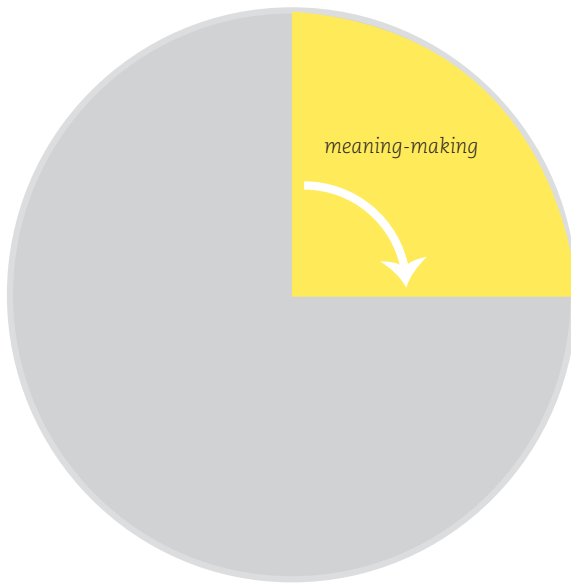
Personas & Scenarios

The design framework is a result of the integration of the learning framework and my design objectives. As a means of contextualizing the use of the note-taking tool by various learner types, I developed personas and scenarios..

JEREMY

1. Jeremy is taking a physics class as part of fulfilling required courses. He has trouble relating to physics because he doesn't know why he's learning it and how it can be useful. The tool helps Jeremy record and review his life goals and aspirations. It also encourages him to connect what he does with his life to how they accomplish his life goals.
2. In class, Jeremy brainstorms on how the physics lessons connect to basketball. He was able to relate acceleration to how he shoots a jumpshot. He captures his ideas and draws connections.
3. In the classroom, Jeremy uses the shared boards in the classroom to collaborate and share his ideas. He and his classmates are able to transfer their own notes from their personal tool to the shared board. The results of the collaboration can then be linked back to Jeremy's tool.

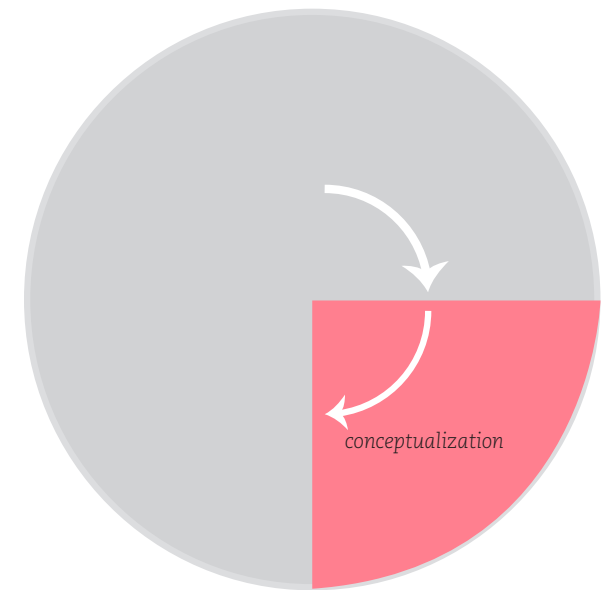
Jeremy is a freshman economics major student who is also participating in collegiate sports. He is a competitive player and works really hard to improve his game. His dream is to one day become a professional athlete.



LILY

1. Lily is taking a history class. She's trying to keep up with the pace of the lecture since the instructor is introducing a lot of new terms and ideas pretty quickly. Lily uses the tool so she does not have to focus on copying facts but spends more time listening and processing while quickly arranges the notes spatially and jotting important thoughts occasionally.
2. When Lily has a spare moment, she is creating metadata for the lecture material such as creating timelines and category organizations. Based on her organization and connecting different concepts, she's able to grasp the big ideas in the course faster.

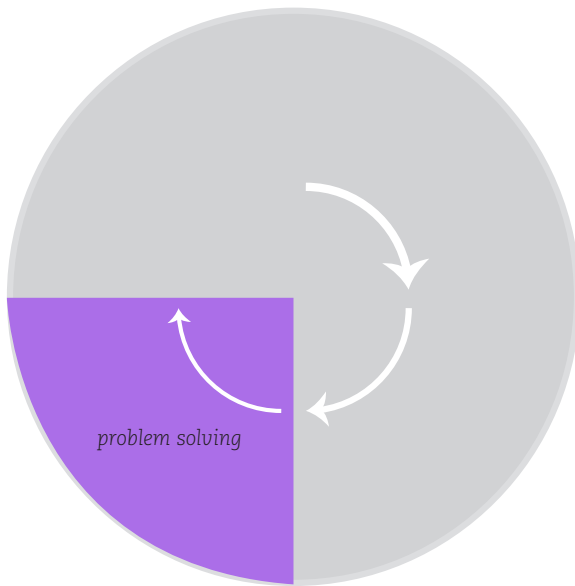
Lily is a freshman mechanical engineering major student who has had a stellar academic track record in high school. She is a hard working student and works very well in traditional school systems. However, she's unsure that mechanical engineering is what she wants to do because she has a tough time relating school work to the outside world.



Les is a freshman student in fine arts. He had a difficult time choosing his major because he has many interests. He ultimately decided to major in fine arts because he likes to make things.

LES

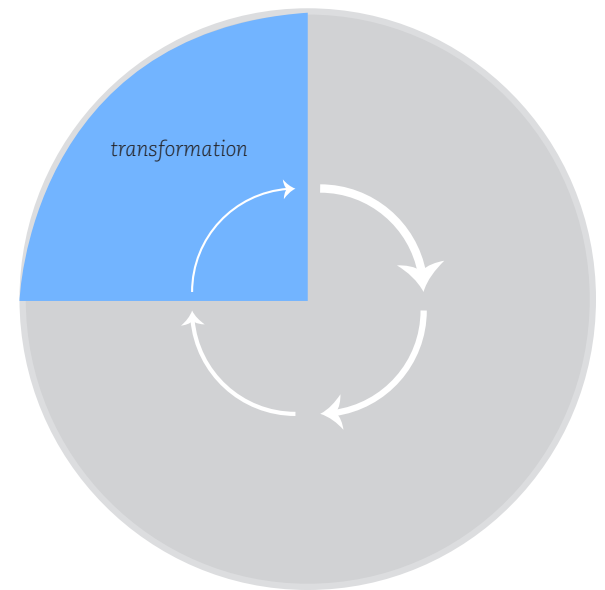
1. Les is taking a design class and is trying to learn the concepts in class through diving into the learning how to use a number of new software applications required for the class. Les runs into a number of roadblocks while learning the new software. When this happens, it becomes challenging for Les to get the learning objective of the class.
2. He uses his tool to connect to his classroom peers and experts in order to get immediate help. He raises his question and almost in real-time, he gets a response from one of his peers that gets him out of the roadblock. Les realizes that participating in the community is helpful for him as well as for his peers to he monitors the community as they progress through the same course, helping out others when he knows what to do.



DANIEL

1. Daniel built a toy as part of a class project, but Daniel was never quite satisfied with it. He hopes to extend his toy on his personal time. Using his tool, Daniel is connected to his class instructor and his past classmates.
2. Daniel's learning network has expanded since he got in touch over the internet with two others who are also interested in building interactive toys.
3. Daniel is able to share his progress and future ideas as well as evaluate other people's progress. The community is a source of feedback, encouragement. Most importantly, it creates an opportunity for him to reflect on his actions. His notebook connects Daniel to a community of learner similar to himself and provides a platform to reflect on his actions.

Daniel is a freshman student double majoring computer science and a minor in business. He is an avid gamer but has big dreams of one day starting his own business.



Interface Design

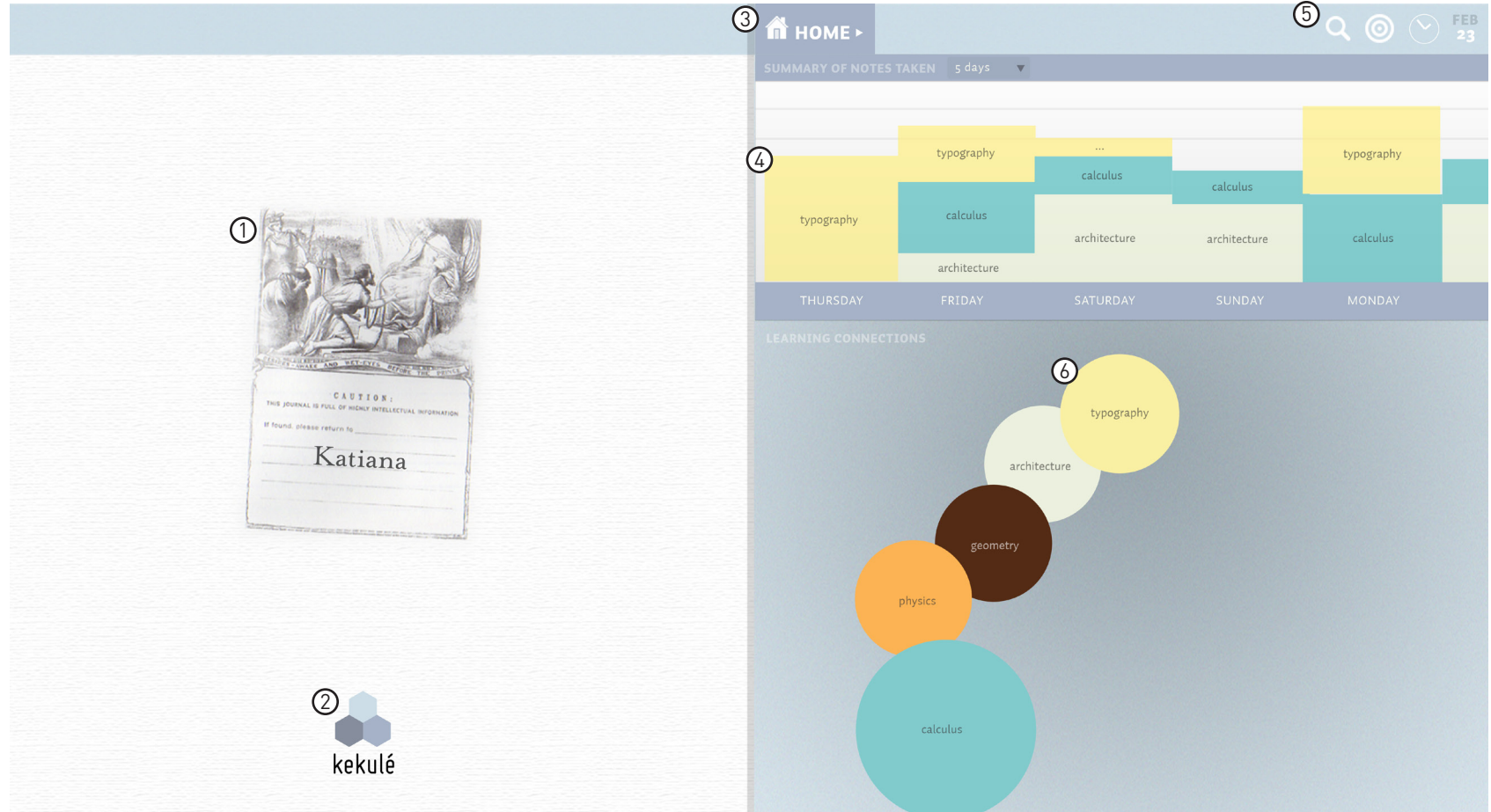
Although certain features were designed for a particular learner type, they are intended to work for any learner type since all learners are encouraged to go through the cycle. In order to demonstrate learning benefits and the proposed features, I collated the scenarios into a single persona. Using this single persona, I designed interfaces that encapsulates the proposed features.

The subsequent section includes a walkthrough of the learning scenario using the primary persona, Katiana, to demonstrate the features.

① Once the book has been opened, Katiana sees this token notifying her that this is her personal digital notebook.

② This is the kekulé logo.

③ The home tab serves as the default screen for kekulé. It is a learning dashboard that summarizes the notes she takes.

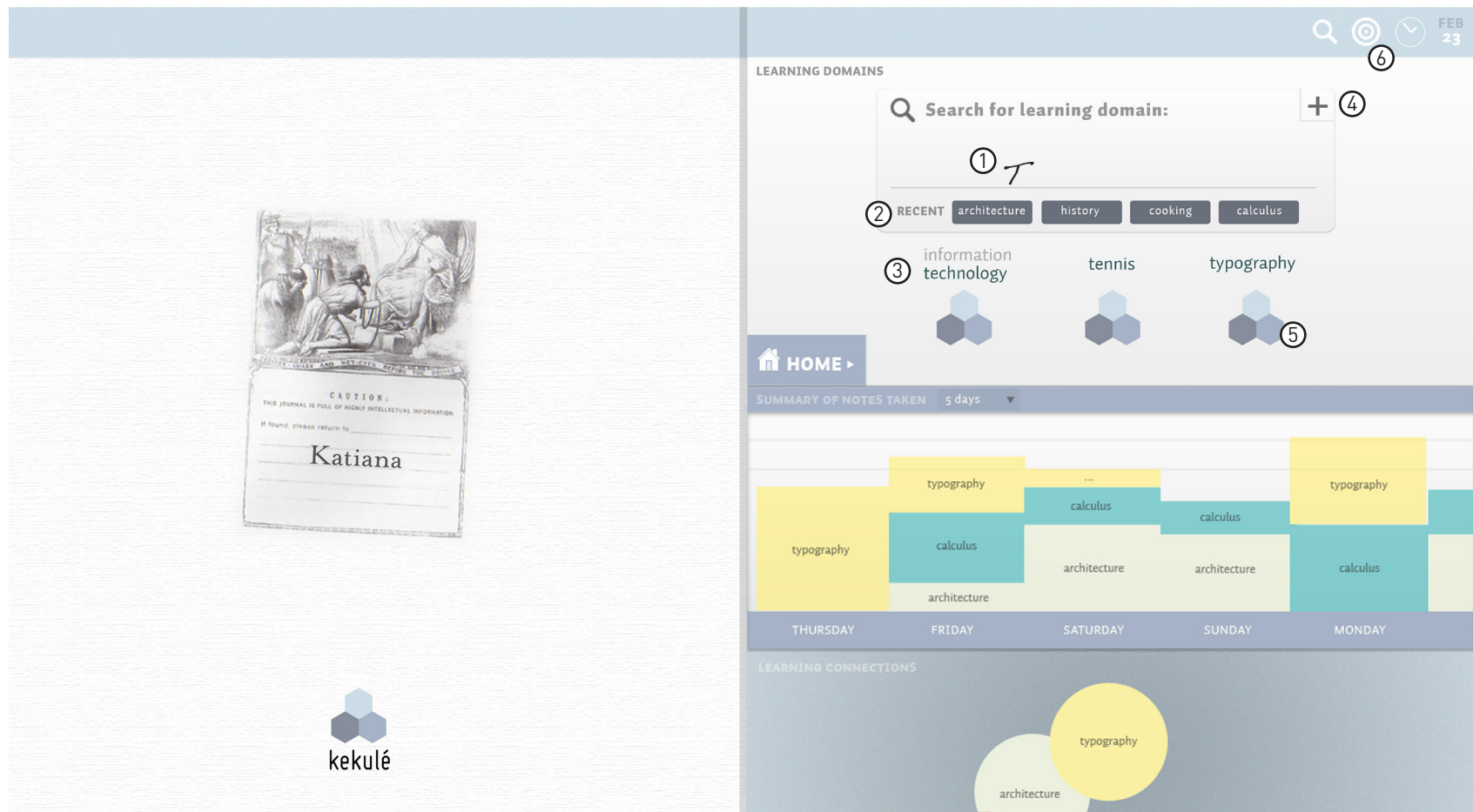


④ A visual summary of the amount and types of notes taken during a customized time period provides a quick overview.

⑤ The search button allows Katiana to jump to a specific domain that she wants to access.

⑥ Learning connections show the relationships between different domains through similar concepts or notes.

- ① Katiana wants to search for her typography domain. She uses the stylus to start writing the word “typography.”
- ② The “recent” area lists domains that she has utilized recently for quick access.
- ③ Writing the letter “T” starts the search and three matching domains shows as results.



- ④ The “+” button allows Katiana to add a new learning domain.
- ⑤ Katiana finds the typography domain and selects it to load the domain.
- ⑥ The drop-to-share feature allows Katiana to share any notes on her screen with nearby digital displays.

① The domain of typography is loaded. Tapping on the typography menu opens a list of topics belonging to the typography domain.

② Livefeed is a live transcription during lectures. The transcription will convert audio to text and visual aids to images.

③ Livefeed will save all text transcriptions so Katiana always has the history available for search and review.



④ The Hub is Katiana's virtual study group made up of her peers, classmates, and coaches around the domain of typography.

⑤ Backpack is a repository for all reference materials such as textbooks, articles, webpages, and websites for Katiana.

⑥ Time and day are important ways for Katiana to stay organized with learning and note-taking which is why they are always visible.

- ① Katiana can name the topic for today at the top. All saved topics will be listed under the domain for future access.
- ② Here Katiana sees another topic named “Kevin Lynch (LATCH) principles.” Selecting the topic

HOME

LIVEFEED OFF

TYPOGRAPHY

Name your topic for today

Kevin Lynch (LATCH) principles

RELATED DOMAINS:

architecture

Interaction and Experience

RELATED DOMAINS:

architecture

web design

Digital Production and Print

RELATED DOMAINS:

architecture

web design

InDesign Layout Tips and Tricks

RELATED DOMAINS:

architecture

Visual Vocabulary

RELATED DOMAINS:

architecture

web design

Grid Systems and Layout

RELATED DOMAINS:

photography

1-6 noteboards of about a hundred

NEXT

HUB

BACKPACK

SEARCH

CALENDAR

FEB 23

4

JAN 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 | FEB 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

- ③ Each topic has a list of related domains that suggests shared notes in multiple domains.
- ④ The calendar timeline below shows which days have recorded note-taking activity under this domain. Grayed-out days have no activity.

① Katiana turns on Livefeed so she can dedicate her attention to listening to the instructor rather than copying notes.

② Livefeed will make visual aids available to Katiana so she can see it in her notes, use it for review, and/or annotate directly on it.

③ Livefeed transcribes lectures to text so that it can be manipulated, copied, and reviewed by Katiana as the lecture happens.

The screenshot displays the Livefeed application interface. At the top, a navigation bar includes 'HOME', 'TYPOGRAPHY', and a search bar. Below this, a 'LIVEFEED ON' indicator shows '1 transcription saved'. The main content area features a video player showing a lecture on typography. The video frame includes a diagram of the letter 'B' with labels for its parts (ascender, x-height, baseline, etc.) and a list of definitions for typography terms. Handwritten annotations in cursive are visible on the right side of the video frame, including 'When combining typefaces look for similar x-heights and character widths.' and 'The x-height or corpus size refers to the distance between the baseline and the mean line in a typeface.' A toolbar on the right edge of the video frame contains icons for various functions. At the bottom, a calendar bar shows the current date as February 23.

②

③

④

⑤

④ Katiana listens to the lecture and annotates her own thinking besides the transcription as she keeps up with the instructor's pace.

⑤ At the right-most edge of the screen, Katiana can access the tools palette. The palette has drawing tools as well as concept organizers.

- ① Katiana notes that one of her favorite typefaces has its origins traced back to the 1400's.
- ② From the lecture, Katiana copies the information about the original typographer from the 1400s.
- ③ The palette offers digital drawing and writing tools such as different digital pen tips, eraser, color, and size.

HOME

TYPOGRAPHY

Name your topic for today

LIVEFEED ON (all transcriptions saved)

Bahpex

In typography, a counter or aperture is an area entirely or partially enclosed by a letter form or a symbol.

X-height is the height of the main body of the lowercase letter or the height of a lowercase x, excluding its ascenders and descenders.

The x-height or corpus size refers to the distance between the baseline and the mean line in a typeface.

Ascender height some elements may extend slightly above the cap height.

The distance from the baseline to the top of the capital letter determines the letter's point size.

The length of a letter's descenders contributes to its overall style and attitude.

The curves at the bottom of letter hang slightly below the baseline. Commas and semicolons also cross the baseline. If a typeface were not positioned this way, it would appear to teeter precariously. Without overhang, rounded letters would look smaller than their flat-footed counterparts.

The baseline is where all the letters sit. This is the most stable axis along a line of text, and it is a crucial edge for aligning text with images or with other text.

When combining typefaces look for similar x-heights and character widths.

The x-height or corpus size refers to the distance between the baseline and the mean line in a typeface.

HUB

BACKPACK

FEB 23

BALLPOINT PEN

ERASER

SIZE

COLOR

ORGANIZER

③

④

① Centaur, designed from 1912 to 1914 by Bruce Rogers, is a revival of Jenson's type.

② Nicolas Jensen, a Frenchman who had learned to print in Germany, established an influential printing firm in Venice around 1469.

⑤ Drag notes into this time period

⑥

+

1469

JAN 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

FEB 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

④ She realizes that this information can be better organized in a timeline so she uses a timeline organizer from the palette.

⑤ Katiana can drag-and-drop her notes into the timeline organizer so they can be presented as a timeline.

⑥ The timeline organizer allows Katiana to add additional time periods.

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① Notes copied preserves the digital type formatting to signal to Katiana that these are not her own words.

② Her own handwriting is preserved even in the digital format.

HOME > TYPOGRAPHY > Name your topic for today

LIVEFEED ON (all transcriptions saved)



In typography, a counter or aperture is an area entirely or partially enclosed by a letter form or a symbol.

X-height is the height of the main body of the lowercase letter or the height of a lowercase x, excluding its ascenders and descenders.

The x-height or corpus size refers to the distance between the baseline and the mean line in a typeface.

Ascender height some elements may extend slightly above the cap height.

The distance from the baseline to the top of the capital letter determines the letter's point size.

The length of a letter's descenders contributes to its overall style and attitude.

The curves at the bottom of letter hang slightly below the baseline. Commas and smicolons also cross the baseline. If a typeface were not positioned this way, it would appear to teeter precariously. Without overhang, rounded letters would look smaller than their flat-footed compatriots.

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BALLPOINT PEN
ERASER
SIZE
COLOR
ORGANIZER

① Nicolas Jensen, a Frenchman who had learned to print in Germany, established an influential printing firm in Venice around 1469.

② Centaur, designed from 1912 to 1914 by Bruce Rogers, is a revival of Jensen's type.

1469 1912

JAN 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 | FEB 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

① Later that evening, Katiana is home working on an assignment. She's hit a stumbling block in her assignment. She accesses her Hub.

② Hub allows Katiana to view updates from her community by people or by topic.

③ Katiana can see how others are progressing and seeks out help by posting a question. They also share tips and tricks to help each other.

The screenshot shows a web application interface for typography learning. At the top, there's a navigation bar with 'HOME', 'TYPOGRAPHY', and a search bar. Below this is a 'LIVEFEED' section with a search icon and a list of typographic definitions. To the right of the definitions is a large text area with handwritten notes. Further right is a 'HUB' section with a list of questions and answers from community members. At the bottom is a timeline showing dates from January to February.

Navigation Bar: HOME > TYPOGRAPHY > Name your topic for today

LIVEFEED ON (all transcriptions saved)

Typographic Definitions:

- In typography, a counter or aperture is an area entirely or partially enclosed by a letter form or a symbol.
- X-height is the height of the main body of the lowercase letter or the height of a lowercase x, excluding its ascenders and descenders.
- The x-height or corpus size refers to the distance between the baseline and the mean line in a typeface.
- Ascender height some elements may extend slightly above the cap height.
- The distance from the baseline to the top of the capital letter determines the letter's point size.
- The length of a letter's descenders contributes to its overall style and attitude.
- The curves at the bottom of letter hang slightly below the baseline. Commas and semicolons also cross the baseline. If a typeface were not positioned this way, it would appear to teeter precariously. Without overhang, rounded letters would look smaller than their flat-footed compatriots.
- The baseline is where all the letters sit. This is the most stable axis along a line of text, and it is a crucial edge for aligning text with images or with other text.

Handwritten Notes:

When combining typefaces look for similar x-heights and character widths.

The x-height or corpus size refers to the distance between the baseline and the mean line in a typeface.

HUB Section:

- VIEW BY PEOPLE | VIEW BY TOPIC**
- JAMES LIN** (4:55PM TODAY): Hey anyone tried the first part of the assignment yet? (2 replies)
- PAUL SMITH** (3:15PM TODAY): How does LATCH really work in graphic design? (2 replies)
- ALICE LEE** (9:11PM YESTERDAY): Anyone know how to turn on the baseline grid via keyboard shortcuts? (2 replies)
- DAVID BLOOM** (8:29PM YESTERDAY): Figured out a real cool trick in InDesign. I'll share the solution through video capture so check it out. (2 replies)
- KATHY ALLEN** (02:32AM TWO DAYS AGO): Anyone up to give me some feedback? (2 replies)
- DANIELLE JOHNSTON** (01:22AM TWO DAYS AGO): Boom! I'm done with the assignment. Check it out. (2 replies)

Timeline:

- 1469: an influential printing firm in Venice
- 1912: Jenson's type.

Calendar: JAN 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 | FEB 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

④ Each Hub member can attach an update with a video/audio recording through the built-in camera, screen capture, or file attachments.

⑤ Multimedia responses are aimed to give Hub members more ways to tell stories and express their questions or answers.

⑥ The Hub is not only helpful for Katiana when she runs into a problem, but also when she wants new ideas to transform her own.

INSIGHTS

Affordances of the framework

The design framework used in developing this proposed concept is an integration of learning theory and human-centered design. There are a number of key affordances of the framework:

- » *Mapping the needs and challenges of learner types.*
- » *Designing features that works for all learner types.*
- » *Ensuring movement through the learning cycle based on learning obstacles.*
- » *Generalizing design for learning into a logical system.*

In the future, I envision this framework being utilized to design learning experiences outside of note-taking. It is a robust model that can be generalized for the design of other experiences.

Affordances of the artifact

At the feature level, the prototype enables the:

- » *Inputting of verbal and visual input to support both modes of thinking.*
- » *Balancing of portability and optimum writing/drawing surface through book form-factor.*
- » *Integrating all external learning materials including supplementary lecture material (PDFs, electronic textbooks, slides, papers, web resources) through Backpack.*
- » *Annotating, highlighting, and note-taking all in one place.*
- » *Indexing and tagging of notes so they can be readily searched and accessed.*
- » *Encouraging social learning by integrating into the immediate physical learning context even during review.*
- » *Reorganizing notes into different information structures through organizers and large writing/drawing surface.*
- » *Transcribing spoken words into text, which can be personalized into notes through Livefeed.*

At a high level, kekulé is designed to sustain a life-long learning process in consideration of different learning environments. During the learning experience, kekulé facilitates further thought by exercising visual and verbal abilities of the learner. It also frees learner from copying and encourages structuring and organizing of new information.

The learner transform data into information through organization. Kekulé works to encourage the learner to see the same information in multiple ways. Kekulé offers flexible information organizers that can be attached to each “concept” to help facilitate organization. Once a learner has captured data and abstracted the data into information, the learner may use the captured thoughts and structures as material for further investigation with the collective.

The Hub is a community consisting of peers and experts. The learner has the ability to name anyone an expert in any given domain. However, contributions can come from all members of the Hub. Naming someone as expert in a domain or theme helps the learner evaluate their feedback; for the expert, it adds to their reputation in the community. The Hub creates an intimate social platform that can be tied to a physical learning environment where learners can ask questions, solicit feedback, or to start a discussion or debate. It is a virtual and physical study group embedded in a tool they carry with them. This Hub also contributes in exploring new ideas and adaptations. Kekulé allows a video capture of the learner and a screen capture to allow learners to present their question or experiment to share with others. The learner can check out other people’s experiments as well as participate in answering questions.

Notes in this notebook are scalable for the learner’s lifetime, not just the years in formal education. Because in today’s world, learning is occurring constantly and in every context. The learner can learn in various domains. Domains are high level classification of human capabilities such as cooking, chemistry, and snowboarding. Domains can have various topics which can correspond to a more direct subject of study. For example, French cuisine may be a topic within the domain of cooking.

Connected to topics are notes. A note can be a sentence, diagram, or anything else that facilitates thought. Kekulé encourages thinking rather than copying notes. Within notes, kekulé offers multiple ways to sort and organize information based on information organization principles. Organizers are used in Noteboards, which are collages of notes. Noteboards can be shared and dynamically displays information in different structures through Organizers.

5 Conclusion

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OUTCOME & FUTURE DIRECTIONS

The metrics for success was set on students' impressions of the note-taking tool, their satisfaction of the experience, and the assessment of sustained learning over time. Unfortunately, only informal hallway testing with peers has been conducted. An immediate next step is to gather formal feedback from potential users of kekulé. Another success factor identified early on the project was whether this project could serve as a framework for developing future products that help people process information. I believe this project has successfully created an approach to address digital products to enhance learning. By using a learning theory as a basis of design, learning benefits can better facilitated.

For future directions of this project, I hope to continue thinking of ways to improve kekulé and would love to see this product to exist for all learners in the future. I have no doubt that one day technology will integrate smoothly into educational environments and I hope that this project will serve as an example of how to design products focused on learning needs and desires rather than pushing what is most convenient from a technology standpoint.

From what I gathered from the "Sleep Review" concept in speed-dating, I think many learners hope that we will be able to tap into our subconscious for extra brain processing power. I think for now, Kekulé's story can serve as an inspiration for all of us dealing with complex problems everyday and hopefully the design of the device will allow us to "learn to dream."

In the process of designing kekulé, I researched for new technology that has yet to be realized in the consumer market for possible innovation. Through this process, I came across many technological concepts that have potential in kekulé such as bendable screens and interaction, stylus input and the tablet computing. This process gave me a glimpse of how powerful technology can be when used in an appropriate context.

PERSONAL REFLECTIONS

There has been many challenges over the course of a year and a half in thinking and making this project. However, the process of completing a project that I personally connected with and feel passionate about has been extremely rewarding. The challenge of keeping my head in the details and also remembering to rise above to see the big picture was especially challenging. The challenge of withholding judgement and allowing a new concept of a device to emerge was also a test of my restraint.

In many aspects, this thesis project has taught me design. First, it is a project where I can connect theory learned from the first year of the graduate design program into application in crafting this thesis project. I was going through the learning cycle much like the learning theory which acted as the basis for my project. In many instances, something I've come across through the first year of the program have come in handy through the course of my thesis project. For example, choosing appropriate research methods such as speed-dating and directed storytelling. Also framing interaction design, as a means to create an environment in order to facilitate a desirable behavior out of people was critical to my project. It de-emphasized designing features but rather shift the focus to thinking of ways to craft the environment that people are in for behavior I'm trying to design for.

Second, it made me see clearly that designers are learners, and designers are teachers. Designers go through the learning cycle in every project when research, synthesis, design implementation, and refinement. These phases are analogous to the learning cycle of meaning-making, conceptualization (abstraction), and problem solving (experimentation), and transformation (adaptation). On the other hand, designers are teachers when communicating design concepts or when facilitating design discussions. Designers need to create the proper environment for different clients, teammates which have different learning preferences in order for the design to be understood.

Bibliography

- Adams, J. 2001. *Conceptual Blockbusting: A Guide to Better Ideas*. New York: Basic Books.
- Ambrose, S., Bridges, M., DiPietro, M., Lovett, M., and Norman, M. 2010. *How Learning Works: Seven Research-Based Principles for Smart Teaching*. Jossey-Bass.
- Bauer, A. 2008. "Designing Note-taking Interfaces for Learning." Doctoral Dissertation, CMU-HCII.
- Bauer, A., Koedinger, K.R. 2006. "Pasting and Encoding: Note-taking in Online Courses." *IEEE ICALT*, 789-793.
- Berliner, D. C. 1969. "Effects of test-like events and notetaking on learning from lecture instruction." Washington, D.C: Paper presented at the meeting of the American Psychological Association.
- Berliner, D. C. 1971. "Aptitude-treatment interactions in two studies of learning from lecture instruction." Paper presented at the meeting of the American Educational Research Association.
- Brotherton, J. A. 2001. "Enriching Everyday Activities through the Automated Capture and Access of Live Experiences — eClass: Building, Observing and Understanding the Impact of Capture and Access in an Educational Domain." Thesis, Georgia Institute of Technology.
- Denning, T., Griswold, W. G., Simon, B., and Wilkerson, M. 2006. "Multimodal Communication in the Classroom: What does it mean for us?" *SIGCSE '06*.
- DiVesta, F. J., and Gray, G. S. 1973. "Listening and notetaking II." *Journal of Educational Psychology*, 64, 278-287.
- Dunkel, P., and Davy, S. 1989. "The heuristic of lecture notetaking: Perceptions of American & international students regarding the value & practice of notetaking." *English for Specific Purposes*, 8, 33-50.
- Fay, A. L., 2006. "Impact of Laptop Computers on Students' Academic Lives." Carnegie Mellon University: The Eberly Center for Teaching Excellence & The Office of Technology for Education.
- Gardner, H. 1999. *Frames of Mind: The Theory of Multiple Intelligences*, New York: Basic Books.

- Hadwin, A. F., Kirby, J. R., and Woodhouse, R. A. 1999. "Individual differences in notetaking, summarization, and learning from lectures." *The Alberta Journal of Educational Research*, 45(1), 1-17.
- Kam, M., Wang, J., Iles, A., Tse, E., Chiu, J., Glaser, D., Tarshish, O., and Canny, J. 2005. "Livenotes: A System for Cooperative and Augmented Note-Taking in Lectures." *CHI 2005 | PAPERS: Educational & Help Systems*.
- Kiewra, K. A., and Benton, S. L. 1988. "The relationship between information-processing ability and notetaking." *Contemporary Educational Psychology*, 13, 33-44.
- Kiewra, K. A., and DuBois, N. F. 1991. "Note-taking Functions and Techniques." *Journal of Educational Psychology* 83, 2, 242-245.
- Kiewra, K. A., Mayer, R. E., Chrstensen, M., Kim, S-I., and Risch, N. 1991. "Effects of repetition on recall and notetaking: Strategies for learning from lectures." *Journal of Educational Psychology*, 83, 120-123.
- Kiewra, K. A., Mayer, R. E., DuBois, N. F., Christensen, M., Kim, S-I., and Risch, N. 1997. "Effects of advance organizers and repeated presentations on students' learning." *The Journal of Experimental Education*, 65, 147-159.
- Khai, N. T., Abowd G. D., and Brotherton J. A. 1999. "Personalizing the Capture of Public Experiences, Georgia Institute of Technology, ACM.
- Marshall, C. C., and Brush A. B. 2004. "Exploring the Relationship between Personal and Public Annotations." *JCDL '04*, ACM.
- McCarthy, B. 2000. *About Learning*. 2nd ed. About Learning Inc.
- McKim, R. 1980. *Experiences in Visual Thinking*. 2nd ed. Brooks/Cole Publishing Company.
- Microsoft. 2009. "Microsoft Courier - How Microsoft Thinks You'll Use It" (video). Accessed May 14, 2012. <http://www.youtube.com/watch?v=pFQWc79TYcU>.
- Moher, T. 2006. "Embedded Phenomena: Supporting Science Learning with Classroom-sized Distributed Simulations." *CHI 2006 Proceedings: Ubiquitous Computing*.
- Palmatier, R.A., and Bennet, J.M. 1974. "Note-taking habits of college students." *Journal of Reading* 18, 215-218.

- Steelcase Education Solutions. "active learning spaces: insights, applications & solutions." Accessed May 13, 2012 at http://www.steelcase.com/en/products/Category/Educational/Documents/SES_active_learning_spaces_interactive.FINAL.pdf.
- Suritsky, S. K., and Hughes, C. A. 1991. "Benefits of notetaking: Implications for secondary and postsecondary students with learning disabilities." *Learning Disability Quarterly*, 14 (4), 7-18,
- Thomas, D. and Brown, J. S., 2011. *A New Culture of Learning: Cultivating the Imagination for a World of Constant Change*. Createspace.
- Williams, R. L., and Eggert, A.C. 2002. "Note-taking in college classes: Student patterns and instructional strategies." *The Journal of General Education* 51, 3, 173-199.
- Wiggins, G. and McTighe, J. 2005. *Understanding by Design*. Expanded 2nd Edition. Columbus, OH: Prentice Hall.