CS6750: Human-Computer Interaction
Team Project

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1 INTRODUCTION

Task: Helping macOS users identify and delete files that are no longer needed in order to quickly reclaim storage space.

Rationale: Our group chose this task domain after several members encountered issues with updating our macOS because of insufficient disk space. We aim to address this common challenge faced by Mac users and provide a solution that simplifies space management.

The goal of the needfinding plans is to understand how users currently manage storage on their Macs – particularly when storage is running low. We will conduct three different needfinding activities to explore users' existing workflows and uncover how they think about and approach storage management. More specifically, an online survey, a think-aloud study, and a heuristic evaluation.

Following the needfinding phase and analysis of results, we will move into brainstorming and initial prototyping. Next, we'll develop an evaluation plan and conduct a second iteration of design and testing, culminating in a refined final prototype and accompanying video demonstration. The project will conclude with a comprehensive evaluation and presentation of final results.

2 NEEDFINDING PLAN

2.1 Online survey

Our first active needfinding activity will consist of an online survey administered to up to **25 current macOS users**. The survey will take 5 to 7 minutes to complete and will be conducted with the **goal of gaining a better understanding of macOS users' existing workflows, pain points, and unmet needs related to the task domain we are investigating**. Participants will be recruited through the class Recruitment Megathread on Ed Disucssion with participation credit as an incentive to complete the survey.

Participants will answer questions about their general experience with macOS and how often storage-related issues occur for them. They will also be asked to report what prompts them to clear up storage on their Mac and how they typically go about doing so. The survey will gather insight into current difficulties users face when managing storage, as well as what information or features might make the process easier.

A potential source of **bias** in the survey is the likelihood of an **over-representation of tech-savvy individuals**, due to participants largely being made up of current Georgia Tech Master's students. Additionally, as data is self-reported, there is the potential of **recall bias**, where participants may inaccurately estimate their storage management habits.

2.2 Interviews

Our second needfinding activity will consist of an interview with **5 current macOS users**. This Interview will paint the picture about the user's current method for solving digital clutter, and their motivations behind certain behaviors. We want to find out **how users feel about their lack of storage, what strategies they currently employ, and what they prioritize to fix the issue.**

Participants will be macOS users who regularly store documents, images, or other kinds of media and have experienced low-storage issues at least once in the past year. We will recruit friends, family, and coworkers through word-of-mouth and interviews will be conducted either in-person or via Zoom. During the interview, participants will be encouraged to **walk through what they usually do and describe their typical process.**

Each interview will be around **20 minutes** including an introduction, a look at their current backgrounds and habits, what storage management methods they currently use, what pain points and emotions they go through, and what they would want in an improved product.

Potential biases during these interviews include **interviewer and social desirability biases**, as participants may overstate their confidence and under report their falures to appear more competent. These bias risks can be mitigated through neutral phrasing and anonymity assurance.

2.3 Heuristic evaluation

Our last, and final, needfinding activity will consist of a heuristic evaluation of the existing macOS options to reclaim storage space. We will evaluate three built in and one third party tool for **all ten of Nielson's usability heuristics**. For each heuristic, we will give brief summaries of any detected issues and provide recommendations to remediate them. The recommendations will be tailored to the application being evaluated, with the goal being to identify common design pitfalls that exist across these separate interfaces.

The built-in tools being evaluated are: **storage settings & recommendation, iCloud's "Optimize Mac Storage", and Disk Utility**. Storage settings and iCloud are the default cleansing solution for when the machine is low on memory, so they were chosen to identify the needs of novice users. While Disk Utility was chosen to identify the needs of advanced users due to its vast selection of terminal-based tools. We also wanted to evaluate a tool that wasn't designed and maintained by Apple, so we added a third party application into the mix. The application, **AppCleaner**, was chosen because it is free.

A potential source of bias of this activity could be **the bias of having only one evaluator**. Since all evaluations are being conducted by a single person, the results is heavily influenced by their personal experiences with these applications. However, this bias can be mitigated by cross checking the evaluation results with the other needfinding activities, as those are conducted using a large population sample.

2.4 Bias Mitigation

Collectively, our three needfinding activities provide different perspectives that help control each other's biases. While the survey risks oversampling highly tech-literate individuals, the interviews allow for more nuanced, contextually-rich accounts of what it's like to use the current interface. The interviews can thus act to validate survey results or expose areas where further investigation is needed. On the other hand, the survey controls biases present in interviews by avoiding social desirability biases, since the responses are anonymous.

The heuristic evaluation further controls for biases by offsetting the limitations of self-reported data. Since the evaluation does not rely on memory or recall, the data is grounded and observable; it can further confirm whether the data from

the interviews and survey are valid and not affected by recall biases. However, as the evaluation is performed by one person, it runs the risk of evaluator-bias. Interviews and survey mitigate this bias by providing data from a broader population.

However, bias may still remain. Our sources may still skew towards tech-savvy individuals due to our recruitment methods (convenience sampling), which limits the generalizability of the data.

3 NEEDFINDING RESULTS

3.1 Survey results

As planned, we were able to conduct an online survey through PeerSurvey, administering the questions as originally drafted. The survey was distributed through the class discussion board and personal networks, leading to **25 responses**. Though a range of experience levels were represented in the survey responses, the large majority of participants reported using macOS for more than three years. Most participants also reported encountering storage issues either occasionally or frequently.

Responses from participants indicate that users mostly rely on the macOS storage management tool, supplemented by manual file deletion in Finder. As shown in Table 1, the most common triggers for storage cleanup were system warnings and failed downloads or installations, indicating that **storage management is largely reactive for most users.**

Table 1—Storage Triggers and Tools Currently Used

Category	Most Common Responses	Frequency
Triggers for Cleanup	macOS low-storage warning	20+
	Unable to download/install	10+
	Slow performance	8
Tools Used	macOS Storage Management	20+
	Finder manual browsing	12+
	Third-party tools (e.g., CleanMyMac)	6–7
	Do not actively identify large files	3

3.1.1 *Key Findings*

Across responses, pain points were relatively consistent: users find it difficult to understand how their storage is being used, feel unsure about which files are safe to delete, and find manual file cleanup time-consuming. Participants also expressed a desire for greater transparency and visual cues when managing their storage, as well as an interest in features such as smart deletion suggestions, duplicate detection, and clearer storage visualizations.

Overall, the results from the survey indicate the need for greater information, transparency, and workflow efficiency for users managing their macOS storage.

3.2 Interview results

We conducted **five semi-structured** interviews with macOS users ranging from age 19 - 25 who had recently encountered low-storage warnings. Sessions lasted around 20 minutes and were all conducted in person. All participants use macOS laptops daily for their school, work, or entertainment. All participants have been using macOS for over three years, and they all reported performing a storage cleanup at least once in the past year. None described it as a routine activity.

Participants were asked to recall their most recent cleanup event, walk through their typical process, describe pain points, and imagine an ideal solution. Two participants chose to show their Finder windows during the interview. Notes were taken regarding the responses for all interviews.

3.2.1 *Key Findings*

Lack of Transparency: Across all interviews, participants expressed that macOS doesn't provide enough information about what is taking up storage and what is safe to be deleted. Categories like "System Data" and "Other" were described as "confusing". This lack of clarity created a lot of paranoia among participants, expressing that they were often hesitant to delete things unless they were completely sure they wouldn't need them. The insight we can take from this is that **user's need clear explanations and justifications to feel confident in their decisions.**

Cleanup Behavior is Essentially Entirely Reactive: All users cleaned their storage only when they were forced, such as when they needed to clear space for a software update or if they received a low-storage warning. "I only clean up

when I have to, then it becomes a problem I have to deal with." They described the whole process as something they constantly put off because it feels overwhelming and time-consuming, indicating that the current system is ineffective when it comes to having the user perform frequent cleanups. **Users need more manageable clean-up sessions that are more digestible for them**

High Cognitive Load: Adding on to the previous Insight, participants often found the whole process to be overwhelming and mentally exhausting due to having to review files one-by-one and manually having to identify files that can be deleted. They noted that existing tools didn't provide enough guidance, forcing them to figure a lot of things out on their own. **The current cleanup task does not support the user well enough in reducing their cognitive load.**

Flexibility: User's expressed the desire to have different cleanup strategies depending on their work style. Some preferred to sort files by last opened, some preferred to sort files by size, but everyone had different methods of clearing space. No existing tool let's them do this easily. **Users want adaptable workflows instead of being confined to a certain method.**

3.3 Heuristic evaluation results

The following subsections contain evaluation results for each of Nielson's 10 heuristic for the four applications mentioned in the needfinding plan. Note that only the overview of the functionalities being evaluated and overall summaries are provided (i.e. summaries of all issues and recommendations for improvements). The raw, qualitative evaluation result is included in the Appendix "Needfinding: heuristic evaluation results".

3.3.1 *Storage setting*

This evaluation was conducted on a 14in MacBook Pro 2024, running on macOS Sequoia version 15.1. The application was accessed via System *Settings* > *General* > *Storage*. The functionalities being evaluated are **optimize storage** and **empty trash automatically**.

- **Issue –** this application is not flexible enough to address most users' needs. Although the application is extremely easy to use, it trivialize the deletion process and could cause users to accidentally delete important contents. This application also does not clearly indicate to users that it is running in the background, and does not keep logs of the contents that are deleted.

- **Recommendations –** overall, this application could benefit from having more flexibility in allowing users to prevent contents from being automatically deleted. It could also benefit from being more visible by alerting users about upcoming deletions. Lastly, this application could do a better job at keeping logs of deleted content, as a user should never wonder what was being cleaned up from their system in the name of "optimization".

3.3.2 *iCloud's "Optimize Mac Storage"*

Similarly to Storage Seeting, this evaluation was conducted on a 14in MacBook Pro 2024, running on macOS Sequoia version 15.1. The application was accessed via *System Setting* > *Apple Account* > *iCloud*. The functionality of this application, however, was not evaluated because "Optimize Mac Storage" is not available for Mac users without an iCLoud+ subscription.

- **Issue –** although the functionality is advertised on Mac User Guide(, 2025) and referenced on the application (i.e. when a Mac is running low on storage), this functionality is not actually available to all Mac user. Amongst others, this missing feature is a clear violation of wrongful documentations, and its mentions in multiple places is confusing to users.
- **Suggestion –** Overall, this application seems like it could be similar to Storage setting. However, the tool is not available to all Mac users, and that non-availability should be made clear to users looking to utilize it.

3.3.3 *Disk Utility*

Just like the previous two applications, this evaluation was also conducted on a 14in MacBook Pro 2024, running on MacOS Sequoia version 15.1. The Application was accessed via the Finder menu, via the keyboard shortcut `ctrl + space` > *"Disk Utility"*. The raw, qualitative evaluation result is included in the Appendix "Needfinding: heuristic evaluation results".

- **Issue –** this application is catered only for very advanced users, and require technical understanding of local storage as a prerequisite for use. The tool offer a tremendous amount of diagnostic capabilities, but parsing the generated logs also require technical skills that an average users may not have. Additionally, although Disk Utility has a very helpful documentation page, it is only accessible via the command line interface. It also does not have the capability for file-by-file deletion, which makes it a poor choice for storage optimization

needs.

- **Recommendation –** Overall, this application is good for advanced users already familiar with the technology (i.e. hard drives and solid state drives) looking for ways to divy up existing storage. It offers a good set of diagnostic tools and functionality that could be leveraged to optimize storage space. The tool could be improved with better documentations catered to novice users (i.e. documentations should be accessible via the GUI as well), and functionality to interact with files within a partition should be implemented.

3.3.4 *AppCleaner*

Again, this evaluation was conducted on a 14in MacBook Pro 2024, running on MacOS Sequoia version 15.1. The application, versioned 3.6.8, was downloaded from https://freemacsoft.net/appcleaner/(, 2025) on November 14, 2025 at 09:35pm EDT.

- **Issue –** this application lacks the functionality to optimize the system as a whole, but at the application level it is excellent at identifying removable contents. Additionally, its application finder is not capable of discovering all applications installed on disc, so users have to use the drag and drop features to force a scan on certain, highly optimizable applications (e.g. Finders).
- **Recommendation –** this application should have a system wide scanner that perform its existing functionality at the application level (i.e. scanning applications and deleting related files). Furthermore, its application discovery tool should include all applications installed on disc, including the os applications like Finders.

3.3.5 *Key Findings*

Lack of transparency and flexibility seems to be the recurring themes across the existing applications used for storage optimization. Although these applications are easy to use, and for the most part are capable of effectively recycling storage spaces, they do not have functionalities in place to prevent themselves from accidentally removing wanted contents. Key

3.4 Key insights from needfinding activities

After reviewing the results of these needfinding activities, we collectively concluded on three main pain points that users face when using existing storage optimization solutions. Additionally, we also identified one additional point for

consideration (denoted by an asterisk below) that was mentioned by an interviewed user. The four insights are:

1. **Lack of visibility** – existing solutions does not let users know about the content of deletions.
2. **Lack of flexibility** – existing solutions does not allow users to explicitly exclude contents from being deleted.
3. **High cognitive load** – existing solutions forces users to remember contents that are being treated as "optimizable".
4. *__Security concerns with third party apps__ – some users mentioned their distrust of third party software, especially those offering storage optimization functionality, because of malware concerns.

4 INITIAL BRAINSTORMING PLAN

After discussing our needfinding results, our team will move into the brainstorming portion of the project. In order to avoid social loafing, our team will **first brainstorm individually before meeting synchronously for a group brainstorming meeting.**

Asynchronously, each team member will generate at least 10 high-level design alternatives. This phase of individual ideation allows each member to explore divergent ideas without the cognitive biases and social pressures, such as conformity and performance matching, present in group settings.

We will then hold a synchronous meeting, where we follow Osborn's brainstorming principles (expressiveness, non-evaluation, quantity, and building), as well as the refinements proposed by Oxley et. al (1996), to guide our behavior during the session. The session will begin with sharing the results of our individual brainstorming in a round-robin format. Each individual idea will be shared with the group to avoid converging around a single idea too early, and participants will present their ideas without explanation or justification (per Oxley et al.'s rules). This encourages expressiveness while minimizing the risk of early critique or persuasion. To mitigate social loading and power imbalances, we will ensure each member has equal opportunity to speak and is encouraged to actively participate.

Once each idea has been shared, the group will discuss the various design alternatives presented, then move to vote on which to further pursue.

5 BRAINSTORMING RESULTS

When we asynchronously brainstormed, we each individually came up with several of our own ideas before converging. The raw notes are included in Appendix 6.3.

From that exercise, we came up with a range of ideas about optimizing macOS storage. We thought about automated self-cleaning folders, smart suggestions for what to delete, and ways to show files with different confidence levels so users feel safer making decisions. We also explored clustering files-especially duplicates - by type to make cleanup easier, along with being transparent about why certain files should be removed. Individually, we emphasized the importance of confirmations, undo options, background indicators, and showing how much space is being reclaimed. We also brainstormed more advanced features like predictive storage alerts, LLM-powered suggestions, a fast-action tool that clears just enough space in seconds, and more intuitive visualizations such as radial folder maps or a Task-Manager-style view of the largest files and their impact.

Next, we reconvened as a group and created rough sketches together over a joint Zoom sketchpad. Based on our individual brainstorming, we each of us took a corner of the shared sketchpad and drew wireframes based on how we wanted this user flow to initially appear. These mockups are included in the following 4 images.

Kate's included:

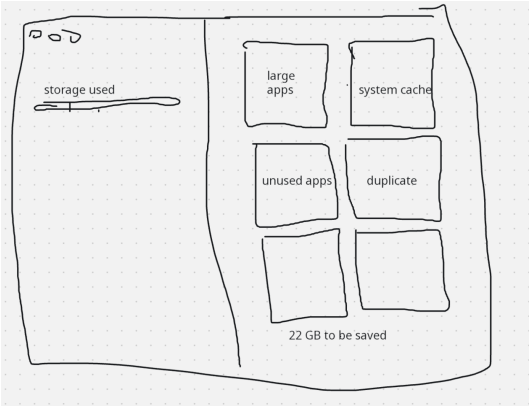

Figure 1—Kate's brainstorming mockup

Gabe's included:

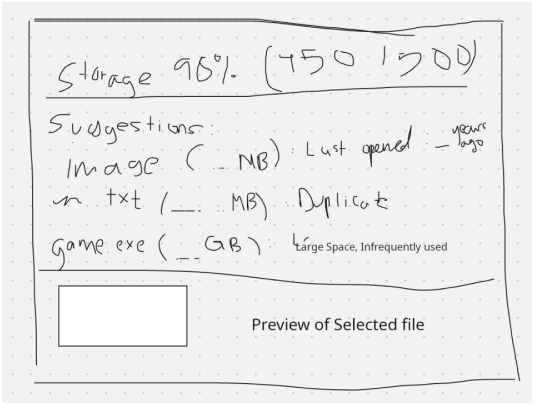

Figure 2—Gabe's brainstorming mockup

Thien's included:

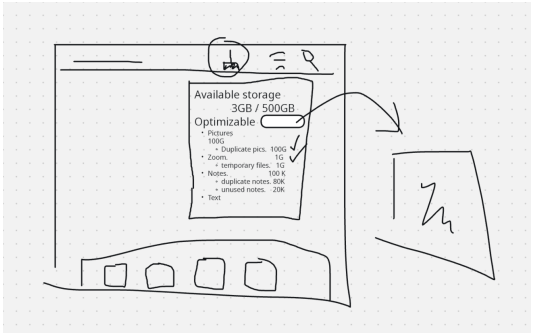

Figure 3—Thien's brainstorming mockup

Calvin's included:

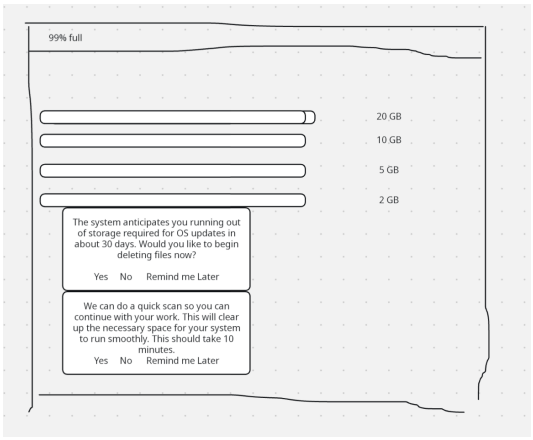

Figure 4—Calvin's brainstorming mockup

After reviewing and discussing each mockup, we decided to divide the next phase of prototyping among three of us (with the the fourth person conducting the survey portion afterward), with each person focusing more deeply on one of the three heuristics: flexibility, visibility of system status, and cognitive load. We chose these since these were common themes that we had uncovered from the needfinding exercise, our individual brainstorming, and our joint brainstorming sketch session. By distributing the work this way, we aim to ensure that each concept area receives focused attention and that our next set of design alternatives meaningfully address the most critical usability challenges we identified. These three design alternatives are what we then would like to take into our next phase of work as a single initial prototype to be evaluated and surveyed.

6 INITIAL PROTOTYPES

6.1 Prototype 1: Card-Based Smart Recommendations

When the user visits their System Settings and navigate to the Storage window, they are greeted by a screen displaying their storage usage breakdown, as well as smart cleanup recommendations, which display recommended items to remove based on user behavior and the types of files that most contribute to clutter. These recommendations help users quickly identify opportunities to reclaim space without having to manually search through Finder. The recommendations are displayed in a card format, and the display of cards is directly tailored to the user. Each card tells the user how much storage can potentially be cleared up, and at the bottom of the window, "Estimated Reclaimable Space" is displayed.

Figure 5—Storage usage overview and cleanup recommendations.

Users can also review the items recommended for cleanup by clicking the "Review..." button in the suggestion card. Here, they can search, sort, and select the items for deletion. They can also select all the items by clicking the first checkbox in the header of the table. As users select items to delete, the window indicates how much storage will be freed alongside the number of items selected. When users finish selecting, they can click the "Delete..." button at the bottom right of the window, which will also prompt a deletion warning message to minimize slips.

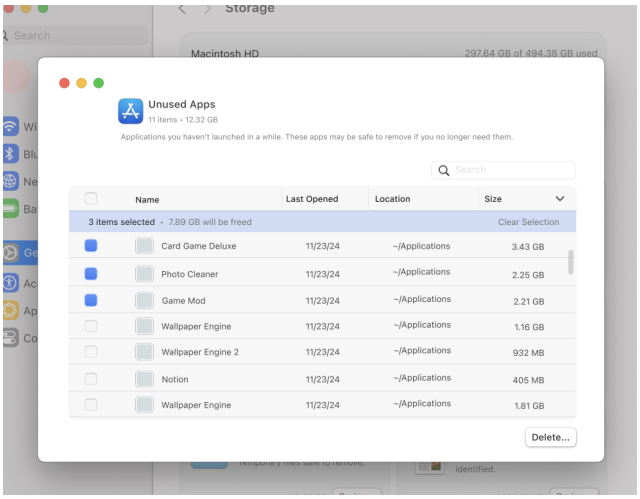

Figure 6—Recommendation review page, showing unused apps to delete.

6.1.1 *Design Rationale*

Visibility of System Status—The primary heuristic kept in mind during the creation of this prototype was **visibility**. This prototype aims to continuously inform users of their storage usage and the impact of their actions. Each recommendation card, for instance, displays how much space can be freed. Also, when users select files for deletion, a status bar in dynamically updated (e.g., 3 items selected • 7.89 GB will be freed) to give immediate feedback to the users of changes in the system status.

These cues ensure that users are always aware of the system's state and the consequences of their choices, supporting greater confidence and understanding when they are managing their storage.

Consistency—The interface of the prototype closely follows existing macOS design choices to ensure predictability for users. Each new feature incorporates elements, controls, and descriptions that macOS users are likely already familiar with, which allows users to rely on their existing mental models of how the system works.

Aesthetic and Minimalist Design—The interface was designed to avoid visual clutter and attempts to leverage macOS minimalism in order to reduce the cognitive load of the user. Ample whitespace, card layouts, and short descriptions

keep the screen visually easy to scan, which makes it easier to execute the task.

6.2 Prototype 2: Session-Based Storage Clearing

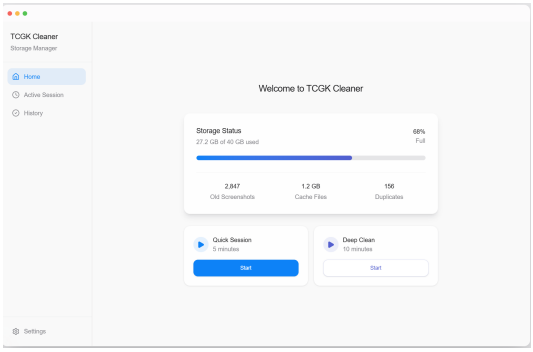

Figure 7—Welcome Screen

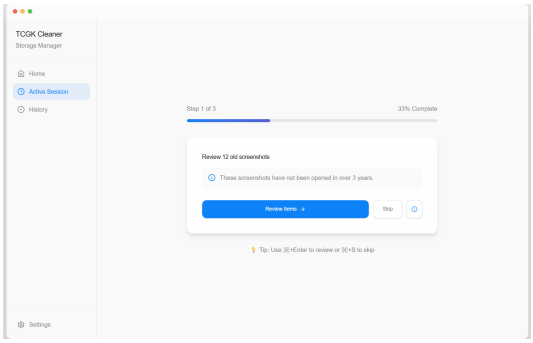

Figure 8—Clearing Process

For this particular design alternative, we wanted to focus on a prototype that prioritized reducing cognitive load by breaking the task up into short, guided sessions. Rather than presenting the user with an overwhelming amount of files in a complex view.

The structure of this prototype breaks the cleanup into small tasks that can each be completed within 5-10 minutes.

The prototype starts with the welcome screen that breaks down the process for the user and allows the user to begin the short cleanup session.

It then moves onto the actual cleanup, displaying one task at a time, such as "Review 12 Screenshots", letting the user preview, select, and delete items that are marked as "safe to delete".

After going through different categories of file deletion, a summary screen pops

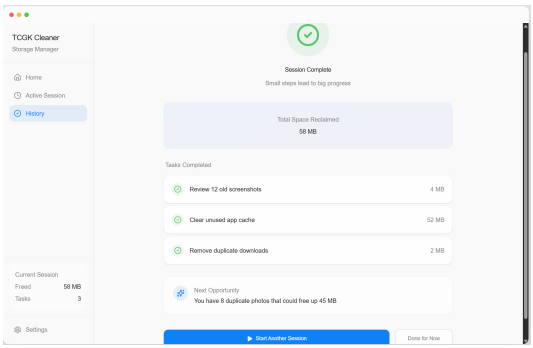

Figure 9—Completion Screen

up and gives the user a rundown of how much space they were able to clear and what files they parted with.

This interface emphasizes simplicity by having large buttons, having the user make one decision at a time, and keeping it short and simple.

6.2.1 *Design Rationale*

Reduced Cognitive Load—From our original need finding, users reported feeling overwhelmed by the volume of files. By chunking the cleanup we reduce cognitive load.

Reducing Gulf of Execution—Our prototype bridges the Gulf of Execution by providing clear instructions, offering a labeled step-by-step, and limiting the amount of actions the user can take per screen. As such, the users always know what the next step to do is.

Reducing Gulf of Evaluation—Our prototype bridges the Gulf of Evaluation by producing immediate feedback, letting the user know exactly how much space is being saved as well as the exact number of tasks the user has completed, letting them know the results as soon as they happen.

Error Prevention—Every action the user takes comes with the ability to undo. We also have preview thumbnails, giving the user a good idea of what they are going to be deleting before they delete it, which provides the user with a good amount of relief as a result.

6.3 Prototype 3: Application-Based Deletion Menu

For the final prototype, we wanted to focus on giving users as many options as possible throughout the storage cleaning process storage. We do this by giving users extensive control over the exact applications that are being cleaned. To do this, we designed a selection feature for users to specify the exact application that they'd like to optimize. User select the application, and our cleaner will scan it for files that are safe to delete, calculate the amount of storage that can be reclaimed, and prompt users to confirm the selection prior to deletion.

The user begins by drag-and-dropping the desired application into our cleaner

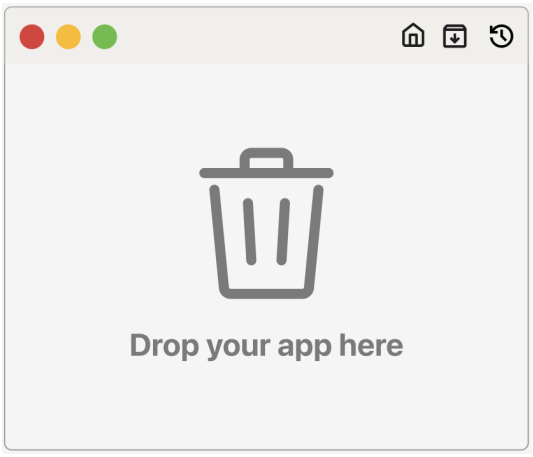

Figure 10—Drag and drop screen

and then confirming the applications that they would like to optimize via this selection menu.

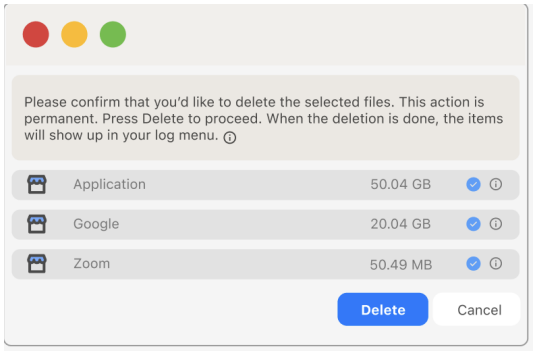

Figure 11—Confirmation menu. This menu will be shown before every deletion.

We also implemented a logging feature where users could see the contents which have been deleted.

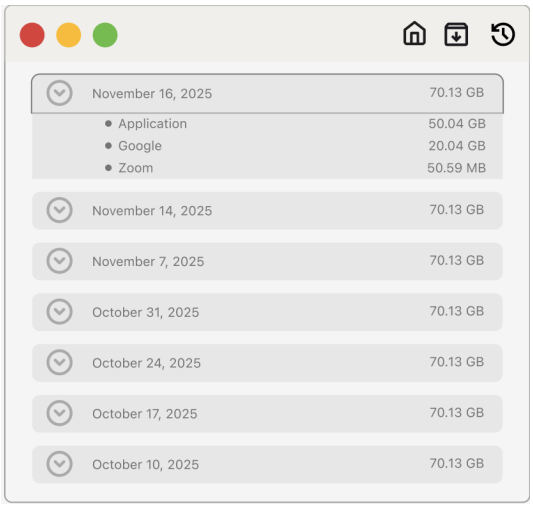

Figure 12—History screen

And, finally, a home page "recommended" screen that automatically suggest deletion candidates upon our cleaner's startup. It also uses toggle buttons for contents selection.

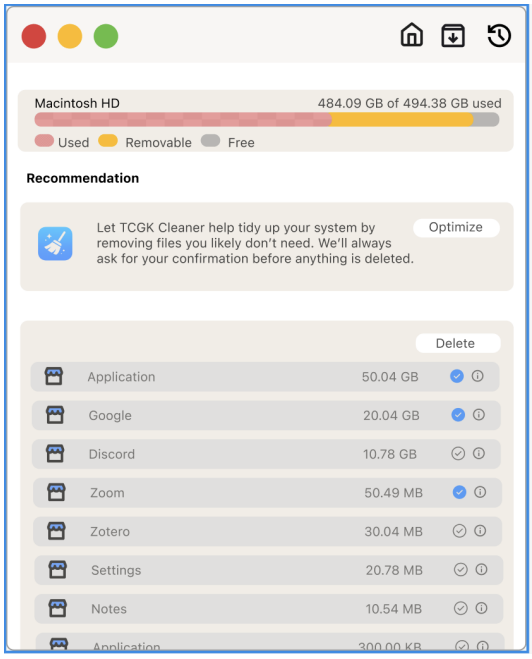

Figure 13—Recommended screen

6.3.1 *Design Rationale*

Flexibility and Efficiency—The primary heuristic influencing this design was flexibility, which we found to be lacking in the existing Mac applications. We wanted to give users as much deletion options as possible without sacrificing visibility. Our design borrows heavily from AppCleaner's drag and drop functionality, because we thought that it was the best form of application selection in a MacOs context. We introduced a history tab so that users could have a reference of past deletions prior to scheduling new ones. And, we designed our home screen to have preset recommendations so that users aren't overwhelmed as soon as they launch our cleaner.

User Control and Freedom—Although we introduced more flexibility by allowing users to select the applications they'd want to optimize, we wanted to prevent the *slips* of accidentally deleting contents that a user may have wanted to keep. In addition to using toggle buttons, we aggressively integrated confirmation screens into the cleaner's deletion flow to reduce the chance of an accidental selection. And, we used clear messaging to explain that deletions are irreversible. We wanted to ensure that users are always in control of the application, and that there is no doubt regarding the contents scheduled for deletion.

Consistency—We wanted to tap into users' familiarity with MacOS so that our app is easier to use. Namely, the drag and drop functionality was decided as the best option for application selection because it is how applications are installed on MacOS (i.e. by drag and dropping the installer into an application installer menu), while the home screen is almost an exact copy of the "optimize storage" feature in storage setting.

7 INITIAL PROTOTYPE EVALUATION PLANNING

To evaluate our three prototypes, we plan on running user survey via PeerMark. The survey will ask users to evaluate the three prototypes individually, where they will be asked to rate how effective a particular prototype is at addressing a particular *design heuristic*. For example, questions pertaining to Prototype 1: Card-Based Smart Recommendation will focus on *system visibility*, whereas those pertaining to Prototype 2: Session-Based Storage Cleaning will focus *cognitive load reduction and error prevention*. The raw survey questions and accompanying result will be included in the appendix: Initial Prototype Survey. After the survey

period has ended, we will meet synchronously and holistically review the results as a group. Each member will share their thoughts, and we will collectively determine key insights to shape our final design.

7.1 Participant Recruitment

We plan on making the PeerMark survey publicly available in order to recruit participants from within Georgia Tech and externally. To account for the Thanksgiving holiday, we plan on having the survey stage last for two weeks starting from week 14 and ending on 15. We will make regular posts on Ed Discussion to recruit classmates, and will send out the survey to our friends and families who are familiar with MacOs. We will not be collecting information regarding respondent's affiliation with Georgia Tech.

8 INITIAL PROTOTYPE EVALUATION RESULT

There were **15 total responses** to our survey outreach. These are the key insights that we extracted from the responses. Statistical methods were not used to assess the quantitative responses due to the small sample size.

8.1 The raw numbers

- Of the 15 responses, two were missing for question 6, three were missing for question 12, and one were missing for question 18. These were the qualitative assessment of prototype 1, 2 and 3 respectively. There were no correlations between missed responses (e.g. it was not the same user who omitted all three responses).
- Prototype one's responses were overwhelmingly positive. Where over %90 of respondents suggested "agree" or "strongly agree" when asked to assess its ability to improving visibility.
- Prototype two achieved similar rating, albeit slowly lower. %80 of respondents were in agreement when asked if it was good at reducing cognitive load.
- Prototype three got the most mixed review, where a only a little over half suggested that it was effective in providing flexibility improvements over existing systems. About half of the users suggested that this prototype was unintuitive.

8.2 Insight 1: Emphasizing the Mac Aesthetic

Users seemed to overwhelmingly prefer a design that embodies Mac's aesthetic. All users responded with *yes* when asked if this design felt like that of a Mac

application, and overwhelmingly cited the semblance as a reason why they preferred Prototype 1: Card-Based Smart Recommendation over the other prototypes.

8.3 Insight 2: Accidental Deletion Concern in these Redesigns

Users also seemed highly concerned about accidentally deleting wanted contents, and this concern was shared across all three prototypes. A couple users suggested the necessity of a *preview panel* in the final design that clearly communicate the exact kind of items that are scheduled for removal.

8.4 Insight 3: Undo Feature

Additionally, users seemed keen on the presence of an undo feature. These are the same users expressing concerns about accidental deletions.

8.5 Insight 4: Drag and Drop is nice to have

Although prototype 3: Application-Based Deletion Menu was universally disliked, the presence of a drag and drop feature was seen as a plus to some users. A small, separate subset of respondents indicated their mild dislikes for clicking, further suggesting that a different modality for interaction would be a positive addition.

9 SECOND ITERATION PLANNING

After completing the first iteration of the design life cycle, we now have a deeper understanding of how users interpret and navigate our three prototypes for Mac storage management. The evaluation revealed both strengths and usability gaps across the designs, particularly around clarity, error prevention, and recoverability. This section reframes the problem space and outlines the plan for the second iteration.

9.1 Revised Understanding of User Needs

The evaluation surfaced several user needs that were not fully captured during the initial needfinding. The most important of these is the need to prevent user error, followed by clarity around system status, better organization of recommendations, clearer navigation, and improved flexibility.

1. Preventing User Error

Across all prototypes, users expressed anxiety about taking irreversible actions without sufficient understanding of the consequences. Several issues contributed to this concern:

- Ambiguous delete buttons that did not indicate what would be removed
- Users accidentally navigating to the wrong screen and being unable to return
- Confusion between similar categories (i.e., photos vs. message attachments)
- Drag-and-drop behavior that felt unclear or easy to misuse
- Lack of previews before deleting files or applications
- Insufficient feedback on progress after completing a deletion step

In the next iteration, preventing user error becomes the guiding design principle. The system must provide clear, explicit actions, previews and summaries, safe navigation paths, and robust undo mechanisms.

2. Transparency and System Status

Users want more visibility into what they are deleting, how much space each action recovers, and their overall progress during a cleanup session. This includes hover previews, progress indicators, and clearer summaries of system state.

3. Organization and Prioritization

Users prefer recommendations grouped or sorted in meaningful ways, such as by urgency (Quick Wins, Large Savings) or by space impact. Improved hierarchy and grouping will help users make decisions more efficiently.

4. Navigation and Recoverability

Several users noted difficulty returning to previous screens or recovering from mistakes. More visible and consistent Back and Undo options are required for the next iteration.

5. Balancing Guidance and Expertise

Prototype 2 offered strong guidance, while Prototype 3 offered more flexibility. Users indicated that both approaches are valuable depending on expertise. The next iteration must support both a guided mode and an expert mode.

9.2 What the Evaluation Taught Us About the Designs

1. Prototype 1 provided clarity, minimalism, and a strong Mac-native feel. However, ambiguous delete actions and limited previews created opportunities for error.

2. Prototype 2 reduced cognitive load through a step-by-step guided flow and strong recoverability. However, users found it overly restrictive, and system status was not always prominent.

3. Prototype 3 offered the most control and flexibility but introduced confusion. The behavior was a bit error-prone and at times misunderstood.

The evaluation indicates that no single prototype adequately addresses all user needs. The next iteration should synthesize the strongest elements of all three while prioritizing error prevention.

9.3 Plan for the Second Iteration

1. Synthesize a Unified Design Prioritizing Error Prevention

The next prototype will combine:

- Clarity and hierarchy from Prototype 1
- Guidance, progress visibility, and recoverability from Prototype 2
- Flexibility and alternative options from Prototype 3

This unified direction will explicitly reduce opportunities for user error by clarifying actions, providing previews, and simplifying interactions.

2. Address Core Usability Gaps

A. Error Prevention Features

- Replace icon-only delete buttons with descriptive labels
- Provide confirmation summaries before destructive actions
- Add previews for photos, apps, and attachments
- Clarify overlapping content categories
- Simplify and standardize drag-and-drop interactions

B. Transparency and Feedback

- Persistent progress indicator (i.e., space cleared)

- On-hover details for recommendations
- Clear system status messaging

C. Flexible Navigation

- Visible Back button on all screens
- Strong and consistently placed Undo control
- Session overview for expert users

9.4 Needfinding Requirements

The evaluation results provided sufficient insight to guide the next iteration. No additional dedicated needfinding is required, though a brief follow-up with expert Mac users could clarify desired advanced controls if time permits.

9.5 Brainstorming and Sketching

The second iteration will include new sketching and conceptual exploration around:

- Safer deletion workflows
- Previews and information disclosure patterns
- A dual-path guided and expert mode structure
- Clearer visual grouping of recommendations
- Simplified drag-and-drop mechanics

9.6 Second Iteration Prototype

The next prototype will integrate the strongest elements across all designs into a single cohesive solution. It will emphasize clarity, error prevention, transparency, and flexibility. The visual style will remain consistent with macOS conventions.

9.7 Second Evaluation Plan

The second evaluation will test:

- Whether users clearly understand actions before completing them
- Whether the interface effectively prevents accidental errors
- Whether previews reduce uncertainty during deletion
- Whether navigation (Back and Undo) is clear and usable
- Whether the balance of guidance and flexibility is appropriate

9.8 Summary

The next iteration uses the first evaluation as its needfinding foundation, with error prevention as the central design principle. By combining clarity, guidance, and flexible control, the second iteration aims to reduce cognitive load, increase trust, and support confident storage management for a broader range of users.

10 FINAL PROTOTYPE

Following our previous evaluation results, we created a high-fidelity prototype that builds upon Prototype 1: Card-Based Recommendations. This prototype evolves the previous design into a macOS-style, system-integrated interface that helps users identify and remove large or unnecessary files with greater clarity, confidence, and error minimization. Compared to the initial prototype, this version introduces more explicit system status cues, improved affordances for selection and review, and a safer, more transparent deletion flow.

10.1 Accessing the Prototype

The full interactive prototype can be accessed here: https://expert-crush-31582923.figma.site/.

10.2 Video Prototype

Here's the link to the video prototype: https://mediaspace.gatech.edu/media/t/1_mv5hsuzp

10.3 Storage Overview and Cleanup Recommendations

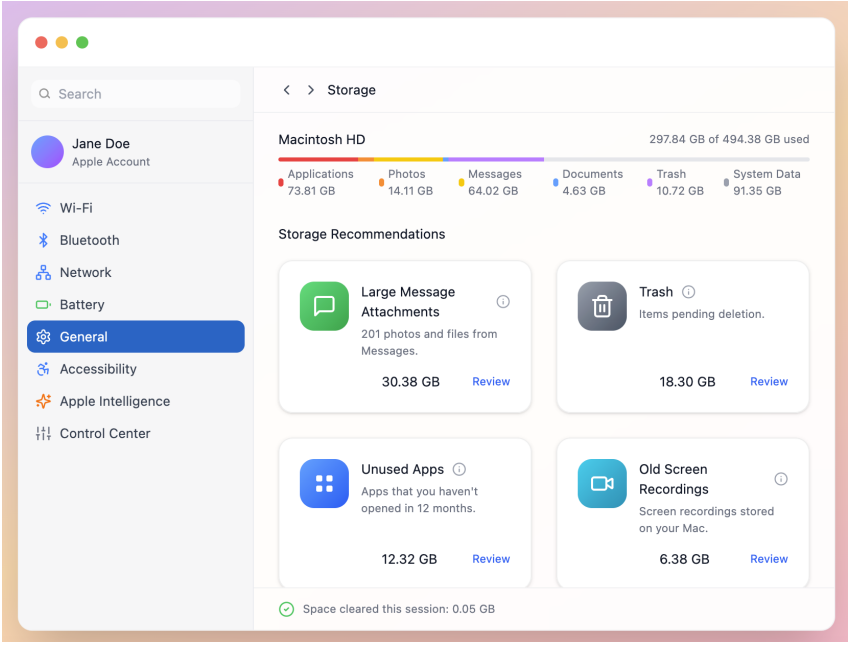

Figure 14—Storage overview page displaying system storage breakdown and personalized smart cleanup recommendations.

The landing screen of the new interface is largely the same as the initial prototype. When the user enters their current macOS system settings and navigates to *Storage*, they are presented with a screen displaying a breakdown of their current storage usage, along with personalized recommendations for cleanup.

10.4 Review Items in a Recommendation Category

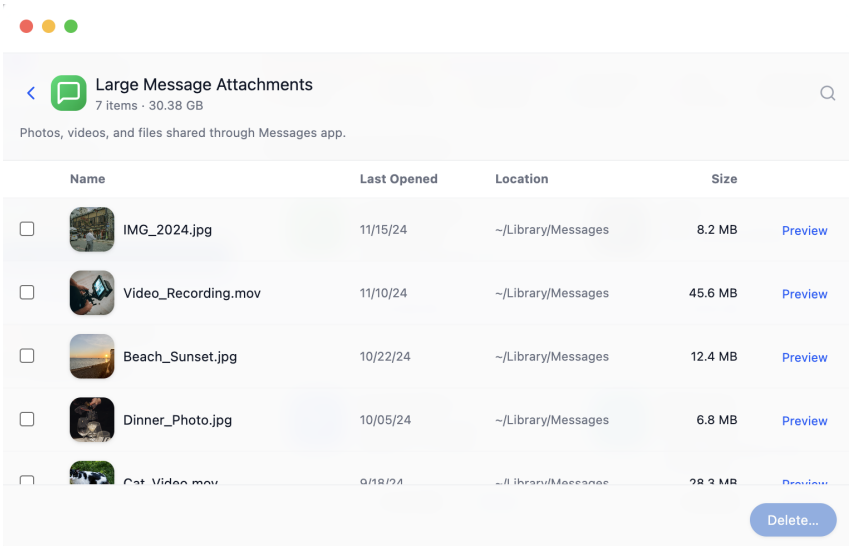

Figure 15—Selecting *Large Message Attachments* opens a structured table view listing each file's name, last opened date, location path, and size.

When users select a recommendation card, they are brought to a detailed file review screen. The screen displays a table that lists all the items within the recommendation category as well as relevant data.

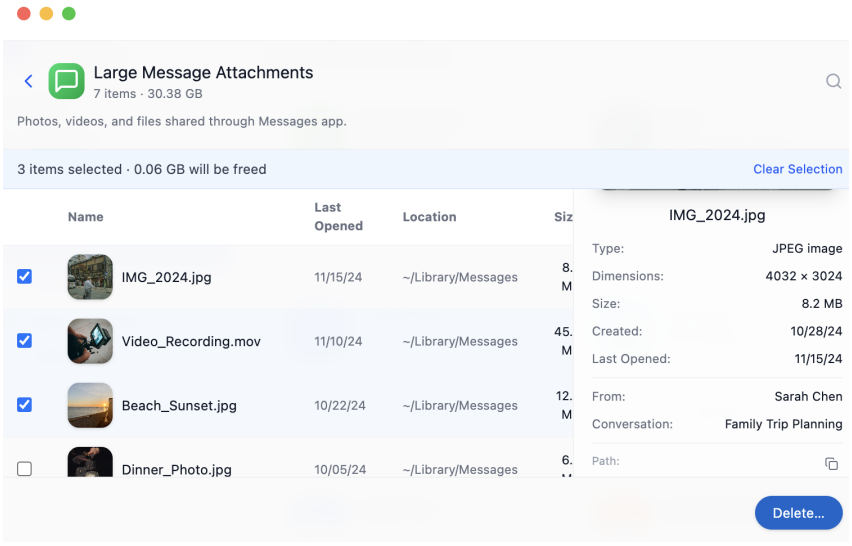

Figure 16—Selecting *Preview* leads to a split view displaying a file preview on the right.

Clicking the *Preview* button opens a split-view interface that displays a thumbnail of the item and relevant metadata. This helps users make more informed, confident decisions before permanently deleting files.

10.5 Post-Deletion Confirmation and Undo

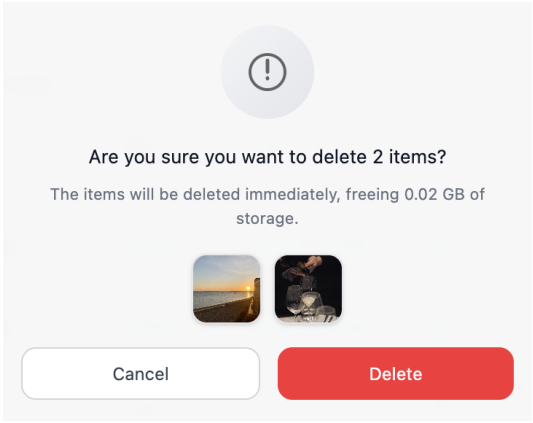

Figure 17—Deletion confirmation modal.

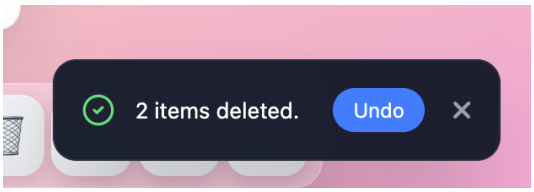

Figure 18—Toast to undo deletion.

After selecting items to delete and clicking the *Delete...* button, users are shown a confirmation modal to ensure they are deleting the correct items. The modal confirms the number of items as well as the storage that will be freed as a result of the deletion. Once deletion is confirmed, a toast notification appears in the bottom-right corner, offering the option to undo the action for a limited time.

10.6 Design Rationale

Visibility of System Status—Carrying over from Prototype 1, a central focus of this prototype was ensuring clear and continuous communication of the system status to users. The design is intentional in informing users of their current storage usage, the categories contributing to it, and the potential impact of their cleanup actions.

Each recommendation card displays the amount of storage that can potentially be cleared within that category, and users can also view the total potential storage that can be saved at the bottom of the storage overview screen. As users delete their storage, the "Space cleared this session" at the bottom of the screen also dynamically updates.

When users are reviewing their files, selecting a file automatically triggers a dynamically updated status bar (e.g., "3 items selected • 7.89 GB will be freed"), providing immediate feedback.

Recognition Over Recall—This prototype also newly introduces a file preview split view, which aligns strongly with the Recognition Over Recall heuristic. Instead of requiring users to remember what a filename such as IMG_2024.jpg refers to, the interface displays a thumbnail, file type, dimensions, creation date, and storage path. Different file types display different, relevant metadata. For instance, when previewing a file in *Large Message Attachments*, the user is also shown who sent the message and what conversation it's from.

Error Prevention—The prototype also builds upon the previous iteration by implementing multiple layers of error prevention. Users must confirm deletion through the confirmation modal, which summarizes the items selected to ensure the user understands exactly what they are deleting. Users are also given the option to undo the deletion as an added safeguard.

11 VIDEO PROTOTYPE

12 FINAL EVALUATION PLANNING

12.1 Overview

The final evaluation will assess the usability, clarity, error-prevention effectiveness, and Mac native-feel of the redesigned Mac storage-management prototype using a survey-based remote study. Participants will interact with the interactive Figma prototype (or watch a short video prototype), then complete a structured survey containing both quantitative Likert-scale items and qualitative open-ended questions.

The evaluation is designed to take approximately 10 minutes per participant.

12.2 Participant Recruitment

Participants are going to be classmates from the course, friends, and family who are familiar with MacOS. The method will be through Edstem and direct outreach. Participation is voluntary and the incentive for our classmates was to return the favor by completing their surveys as well. The sample size we expected was 20 completed responses but we received 27!

12.3 Measurement Plan

Participants rated statements on a 5-point scale (Strongly Agree –> Strongly Disagree). Quantitative metrics captured include: understanding of system status, perceived cognitive load, error-prevention effectiveness, clarity of labels, ease of undoing actions, and overall usability and "Mac-likeness" of the interface.

The survey also included open-ended questions asking participants to describe what they liked and disliked about the prototype, as well as what could use improvement. This meant to capture: moments of confusion or hesitation, features that helped prevent mistakes, what else they'd want in a storage flow, and suggestions for improvement. These responses provided richer insight into why participants rated the design the way they did.

12.4 Data Analysis Plan

Since the prototype focuses on one prototype, and not comparing against other prototypes, the analysis focuses on descriptive statistics. This includes mean, median, mode, frequency distributions showing agreement and disagreement patterns, themed grouping, and Likert-style metrics.

12.5 Expected Outcomes

This survey-based evaluation is expected to reveal multiple insights, including:

- Whether the redesign meaningfully improves error prevention
- Whether users feel guided and confident during storage cleanup
- Whether previews and labels sufficiently reduce anxiety around file deletion
- Whether category clarity and task flow reduce cognitive load
- How well the interface matches macOS UI expectations

The results will guide the final discussion on what worked and what requires further refinement

13 FINAL EVALUATION RESULTS

We made the survey available on Thursday, December 4th and concluded our study on Saturday, December 6th. In these two days, we collected a total of 27 responses, with some coming from Georgia Tech students and some coming from external sources.

Our survey consisted of 7 questions in total, where Q1 is a contingency question assessing whether respondents are able to access our figma design, Q2-Q5 are Likert-scale quantitative questions, and Q6-Q7 are qualitative ones. There were no respondents that weren't able to access our figma prototype, so all responses are considered valid. But, there were two responses that did not contain qualitative data (i.e. the responses to both Q6 and Q7 were left blnak). In the following subsections, we present the raw results and some insights that were learned from them.

13.1 Quantitative Analysis

Table 2—Q2: I found this interface helpful and easy to understand

Value	Frequency	% of total (Approx.)
Strongly Agree	7	26
Agree	14	52
Neutral	1	3
Disagree	0	0
Strongly Disagree	5	18

Although the majority (mean of $\overline{3.48}$ on Likert scale where Strongly agree is given 5 points and Strongly Disagree is given 1) of respondents felt that our redesign is easy to understand, the strong cluster of strong disagreement would indicate that our redesign **needs significant revamps to provide better clarity**.

Table 3—Q3: This prototype adequately gives the chance to preview before deleting

Value	Frequency	% of total (Approx.)
Strongly Agree	13	48
Agree	11	40
Neutral	2	7
Disagree	1	4
Strongly Disagree	0	0

On the other hands, these strong rating ($\overline{4.3}$) would suggest that our redesign provided adequate previews of deletion contents. This would indicate that **we were successful** in addressing one of the primary concerns identified in our initial prototype evaluation.

Table 4—Q4: This prototype gives me an easy way of undoing my actions

Value	Frequency	% of total (Approx.)
Strongly Agree	12	44
Agree	8	30
Neutral	3	11
Disagree	3	11
Strongly Disagree	0	0

Although the majority of respondents agreed that our prototype provided an easy mechanism to undo a deletion ($\overline{3.85}$), the neutral and disagreement responses seems to indicate that further work is needed to improve the undo mechanism. Given the lack of strong disagreement, it would seem that our redesign is on the **right track but requires small tweaks to improve this functionality**.

Table 5—Q5: This interface looks and feels Mac-native

Value	Frequency	% of total (Approx.)
Strongly Agree	12	44
Agree	11	41
Neutral	2	7
Disagree	2	7
Strongly Disagree	0	0

Lastly, it would seem that the theme of our redesign is consistent with Mac-native applications ($\overline{4}$). Given the overwhelming agreement in the responses, it would seem that our redesign was **successful in capturing the Mac-native feels**.

13.2 Qualitative Analysis

Overall, it seems that most users thought that the design was clean and intuitive, where an overwhelming majority of respondent attributed these feelings to the Mac-like design. The preview functionality seemed very well liked, with multiple users expressing support for this feature. The grouping of files into categories was also another feature that resonated with respondents. It seemed that users liked the pre-determined grouping categories, and they did not express distrust in this system.

On the other hand, a small subset of users expressed concerns regarding the undo feature. One user responded by saying that the "undo button goes away in a few seconds", while another mentioned that "[they] didn't see how [they] could undo". Additionally, there was one user who expressed that there were "too much going on at once" in the design's main screen, while another one indicated that our layout's post-click shift could create accidental selection.

Overall, it seemed that our redesign was successful in **improving trust in the smart removal feature**, but there are minor concerns regarding the overall **usability** of our design. These are some improvement suggestions that we compiled from the responses:

1. Batch deletion feature (one user suggested minor annoyance of not being able to delete multiple categories at once)
2. Fullscreen preview option

3. Persistent undo / trash-bin system instead of a post deletion pop up
4. Better file filtering: by size, type, or recency
5. Improve "navigation to previous screen" functionality

The following section will explain the overall insights that were gained, and possible next steps to further refine this prototype.

13.3 Overall insights / outcomes

These are the overall outcomes of our final prototype evaluation, in accordance to our objective as outlined in *Final Evaluation Planning: Expected Outcomes*

13.3.1 *Preventing user error*

Through the preview panel, it would seem that we were successful in *preventing user errors*. Our preview functionality was universally liked and seems sufficient in preventing accidental deletion

13.3.2 *Increasing confident and reducing anxiety*

It also seemed that users are comfortable in using our redesign. There were no mentions of distrust in the interface and/or its recommendations, so it would seem reasonable to conclude that we were successful in *increasing confident and reducing anxiety around file deletion*.

13.3.3 *Cognitive load reduction*

As far as reducing cognitive load is concerned, it would seem that our redesign is insufficient. A lot of negative sentiment in the survey is centered around the overall usability of our interface which would suggest that more work is needed to address this pain point. The next iteration would need to focus on reducing overall clutter of the main page.

13.3.4 *MacOS UI expectation*

Our interface is rated very highly in regard to conforming with macOS UI expectation. It would seem that we did well in this regard.

14 REFERENCES

[1] *AppCleaner* (Dec. 7, 2025). URL: https://freemacsoft.net/appcleaner/ (visited on 12/07/2025).

[2] *Store files in iCloud Drive on Mac* (Dec. 7, 2025). Apple Support. URL: https://support.apple.com/guide/mac-help/store-files-in-icloud-drive-mchle5a61431/mac (visited on 12/07/2025).

15 INDIVIDUAL REFLECTIONS

15.1 Individual Reflection - Calvin Fong

Throughout the course of this project, I contributed to several components across the design cycle. I wrote the introduction to the project and helped with needfinding including designing, distributing, and synthesizing the initial surveys that shaped our problem framing. I also generated and organized the brainstorming results, helping translate raw ideas into actionable design directions for our first prototypes. For the final phase, I conducted and gathered the final prototype evaluation survey responses and wrote the full evaluation plan outlining participant recruitment, study structure, quantitative and qualitative measures, and analysis methods.

My teammates played critical roles in bringing the project together. Kate contributed heavily to early-phase organization and execution: she developed the needfinding survey plan, synthesized early survey results, and created the brainstorming plan. She also produced Initial Prototype # 1 (which performed very well) and collaborated with Gabe to build and refine the final prototype. Additionally, Kate wrote the final prototype documentation, which tied together our design decisions across iterations. Kevin contributed primarily to analytical and evaluative components. He authored the needfinding heuristic evaluation plan and conducted the heuristic evaluation, producing the key insights that directly informed our first iteration. Kevin also created Initial Prototype #3, developed the initial prototype evaluation plan, and completed the initial prototype evaluation results. For the final phase, he contributed to the final prototype evaluation results as well. Gabe was instrumental in conducting needfinding and synthesizing results, as well as the creation of Initial Prototype #2. He also worked meticulously with Kate on the final prototype. He then tied it all together by recording the video prototype for us. All three of them contributed ideas during brainstorming, while I handled most of the formal results writeup.

Overall, the project progressed smoothly, and our team complemented each other's strengths well. Our decision to anchor the design process in clear user data made later stages much more focused. One thing that worked well was our willingness to iterate quickly once we received evaluation feedback; this allowed us to make meaningful improvements across prototypes rather than superficial adjustments. We were also communicative and it went really smoothly using Dis-

cord. Kate contributed to well-performing ideas and prototypes, Kevin helped lead and keep us on the right track while handling analytical and evaluation-heavy content, and Gabe put forth well-polished and high-fidelity prototypes.

What perhaps could have worked better was our early alignment on roles and timelines. During the needfinding stage, we occasionally had uncertainty around when to meet for certain deliverables. In future projects, I would establish a clearer work breakdown structure at the beginning, including checkpoints for prototype integration and evaluation design. That said, the project was rewarding, collaborative, and offered a great opportunity to practice a full design cycle as a group from initial needfinding to final evaluation.

15.2 Individual Reflection - Thien/Kevin Bui

For this project, I worked on and did the writeup for *Needfinding Plan: Heuristic Evaluation*, *Needfinding Results: Heusristic evaluation results*, *Needfinding Results: Key insights from needfinding activities*, *Initial Prototypes # 3: Application-Base Deletion Menu*, *Initial Prototype Evaluation Planning*, *Initial Prototype Evaluation Result*, and *Final Prototype Evaluation Result*. Like everyone else, I contributed to the brainstorming activities and overall synthesis of the initial prototype evaluation result during our two synchronous session. In the synchronous session, I shared in the note taking responsibility and contributed ideas to ensure that the meetings remain productive.

My teammates were essential in bringing this project together. Every member significantly contributed to the project, and each of us worked together on Discord and in synchronous meetings to ensure the project was delivered on a timely manner. As mentioned by Calvin, Kate contributed heavily to the needfinding activities and brainstorming plan. She produced the Initial Prototype #1, which served as the base to our final prototype and collaborated with Gabe to build it. She also did the final prototype writeup, which beautifully tied together our design decisions across the two iterations. Calvin was responsible for producing both of our prototype evaluation surveys and was crucial in participant recruitment. He and I worked together in the final evaluation, and was instrumental for getting the response needed in the surveys. Gabe was responsible for ensuring that we had live interview results in our need finding phase (in addition to surveys), and he worked with Kate to ensure that our prototype was functional. He is also responsible for our *Video Prototype*.

Overall, the project progressed smoothly, and our team worked together quite well. We were all active in Discord communications, and we each delivered in our various assigned parts in a timely manner. I share in Calvin's sentiment that there were small uncertainty around the timeline of certain deliverables in the beginning, but after our first synchronous meeting the uncertainties were resolved when concrete timelines were agreed upon. This has been a rewarding, collaborative, and most importantly fun project, and I feel that these would not have been possible without full cooperations from every member of the team!

15.3 Individual Reflection - Gabe

For this project, I contributed primarily in the needfinding, conceptual design, and prototyping phases. My main responsibilities included conducting interviews during the needfinding stage, and recording the results. I also participated in participating in the brainstorming activities, then creating an initial medium-fidelity prototype that emphasized reducing cognitive load. I then developed the final high-fidelity prototype alongside Kate ,and filmed the video prototype. Throughout the project, I actively engaged in team discussions and meetings, overall contributing heavily to the final outcome of the project.

My teammates also contributed significantly throughout the process. Calvin developed the introduction, designing and analyzing the needfinding survey, contributing to brainstorming results and leading the final evaluation planning as well as collecting data for the evaluation study. Kate wrote the survey needfinding plan, creating the survey results section, as well as developing initial prototype 1, which heavily inspired the final prototype. Working along with her, we both designed the final high-fidelity prototype, and she further contributed by writing up the final prototype writeup. Kevin created the heuristic evaluation plan and then conducted the evaluation and wrote the results.

Overall, I would say our group meshed extremely well. We had a constant stream of communication and everybody's ideas were considered equally. Everyone did their part as agreed and there wasn't any struggle within the group. The deadlines did feel a little compact and overwhelming at first, but after meeting with group members multiple times and discussing things over the phone, we were able to lay out a clear path for ourselves.

15.4 Individual Reflection - Kate Yoon

Overall, the workload of the project was distributed evenly and fairly. I personally worked on one of the needfinding activities (the survey) and writing its planning and result, as well as the bias mitigation portion of the needfinding section. I also wrote up the initial brainstorming plan for the project and created Initial Prototype 1: Card-Based Recommendations. During the final stages of the project, I worked on creating the final high-fidelity prototype with Gabe and added the final prototype write-up to the deliverable.

During the needfinding phase of the project, Gabe and Kevin conducted the other two needfinding activities, with Gabe conducting interviews and Kevin conducting a heuristic evaluation. Since only three activities were required, Calvin instead wrote our project introduction. After our brainstorming session, Calvin also recorded the results and outcomes and added those to our project deliverable. Though, it is important to note that each member contributed significantly to the brainstorming process. Then, since only three initial prototypes were required, we decided that three of us would work individually on a prototype, while the fourth member would work on the evaluation of those prototypes. I did one prototype, Gabe created Initial Prototype 2, and Kevin created Initial Prototype 3. Calvin handled the evaluation of the prototypes by creating and distributing an online survey, and Kevin contributed to the writeups for this portion (Initial Evaluation Planning and Results). In the final phase of the project, Gabe and I worked on the final prototype, with Gabe completing the video prototype, while Calvin and Kevin worked on the evaluation of the final prototype.

Overall, everyone contributed significantly, and the workload was divided fairly among all the team members. I feel fortunate that everyone in the group was willing to participate and contribute, and that we were all active in our communications and meetings. One possible area for improvement is starting certain tasks a bit earlier so we have more buffer time and less last-minute pressure, but since we were able to get everything done on time, I think it all worked out.

16 APPENDICES

16.1 Needfinding Survey Questions

- **Q1 (Multiple Choice).** How long have you been using macOS?
  - Less than 1 year
  - 1–3 years
  - 3–5 years
  - More than 5 years
- **Q2 (Multiple Choice).** How often do you encounter low storage space warnings or issues on your Mac?
  - Never or rarely (less than once a year)
  - Occasionally (a few times a year)
  - Frequently (monthly or more)
- **Q3 (Select All That Apply).** What typically triggers you to manage your storage space?
  - Low storage warning from macOS
  - Unable to download or install something
  - Slow system performance
  - Routine maintenance habit
  - Before a software update
  - Other
- **Q4 (Short Answer).** If "Other," please specify.
- **Q5 (Select All That Apply).** What methods do you currently use to identify files taking up storage space?
  - macOS Storage Management tool (System Settings)
  - Finder search or manual browsing
  - Third-party applications (e.g., DaisyDisk, CleanMyMac)
  - I do not actively identify large files
  - Other
- **Q6 (Short Answer).** If "Other," please specify.
- **Q7 (Select All That Apply).** What challenges do you face when trying to free up storage space?
  - Difficult to determine where storage is being used
  - Cannot tell which files are important versus unnecessary
  - Fear of deleting something needed later
  - Time-consuming to review files manually

- Hard to identify duplicate or old unused files
- Do not understand certain system file types
- Other

- **Q8 (Short Answer).** If "Other," please specify.
- **Q9 (Likert Scale).** I find it easy to identify which files are taking up the most space.
  - Strongly Agree
  - Agree
  - Neutral
  - Disagree
  - Strongly Disagree
- **Q10 (Likert Scale).** I am confident I can delete files without negative consequences.
  - Strongly Agree
  - Agree
  - Neutral
  - Disagree
  - Strongly Disagree
- **Q11 (Likert Scale).** Current macOS tools provide enough information to make good deletion decisions.
  - Strongly Agree
  - Agree
  - Neutral
  - Disagree
  - Strongly Disagree
- **Q12 (Select All That Apply).** What information would be most helpful when deciding whether to delete a file?
  - File size
  - Last accessed or opened date
  - File type or category
  - Whether the file is backed up elsewhere
  - How often similar files are accessed
  - Automated suggestions based on usage patterns
  - Other
- **Q13 (Short Answer).** If "Other," please specify.
- **Q14 (Select All That Apply).** What features would make storage management

easier for you?

- Visual representation of storage usage (charts or graphs)
- Smart suggestions for files to delete
- Bulk selection tools for similar files
- Preview functionality before deletion
- Duplicate file finder
- Safe cleanup of system caches and temporary files
- Better categorization of file types
- "Safe to delete" confidence ratings
- Other

- **Q15 (Short Answer).** If "Other," please specify.
- **Q16 (Short Answer).** If you could change one aspect of how you currently manage storage space on your Mac, what would it be?

16.2 Needfinding Survey Results

The raw csv file with responses can be found at: https://docs.google.com/spreadsheets/d/1lo75s3U7uZFDhmBr9cqHfFYdLiIO2qO0K5Y9js7WpjY/edit?gid=1519836104#gid=1519836104

16.3 Heuristic Evaluation Results

16.3.1 *Storage setting*

1. Visibility of System Status
   - **Issue –** this application doesn't show how much space is overall available on the system. But it does a good job at showing how much space each individual applications are taking up.
   - **Recommendation –** there needs to be some sort of notifications letting users know that cleanup is occurring, and a log to show the contents being removed.
2. Match Between the System and the Real World
   - **Issue –** None. The application uses correct terminology, and sufficiently explains what each functionality is doing.
3. User Control and Freedom
   - **Issue –** there is no options for users to select the kind of contents to be removed.
   - **Reccomendation –** there should be an exception functionality to exclude certain contents from being inadvertently removed.

4. Consistency and Standards
   - **Issue –** None. This application follows Apple's Human Interface Guideline (see bibliography for more details (, 2025)).
5. Error Prevention
   - **Issue –** there is no mechanism in place to prevent the system from deleting contents that are marked for deletion by accident (i.e. users accidentally placing an important document in "trash")
   - **Recommendation –** a favorite functionality could be added for every file on the system. Once a file is marked as favorite, the automatic cleanup will not delete that file. Additionally, a confirmation dialog could also be implemented prior to the scheduled deletions. This confirmation could contain a log of all files that are scheduled for deletion, and users will have to manually testify for deletion to occur.
6. Recognition Rather than Recall
   - **Issue –** None. This application follows Apple's Human Interface Guideline (, 2025) which has a fantastic catalog of easily recognized icons.
7. Flexibility and Efficiency of Use
   - **Issue –** there is no options for users to select the kind of contents to be removed.
   - **Reccomendation –** an exception functionality would be a good place to start.
8. Aesthetic and Minimalist Design
   - **Issue –** None. This application follows Apple's Human Interface Guideline (, 2025).
9. Help Users Recognize, Diagnose, and Recover from Errors
   - **Issue –** there is no way for users to recognize that cleanup is successful, and also no way for users to recover from accidental deletions.
   - **Reccomendation –** Prior to deletions, have an attestation step to let users know about the contents being deleted and when the deletion is occurring. Once deletion happens, let users track progress via task bars, and notify them of any problems
10. Help and Documentation
    - **Issue –** None. Although there is no built in documentation, each functionality is sufficiently explained in the toggle menu that enables them.

16.3.2 *Disk Utility*

1. Visibility of System Status
   - **Issue –** None. The application does a good job at letting users know about the amount of *partitions* and *available storage* on the current device.
2. Match Between the System and the Real World
   - **Issue –** None. The application's icon of a stethoscope next to a Hard Drive clearly convey that this is a tool meant to be used for diagnosis of disc related problems. Within the app, there are clever names (e.g. "first aid" to access the partition diagnostic tool) to indicate functionalities.
3. User Control and Freedom
   - **Issue –** None. The user is able to specify, with great specificity, exactly what they would like the application to do in regard to their storage space.
4. Consistency and Standards
   - **Issue –** None. This application follows Apple's Human Interface Guideline (see bibliography for more details (, 2025)).
5. Error Prevention
   - **Issue –** None. This application offer a variety of confirmations prior to deletions, and in case of problems there are a variety of logs to aid troubleshooting. The "first aid" option is also good for quickly identifying problems caused by the tool.
6. Recognition Rather than Recall
   - **Issue –** None. This application follows Apple's Human Interface Guideline (, 2025) which has a fantastic catalog of easily recognized icons.
7. Flexibility and Efficiency of Use
   - **Issue –** In regard to optimization of storage space, this utility does not offer any functionality for direct interactions with files. This tool is only good at interacting with drive partitions, which can be set up to encompasses large grouping of files.
   - **Recommendation –** add functionality that would allow users to manipulate files within the tool.
8. Aesthetic and Minimalist Design
   - **Issue –** None. This application follows Apple's Human Interface Guideline (, 2025).
9. Help Users Recognize, Diagnose, and Recover from Errors
   - **Issue –** Although the "first aid" tool is great at diagnostic and recovery,

there is no functionality to help assist users with recognition. Users, currently, would have to already been aware of problems (e.g. trying to access a corrupted partition and noticing errors) before they're able to access the "first aid" tool for recovery.

- **Recommendation –** the "first aid" tool could be enabled on disk utility startup so that it alert users of any potential problems with their disk.

10. Help and Documentation
    - **Issue –** This tool is made for users who are very familiar with Unix operating system (i.e. the concept of a disc partition isn't colloquially known), so clear documentations are clear prerequisite for using the tool. Current documentations can be accessed using the command line `man` utility, but within the graphical interface there is no way to access the same information.
    - **Recommendation –** There should be a help menu within the graphical user interface that explains the action being performed. It would also be helpful to have a dedicated tutorial for this tool, which could be modeled after the `vimtutor`!

16.3.3 *AppCleaner*

1. Visibility of System Status
    - **Issue –** None. This application does an exceptional job at letting users know about the files being cleaned. Users can easily tell from the main page which file is being cleaned up.
2. Match Between the System and the Real World
    - **Issue –** None. The application does a good job at using the right icons to indicate the operations being done. The recycle symbol on the application's icon is a fantastic choice.
3. User Control and Freedom
    - **Issue –** None. This application allow users to pause and exit any unwanted deletion.
4. Consistency and Standards
    - **Issue –** None. This application uses very consistent theme-ing in its design. The drag and drop to delete functionality is consistent with Apple's drag and drop to install.
5. Error Prevention
    - **Issue –** None. This application has an attestation screen prior to deletion which allow users to know exactly what is being removed.

6. Recognition Rather than Recall
   - **Issue –** None. This application utilizes drag and drop functionality of other popular MacOS app extremely well (e.g VLC media player, Apple's install an application screen).
7. Flexibility and Efficiency of Use
   - **Issue –** This application does not allow deletion of individual files, and doesn't allow deletion of Mac specific files either (e.g. AppCleaner doesn't allow for deletion of unused notes).
   - **Recommendation –** extend the app so that more applications can be used. For example, there are a lot of files inside of Finders that are cleanable, but AppCleaner doesn't have the capability to access it using its file finder feature..
8. Aesthetic and Minimalist Design
   - **Issue –** None. There are only three possible actions from the GUI, which is "drag and drop", "find an application", and "clean".
9. Help Users Recognize, Diagnose, and Recover from Errors
   - **Issue –** This application does not let users know about undeletable files (i.e. trying to delete locked file on MacOS will not trigger any errors or warnings).
   - **Recommendation –** When encountering problems during cleaning, the application should let users know via a pop up.
10. Help and Documentation
    - **Issue –** None. Although this application doesn't have a help and documentation feature, its functionality is simple enough that it is not warranted.

16.4 Brainstorming Results

Kate first shared her ideas, which included:

- Self-cleaning folders, where for example, there would contain rules for downloads that would include scenarios like files over 30 days old slated for deletion.
- Smart suggestions, where cleanup would be automated, but files would also be suggested for deletion.
- Shown files sorted by different tiers of confidence to address users that weren't quite sure what to delete (or know which files should not be deleted)
- A different visualization for system folders in a radial chart that could be zoomed in and out of different directories

Gabe then shared his ideas, which included:

- Clustering items together to make more organized deletion and sort things by file type (screenshots, downloads). For example, a user might have 8 different versions of the same thing (like the same version of a paper), and the user could cluster based on duplicates.
- If a file is going to be deleted, then suggest why it should be deleted (such as it being a file that isn't used often). The system should be transparent with users
- Giving users an undo or confirmation option - we don't want something to be deleted that we don't want
- In thinking of cognitive load, because of the issue of overwhelming the user, every so often, the system should have a short session where the user can just spend time deleting things so that it doesn't have to be done all in one go

Thien then shared his ideas, which included:

- Prior to deletion, there should be a confirmation window saying which files will be deleted
- When deletion is scheduled, there should be a clear way to alert users that this is happening in the background (icon at the top where the Wi-Fi is) saying deletion is occurring in the background
- When deletion is occurring, the system should show how much space is being reclaimed so the user know what's going on
- Using LLMs to offer suggestions

Calvin concluded by sharing his ideas, which included:

- Fast-action tool that deletes the necessary amount of / the minimum required amount of files to make space in 30 seconds, for instance for a quick method
- Instead of being a reactive action, the system can be predictive and tell the user it anticipates running out of memory in x amount of days, or this is what the current memory looks like
- A tool like Ctrl + Alt + Delete on Windows that shows files sorted by largest and what deleting them would do to the overall storage

16.5 Initial Prototype Evaluation Survey

Survey Questions Prototype 1

1. Can you access Prototype #1?

2. Prototype #1: I always understood the system's status and my next action
3. Prototype #1: This looks and behaves like a built-in Mac feature
4. Prototype #1: This design minimizes clutter and noise, showing only the information I need to accomplish tasks
5. Prototype #1: The storage recommendation cards were easy to understand.
6. Prototype #1: How else would you like to be presented with recommendations for clearing up storage space?

   Prototype 2
7. Can you access and interact with Prototype #2?
8. Prototype #2: This method for deleting storage on my Mac reduces my cognitive load
9. Prototype #2: I feel guided and that the instructions are clear on what the next steps are
10. Prototype #2: I'm provided with immediate feedback that shows me the results of what I've done
11. Prototype #2: It's easy for me to undo any actions I take by mistake
12. Prototype #2: What else would you like to see in this session-based storage flow?

    Prototype 3
13. Can you access Prototype #3?
14. Prototype #3: This gives me the right amount of deletion options necessary to optimize my storage
15. Prototype #3: I feel like I'm fully in control at every step of the process
16. Prototype #3: I felt the drag-and-drop application selection was intuitive and efficient
17. Prototype #3: The design felt consistent with macOS conventions I'm familiar with
18. Prototype #3: If you could change one thing about this prototype, what would it be and why?

16.6 Initial Prototype Evaluation Result

The raw csv file with responses can be found here

16.7 Final Prototype Evaluation Survey

1. Can you assess this prototype? (yes/no)

2. I found this interface helpful and easy to understand (strongly agree, agree, neutral, disagree, strongly disagree)
3. This prototype adequately gives the chance to preview before deleting (strongly agree, agree, neutral, disagree, strongly disagree)
4. This prototype gives me an easy way of undoing my actions (strongly agree, agree, neutral, disagree, strongly disagree)
5. The interface looks and feels Mac-native (Strongly agree, agree, neutral, disagree, strongly disagree)
6. Any comments? What did you like/dislike most about this prototype? (Free response)
7. What improvements would you suggest for this prototype? (Free response)

16.8 Final Prototype Evaluation Result

The raw csv file with responses can be found here