Designing Sketch and Learn: Creating a Playful Sketching Experience that Helps Learners Build a Practice Toward Visual Notetaking (aka Sketchnotes)

Kenneth Fernandez and Jiayu He

Abstract
Notetaking is an important practice in classrooms around the world and is useful for capturing information and forming connections between large amounts of information and ideas. However, traditional notetaking methods tend to follow a linear structure, and students are often trained to capture information in a verbose text-based format. Visual notetaking, also known as sketchnoting, is an under-recognized strategy that can enhance the practice of notetaking. Sketchnoting taps into both the verbal and visual processes of decoding and encoding information, allowing learners to use a combination of words and images to make meaning from verbal or text-based information. Not only do studies show the potential benefits of sketchnoting, educators who have taught sketchnotes in their classrooms have also reported that it opened up opportunities for minority students such as neurodiverse individuals and language learners, providing them with another means of expressing their ideas and showing their understanding of content.

To facilitate the learning of sketchnotes, we designed Sketch & Learn, a web-based game that engages learners in playful sketching quests that help them build a visual library and a dedicated practice toward sketchnoting. Drawing insights from learning theories on scaffolding, game design, and best practices from educators, Sketch & Learn uses a relevant narrative and short challenges to recruit interest from novice learners and support long-term engagement. Pedagogically, we used gameplay to establish a playful low-stakes learning environment and used worked examples to ease learners into sketchnoting.

Preliminary testing results showed that the narrative and quests sparked interest, promoted engagement from users, and elicited learning gain. Users expressed interest in further engagement, and a digital version of the visual library feature. With promising results from our design concept, we are one step closer to our mission to equip learners with tools that help them take control of the information around them, form connections, express ideas, and make their learning visible.
**The Challenge**

Notetaking is considered an important activity for students across different cultures (Dunkel & Davy, 1989). Di Vesta and Gray (1972) found that classroom notetaking is beneficial for both encoding information and storing information externally for reference. In many classrooms today—because of the proliferation of laptops, the speed of typing, and easy access to the internet—notetaking has become more of an attempt to capture information in an unsynthesized, text-based format. Combined with “the linear and compartmentalized manner in which school knowledge is presented” for efficient delivery, of which “destroys the connections between academic knowledge” (Shambaugh, 1994, p.2), students are left with the challenge to construct personalized meaning to disconnected information:

> College is really like a collection of these very different things. Yeah, and they don’t talk to each other … stitching it together is your problem. (V. Gupta, personal communication, February 25, 2019)

As early as 1994, Shambaugh (1994) recognized this challenge and advocated for visual notetaking as a way to build “visual constructions to help students to re-establish for themselves the unity of knowledge from bits of knowledge and to create personalized meanings to this knowledge” (p.2). Visual notetaking, also known as sketchnoting, is a method of notetaking by hand that uses a combination of words and images to make meaning from verbal or text-based information. Besides aiding the transformation of information into knowledge, literature has suggested other potential benefits of sketchnoting, such as allowing for efficient decoding and encoding of information and boosting memory. Appendix A provides a detailed literature review of the potential benefits of sketchnoting.

We see sketchnoting as a potential solution for the grand challenge that learners need a personalized notetaking and learning practice to create meaning and construct knowledge from bits of seemingly separate information. By designing a learning experience for sketchnoting, we can help learners develop a sketchnoting practice that works for them.

**User Research and Needfinding**

*Why aren’t people doing it already?*

To better understand what sketchnoting is, what skills it takes, and how to teach it, we conducted interviews and observations with different groups of people. To understand the process, techniques, and mindsets of a sketchnoter, we talked with graphic facilitators and people with some sketchnoting experience. To understand the barriers to entry, we talked to people who have tried sketchnoting before but didn’t persist. Further, we also talked to educators who teach sketchnoting to adults and children to understand what best practices are for teaching sketchnotes. Key insights are summarized in Table 1.
Table 1: Insights and needs identified based on needfinding observations

<table>
<thead>
<tr>
<th>What people say, do, think, and feel</th>
<th>Insights</th>
<th>Needs</th>
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</thead>
<tbody>
<tr>
<td><strong>Non-sketchnoters:</strong></td>
<td></td>
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<tr>
<td>• “I suck at drawing”</td>
<td></td>
<td>• Remove the psychological barrier by promoting sketchnotes as being about ideas, and not art.</td>
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<tr>
<td>• “I always assume that I cannot draw”</td>
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<td>• Establish a low-stakes learning environment without confronting learners with their “artistic ability.”</td>
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<tr>
<td>• “I don’t really like to draw, because I’m not that good at it”</td>
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<td>• Facilitate the speed of taking sketchnotes.</td>
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<td>• “I’m much slower at drawing than writing”</td>
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<td>• “I quit because it just feels like it takes longer to write down my notes”</td>
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<tr>
<td>• “I’ve tried visual note taking, but is much slower at drawing than writing. The facility of speed is huge for me.”</td>
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<td>• “Hacks will be useful”</td>
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<td><strong>Sketchnoters:</strong></td>
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<td>• “I’ve never like practice sketching. That’s probably one thing I need to do. I want to continue to develop this skill… There were things I always wanted to do that I could never figure out, like drawing faces.”</td>
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<td>• Promote long-term engagement and a dedicated practice to encourage improvement and persistence.</td>
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<td><strong>Sketchnoting educators:</strong></td>
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<tr>
<td>• “You need to give people some basic knowledge, and maybe some framework so they do it often. Not afraid and not embarrassed. By doing it they learn.”</td>
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<tr>
<td>• “It’s something that, they’d learn if they see more and practice more. It’s not something you can do from just watching some videos and class”</td>
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<td><strong>What sketchnoters do:</strong></td>
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<tr>
<td>• Create icons, books, cheat sheets, and reference them frequently.</td>
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<td><strong>Sketchnote educators:</strong></td>
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<tr>
<td>• “I have them build a visual vocabulary or universal language for the class.”</td>
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<tr>
<td>• “It’s about building a visual vocabulary.”</td>
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<td>• “Any art, you have to steal a little bit and get inspired”</td>
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<td>• “You can definitely go to icons8.com and look up icons for things. And sometimes I do is for inspirations”</td>
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<td>• “Having someone do it, mentoring, give examples, help people to see the value, having a mentor do it live, people can ask questions...make the notetaking public so everybody can see it...”</td>
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<tr>
<td>• There is a false belief (a psychological barrier to entry) that sketchnoting is only about drawing.</td>
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<tr>
<td>• Drawing is an entry barrier.</td>
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<td>• Sketchnoting takes longer and some people want speed.</td>
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<td>• Sketchnoting is largely skill based. It requires learners to learn the basics and to practice.</td>
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<td>• People who overcame the initial barrier of drawing recognize their room for improvement and have a desire for deliberate practice, but lack motivation and meaningful prompts/triggers.</td>
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<tr>
<td>• Help learners develop a visual vocabulary and having a learning community to learn and “steal” from is critical for developing a practice toward sketchnoting.</td>
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<tr>
<td>• Best teaching practices involve modeling, giving examples, mentoring, encouraging learning from others, and promoting a learning community for collective intelligence.</td>
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<tr>
<td>• Building a visual library to build self-efficacy toward sketchnoting and speed up the sketchnoting process.</td>
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<tr>
<td>• Build a learning community that promotes sharing and collective intelligence.</td>
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</table>
Knowledge Components of Sketchnoting

To better understand what component skills are required for mastering sketchnoting, we conducted several cognitive task analyses (CTAs) with a combination of working professionals, educators, and students who use sketchnoting and visual communication in their work and everyday life. CTAs were conducted using a think aloud protocol and benchmark tasks to identify component skills, processes, and mindsets of sketchnoting. See Appendix B for details and analysis.

Combining the insights from literature, user research, and CTAs, we constructed a knowledge map (see Figure 1) that consists of key knowledge components of sketchnoting. It served as a foundation for determining the learning goals of prototypes we would design. Additionally, the knowledge served as a representation of our theory of change as we intentionally chose areas of the knowledge map that would help drive learners to build a practice toward sketchnoting.

Figure 1: A knowledge map of sketchnoting constructed from data collected from user research. To develop a sketchnoting practice, learners need declarative knowledge of the basics of sketching and associated metacognitive beliefs. Procedural knowledge can be categorized into encoding and decoding skills. Visual vocabulary is an important element of sketchnoting. Knowing the sketchnoting basics can facilitate the building of visual vocabulary and promote the development of visual construction.
Given what we learned from user research and needfinding, the following statement guided our design: **How might we facilitate the learning of sketchnotes in a way that builds a dedicated practice?**

**Existing Solutions**

To create a learning experience that effectively uses design and technology to facilitate the learning of sketchnotes, we analyzed existing solutions for sketchnoting, notetaking, and drawing. As shown in Figure 2, when put existing solutions into a framework of learning content (i.e., instruction on how to sketchnote), interaction design (i.e., engagement in an experience), and technology use (i.e., convenience and automation), solutions tend to exhibit strength in only one area. See Appendix C for a detailed analysis.

![Figure 2: A Venn diagram depicting the existing solutions landscape with three areas of strength: (1) learning content (i.e., instruction on how to sketchnote), (2) interaction design (i.e., engagement in an experience), and (3) technology use (i.e., convenience and automation).](image-url)
Our scan of existing solutions suggests that, despite great individual products in the design and technology category, the learning of how sketchnote was rarely targeted. Even when the product was about learning sketchnoting (e.g., books and online courses), there lacks innovation in leveraging interaction design and advanced technology tools. Thus, an opportunity exists for a learning experience for sketchnoting that effectively leverages technology, the fun of sketching games, and the best practices in teaching sketchnoting.

**Early Prototypes and What We Learned**

Our user research and needfinding process helped us identify that a dedicated practice of sketchnoting consists of many component skills in different areas (Figure 1), and so we moved into developing prototypes in some of those areas to understand how learners might experience learning sketchnotes in different contexts. Before arriving at our latest prototype, several prototypes were developed which helped us find an opportunity to help learners develop a sketchnoting practice. Building on our analysis of existing solutions, we evaluated each of our prototypes using the same criteria: 1) learning content, 2) interaction design, and 3) technology use, and used a radar chart to visualize our progress in each dimension. This self-evaluation of our prototypes helped us to consolidate insights and to iterate strategically.

**Prototype 1.0: Building a Visual Library with Manipulatives**

**Sketchnote “Magic Binder”**

Inspired by the power of hands-on “learning through making” (Ackermann, 2001, p. 4) from constructionist theories (Papert, 1980), and Universal Design for Learning principles of using physical objects to recruit interest (Meyer, Rose & Gordon, 2014), we prototyped an idea that explores using tangible objects to build an online visual library. Our first prototype (Figure 3) is a sketchnote “magic binder” that contains: (1) a magnetic whiteboard with drawing aids, such as stencils and shapes, that functions as a sandbox for users to sketch their ideas; (2) a one-page crash course of basic techniques to scaffold the learning of sketchnoting, and a set of stickers for expanding visual vocabulary and lowering the entry barrier for drawing; and (3) pairs of magnetic fiducial tokens (i.e., unique QR codes for image processing) that can be used to digitally crop important elements from a learner’s notes and save them to the cloud into organized albums (see Appendix D for a description of the technologies used). For example, the pair of fiducials marked with a “?” (question mark) represents a question the learner still has and the information cropped would be automatically stored in the “My Questions” album to be revisited by the student, the teacher, or the whole class.
As learners upload more drawings from their notes, Google Photos albums become an online manifestation of their visual library—ultimately allowing learners to assimilate and accommodate (Ackermann, E., 2001; Papert, 1980) new drawings and internalize them by creating subjective meaning and making them their own.

Through testing this prototype with learners and experts during two exhibitions, including the 2019 Interaction Design and Children (IDC) conference, we were excited to observe that many learners enjoyed using tangible objects that we built (see Appendix E for transcribed feedback). The physical affordances of the fiducials elicited a playful experience for learners. Figure 4 summarizes key observations and insights, with the most important ones being the lack of meaningful prompts to trigger an interaction and the need for more scaffolding and context for using sketchnoting techniques. Moving forward, we saw the need to improve the learning content and design for activities that engage learners to practice.
Figure 4: A radar chart that summarizes key observations and insights from Prototype 1.0, with the most important ones being the lack of meaningful prompts to trigger an interaction and the need for more scaffolding and context for using sketchnoting techniques.

Prototype 2.0: Sketchnote Workshop for Teaching the Basics

Splash Courses
To improve the learning content from our first prototype, and to model best practices for learning how to sketchnote, we conducted two 105-minute teaching sessions at Stanford Splash. Splash is “a program that brings students in grades 8-12 from everywhere to Stanford’s campus for a two-day learning extravaganza” (https://stanfordesp.org). We prepared our teaching content in formats that mimic what we might create if we were to build an online module for sketchnoting that covers what it is, why it is beneficial, and demonstrating basic techniques. Inspired by learning theories of scaffolding (Nasir et al., 2006; Schwartz et al., 2016) and our conversations with sketchnote educators, we facilitated the workshop by providing worked examples, guided activities, peer evaluation, and sharing reflections and resources for extending the learning further. In particular, worked examples provide a breakdown of a task and give explanations for each step, which can lower the entry barrier to help learners get started and provide opportunities for early success to promote self-efficacy (Ambrose et al., 2010, Schwartz et al., 2016).

To evaluate learning gains, we asked three self-assessment questions before and after the class, and collected pictures of notes they took on a video we showed before and after the sketchnote workshop. Details of the workshop and data collected are provided in Appendix F.

Our 8-12 graders showed visible learning of sketchnoting skills after a short intervention. Not only did all self-assessments show changes over time, we saw qualitative changes in their notes from before and after learning how to sketchnote, such as more meaningful use of visuals and
organization of notes to connect ideas to one another (Figure 5). In a reflection exercise, learners reported that “sketching is beneficial and FUN”.

![Before sketchnote intervention]

![After sketchnote intervention]

Figure 5: An example of a student’s sketchnotes which shows qualitative changes in their notes from before and after learning how to sketchnote, such as more meaningful use of visuals and organization of notes to connect ideas to one another.

Shown in Figure 6, from this workshop experience prototype, we saw a high level of learning gain and engagement with the basics of sketchnoting. Our main takeaway was: as experts suggested from needfinding, the basics of sketchnoting are teachable through worked examples, guided activities, and peer feedback. However, the high cost of labor made this approach hard to scale. Moving forward, we needed to think more about how we could generate similar learning gains without requiring immediate modeling and feedback from the facilitator(s).
Prototype 3.1: Practicing Sketchnotes to Service Reading Comprehension

Character Visualization Sketchbook

To put sketchnoting into a classroom context, we experimented with a design that would help middle schoolers practice sketchnotes in English class. Through this prototype, we prompted learners to draw images next to a passage from a middle school literary fiction, allowing them to use sketching as an aid for representing information visually. The goal was to help middle schoolers use sketchnoting to support their reading comprehension.

Leveraging unique affordances of the iPad Pro, such as the split-screen feature, we allowed learners to sketch alongside the passage as a form of annotation. Additionally, we utilized an interactive prototyping software (Adobe XD) to deliver a page-by-page experience that guided learners through a reading and sketching activity. Learners would read a passage from a literary fiction, highlight traits related to the main character, sketch representations of the character traits (by tracing existing sketches or by sketching their own), and then complete a short assessment that asks them to answer an inferential multiple-choice question about the passage.

Figure 6: A radar chart that summarizes key observations and insights from Prototype 2.0. Our main takeaway was that the basics of sketchnoting are teachable through worked examples, guided activities, and peer feedback. However, the high cost of labor of a sketchnote workshop is hard to scale.
After completing the activity, we asked follow-up questions (e.g., What do you think the purpose of this activity was? What do your sketches mean?). From the short assessment and learners’ answers to our questions, we were excited to see that they used their sketches as a basis for elaborate self-explanations and summaries of main ideas from the passage. As learners were answering the inferential question in the assessment, we also noticed they would scroll through their sketches before selecting an answer. This confirms the idea that visuals can serve as markers or reminders of certain content. Thinking about visuals as markers for referencing content, we began to think of ways we might be able to encourage users to revisit their sketchnotes more often by resurfacing visuals they have drawn. One idea that evolved from this thinking is elaborated in Appendix I.

Our insights from this prototype are summarized in Figure 8. Overall, we learned that putting sketchnotes in the context of a specific school subject helped learners understand the benefits of using visuals as quick references for information, essentially helping them see that sketchnoting is about representing ideas. Further, this prototype was endorsed by an educator who said:

I could see how it connected to student work. Like, as an educator, I could understand why this would be useful for my students… Similarly, I could see how it would be helpful to me as a student in the sense that I could understand how drawing might help me note and remember key points and ideas from the text. (I. Huff, personal communication, July 19, 2019)
"As an educator, I could understand why this would be useful for my students."

"It helps to remind me of what I read."

Opportunity to leverage the power of putting sketchnoting into context to onboard learners with the benefits of sketchnoting

"I like that you gave me something to trace and then something to try out myself... I liked the quiz at the end because again it helped me see the importance of the sketchnotes.

Leverage technology to allow for drawing, tracing, and giving feedback!

Figure 8: We learned that putting sketchnotes in the context of a specific school subject helped learners understand the benefits using visuals as quick references for information, essentially helping them see that sketchnoting is about representing ideas.

Defining Learning Objectives
Combining what we learned from each of our prototypes, we revisited our knowledge map (Figure 1) and identified the scope within which our latest design concept, Sketch & Learn, would fit. For the highlighted areas in Figure 9 (Declarative Knowledge, Metacognitive Beliefs, Visual Vocabulary, Sketchnoting Basics), we crafted the learning objectives in the following table. Table 2 provides a text summary of the learning objectives and how they correspond to the knowledge map.

Knowledge Map for Building a Sketchnoting Practice

Figure 9: The highlighted areas of our knowledge map represent the scope of our latest design concept, Sketch & Learn.
Table 2: Learning objectives that guided the design of our latest design concept

<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Knowledge Map Placement</th>
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<tbody>
<tr>
<td>After playing Sketch &amp; Learn, learners will be able to:</td>
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<tr>
<td>• Use simple shapes (i.e., squares, circles, triangles, lines, dots, etc.) to sketch objects, people, and faces that represent ideas and emotions.</td>
<td>• Sketchnoting Basics</td>
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<tr>
<td>• Use diagram elements (i.e., containers, arrows, brackets, etc.) to organize information and indicate relationships between ideas.</td>
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<td>• To draw handwritten lettering and use color to organize information and establish a visual hierarchy.</td>
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<tr>
<td>• To use different layouts to emphasize information that they want to emphasize</td>
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<tr>
<td>After playing Sketch &amp; Learn, learners will be able to:</td>
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<tr>
<td>• Understand what sketchnoting is and when and how it may be useful.</td>
<td>• Metacognitive Beliefs</td>
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<td>• Internalize that sketchnoting is about ideas, and not art.</td>
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<td>• Understand that the sketches or visual constructions they choose should be intentional and meaningful.</td>
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<td>• Recognize the importance of practice as “practice makes permanent.”</td>
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<tr>
<td>After playing Sketch &amp; Learn, learners will be able to:</td>
<td>• Visual Vocabulary</td>
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<tr>
<td>• Build a visual library of images that they can refer to and use at will (as measured by the number of visuals they can draw from memory).</td>
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<td>After playing Sketch &amp; Learn, learners will be able to:</td>
<td>• Center: Having a sketchnoting practice that works for them</td>
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<tr>
<td>• Develop a dedicated practice toward sketchnoting (as measured by sustained engagement and self-efficacy toward sketchnoting).</td>
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<tr>
<td>• Identify themselves as a sketchnoter and internalize an identity of a creative problem solver and sense-maker.</td>
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Prototype 4.0: Sketch & Learn Web-based Game (Design Concept)

Insights from previous prototypes, and our learning objectives, culminated in our latest design concept, Sketch & Learn: a web-based game where learners pursue playful sketching quests that help them build a practice toward sketchnoting. In the game, the learner is put into the shoes of an experienced sketchnoter whose full-time job is to teach English in non-English speaking countries. Learners complete a series of sketching quests that pertain to the different areas of our knowledge map. For example, the narrative situates the learner into the setting of an airplane ready for takeoff, and the learner is tasked with sketching objects in their environment that they might want to request from a flight attendant (e.g., coffee, and pillow), and so they must complete the task by using basic shapes to sketch a cup of coffee and a pillow.
To complete the quests, learners sketch on the digital canvas using a stylus. To lower the barrier of drawing, learners have the option to trace over existing sketches before moving on to sketching their own. Everything they sketch in the canvas can be saved into their personal visual library where sketches can be viewed, updated, and shared. Learners are also encouraged to name and add descriptions and tags to their sketches in order to create personal meaning (Figure 11). Descriptions can be anything that add contextual information to the sketch, such as what it means to them and how it was used. Naming and tagging allows learners to make different versions of a sketch, keep a history of what they have created, and view other’s sketches under similar tags.

Figure 10: Learners read the narrative and must sketch on the digital canvases to progress through the game.

Figure 11: Learners are encouraged to name and add descriptions and tags to their sketches in order to create personal meaning. Naming and tagging allows learners to make different versions of a sketch, keep a history of what they have created, and view others’ sketches under similar tags.
To provide another means of engagement using pen and paper, we created a physical version of Sketch & Learn in the form of a booklet (Figure 12). Learners have the option to use the booklet version while still being able to complete quests and build their visual library. We utilized the same fiducial and image processing software from Prototype 1.0 to perform image cropping, extraction, and saving to the learner’s visual library.

![Figure 12: To provide another means of engagement, we created a physical version of Sketch & Learn in the form of a booklet. We utilized the same fiducial and image processing software from Prototype 1.0 to perform image cropping, extraction, and saving to the learner’s visual library.](image)

**Approach to Learning Experience Design**

Informed by needfinding, we see the importance of scaffolding in designing for learning how to sketchnote. Nasir et al. (2006) suggested that scaffolding is critical in developing expertise. Scaffolding, in their perspective, involves:

1. organizing participation in activities in ways that address basic human needs for a sense of safety as well as belonging;
2. making the structure of the domain visible and socializing participants for dispositions and habits of mind necessary for expert-like practice;
3. helping novices understand possible trajectories for competence as well as the relevance of the domain to the learners;
4. providing timely and flexible feedback. (p.4)
The learning experience design of Sketch & Learn is largely guided by this understanding of scaffolding. Additionally, ideas from game design and behavior design were used to support the design of scaffolding. In short, Sketch & Learn uses a relevant narrative and small and frequent quests to establish a safe and playful learning environment that recruits interest and supports long-term engagement. By adopting the perspective of a sketchnoter and a teacher, and by framing sketchnoting as a skill that can help navigate language barriers and aid teaching, we hope learners can internalize an identity of a creative problem solver and sense-maker from the start.

The primary learning mechanics at play are worked examples to get learners started. As learners build their skills by completing quests and adding more sketches to their visual library, the core engagement loop (explained in Figure 13) gradually becomes an important part of the learning experience. Prior findings suggest that drawing and completing quests can be rewarding, so we made an assumption here that completing sketching quests and expanding one’s visual library can drive the core engagement loop for more practices.

The feedback loop for learning is implemented in the visual library, as learners will be able to see their progression and get inspired from seeing other’s visuals, promoting self-correction and learning gain.

Figure 13: A core engagement loop facilitated by the intrinsic motivation of expanding a personal visual library or visual vocabulary.

Table 3 integrates how learning theories, game design, behavior design, needfinding and prototyping insights collectively informed the design features for Sketch & Learn.
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<th>Feature</th>
<th>Design Rationale</th>
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<tr>
<td><strong>Narrative-based Adventure Game:</strong>&lt;br&gt;• Playful learning environment for low-stakes gameplay&lt;br&gt;• Narrative from a sketchnoter’s POV</td>
<td><strong>Insights from needfinding and prototyping:</strong>&lt;br&gt;• There is a false belief that sketchnoting is only about drawing. Drawing is an entry barrier.&lt;br&gt;• Learners need a low stakes environment to practice and improve.&lt;br&gt;• Put sketchnoting in context to make its benefits apparent (Prototype 3.1).&lt;br&gt;&lt;br&gt;<strong>Learning Design:</strong>&lt;br&gt;• Use narrative from a sketchnoter perspective to foster a sense belonging (Maslow, 1962; Nasir et al., 2006, Schwartz et al., 2016), and to help learners see themselves as a sketchnoter.&lt;br&gt;• Use gameplay to create excitement and turn up attention and arousal (Schwartz et al., 2016).&lt;br&gt;&lt;br&gt;<strong>Game Design:</strong>&lt;br&gt;• Use narrative, and game as drama (Hunicke, LeBlanc &amp; Zubek, 2004), to promote engagement.&lt;br&gt;<strong>Behavior design:</strong>&lt;br&gt;• Use perspective-taking to cultivate an identity of sketchnoter from the onset to reframe beliefs and mindsets about sketchnoting.</td>
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<td><strong>Low floor High Ceiling:</strong>&lt;br&gt;• Worked examples and tracing as a way to scaffold drawing&lt;br&gt;• Quests inspired by real life applications of sketchnoting</td>
<td><strong>Insights from needfinding and prototyping:</strong>&lt;br&gt;• Sketchnoting is teachable via worked examples, activities, and peer feedback (Prototype 2.0).&lt;br&gt;• “I liked... something to trace and then something to try out myself.” (Prototype 3.1).&lt;br&gt;• Sketching can be intrinsically rewarding and fun (Prototype 3.2, detailed in Appendix G).&lt;br&gt;&lt;br&gt;<strong>Learning and Behavior design:</strong>&lt;br&gt;• Scaffold using worked examples to provide access to expert’s activity flow (Nasir et al., 2006).&lt;br&gt;• Use small and frequent victories “to provide early success opportunities,” and to promote sustained engagement and self-efficacy (Ambrose et al., 2010, p. 86).&lt;br&gt;• Real-world tasks can help learners “concretely see the relevance” of sketchnoting (p. 83).&lt;br&gt;• Provide deliberate practice of component skills to increase fluency (Ambrose et al., 2010; Schwartz et al., 2016)&lt;br&gt;&lt;br&gt;<strong>Game Design:</strong>&lt;br&gt;• Use challenges and quests to make the game challenging—game as obstacle course (Hunicke, LeBlanc &amp; Zubek, 2004)&lt;br&gt;• Leverage the fun nature of sketching and self-efficacy from completing quests to facilitate cycles through a core engagement loop.</td>
</tr>
<tr>
<td><strong>Visual Library:</strong>&lt;br&gt;• Store sketches&lt;br&gt;• Learn with a community&lt;br&gt;• Receive feedback&lt;br&gt;• Find inspiration</td>
<td><strong>Insights from needfinding and prototyping:</strong>&lt;br&gt;• Building a visual vocabulary and having a learning community is critical for developing a practice toward sketchnoting.&lt;br&gt;&lt;br&gt;<strong>Learning Design:</strong>&lt;br&gt;• Scaffold by providing timely, flexible feedback (Nasir et al., 2006) through the visual library. Learners can see their progression and other’s work for the same quest.&lt;br&gt;&lt;br&gt;<strong>Behavior design:</strong>&lt;br&gt;• Reduce friction for people to do things they already like to do, such as sketching and completing quests (Clear, 2018).</td>
</tr>
<tr>
<td><strong>Multiple means of engagement:</strong>&lt;br&gt;• Use the web-based interface or printed game booklet</td>
<td><strong>Insights from needfinding and prototyping:</strong>&lt;br&gt;• Some prefer a digital interface and drawing on a tablet, while some prefer pen and paper for engagement.&lt;br&gt;• Leverage technology to allow for drawing, tracing, and feedback.&lt;br&gt;&lt;br&gt;<strong>Universal Design for Learning:</strong>&lt;br&gt;• Provide multiple means of engagement (Meyer, Rose &amp; Gordon, 2014) to increase engagement and accessibility.&lt;br&gt;• Learners have the option to use the web-based interface, or print out the game booklet that includes fiducials/images codes for easy upload to the visual library.</td>
</tr>
</tbody>
</table>
Evidence of Success and Areas for Improvement
A survey containing a narrative engagement measure developed by Busselle and Bilandzic (2009) and questions about design features was designed to test our design concept and the effectiveness of our narrative and quests. Details about the survey and direct evidence are discussed in Appendix H.

Table 4 compares our narrative scores with three popular TV shows scores as a benchmark. For 25 samples collected, all our Cronbach’s alphas were close to or higher than benchmarks, suggesting the data collected using this survey were reliable. In sum, our narrative scored high in “attentional focus” subscale, and had a “narrative presence” score comparable to the benchmarks. However, our narrative scored lower on “narrative understanding” subscale. Despite that this may be due to the incompleteness of the narrative as an excerpt, we see the need to improve the clarity of the narrative and quests to optimize its overall quality.

Table 4: Adapted 9-Item Narrative Engagement Scale, Subscales, Items, Means and Standard Deviations for Sketch & Learn Narrative Excerpt and Benchmark Scores from Rescue, Agent and ER (popular TV shows).

<table>
<thead>
<tr>
<th></th>
<th>Sketch &amp; Learn (n = 25)</th>
<th>Rescue (n = 413)</th>
<th>Agent (n = 211)</th>
<th>ER (n = 87)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Narrative understanding:</td>
<td>4.69 1.59</td>
<td>5.63 1.12</td>
<td>5.13 1.38</td>
<td>5.54 1.18</td>
</tr>
<tr>
<td>At points, I had a hard time making sense of what was going on in the program. (-)</td>
<td>3.88 1.67</td>
<td>5.44 1.51</td>
<td>4.98 1.69</td>
<td>5.68 1.46</td>
</tr>
<tr>
<td>My understanding of the character is unclear. (-)</td>
<td>4.92 1.35</td>
<td>5.66 1.33</td>
<td>5.44 1.62</td>
<td>5.14 1.47</td>
</tr>
<tr>
<td>I had a hard time recognizing the thread of the story. (-)</td>
<td>5.28 1.43</td>
<td>5.82 1.28</td>
<td>4.96 1.66</td>
<td>5.79 1.39</td>
</tr>
<tr>
<td>Cronbach’s alpha for narrative understanding</td>
<td>(.82)</td>
<td>(.74)</td>
<td>(.78)</td>
<td>(.76)</td>
</tr>
<tr>
<td>Attentional focus:</td>
<td>5.41 1.57</td>
<td>5.23 1.36</td>
<td>4.30 1.58</td>
<td>3.71 1.61</td>
</tr>
<tr>
<td>I found my mind wandering while the program was on. (-)</td>
<td>5.04 1.77</td>
<td>5.26 1.66</td>
<td>4.24 1.94</td>
<td>3.60 1.82</td>
</tr>
<tr>
<td>While the program was on I found myself thinking about other things. (-)</td>
<td>5.52 1.53</td>
<td>4.64 1.84</td>
<td>3.83 1.82</td>
<td>3.47 1.83</td>
</tr>
<tr>
<td>I had a hard time keeping my mind on the program (-)</td>
<td>5.68 1.38</td>
<td>5.83 1.33</td>
<td>4.82 1.80</td>
<td>4.06 1.95</td>
</tr>
<tr>
<td>Cronbach’s alpha for attentional focus</td>
<td>(.92)</td>
<td>(.70)</td>
<td>(.72)</td>
<td>(.84)</td>
</tr>
</tbody>
</table>
Table 4 (continued)

<table>
<thead>
<tr>
<th>Narrative presence:</th>
<th>3.73</th>
<th>1.63</th>
<th>4.38</th>
<th>1.37</th>
<th>3.74</th>
<th>1.51</th>
<th>2.81</th>
<th>1.44</th>
</tr>
</thead>
<tbody>
<tr>
<td>During the program, my body was in the room but my mind was inside the world created by the story.</td>
<td>3.96</td>
<td>1.70</td>
<td>4.72</td>
<td>1.76</td>
<td>4.05</td>
<td>1.83</td>
<td>2.77</td>
<td>1.76</td>
</tr>
<tr>
<td>The program created a new world, and then that world suddenly disappeared when the program ended.</td>
<td>3.76</td>
<td>1.48</td>
<td>4.35</td>
<td>1.73</td>
<td>3.73</td>
<td>1.89</td>
<td>2.77</td>
<td>1.76</td>
</tr>
<tr>
<td>At times during the program, the story world was closer to me than the real world.</td>
<td>3.48</td>
<td>1.73</td>
<td>4.06</td>
<td>1.70</td>
<td>3.43</td>
<td>1.89</td>
<td>2.66</td>
<td>1.60</td>
</tr>
<tr>
<td>Cronbach’s alpha for narrative presence</td>
<td>(.76)</td>
<td>(.70)</td>
<td>(.72)</td>
<td>(.84)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall scale score</td>
<td>4.61</td>
<td>1.72</td>
<td>5.11</td>
<td>0.86</td>
<td>4.50</td>
<td>1.04</td>
<td>4.10</td>
<td>1.02</td>
</tr>
<tr>
<td>Cronbach’s alpha for overall scale</td>
<td>(.84)</td>
<td>(.80)</td>
<td>(.82)</td>
<td>(.84)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(-) indicates reverse coded.

Engagement scores were triangulated with other survey responses. Participants gave an average score of 6.56 (sd = 2.15, n = 25) out of 10 for how much they like the prompts, and 6.40 (sd = 2.80, n = 25) for how motivated they were to complete the quests. 18 out of the 23 collected responses suggested the narrative was helpful and/or engaging. Lastly, 15 out of 24 responses (excluding one who did not understand the question) showed definite interests in engaging more with our narrative and quests suggesting our narrative and prompts promoted engagement.

When asked about the “visual library”, of which we described as a feature that collects and saves all the visuals they created for the quests, several participants expressed that knowing their drawings can be saved and referenced in the future may motivate them to complete quests. In fact, 14 out of 25 participants reported they referenced previous drawings or provided visuals.

When asked whether they were interested in using this function (i.e., drawing on a canvas and saving the drawings in their visual library), almost all participants who were onboarded with the idea of sketchnoting and found it relevant said yes, such as: “Yes, that would make it much easier to sketch!!” These responses validated our assumption of the usefulness of a visual library feature and confirmed the need to allow hand-drawn visuals and handwritten notes to be uploaded.

Putting the Sketch & Learn proof of concept into the learning, design, and technology framework used previously, we believe the web-based adventure game prototype will be an improvement from all previous designs. Comments in Figure 14 affirm many of our learning, design and technology decisions (comments on each dimension; learning gains, interaction design and engagement, and effective technology use were color-coded in blue, orange, and green, respectively).
Figure 14: Comments on each dimension used to evaluate our prototypes; learning gains, interaction design and engagement, and effective technology use were color-coded in blue, orange, and green, respectively.

- "I felt motivated because of the feeling of learning something new."
- "The quests were fun and I felt like I was learning."
- Each task was different, in my own way interesting, new to me, stimulating to think."
- "To me, it's so funny... I couldn't do that [sketch] before."
- "It's a fun story with fun tasks"
- "The story was becoming more interesting the more I did it"
- "Simple tasks and easy tasks make me motivated to do more and more"
- "Adding a background story made me feel more connected to the environment. It also enabled me to focus and made me feel like an active agent throughout the project in a simple way."
- "I really liked the task, I felt a bit like a child ;)"
- "It was interesting and it finished too soon"
- "A good and educational survey for me, as I believe that I have learnt a new skill. It would have been good to have been able to create something online though"
- "It would motivate me more knowing I may help others"
- "It would be nice to have things to return to and ways to see how my notes have changed over time"
- "Yes it would increase my motivation- autosaving notes sounds very good"
- "The fact that I will be getting a resource (visual library) that may be useful in the future motivates me."
- "I would love to be able to share my sketchnotes and see others from the same prompts, thus widening my variety of sketches and their uses"
- "I was engaged in the story and I enjoy drawing"
- "It would be fun to try it digitally"
Conclusion and Next Steps

The narrative and sketching challenges we tested have shown to be promising in creating learning gains and engagement. Users also wished to see the technology features that we were planning to implement, such as bringing the game to a web interface, and creating a visual library where learners can reference their own sketches, see their progress over time, see others’ sketches of the same prompt, and participate in an online sketchnoting community. Our immediate next steps will be to:

- Continue software development.
- Improve the clarity of the overarching narrative.
- Build more quests that address other areas of our knowledge map.
- Make quests more relevant to real life applications of sketchnoting.

Future directions include:

- Adding a feature to allow users to create customized practice sheets from personal their visual library to facilitate deliberate practice.
- Providing more informative illustrations and voiceover and consult Multimedia Learning by Richard E. Mayer (2009) to optimize multimedia learning and accessibility.
- Developing a rubric that facilitates self-assessment and peer feedback.
- Building an online learning community with features for sharing sketchnotes to facilitate feedback loops for improving sketchnoting teaching and learning practices, ultimately reinforcing learners’ identity as a sketchnoter and fostering a sense of belonging to a sketchnoting community.
- Leveraging Artificial Intelligence to prompt/trigger motivations to transform text-based notes into sketchnotes (Elaborated in Appendix I).
- Conducting longitudinal studies to assess learning gain and effectiveness of Sketch & Learn.
References


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We would like to acknowledge and thank the following people for providing ongoing support and thought partnership for our project, including but not limited to:

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- all the LDT students for their support and collective intelligence
- Caitlin Go for collaboration on Prototype 1.0.
- our faculty advisors Dr. Hilda Borko and Dr. Roy Pea for their wisdom and support.
- Dr. David Rose and Dr. Nicole Ofiesh for their guidance and advice on incorporating Universal Design for Learning into our project.
- sketchnoters and educators Sherrill Knezel, Christina Wodtke, and Anna Iurchenko for their invaluable guidance and feedback.
- prototyping partners Caitlin Go, Yuqi Yao, Grace Chiang, Thieny Nguyen, and Jina Lee for contributing ideas and hard work that helped shape our final product.
- all our user testers who gave us invaluable feedback for improvement.
- Reece Duca who funded the LDT projects, fueled the passions that allowed all the collective intelligence to happen and persist in the world and make an impact.
APPENDIX A

Literature Review: The Potential Benefits of Sketchnoting

As the saying goes, “a picture is worth a thousand words”, and visuals support high computational efficiency when decoding information (Larkin and Simon, 1987). The well-replicated picture-superiority effect (Paivio, Rogers & Smythe, 1968) has shown that pictures are more likely to be remembered than words. The handwritten nature of sketchnoting is also endorsed by studies showing that handwritten notes can be more powerful than typing notes on a laptop as they promote deeper processing (Craik & Lockhart, 1972; Mueller & Oppenheimer, 2014). Further, Fernandes, Wammes and Meade (2018) specifically studied the physical act of drawing and found that depicting information through drawing is superior in boosting memory compared to encoding strategies of visualizing, viewing, listing, and writing because “drawing improves memory by providing vivid contextual information that can later be called on to aid retrieval” (p. 305).

In addition to the above-mentioned benefits, sketchnoting promotes engagement, and allows for distributed cognition. The act of drawing and taking notes requires learners to be “minds-on,” promoting active and engaged learning (Hirsh-Pasek et al., 2015). The fun nature of sketchnoting can “improving the engagement of learners to tasks” (Shambaugh, 1995, p.4). Aspects of sketchnoting align well with the guidelines for universal design for learning, as it provides an alternative means for engagement, representation, action and expression (Meyer, Rose & Gordon, 2014). In classrooms, educators also observed that sketchnoting opened up many opportunities for minority students, autistic students, students with dysgraphia and dyslexia, and English-Language learners, providing them with multiple means of action and expression (S. Knezel, Educator and Graphic Facilitator, personal communication, February 28, 2019; D. Rose, neuropsychologist and Universal Design for Learning expert, personal communication, February 28, 2019). Furthermore, sketchnoting allows opportunities for distributed cognition as learners can make cognition “visible” and distribute it in the wild, to expand their own mental capacities, to be shared, communicated and assessed (Hutchins & Klausen, 1996; Tversky, 2002). In education, distributed cognition affords alternative means of evaluation and assessment in that it can:

make external the intermediate products of thinking … which can then be analyzed, reflected upon, and discussed. Transient and private thought process subject to the distortions and limitations of attention and memory are “captured” and embodied in a communicable medium that persists, providing material records that can become objects of analysis in their own right--conceptual building blocks rather than shifting sands. (Pea, 1987, p. 91)
APPENDIX B
Cognitive Task Analysis (CTA)

Two versions of Cognitive Task Analyses (CTAs) were conducted with expert sketchnoters in order to identify their workflow of sketchnoting, and understand which steps in their process could be leveraged for learning.

CTA Version A:

1. **[Off-air information processing and abstraction]** Read and sketchnote this short science article (choose one):
   a. Read [Intro to Scientific Method: Controlled Experiment](#).
   b. Or [Scientific Method Review](#) [excerpt here]
   c. [Information interview techniques](#) [worksheet]

2. **[On-air information processing and abstraction]** Watch and sketchnote one of the following
   a. [3-minute TED Talk](#)
   b. Or [Geoff Mulgan: a short intro to the studio school](#)
   c. Or [https://www.ted.com/talks/adora_svitak#t-334303](#)
   d. TED Talks on UX: [https://blog.prototypr.io/practicing-sketchnoting-3b6d2e8888bc](#)

3. **[Abstraction]** Give specific words and ask for visual representations [5 mins]
   a. Isolation, connection
   b. Friendship, romantic relationship
   c. Hardship

4. **[Audio record the process]** Follow up interview questions:
   a. Ask them at the end and ask which task is harder; ask follow up questions
   b. Ask them how they practice these skills
   c. What activities do you do? How do you evaluate your work? Do you share your notes? Why?
   d. Have you attempted to teach anyone?
   e. What subject matter/class do you sketchnote for?
   f. Ask for other people do sketchnote?
   g. Any info you think can help us?

CTA Version B:

1. **[Warm-up task]** Sketch four things that you did today (1-2 minutes)
   a. Before they start, tell them to think aloud as they sketchnote.
   b. Video and audio record the process to refer back to later.

2. **[Benchmark task]** Watch and listen to this TED Talk about Leadership (Everyday leadership - Drew Dudley: [https://www.youtube.com/watch?v=uAy6EawKKME](#)) and sketchnote the main ideas.
   a. Let them know that they can feel free to pause the video at anytime.

3. Video and audio record the process to refer back to later.
Findings
In sum, the experts exhibited the mindset that sketchnoting is about ideas, not art. They used simple sketches such as stick figures to convey their ideas, and used basic diagram elements such as containers, arrows, and brackets to indicate relationships. Additionally, throughout their sketchnoting process, experts made stylistic choices regarding color and text size to further convey relationships, visual hierarchy, and layout. The visualizations generated were intentional, not random, and convey meaning that is sometimes only meaningful to them—such as a personal memory. Moreover, the experts shared another commonality: they had a personal visual library—a repertoire of images they could draw from memory. This visual library facilitated the speed of sketchnoting as they were able to focus on getting ideas down on paper, rather than spending too much time drawing a single image. In addition, experts pointed out that it is important to actively listen pay attention to verbal cues that signal key information.

From the CTAs, we realized the critical learning problem is deciding how to visually portray an idea. Experts emphasized the importance of making connections between ideas and using “containers” (e.g., thought bubbles, boxes, and quotes) and “connectors” (e.g., arrows) to make relationships visible. One expert said: “the awesome part about visual thinking, and having arrows and things that are grouping together is that when you look back at it, it’s much easier to process.” (C. Gibbs, personal communication, May 4, 2019). Experts also pointed out how they would use context, their emotions, and existing knowledge to make associations and abstract information into visuals: “I look at the words and I feel … it’s a very emotional thing because its associations is about how you interpret the world, what images come to mind.” (C. Gibbs, personal communication, May 4, 2019). We observed that experts built on what they drew previously, used visual elements from their “database” of visuals, and used consistent styling. In addition, there is a verbal abstraction process: “I would jot this down in my own words” (S. Cook, personal communication, May 3, 2019), as well as verbal to visual abstractions such as using the same stick figure but different sizing to signify “adults” and “children”.

Discussion
Many of the skills demonstrated by the experts, such as encoding and decoding, were procedural skills in nature, meaning it takes practice to build. Visual construction, use meaningful and emotional information to help construct visuals and give meaning to information, is also advance in that it requires both abstraction skills and visual vocabulary. We eventually decided to leave the procedural skills related to sketchnoting out of the scope of the current design.
APPENDIX C
Existing Solutions Landscape
We came up with a learning, design and technology framework to evaluate existing solutions (shown in Figure 1), where solutions were characterized by strength in 1) learning content (i.e. instruction on how to sketchnote), 2) interaction design (i.e. engagement in an experience), and 3) technology use (i.e. convenience and automation).

![Venn diagram](image)

Figure 1: A Venn diagram depicting the existing solutions landscape with three areas of strength: (1) learning content (i.e., instruction on how to sketchnote), (2) interaction design (i.e., engagement in an experience), and (3) technology use (i.e., convenience and automation).

There are many resources for learning how to sketchnote, such as books and online courses, which are all great starting places for learners to learn the basics of sketchnoting. However, they only allow for one-way interaction, and it is up to learners to seek feedback, build their visual vocabulary, and practice on their own to advance their skills.

Some solutions feature great interaction design, such as highly engaging games that provide
scaffolds for drawing, narratives that draw players to the world of the game. However, most of them were not designed for learning, and provide limited feedback for improvement. Lastly, they are all about drawing and art, not about sketchnoting or forming connections between ideas.

As for technology, there exist both software applications such Notability and GoodNotes, where users can take notes on tablets. There are also tools such as RocketBook and smartpens that preserve the pen and paper feeling of taking notes, while affording the efficient digitization and storing of notes online. These solutions are, in essence, notetaking tools and do not provide a learning experience for sketchnoting. However, their affordances provide opportunities to reduce the friction for learners to build their visual vocabulary and share their notes with others.

Table 1 shows a detailed list of technologies analyzed.

**Table 1: Detailed list of reviewed products depicted in the existing solution landscape**

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Digital notetaking applications | Mobile applications on the iPad, such as Notability and GoodNotes successfully implement notetaking tools such as PDF annotation, highlighting, and organizing notes by subject.  
• Notability  
• GoodNotes  
• InkFlow | However, these digital-only solutions comprise of features that attempt to make the digital medium look and feel like analog pen and paper. In other words, they are attempting to reproduce paper-based affordances with digital technology instead of pushing the boundaries of what physical journals and manipulatives can do with the aid of technology.  
Because we know that the act of drawing can improve memory and aid retrieval (Fernandes, Wammes and Meade, 2018), with VisualNote we are utilizing the affordances of simple pen and paper to facilitate the practice of sketchnotes, and relying on existing technologies to easily transfer and store sketches online for users to revisit. |
| Smart Pen or “pen-and-paper-feel” technologies | Many digital notetaking applications and smartpens have emerged to allow users to take handwritten notes, while offering them ways to upload notes to the cloud. These applications have been made possible by new technologies, such as the Apple iPad Pro and Apple Pencil, Google Chromebooks, and Microsoft Surface.  
• RocketBook  
• smart pens | Primarily, technologies created by Neo Smartpen and RocketBook excel in the ease of uploading and transcribing notes and sketches. However, they are mere tools and do not help people develop and improve notetaking practices.  
These technologies afford us to focus on the creation of content and prompts that help learners build a visual vocabulary and assess their own, and others, sketchnotes. |
<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Comments</th>
</tr>
</thead>
</table>
| Sketchnoting Learning Content | When it comes to teaching sketchnotes, there exists a number of online courses that aim to teach the basics of visual notetaking. Many avid sketchnoters and graphic facilitators create their own content in which they teach learners how to create different combinations of text, imagery, layout, and color to communicate ideas.  
  • The Sketchnote Handbook  
  • Verbal to Visual  
  • The Doodle Revolution | However, many of these courses assume that learners are starting from scratch, and visual notetaking techniques are taught outside of the context of learners’ current notetaking strategies and styles. We aim to meet learners where they are at by building on their existing repertoire of visuals, their unique sketching style, and their existing notes.  
  All content were delivered either in books or online courses format and focuses on teaching sketchnoting. There is an opportunity for innovations on engaging learning in practicing sketchnoting, as practice is what makes permanent. We aim to leverage the collective intelligence from the existing document and expert knowledge, and take the insights from game design principles and behavior design to build learning experience around playful and purposeful practices. |
| Sketching games | There are games with a core engagement loop that involves sketching. After reviewing them, we categorized them in three categories.  
  1. Highly engaging but with little learning design. Examples are Draw Story! (APP), Draw a Stickman series (APPS; shown below)  
  2. Highly engaging and with feedback that may help build visual vocabulary. Examples are Google Quickdraw (web-based; shown above) and its derivatives. Users are given only 20 seconds to draw an object while an AI guesses what the drawing is. In a sense, the AI is providing users feedback on if the drawing is depicting the target object. The feedback is not designed to help learners improve drawing, but the learners can see others drawings and learning may happen there.  
  3. Educational but less engaging. Examples are DrawEverything (APP; shown below) and Drawception. DrawEverything is a great app with scaffold, such as stepwise instructions and tracing. Drawception has a drawing and guessing component as a form of feedback and a learning community where learners can see what others draw for the same task and give others feedback. It affords learners to learn from observations and peer feedback. |                                                                                                                                                                                                                                                                                                                                 |
| Picture dictionary and icon libraries | • Dictionary such as Widgit and websites such as Flaticon and the Noun Project provide icon libraries that allow for fast reference. | There are great tools to provide fast reference but do not provide the learning experience of sketching or sketchnoting. |
APPENDIX D

Technology Used in Prototype 1.0

The hardware for the prototype consists of a computer and a webcam. The software was built in Processing 3, TUIO for Processing, ReacTIVision, and the Google Photos API. SplitCam was used to create a virtual video driver to allow for image capture and the ReacTIVision detection. TUIO for Processing is used to display and process the location of the fiducial tokens from the ReacTIVision fiducial detection engine. From the locations of fiducial tokens, we can use Processing 3 to crop the video stream and save this snapshot locally or to the cloud using the Google Photos REST API. The id number of the fiducial tokens indicates what type token has been detected, which leads to saving the image in both a main, “My Notes” folder, and the relevant token folder. We chose Google Photos in order to take advantage of its existing capabilities, such as photo sharing, dynamic albums, and image recognition and search — allowing learners to share notes and drawings with classmates to fill in gaps in understanding, and to be intrigued by the images and associations that their classmates have created. This same technology was also used to perform image cropping, extraction, and saving for the book version of Sketch & Learn.
APPENDIX E
Prototype 1.0 Feedback

**Project Name: Visual Notetaker**
Team: Kenneth Fernandez; Joyce He; Caitlin Go

**Things I liked:**
- Exciting to see my drawing scanned and organized into different folders. Never felt I could be so organized.
- Thoughtful integrated design.
- Organic mixed physical and digital notetaking. Support sheets break down the barriers to learning.
- Nicely executed—feels polished. Easy for student who “don’t draw” with engaging features for those who do.
- Introduces new way to take notes.
- That it’s connected to Google Photos. Learning goal of revising notes, which I don’t do because my notes are ugly. I need to do this more!
- Encouraging notetaking. Summarizing content.
- Using prescribed visual lexicon but allowing for modification.

**Things I’d like to see more:**
- Process could be faster. Maybe I’d become faster as I became more familiar with fiducials. Other ways to organize and visually present all my visual notes.
- Demonstrable applications.
- More organic way to scan and save notes with the using to camera on every piece.
- Another layer of what to draw, just (just) how. Big ideas.
- Knowing from start to finish what the learner’s journey is: stickers to notetaking to notes review. Display some actual notes from a student.
- Associate snapshots across users to build collective visual impression.

**Questions:**
- Could the fiducials be replaced by icons/shapes/colors so that U don’t’ have to flip them over every time?
- How do I integrate this into a lesson plan?
- How to connect to a classroom? Supporting research that compares visual notetaking with conventional approaches?
- How this works in the classroom with a teacher?
- How to create step-by-step exercises for kids to learn?
- How could all the kids scan their notes at the same time? Phones? Seem like a bulky process.
- Assistive tech for non-verbal students looking to move beyond non-nuanced picture lexicons.
APPENDIX F
Splash Sketchnote Workshop Lesson Plan

Learning Objectives

By the end of this session, learners will be able to:
• Understand what sketchnoting is and what it could be used for.
• Use sketchnote basics such as imagery, text, color, and layout, to communicate information visually.
• Take sketchnotes while listening to stories and information.
• Construct a plan for practicing sketchnotes in the future.

Agenda

1. Pre-assessment (7 minutes)
   a. From 1 to 5, how confident are you in your notetaking skills?
   b. From 1 to 5, how would you rate your sketch and doodle skills?
   c. From 1 to 5, how much you pay attention to your last class last week?

2. Warm-up activity (10 minutes)
   a. Directions:
      i. Find a partner and introduce yourselves.
      ii. Then, without talking, use markers and post-its to find three things you have in common.
      iii. Share out.
   b. Debrief. Ask questions like:
      i. How did that feel?
      ii. Did you find anything challenging?
   c. Transition.
      i. Yes, it can be challenging to communicate your ideas visually, and there are many people who say, “I just can’t draw.” Today, we are here to change that. We want to show you some basic tools that you can use in order to easily communicate your ideas visually.

3. Define sketchnotes and show examples (7 minutes)

4. Practice sketchnote basics (30 minutes)
   a. Imagery
   b. Text
   c. Color
   d. Layout
5. Evaluate sample sketchnotes (10 minutes)
6. Apply sketchnote basics through activities (25 minutes)
   a. Listen to TED Talk → sketchnotes → Gallery walk (post-assessment)
   b. Partner up → tell life story → sketchnotes → switch → share with partner
7. Construct practice session (5 minutes)
8. Reflection (10 minutes)

**Splash Workshop Materials:**

- Slide deck used: https://docs.google.com/presentation/d/1EvxLSqiMKxh0s9pj8Nss9EwJIQk0mCbCNljOTYA2sQw/edit#slide=id.p
- Data available from: https://docs.google.com/spreadsheets/d/1cnIEUKeiPL3jJfBhSz-hyHvmzj4r4d9OWqk5-xCLEw/edit#gid=0
APPENDIX G
Additional Prototype - Prototype 3.2: Practicing Visual Abstraction to Compose a Sketchnote

Built concurrently with Prototype 3.1, as an exploration of game design thinking and designing for excitement, deliberate practice and feedback (Schwartz et al., 2016), we built a game that focuses on the component skill of visual abstraction—synthesizing information and then expressing ideas using visuals and paraphrased text. In this prototype, learners are given a passage and tasked with picking a visual that best represents the main ideas. The passage chosen was matched to a middle school literacy level. Visuals were provided to reduce the cognitive load so that learners can focus on practicing the skill of visual abstraction, allowing them to compose a sketchnote with a drag-and-drop interface without having to worry about drawing. After learners read the passage and chose their desired visuals to compose a sketchnote, they were given an example sketchnote designed by us (experienced sketchnoters), with rationale for why we chose certain visuals over others. We used this for both assessment and feedback purposes, in the sense that learners can use the example sketchnote as a rough “rubric” to grade themselves and use the rationale we provided as informative feedback for future improvements.

![Visualize It! Work Example](image-url)

**Step 5:**
Lastly, I can use words and visuals to represent my thoughts.

**Tips to find a healthy school-life balance**

With the pressure of completing homework and trying to enjoy school activities, sometimes I feel a little too busy.

Luckily, here are 3 tips to help you attain—and maintain—balance throughout your school life.
From testing with four middle schoolers from age 10 to 11, we found that in order to set motivations for engagement it is important for them to know what the end goal was and why they are doing this particular activity. This game might be useful after learners were onboarded with the basics of sketchnoting. With the ability to choose visuals and arrange them with a drag-and-drop interface to compose a sketchnote, we hoped to ease learners into the practice of sketchnoting. By providing an example sketchnote to help learners see what success looks like, we hoped to promote self-efficacy and encourage further engagement. Surprisingly, even though we know that drawing can be a barrier to entry, learners we tested with wished to draw their own visuals. Given this observation, we considered adding an option for learners to draw their own visuals. Regarding our exploration of using feedback and assessment, learners reported that: “It was kind of hard to get the best picture that would describe what you were thinking” (middle schooler, 11 years old). This observation revealed that visual constructions are deeply personal and subjective. Although automatic feedback reduces human involvement, it requires an appropriate assessment and rubric to be helpful.
Figure 3: A radar chart that summarizes key observations and insights from Prototype 3.0. We observed that, even though drawing can be a barrier to entry to practicing sketchnotes, learners we tested with wished to draw their own visuals. This observation revealed that visual constructions are deeply personal and subjective.

- **Observations**
  - "I don’t know why this would be useful"
  - "I want to draw my own"
  - "It was kind of hard to get the best picture that would describe what you were thinking"
  - Need to onboard the basics before training and practicing skills!
  - "I think I prefer to draw it"
  - Intrinsically rewarding to draw? Let learners draw!

- **Insights**
  - Less labor intensive, and affords immediate feedback, but requires better assessment and feedback rubric for the subjective nature of visual constructions.
APPENDIX H
Sketch and Learn Proof of Concept Testing
Method
To test this design concept, the effectiveness of the narrative and quests, we designed a survey with the instructional content and visual elements designed by us. The survey was distributed online (n = 22, through Prolific, a survey distribution platform, offering compensation of $7.5 per participant) and conducted offline in person (n = 3). Twenty-five responses were collected. Participants came from 13 different countries, split almost equally between genders (female = 13, male = 11, not disclosed = 1) and aged between 18 and 47. The majority of the participants had no prior experience in sketchnoting (n = 21).

In the survey, we asked participants to rate how compelled they were to finish certain quests to measure the engagement level and the quality of the quest. Data on narrative engagement were also collected using a narrative engagement measure developed by Busselle and Bilandzic (2009). The original scale contains four subscales: “narrative understanding,” “attentional focus,” “narrative presence,” and “emotional engagement,” with three items each. The “emotional engagement” was left out for this test because the narrative excerpt did not contain emotional events.

Results and Discussion
Additional questions were asked to triangulate the engagement scale results (shown in Table 4) and proved that narrative can be useful and promote engagement. When asked if the narrative is useful, necessary or if it didn’t make a difference for their experience, 18 out of the 23 collected responses suggested the narrative was helpful and/or engaging, with one response saying: “It is useful to some extent when it is related to my daily life. If it is not, there is no difference.” When asked to give a score from 1-10 for how much they liked the prompts/quests, participants gave an average score of 6.56 (sd = 2.15, n = 25).

The same 10-point scale was used to ask how motivated participants felt to complete the quests, the responses ranged from 0 to 10 with a mean of 6.40 and a standard deviation of 2.80. Some participants who gave low scores on this item expressed that they did not see the benefit of doing the quests: “I didn’t feel like the intended purpose of the exercises was explained (i.e. “Why should I complete them?”). Some suggested they lost interest because they could not relate to the prompts: “I was motivated to build up my visual vocabulary, but then a lot of the prompts and the quests didn’t relate to me at all, so I started to lose interest — I couldn’t see how I would apply it in my life.” These observations suggested the need to further develop the narrative to make the benefit and relevancy of sketchnoting to everyday life more apparent and to develop quests that would appeal to a larger audience. For people who gave high scores to this motivation item, their free responses suggested that their motivation came from the feeling that they were learning, which validated our assumption
that small quests and victories promote self-efficacy. In particular, people said: “Simple tasks and easy tasks make me motivated to do more and more” and “The quests were fun and I felt like I was learning.”

When asked about the “visual library,” of which we described as a feature that collects and saves all the visuals they created for the quests, several participants expressed that knowing their drawings can be saved and referenced in the future may motivate them to complete quests: “Yes. If I can have a physical thing I can refer back to I will be encouraged to do it.” In fact, one participant’s response, “The fact that I will be getting a resource that may be useful in the future motivates me,” directly validated our assumption that expanding visual vocabulary is intrinsically rewarding.

When triangulated with another response on their behavior, that is if they went back and referenced the visuals they created during the experience, most participants who suggested a visual library would be helpful actually did reference either their drawings or the cheat sheets we provided for them as scaffolding. In total, 14 out of 25 participants reported they referenced previous drawings or provided visuals. For those who provided reasons for why not, four indicated they were confident in completing the quest without the reference and one indicated that he/she didn’t like sketching. Even for people who did not express that having a visual library may be useful or motivate them to do more quests, they did take advantage of their previous drawings and the drawings we provided: “Yes each time, to make it easier to create the images”, “It was still in front of me—and I had practiced coffee cups! (the quest asked for a drawing of coffee cups).”

When asked if they were interested in using this digital function, drawing on a canvas, and saving the drawings in their visual library, almost all participants who were onboarded with the idea of sketchnoting and found it relevant said yes: “Yes, I would love to be able to see and share my sketchnotes in the future particularly with other students in my university classes,” “Yes, that would make it much easier to sketch!!!” Four participants (of which two were not interested in this digitalization idea) pointed out they would prefer hand-writing notes. These responses validated our assumption of the usefulness of a visual library feature and confirmed the need to allow hand-drawn visuals and handwritten notes to be uploaded.

Lastly, 15 out of 24 responses (excluding one who did not understand the question) showed definite interests in engaging more with our narrative and quests. Four who expressed no interest in further engagement suggested the narrative was not thrilling or need more structure, suggesting the need for further improvements. Two suggested that they were not interested because they were “not interested in sketching or its claimed benefits” or they did not see how sketchnoting is relevant, suggesting more work needs to be done to spark interest for learners to give sketchnoting a try.

Qualtrics Survey Link available at: https://stanforduniversity.qualtrics.com/jfe/form/SV_5u3T6ikQiJDHdQh
APPENDIX I  
Elaboration on Future Direction Ideas
To further leverage the power of technology, we hope to use artificial intelligence such as computer vision (e.g., handwritten text recognition) and natural language processing (NLP) to prompt users to revisit and transform old notes into sketchnotes. The technology can be used to scan the text-based notes for key information and recommend visuals from users’ existing visual library for them to transform their notes into sketchnotes. It lowers the activation energy to initiate a sketchnoting practice and a notification can prompt the action. In this case, the technology does not take away the cognitive effort needed to do a sketchnote, thus retaining the benefits associated with creating a sketchnote.

Longitudinal studies should be done in the future to measure learning gain and effectiveness of Sketch & Learn. Once we have a better understanding of the learning curve and challenges associated with different knowledge components, we can target more learning problems at a finer scale.