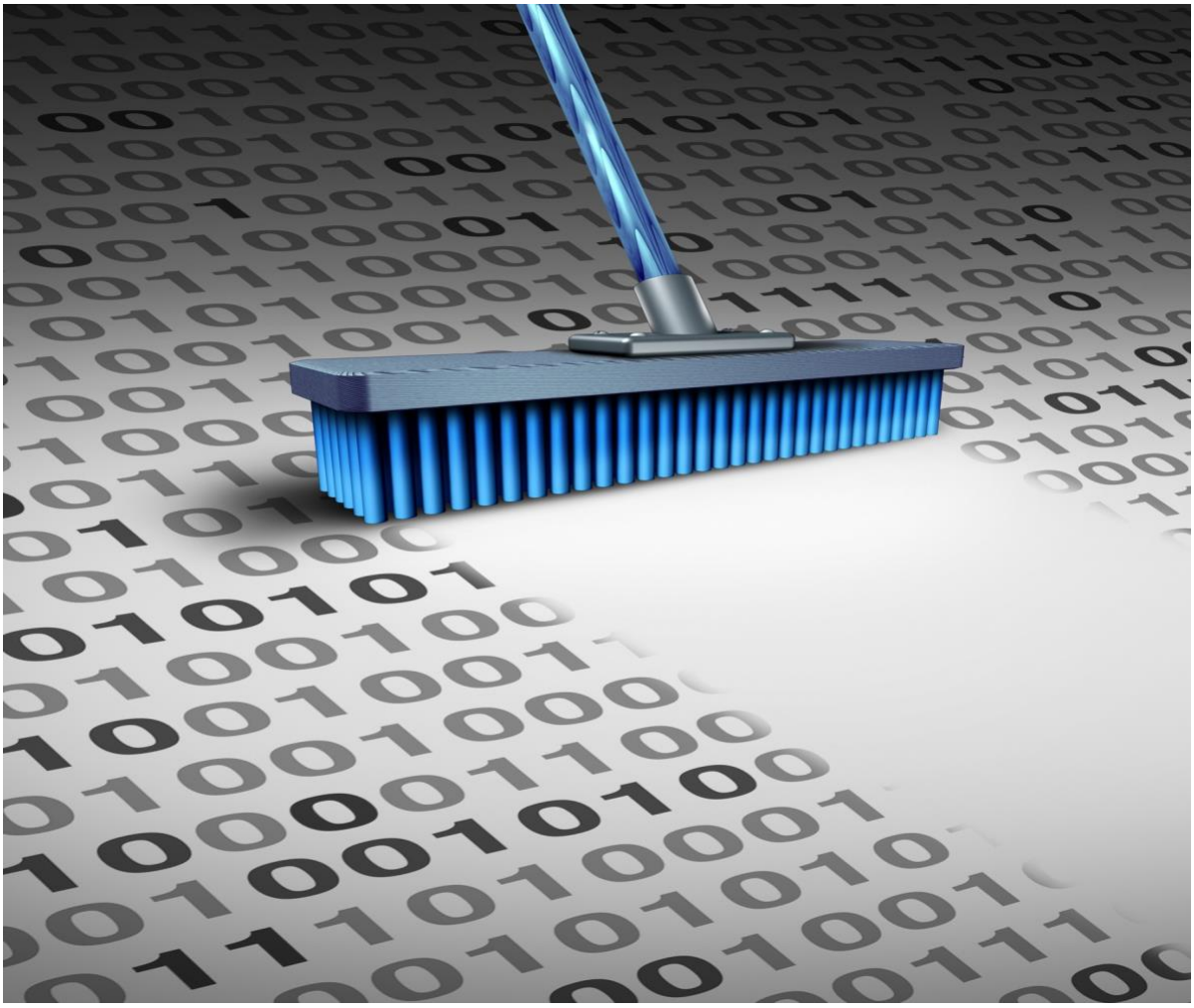
CAPSTONE THESIS

Helping Users Avoid Data Hoarding by Understanding Workflow Contexts



MS HCI/d

SP24: i695 – HCI/d capstone | Kayce Reed-Buechlein
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Overview

Introduction

What problem is this project solving?

This project deals with data hoarding defined as the accumulation of large amounts of data without a clear purpose or strategy.

What is the goal of this project?

The goal of this project is to help people avoid or reduce hoarding data (deleting unwanted data) by integrating the design intervention into their workflow to provide a seamless experience without adding any additional workload.

Why is it needed?

Hoarding behaviors have been shown to increase anxiety, reduce work efficiency, and increase cyber security threats.

How is this problem being solved?

This intervention aims to avoid data hoarding by encouraging users to review and delete unwanted data regularly. But it also takes it a step further by understanding the context of the user's workflow to intelligently aggregate files relating to a workflow as a single source of truth (files stored locally + cloud applications), and generating a file report at the end of a workflow for encouraging users to delete data that are no longer needed. Thus, avoiding hoarding.

Who is this designed for?

This intervention is targeted towards college students (both grad and undergrad).

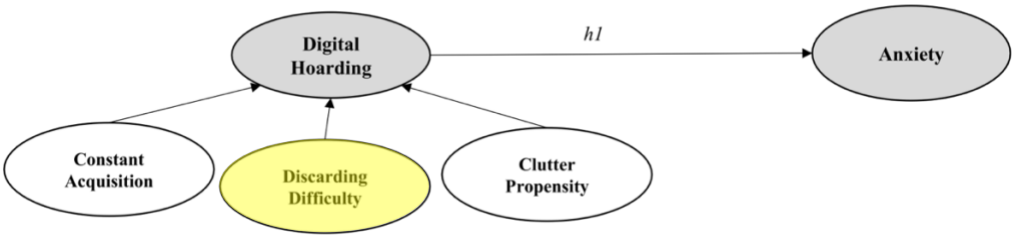
About the problem

What is Data Hoarding?

Data hoarding refers to the practice of accumulating large amounts of data without a clear purpose or strategy for its use or management. This can involve collecting vast quantities of digital information, such as files, documents, emails, photos, videos, or other types of digital content, often without organizing or categorizing it effectively.

Consequences of Data Hoarding

- Reduced productivity
- Increased cyber security threat
- Increased anxiety. When individuals acquire excess data and fail to delete existing data, it leads to clutter (hoarding) which ultimately causes anxiety.



Data hoarding a priori model (Sedera,D., 2022)

Factors motivating data hoarding

- Retaining data for future use
- Retaining data as evidence
- Emotional attachment associated with data
- Laziness and time constraints

90% of research participants said laziness and time constraints were the major factor motivating them to hoard data.

Problem frame

The project further narrows down to dealing with data hoarding resulting from **discarding difficulties and laziness & time constraints.**

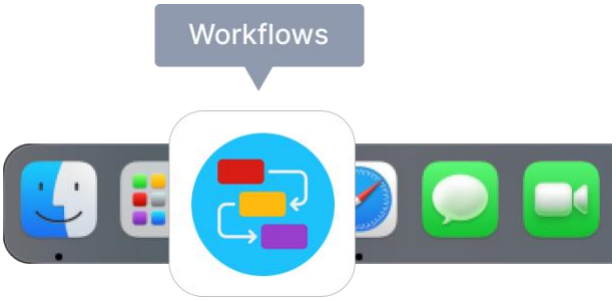
How Might We Help College students with discarding unwanted files to avoid data hoarding resulting from laziness and time constraints?

Overview of the final outcomes

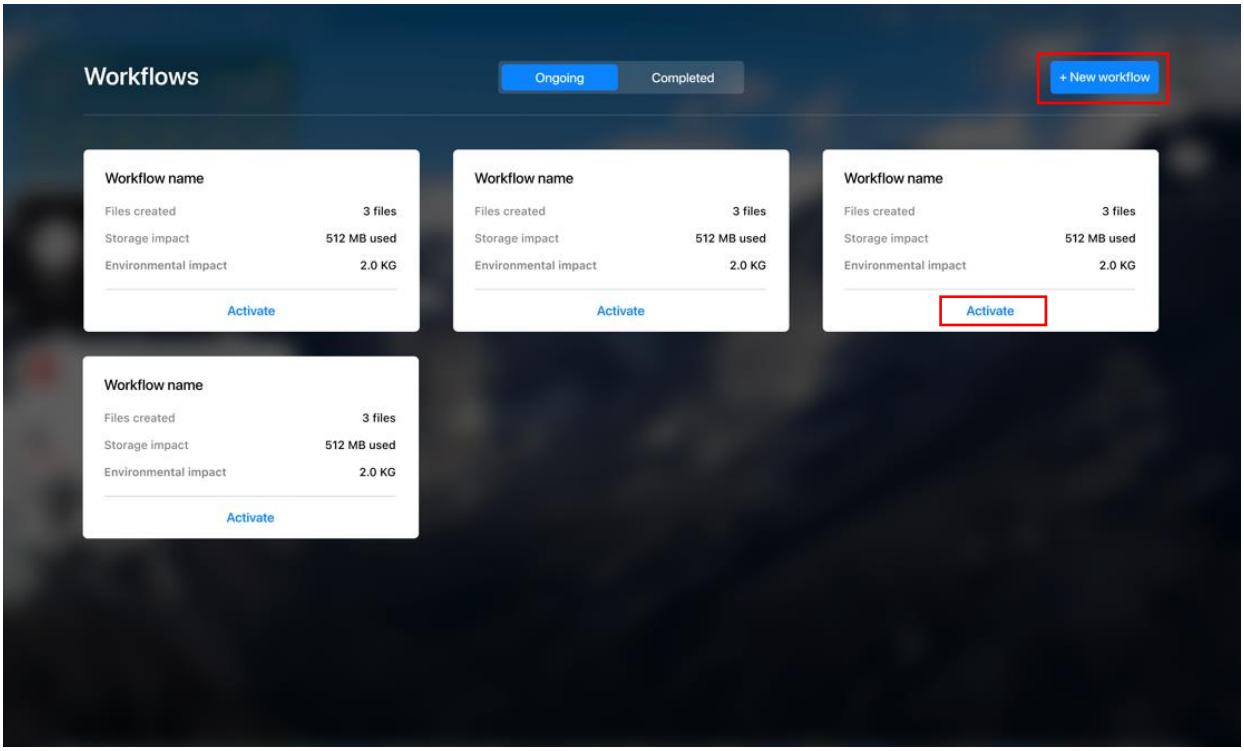
The final solution is a feature implemented in the Mac Operating System called “The Workflow mode”. The workflow mode tracks files that were created (locally on the device or on the internet) or downloaded, and associates it with the user’s ongoing workflow, enabling the user to see files based on workflows.

How does it work?

Step 1: Workflows can be accessed by launching the workflow manager from the dock

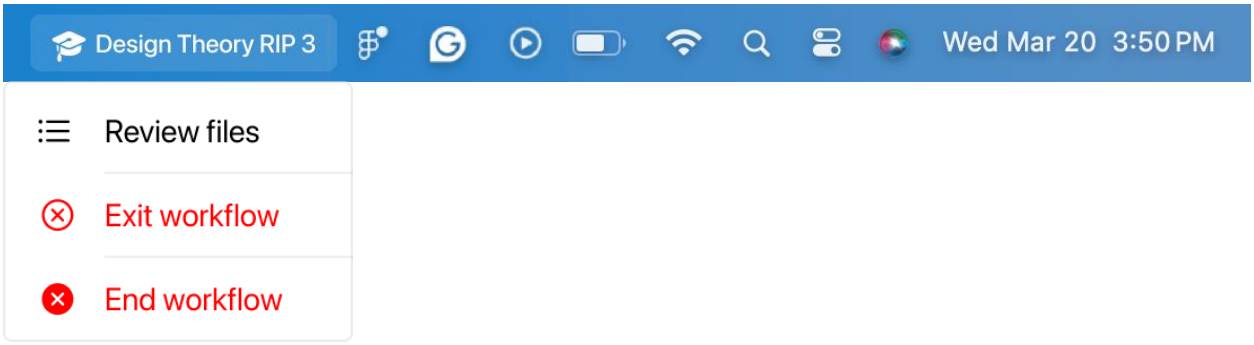


Step 2: Select a workflow or start a new workflow from the workflow manager

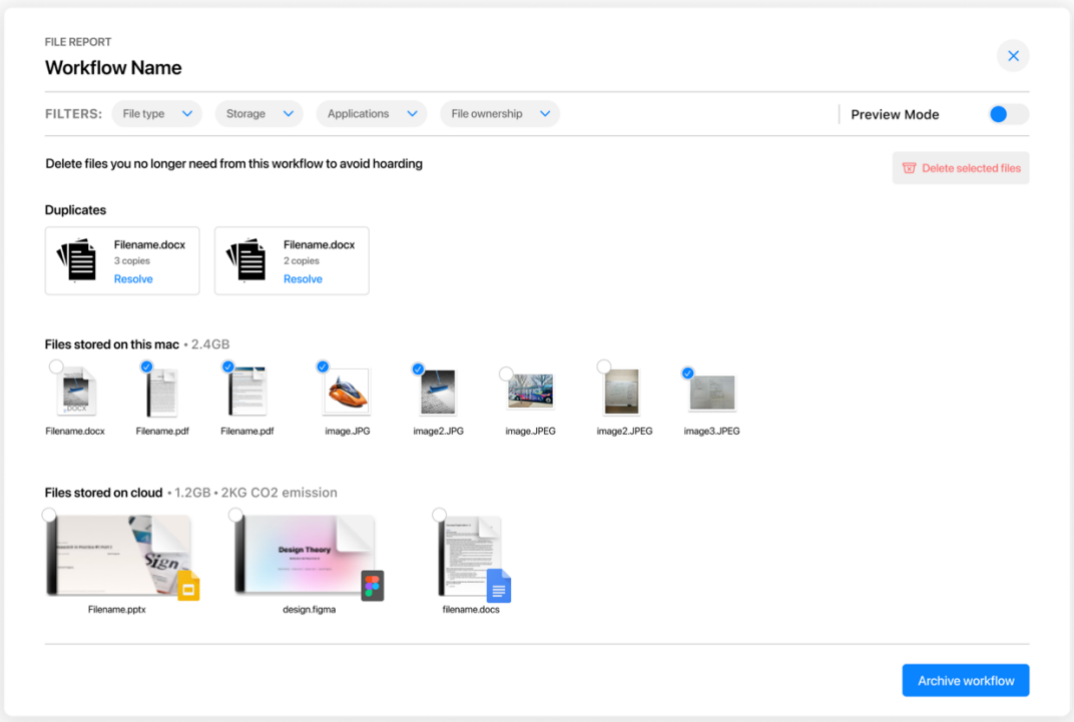


Note: A workflow can be associated to an assignment, project, or a specific activity involving the creation of multiple files.

Step 3: Use the menu bar to exit or end (when you have completed a workflow) the current workflow mode



Step 4: When a workflow is ended, a file report is generated showing all the files that were created over the course of the workflow, and the user is prompted is deleted all the unwanted files.



By prompting the user to delete unwanted files right after they complete a workflow, this intervention prevents data hoarding. Additionally, workflows can give additional context making it easier for the user to delete files.

Process followed

This project was completed in 3 design sprints, out of which 2 sprints were completed in the fall 2023 semester and the other in the spring 2024 semester. The scope of these sprints was as follows:

Sprint 1

Objectives

- Learn different techniques/concepts that can be used to make people environmentally conscious
- Understand student's use of cloud storage technologies
- Generate initial ideas for feedback

Activities Performed

- Secondary research
    - Research papers
- Primary research
    - User interviews
- Ideation based on secondary research insights
- Low-fidelity prototyping

Sprint 2

Objectives

- Address feedback received from milestone 1 based on ideas generated in sprint 1.
- Understand the emotional attachment associated with data
- Look at the broader data hygiene umbrella to address the root cause of data hoarding

Activities Performed

- Secondary research
    - Research papers
- Primary research
    - User interviews with a new protocol
    - Analysis of students' artifact ecology
- Ideation based on secondary + primary research insights
- Low-fidelity prototyping
- High-fidelity prototyping

Sprint 3

Pivot

At this stage, the focus of the project pivoted from sustainability to data hoarding which is the main issue at hand, with the environmental impact being one of its consequences

Objectives

- Decide if I want to focus data hoarding for cloud storage, or also include local storage as part of the scope based on the target user's usage patterns
- Synthesize concepts to reflect the new focus of the project and address feedback from sprint-2
- Design low-fidelity prototypes for concept testing
- Design high-fidelity prototypes with feedback from concept testing
- Understand factors motivating data hoarding

Activities performed

- Primary research
    - Contextual inquiry
- Secondary research
    - Research papers

Sprint 1

Initial Problem Statement

This project started off with a focus on sustainability. The objective of this project was to reduce the environmental impact of cloud storage by encouraging users to regularly delete unwanted files from their cloud storage.

Rationale

The cloud now has a greater carbon footprint than the airline industry. A single data center can consume the equivalent electricity of 50,000 homes ("*The staggering ecological impacts of computation and the cloud*", 2022). According to the Institute for Engineering & Technology in the UK, approximately 355,000 tons of CO2 could be reduced every year in the United Kingdom if people deleted unwanted data("Dirty Data", 2021). The potential CO2 reduction that can be achieved by raising awareness and getting rid of unwanted files inspired me to pursue this problem space initially.

Research papers (secondary research)

Objectives

The objectives for this activity were as follows:

1. Creating an eco-feedback loop
2. Encouraging pro-environmental behavior
3. Investigate various behavior change models to break and form habits using digital interventions

Papers referred

Papers referred to as part of this activity are included in the appendix

Insights

1. Different approaches such as goal setting, social influence, and incentives enhance the eco-feedback loop
2. Creating an eco-feedback loop is very important in encouraging pro-environmental behavior
3. Apart from the design & technical aspects of the eco-friendly product, the policy associated should also be formulated to be effective.
4. Irrational cultural factors also play an important role in the adoption of eco-friendly technologies, especially in low-income/developing regions.

5. Pro-environmental behaviors are pronounced when the costs are low and benefits are evident.
6. It is important to educate people with the required knowledge of environmental

User interviews (primary research)

Objective

I wanted to learn the following from user interviews:

1. Understand the target audience's usage of cloud storage technologies
2. Learn about their understanding of the environmental impact of cloud storage
3. Actions they currently take to avoid hoarding unwanted data and the barriers they face
4. What motivates them to delete files on their cloud storage

Interview protocol (v1)

The interview protocol used for this interview is included in the appendix

Sample size

A total of 8 participants were interviewed.

Insights

Insight #	**Insight details**
1.1	Time is the biggest barrier to reviewing and deleting files on the cloud
1.2	There was a strong correlation between file deletion and file organization – some did it to keep their virtual world clutter-free
1.3	Some people wait until their cloud storage is completely full before deleting unwanted files while others do it on a regular basis
1.4	Anything important/work-related will be saved on the cloud
1.5	Deleting an important file that they might need later is one of their biggest fears
1.6	Most of the people interviewed had subscribed to additional cloud storage while some would create a new account when they ran out of storage
1.7	Incentives motivate them to form & follow the habit of deleting unwanted files regularly
1.8	Convenience is more important than environmental concerns
1.9	Some people find it very difficult to review and delete unwanted files (especially photos)

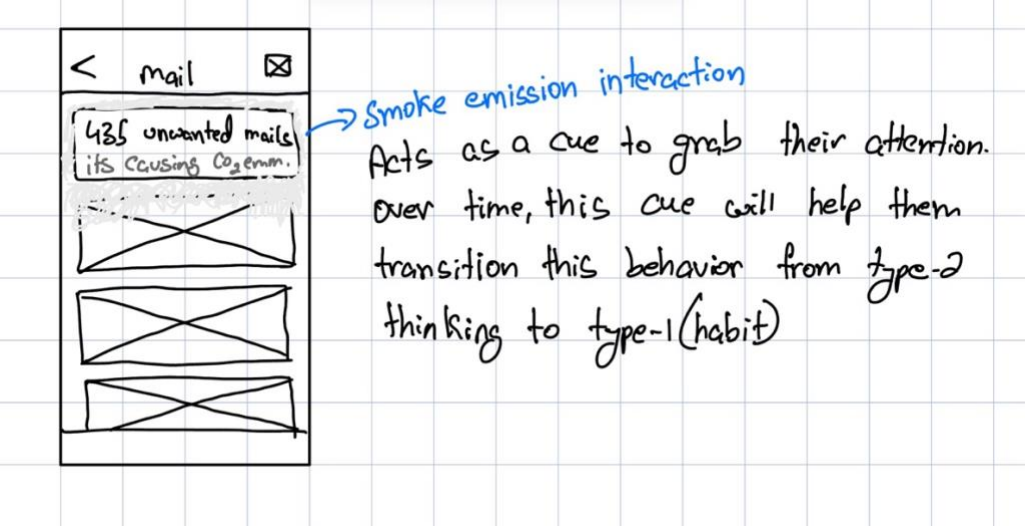
Ideation

This concept is designed to be an OS (operating system) level implementation that takes 2 different forms:

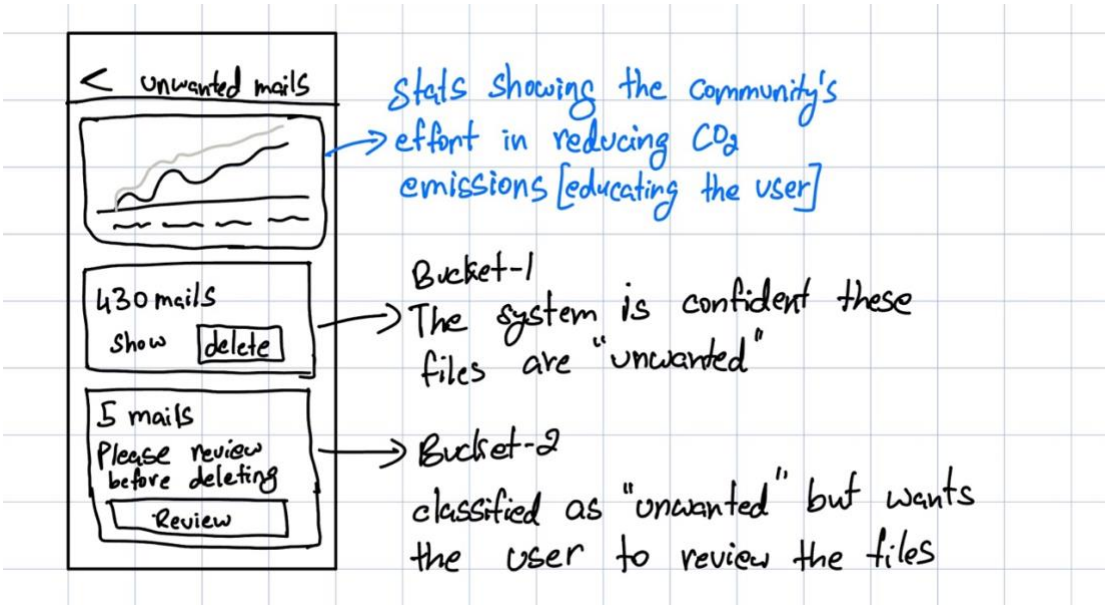
1. App-specific form: Relevant cues and actions will be designed for the targeted app to trigger the required action (e.g., deleting mail in the mail app, photos in the Photos app, etc.)
2. Centralized form: One place to get a holistic view of the user's cloud storage status, dig deeper into specifics (such as files from a specific cloud account, emails from a specific email ID, etc.), and take all the required actions

App-specific form

Suppose the user is in the mail app, a smoke emission interaction will grab the user's attention to deal with unwanted emails sorted by the mail app. This interaction will act as a cue to help transition from type-2 thinking to type-1 thinking (habit) inspired by the Habit Alteration Model (HAM).



Clicking on the banner will take the user to a new screen to easily delete unwanted emails with just a single click (shown in next page).



A confidence score will be used to bucket the emails – a bucket containing emails classified as “unwanted” with a high score & another with a low score requiring the user to review before deleting. Stats showing the community’s efforts related to mail deletion will be shown to motivate the user.

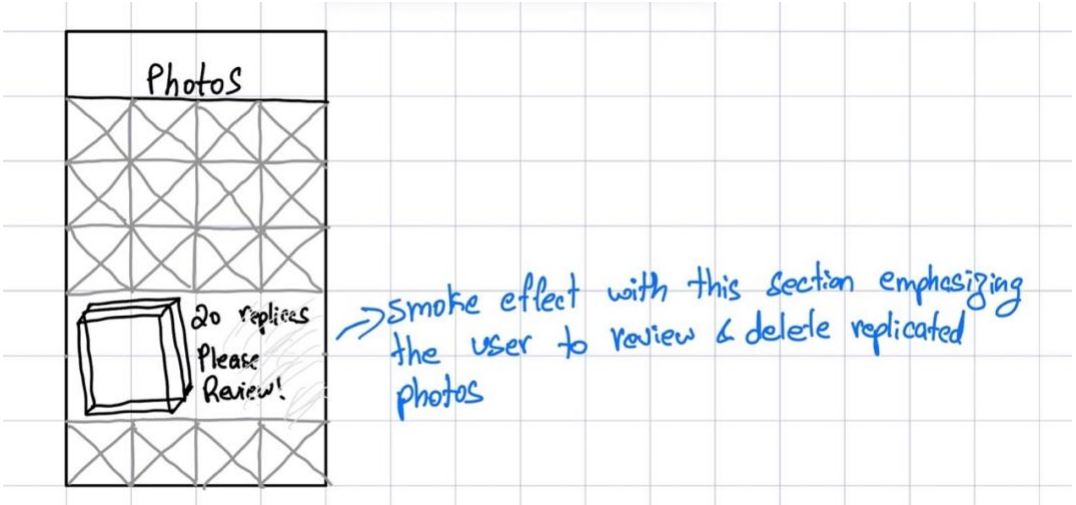
Rationale

Insight 1.5

Deleting an important file that they might need later is one of their biggest fears.

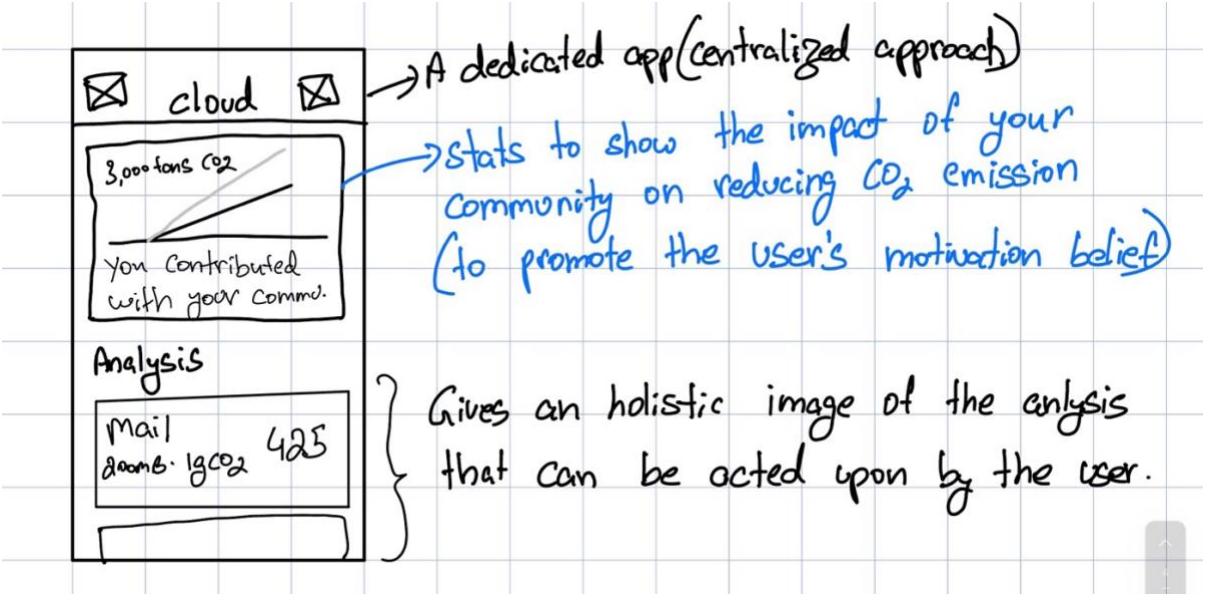
Photos app

Similarly in the Photos app, replicated photos will be shown differently with the same smoke emission interaction to prompt the user to review and delete replicated images (consistency is maintained by using the same cue)



Centralized approach

This approach can be complementary to the app-specific approach to provide a holistic view to the user in one place in the form of an app. (establishing an eco-feedback)

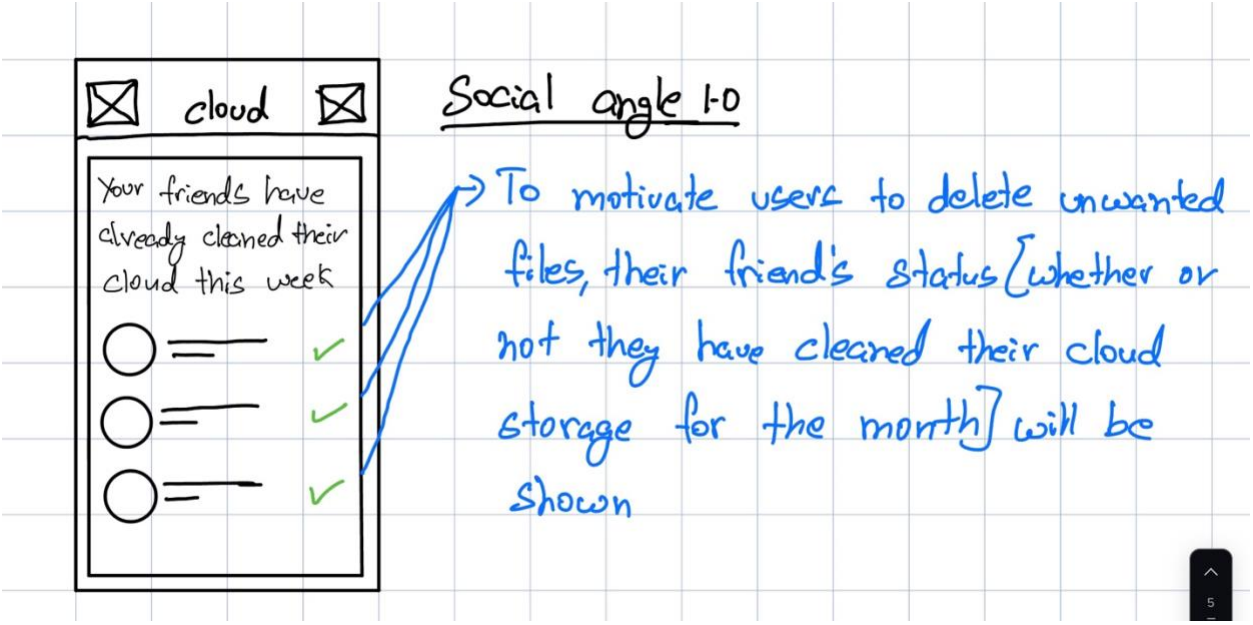


Rationale

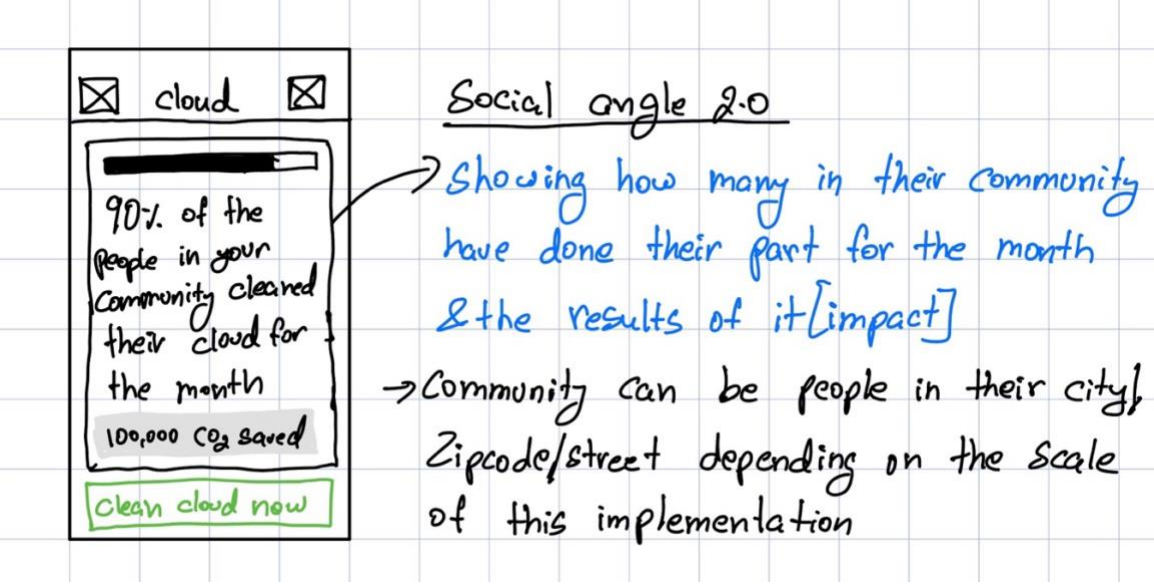
Insight from secondary research

Creating an eco-feedback loop is very important in encouraging pro-environmental behavior

To further promote behavior change, a social component can be included



To show the impact, and make the user feel included (improve their motivation to cause a change), the positive environmental impact caused by the user's community will be shown (e.g., "Your community cleaned their cloud this month reducing 1000TB of data resulting in 300Kg of carbon dioxide). The user's community can be as their city/pin code/street depending on the adoption of the app.



Rationale

Insight from secondary research

Different approaches such as goal setting, social influence, and incentives enhance the eco-feedback loop.

Feedback

Feedback from Milestone 1

1. The interview protocol needs to be revamped because there are too many yes/no questions, and many questions are not open-ended
2. The cadence at which users are required to perform the action of reviewing & deleting unwanted files is not frequent enough to cultivate behavior change effectively. Think of making this activity fun and memorable.

Feedback from mid-term crits

1. The solutions seem to be generic and not really focused on students
2. Rather than just focusing on deleting unwanted files, think of helping people mark important files as well (treasure important memories)
3. Correlate these concepts with data hygiene practices and show how your project is integrated into the data storage and management journey

4. Define the carbon credit implementation

Influence on the project direction

Based on feedback for the concepts showcased, the following plans for made for the next spring

- Analyze student's usage pattern and their ecology to tailor it for their use.
- Expand the scope of the project to deal with data hygiene (data organization) as it correlates to data-discarding complications.

Sprint 2

The focus of this sprint

With this sprint, I wanted to accomplish the following based on feedback from sprint 1:

1. Analyze students' use of cloud storage and their artifact ecology to tailor the solutions to their needs
2. Understand the emotional aspects of data
3. Look at the broader data hygiene umbrella to address the root cause of data hoarding

Research papers (secondary research)

Objectives

The objective of secondary research was the learn the following:

1. Emotional attachments to data
2. Understand the motivating factors to encourage the reduction of carbon emission
3. Learn more about data hygiene and its correlation to data hoarding, and steps to improve hygiene

Papers referred

Papers that were referred to as part of secondary research are included in the appendix

Insights

- Data hoarding has been proven to reduce productivity, imply false knowledge, and impact the productivity of a team in a work context. The cause of data hoarding in the digital context is unknown
- 4 relationship types connected to attachment are:
    - Engagement
    - Histories
    - Augmentation
    - Perceived durability
- Lack of technology knowledge, public information, and social awareness are common among digital natives
- Motivations like personal well-being help with limiting the usage of technologies, but certain hedonic activities counter this
- People are willing to sacrifice certain attributes of an experience as long as it does not sacrifice the key functionalities
- The unclear impact of individual actions was a barrier to behavior change. Visualizing footprint proved to increase agency

User Interview – Primary Research

New objectives for user interviews & changes to the interview protocol

A new protocol was created to address the shortcomings (too many yes/no) of the previous protocol based on feedback from the previous sprint. The new protocol includes the following objectives:

- The type of data that they (the target audience) store on the cloud
- Based on what factors do they classify a file as "unwanted"
- Reasons for not deleting an "unwanted" file
- Understand if they have any emotional or sentimental attachment to their files
- Their usage of cloud storage in the context of their academic and personal life
- Challenges associated with deleting files on a regular basis

Interview protocol

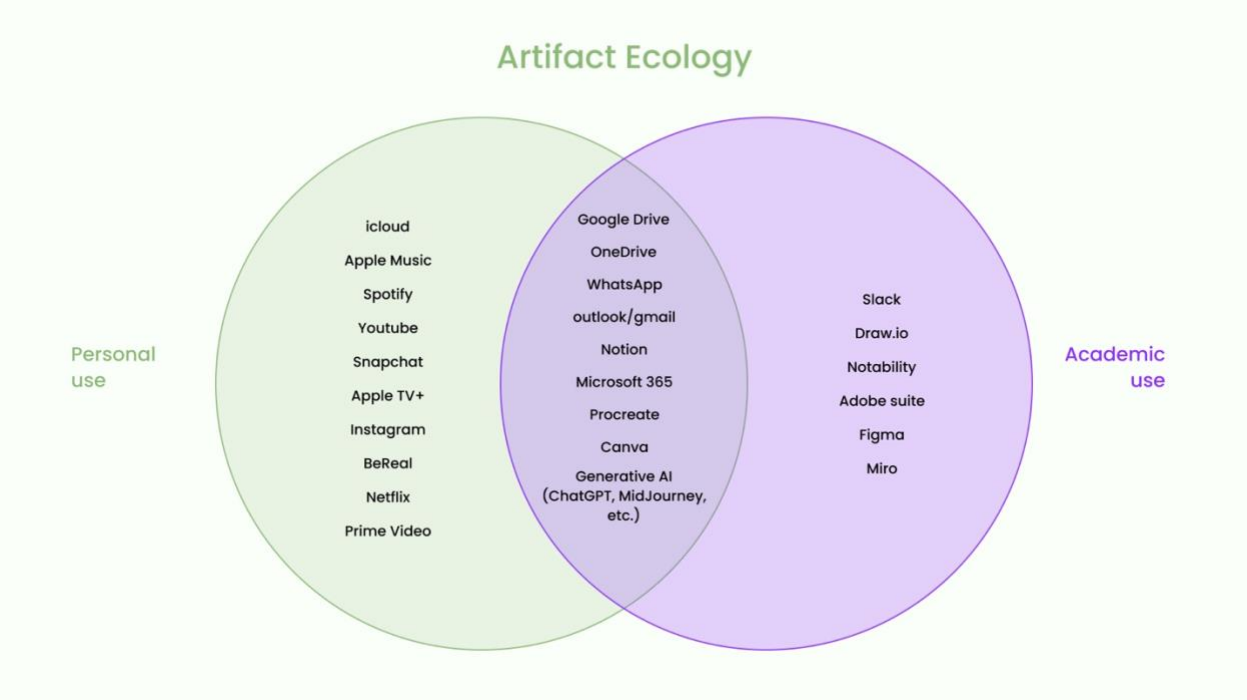
The interview protocol used to conduct user interviews in this sprint is available in the appendix

Insights

Insight #	**Insight details**
2.1	The Majority of the files in an academic setting are generated by cloud-based applications that use cloud storage. E.g., Google docs, Notion, Figma, etc.
2.2	Docs/PDFs are the most commonly generated files in an academic setting
2.3	Students have an emotional attachment to assignment files
2.4	Students often find themselves in a position where they are completely out of cloud storage
2.5	Duplicates and draft files are considered "unwanted" by most students
2.6	Students feel confident deleting files if they know they have not opened them in a long time
2.7	Students absolutely want some sort of incentive to motivate them to delete unwanted files on a regular basis The anxiety of deleting a file that they might need later is the biggest barrier to deleting unwanted
2.9	Time if the biggest barrier and there are no reminders or incentives

Artifact Ecology

To help me tailor the solutions and decide on an effective touchpoint to solve this problem, I created an artifact ecology based on primary research.

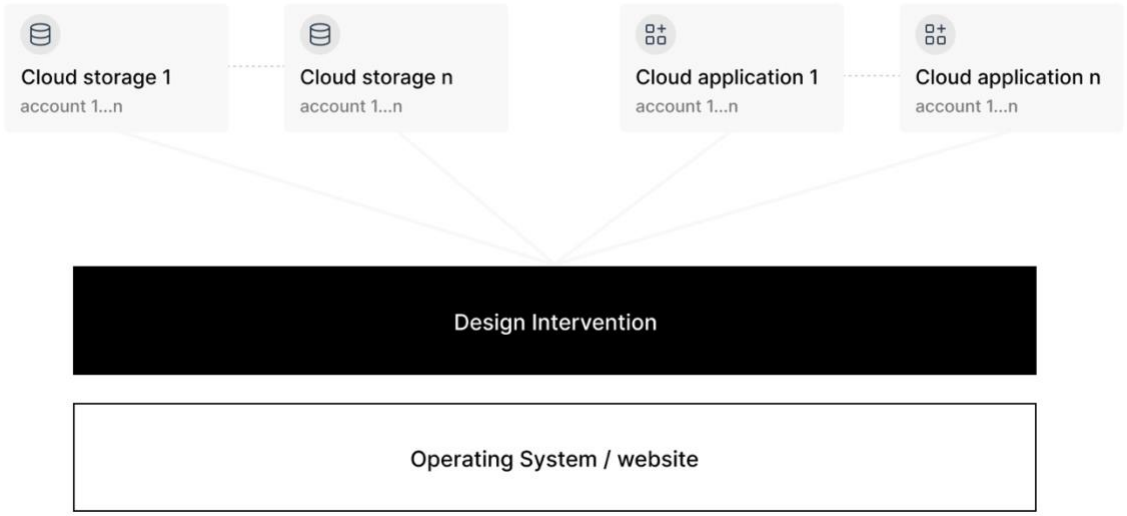


Insight #	Insight detail
2.10	The majority of these digital products are used by students for their personal and academic lives. Those products used in their personal life also consume significant cloud storage

Ideation

Implementation overview

The new design intervention takes a radically different approach to dealing with the wide range of digital systems used by students. This intervention is a layer on top of the Operating System (OS) or it can also be a web app with the ability to connect to various cloud providers and cloud-based applications to fetch details regarding cloud storage utilization based on the user's accounts – both academic and personal accounts.



Rationale

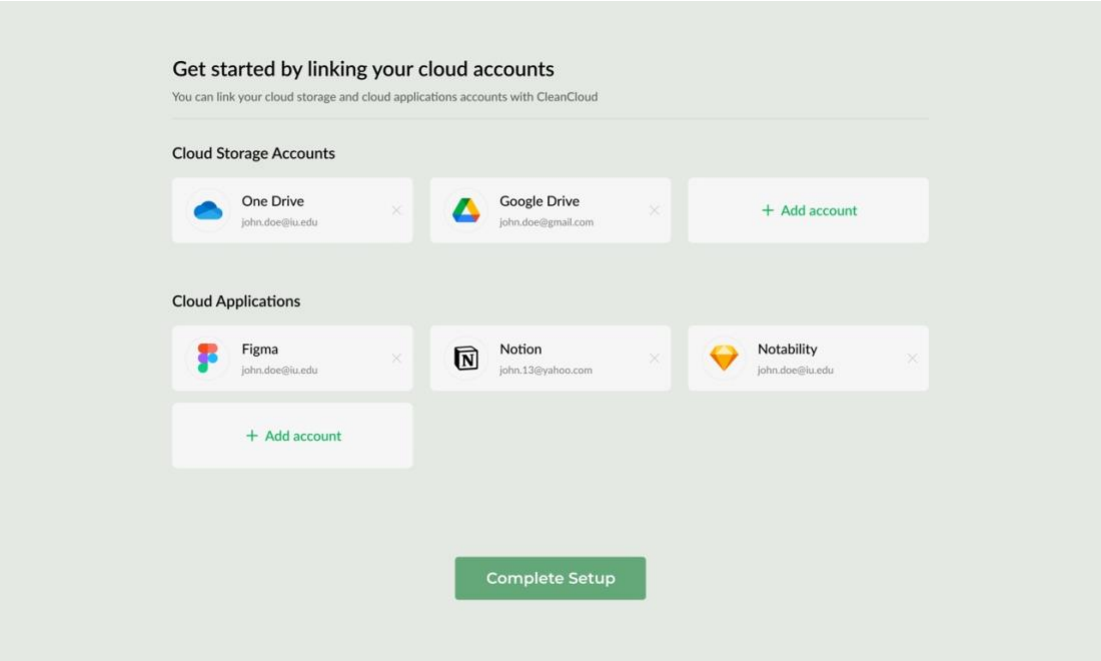
Insight 2.1

Most of the files in an academic setting are generated by cloud-based applications that use cloud storage. E.g., Google Docs, Notion, Figma, etc.

This implementation involves 3 components:

Triggers	Core activity	Rewards

In this implementation, the user starts by syncing all their cloud accounts (cloud storage + cloud applications)



Core Activity: Data Dating – A short bi-weekly activity

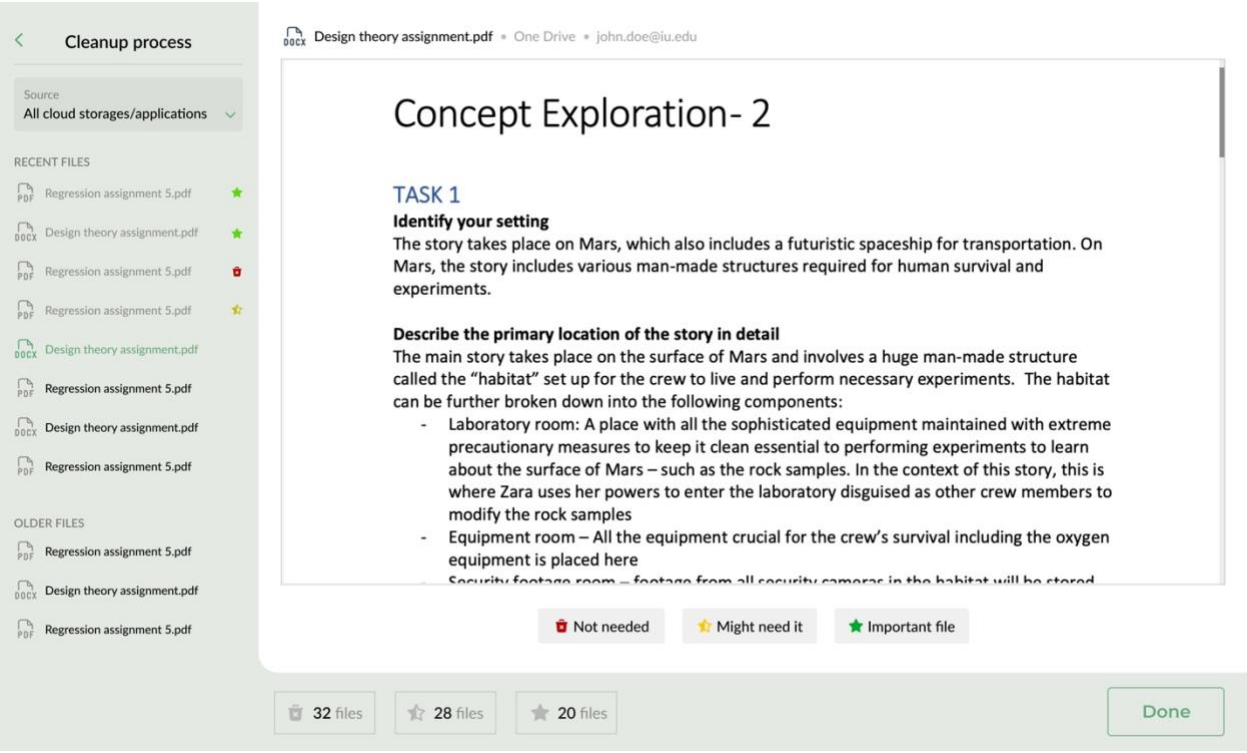
The design intervention aggregates files from all the cloud storage providers and cloud applications across different user accounts. Files that were created in the last 7 days will be shown. For each file selected, a preview of it will be shown in the center of the screen. The user can accordingly select one of the 3 options – Important file, might need it, not needed. Once all the files are categorized into one of these buckets, the activity will be completed.

This is synonymous with the dating world that students are accustomed to with their usage of dating apps like Bumble, Tinder, etc.

Rationale

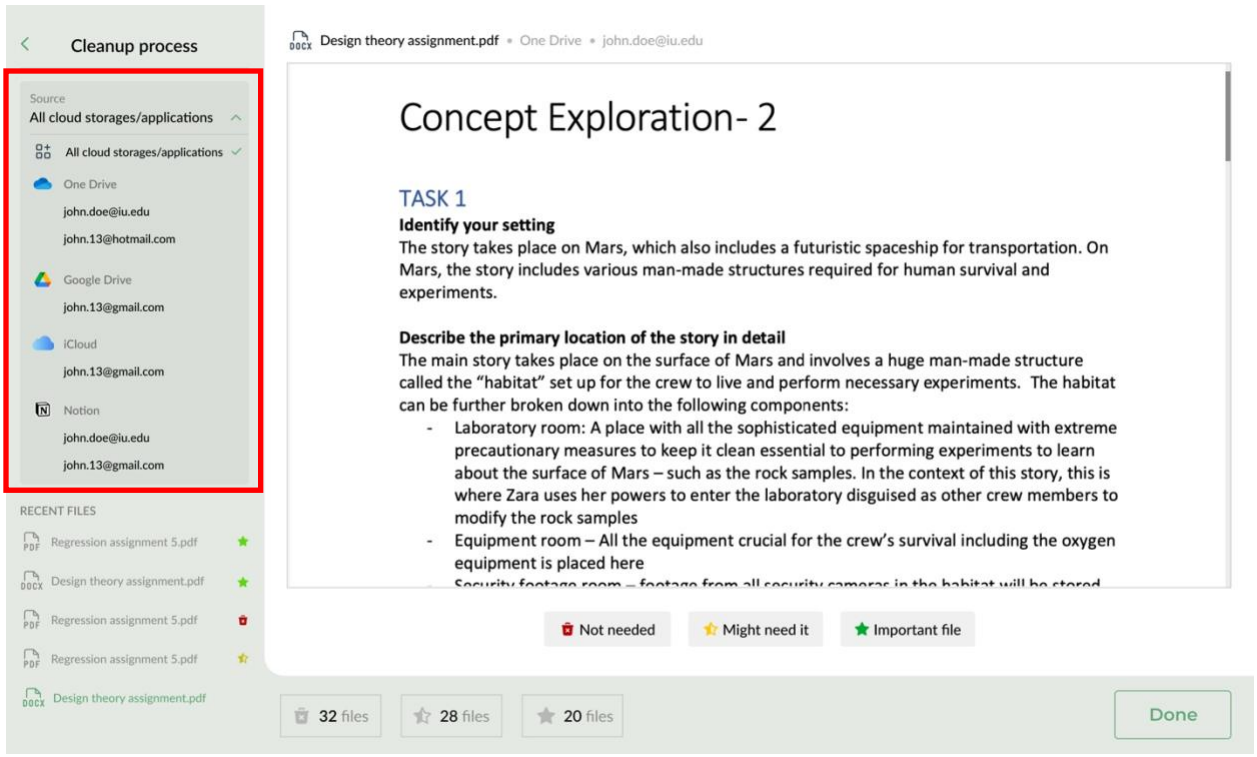
Insight 2.9

- Time is the biggest barrier and there are no reminders or incentives
- This addresses the feedback from mid-term crits: “Help users highlight important files”



Bird's Eye View

The design intervention can aggregate data from all the user-initialized cloud providers and cloud applications. Additionally, if required, the user can drill down into a specific cloud storage or application and within each of the accounts in the services they use.



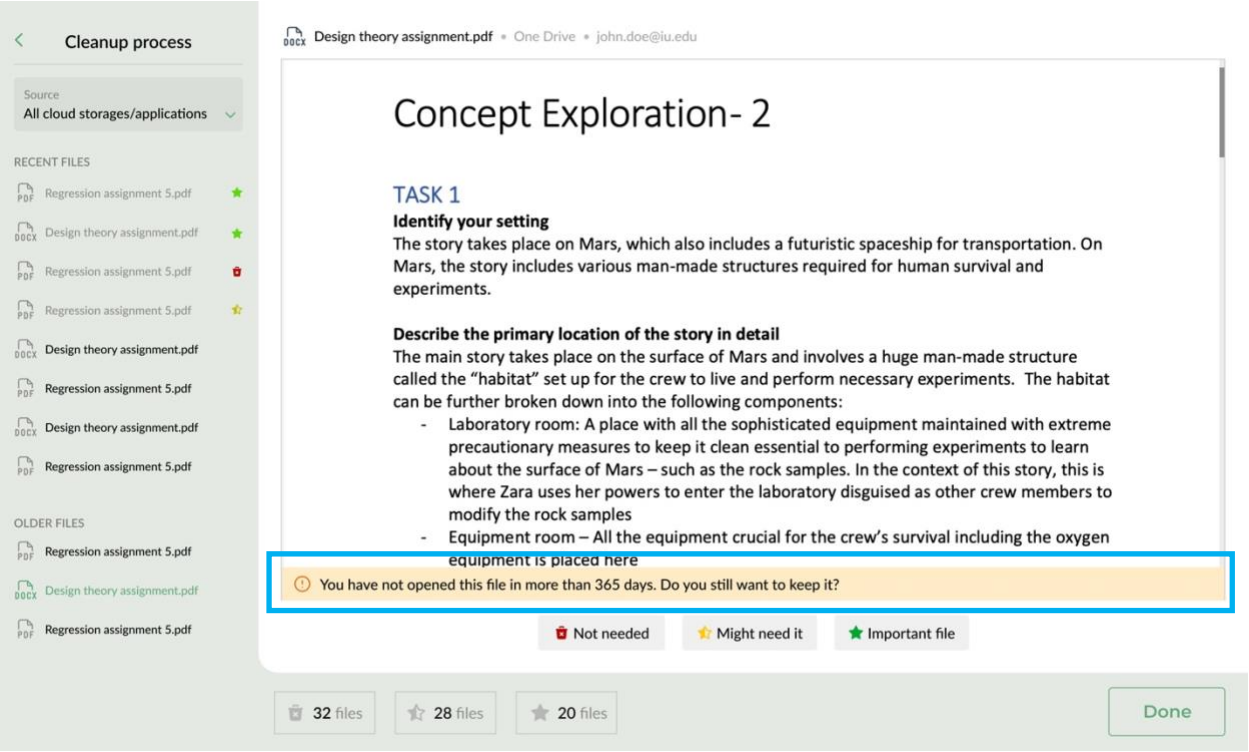
Deleting unused files

If a file was previously flagged as “might need it”, the design intervention will add it to the review queue if the file has not been opened for a long time because people are willing to delete files they have not opened in a long time. Files that were marked as important will not be added to this queue even if it has not been opened in a long time.

Rationale

Insight 2.9

Students feel confident deleting files if they know they have not opened them in a long time



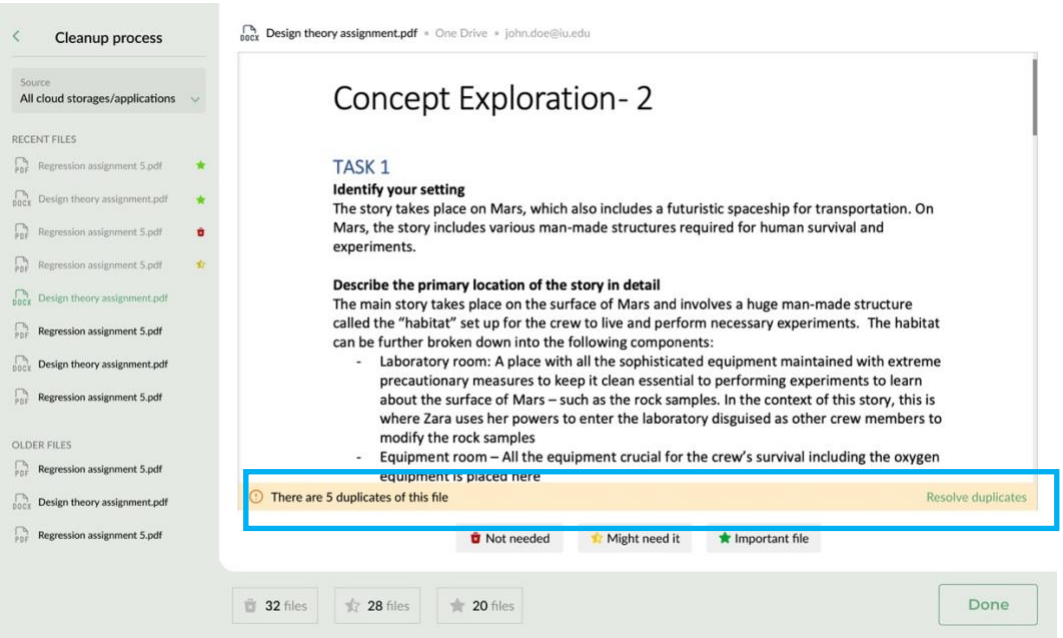
Resolving duplicates

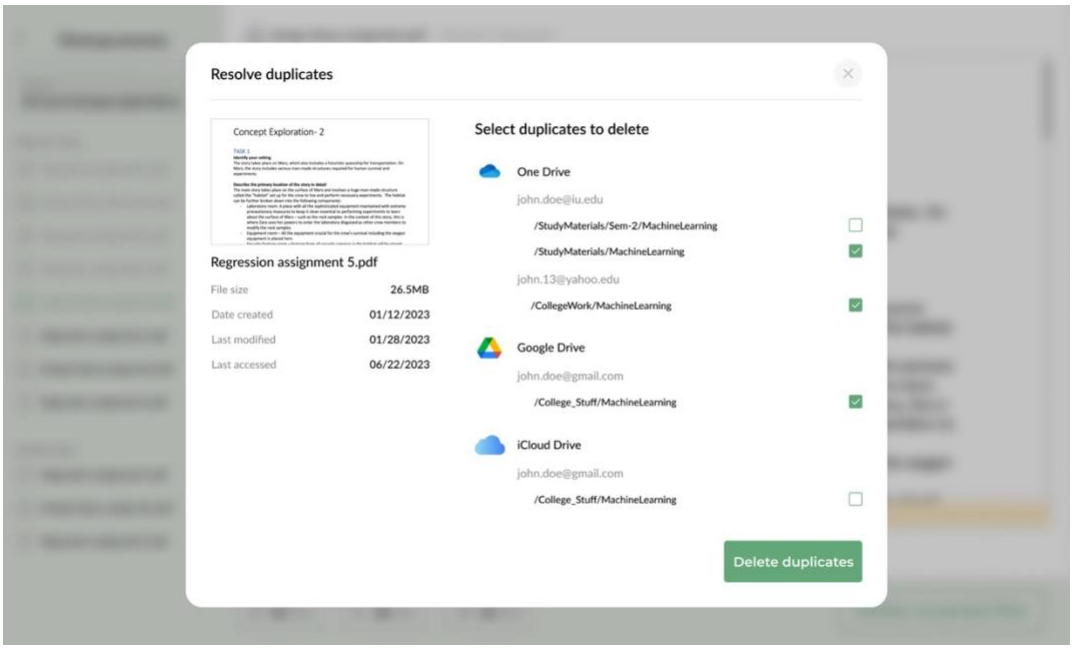
If an exact file is stored in more than one location, the user will be notified and prompted to resolve duplicates.

Rationale

Insight 2.5

Duplicates and draft files are considered “unwanted” by most students





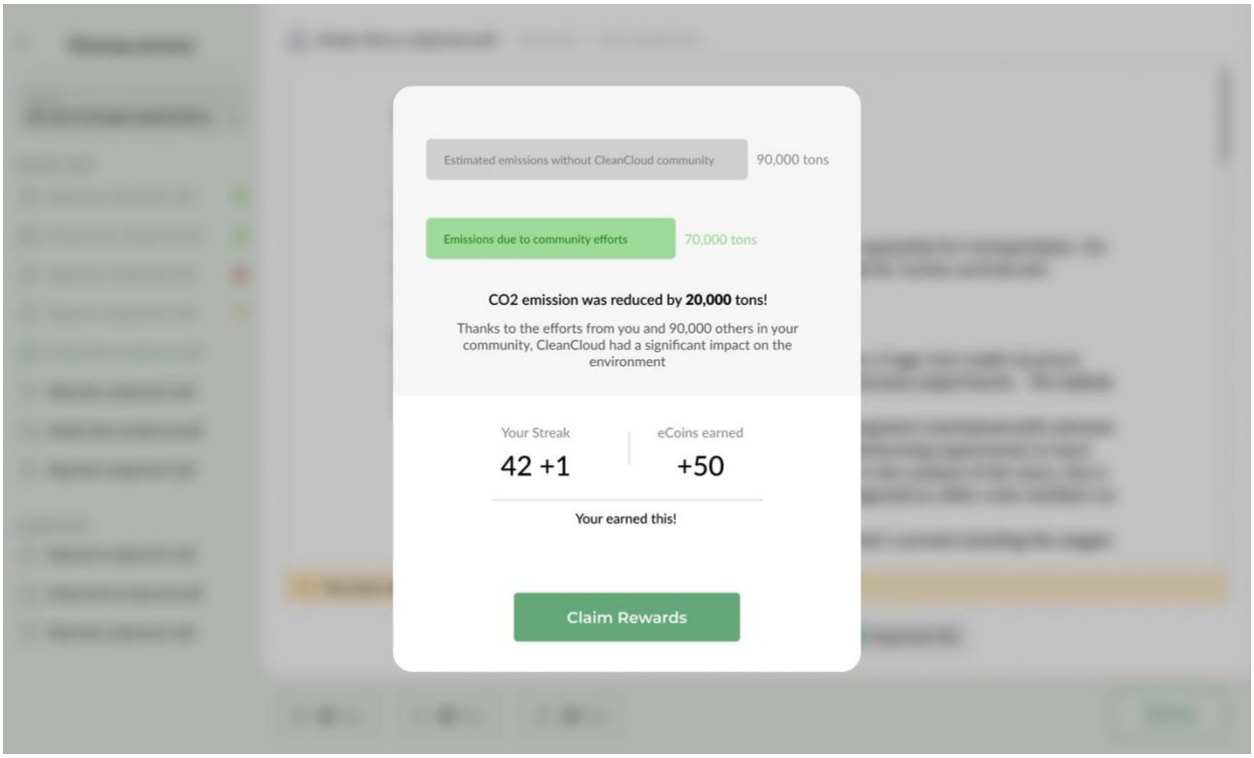
Visualizing the impact

If the user completes the activity, a visualization displaying the impact of the community effort will be shown to further motivate them.

Rationale

Insight from secondary research

“The unclear impact of individual actions was a barrier to behavior change. Visualizing footprint proved to increase agency”

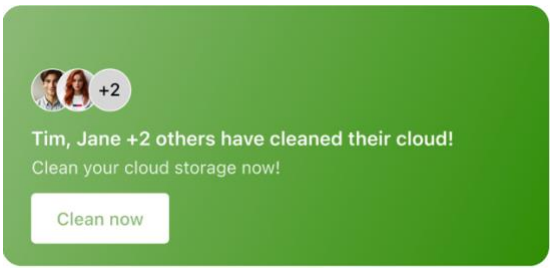


Triggers

Triggers are designed to encourage users to perform the bi-weekly activity regularly.

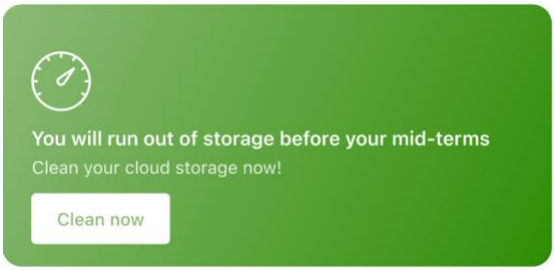
Trigger 1 – Social angle

From secondary research, I learned that social pressure and norms play an important role in encouraging pro-environmental behavior.



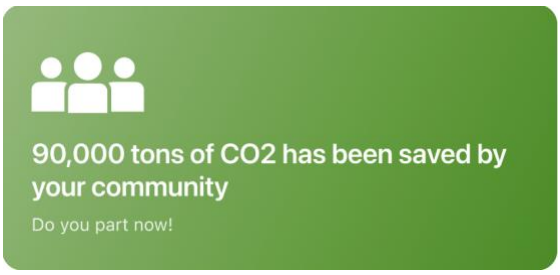
Trigger 2 – pre-emptive measures

A lot of students, especially undergraduate students reported running out of storage during critical times of the semester. Therefore, this can be leveraged to motivate them to review their cloud files



Trigger 3 – community impact

Inspired by “Epic meaning & call” from the octalysis model, this trigger aims to make the user feel they are “doing something greater than themselves”. This also further increases social pressure on the user



Trigger 4 – a metaphorical visual cue
Inspired by the HAM mode previously discussed, I wanted a visual cue to subconsciously trigger the user into performing the bi-weekly activity (data dating). To do this, I am envisioning a short 5 seconds smoke animation that sweeps across the user's desktop when it is time for them to review/clean their cloud storage

Rewards: Carbon credit

The Carbon credit is a system to incentivize target users to delete unwanted files on a regular basis to avoid hoarding data.

Rationale

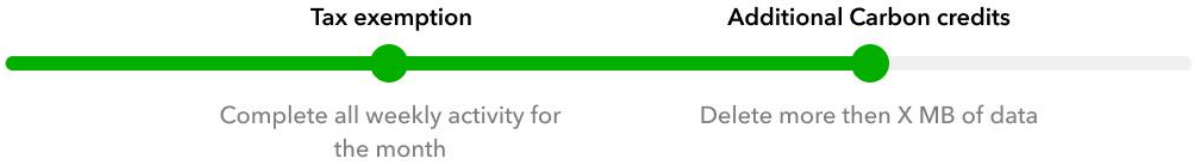
Insight 2.7
Students absolutely want some sort of incentive to motivate them to delete unwanted files on a regular basis

How can users get carbon credit?
Every week users are required to perform the action using the design intervention shown above. If the user performs this action every week of the month, a sufficient amount of carbon credits will be awarded to the user that can be used to avail tax exemption on their cloud subscriptions. This is irrespective of the amount of data they end up clearing.

What can they do with carbon credit?

- Avail tax exemption on their cloud subscriptions irrespective of the amount of data deleted
- If X MB of data (x – an amount to be determined) or more is deleted, additional carbon credits will be given that can be used with other services like:

- ChatGPT: to unlock the paid version of chatGPT for a certain amount of time (based on the carbon credits they have)
- MidJourney: carbon credits can be exchanged for GPU time on MidJourney
- This concept can be expanded to other cloud-based products as mentioned above



Feedback

Feedback from Milestone 2

The main feedback from milestone 2 was to make the scope/focus of the project clear. Initially, it was not clear that the project was focusing on the student's academic and personal life. This fuzzy line was not communicated. Therefore, I emphasized this fuzzy line during my final presentation and also in this document.

Failures/Shortcomings

Based on my conversation with my peers and instructors, I realized that the current solution has quite a lot of limitations and may not be effective enough for the following reasons:

- This solution still seems to add quite a lot of overhead (additional work for the user)
- Triggers and rewards are not enticing enough
- Some of the triggers used (like notifications) and the concept of carbon credit is adding to the environmental impact
- This solution does not address the core problem of data hoarding or poor data hygiene that is contributing to environmental impact
- This solution does not accurately represent the true mentality of students

Based on this feedback, I decided to majorly re-focus this project by pivoting

Change to the project focus (pivot)

What is the new focus?

Based on the feedback for my previous solution, I decided to directly focus on helping users avoid data hoarding the implication of which will also have a positive environmental impact in the context of cloud storage.

Why am I pivoting?

- The target audience (students) is not aware of the environmental impact of cloud storage, and hence environment cannot be used as a motivating factor
- Solving data hoarding will ultimately lead to the reduction in environmental impact caused by cloud storage. This focus will lead to the solution (avoiding data hoarding) rather than the implication (reducing environmental impact). Ultimately, the previous goal of reducing environmental impact requires avoiding/reducing data hoarding. Therefore, with this focus, the proposed solution will target the main problem at hand – data hoarding.

Sprint 3

The focus of this sprint

The focus of this sprint is based on feedback from spring 2 (previous semester):

- Focus on data hoarding, which is the core issue causing negative environmental effects, rather than focusing solely on environmental sustainability as the primary driving force
- Narrow down on a single cloud provider (like Google Cloud) to design an intervention aimed at cultivating data hygiene practices (which also includes the data hoarding component)

Primary research – contextual inquiry

Objectives

The objective of this contextual inquiry was to figure out the target user's (students) cloud organization behavior and usage patterns with Google Drive as I was considering it as an example service for this project. This would also help me validate the new direction of the project.

Process

I asked students to open their primary cloud storage and walk me through their data organization patterns. This study was conducted both in-person and online via Zoom. During the contextual inquiry, some of the following questions were asked:

- Are you aware of the number of files in different folders?
- Do you have an idea of what files are in your cloud?
- Can you recognize unwanted files in your storage?
- If you have to delete files, how do you decide on which files to delete?
- Can you confidently delete one or more files you classified as unwanted?

Sample size: A total of 8 students were interviewed across different majors and universities.

Insights

The insights from this activity played a major role in influencing the direction of this project. The insights are as follows:

- Most of the space was consumed by Photos (in the case of iCloud and Google Photos)
- Most of them wait until they run out of storage before deleting unwanted files
- Very few had a proper cloud storage file organization. Most of the students just dumped their files

- Students rarely access Google Drive. They directly go to their software of choice (like Google Docs, slides, Figma, etc.)
- Most of the students had files stored locally on their desktop
- Deciding on a file to delete was not an issue
- In most cases, students had a good idea of the files they had stored
- Google Drive was mostly used to deal with shared files

Influence on the project direction

From this research activity, it was clear that students were not storing a lot of files on their cloud storage (excluding photos) and they were not accessing cloud storage services like Google Drive directly. Instead, they were storing most of the files locally on their device.

Therefore, I decided to broaden my intervention to deal with data hoarding as a whole, and not just the cloud. Local device storage is now the main aspect of this design intervention with some level of cloud management capabilities.

Research papers – secondary research

Objectives

From my secondary research, I wanted to learn the following:

- Factors motivating data hoarding
- Consequences of data hoarding
- Encouraging data hygiene practices

Papers referred

Papers that were referred to as part of secondary research are included in the appendix.

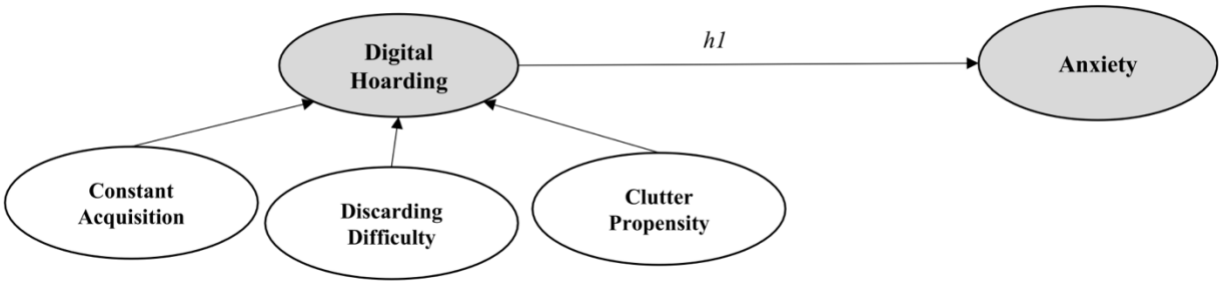
Insights

The following are the primary factors promoting data-hoarding behaviors

- Holding onto files thinking they might be needed in the future
- Holding onto files as a form of proof (Email, receipts, etc.)
- Laziness to spend energy reviewing and deleting files

The consequences of data hoarding are as follows:

- Reduced work efficiency
- Increased anxiety. When individuals acquire excess data and fail to delete existing data, it leads to clutter (hoarding) which ultimately causes anxiety.



(Sedera,D., 2022)

Influence on project direction

The above-mentioned insights are very similar to my findings from primary research performed last semester. However, I realized that there is a correlation between data acquisition and discarding difficulty, which can be visualized in terms of the user's workflow. This insight played a pivotal role in helping me synthesize the concept described in section 4 – approach 3.

Conceptualizing options for intervention

Based on my analysis of the research data and discussion with my peers, I realized that at a granular level, there are 3 approaches that I can take with my project:

Approach 1: De-cluttering after hoarding data

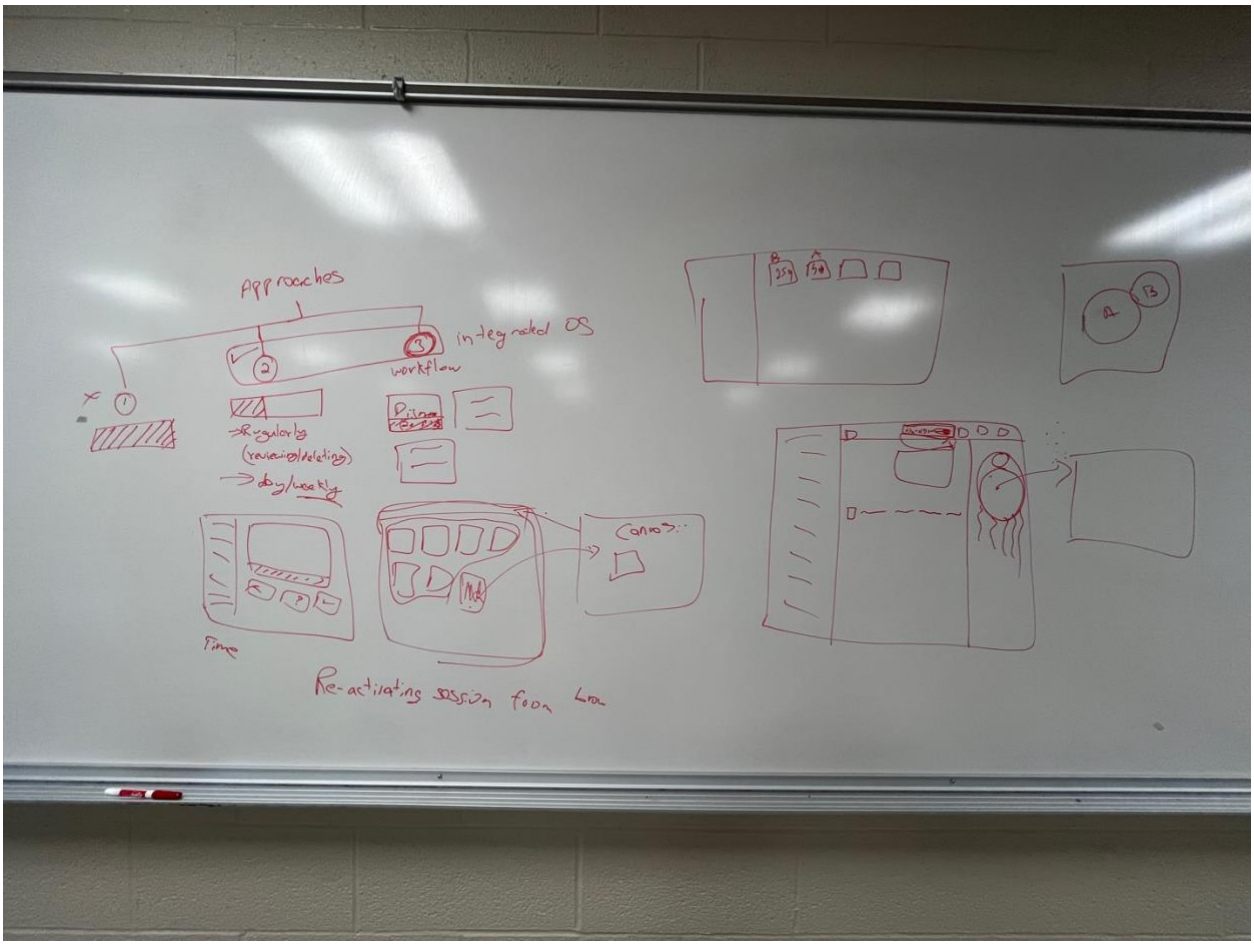
In this approach, the objective of the design intervention is to make it easy for the user to review and delete files (assuming they are already hoarding). This approach seems to be similar to many data-cleaning tools out there like "CleanMyMac X". Also, this approach does not solve issues related to data hoarding such as anxiety. Therefore, I decided not to go ahead with this approach.

Approach 2: De-clutter regularly to avoid data hoarding

In this approach, the objective of the intervention is to persuade the user to review and delete files regularly, thus eliminating the problem (data hoarding). This is also the strategy I am using with my current iteration that was showcased last semester. I also discussed a few potential changes to make this implementation a part of the user's daily habit by using analogies such as "making your bed in the morning". However, this approach does not address one of the major feedback items from last semester.

Approach 3: De-cluttering on-the-go

The objective of this approach is to seamlessly integrate the intervention with the user's workflow such that the act of reviewing/deleting files should not feel like an additional task. I am conceptualizing this as an add-on/modification to the focus mode feature on Mac OS. I will build on top of this feature to bring context awareness that can be used to aggregate files for review once the user is done with a workflow, which is when the user exits a focus mode. I am also exploring different techniques to visualize data hoarding throughout the finder windows. This feature will also allow users to review files based on workflows later on. Overall, this approach will be implemented at an OS level.



Ideation sketches from the 2nd studio session

Influence on the project direction

Approach 3 provides a seamless experience, but there are scenarios when a user may not be willing to do the cleanup activity after their workflow, in which case, approach 2 will be useful. Therefore, the data dating activity from last semester (following approach 2) will co-exist with approach 3 in the final implementation.

Low-fidelity – V1 prototype

Low-fidelity prototypes were created for approach 3 – de-cluttering on the go. Since this concept is based on an existing Mac OS feature, the prototype is a combination of high-fidelity screenshots, along with low-fidelity UI elements.

About workflow mode

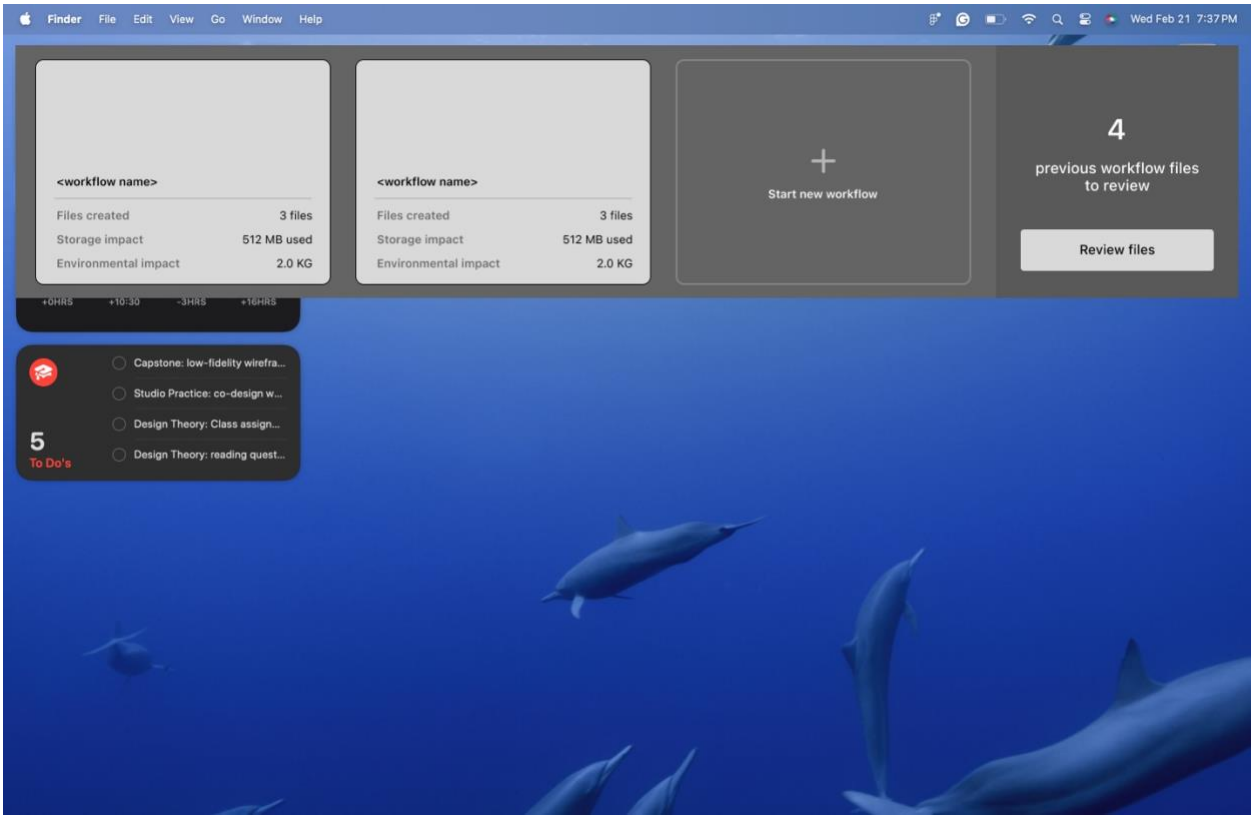
This concept introduces a new mode to the OS called "the workflow mode" that monitors all the files created or downloaded by the user across different applications both online and offline. It also retains all the windows that were left open during the workflow's last session. The idea is for the user to create a workflow for each of the tasks they are working on.

Entering a workflow mode

The user can enter a previously created workflow mode or start a new one by activating the "study focus" mode on Mac OS as shown below.

STEP 1: Selecting the "study focus" mode from the Mac OS control center

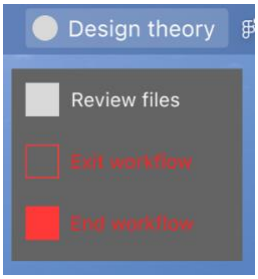
STEP 2: Select an existing workflow or create a new workflow



Exiting or ending a workflow mode

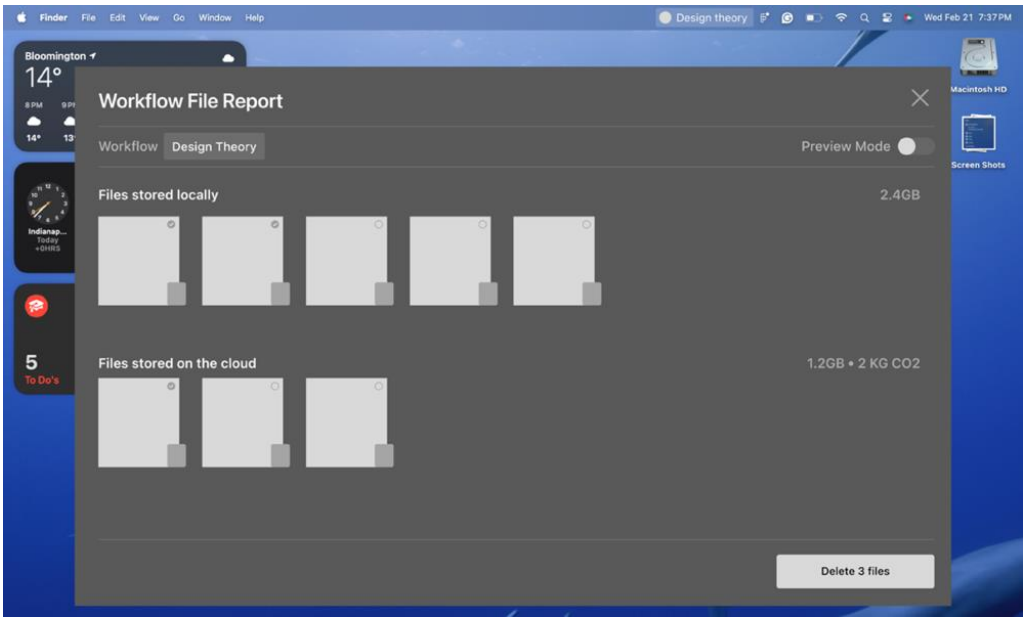
When the user is in workflow mode, it will be indicated on the top right corner of the Mac OS menu bar

Clicking on the workflow indicators will bring up an option to review files that have been created in the workflow, exit the workflow (users can again enter the workflow if needed), or end the workflow (when the user is done with the task; users won't be able to see/enter the workflow again).



Reviewing files to delete after ending a workflow

When the user ends a workflow or explicitly wants to review files associated with a workflow, the following window will be shown listing all the files that were created/downloaded across different applications (both online and locally on the device). The user is prompted to select all the unwanted files to delete. This ensures the user is deleting unwanted files right after completing a workflow, helping them avoid data hoarding.



Concept testing

Process

Before showing the prototypes, the problem, and the approach of this solution – understanding workflow contexts were explained to help the audience get to speed with the goal of the design intervention. The screens shown above were used to walk the audience through the flow by describing the actions of each of the buttons and explaining all the feature sets.

Sample size: A total of 8 students were involved in concept testing, most of whom were part of the initial primary research – contextual inquiry.

Insights

1. Having to turn on or change a focus mode explicitly might be tedious and users might forget to do it
2. Users like to retain a workflow after ending it (and resolving it). They want to use it as another way to browse through their files in terms of workflow
3. An option to consolidate and delete duplicate files in the review windows would be helpful
4. Incorporate features to deal with files that are shared with others
5. Additional metadata is required to make an informed decision to delete files
6. Switching workflows does not feel seamless. Some way of proactively switching or turning on a workflow mode is required
7. An option to reuse a workflow might be useful
8. Think of a scenario when duplicate files are created for backup purposes
9. Users generate a lot of screenshots, which are not captured by workflow mode and not shown in the file review window
10. Workflow mode can exist as an independent feature rather than relying on the focus feature
11. Option to delete certain file types

Action plan

Based on the insights from this activity, I decided to focus on the following improvements for Version 2:
Improvement 1 - Think of a proactive way to trigger/switch to a workflow mode automatically
Improvement 2 - A way to access completed workflows
Improvement 3 - Decouple workflow mode from the focus feature
Improvement 4 - Improving the robustness of the file review system to handle the following:

a. Duplicates
b. Screenshots
c. Shared files
d. Filtering files based on file types

High-fidelity – V2 prototype

High-fidelity wireframes were created based on low-fidelity wireframes and incorporates changes/additions based on insights from concept testing (Action plan: improvements 1 – 4).

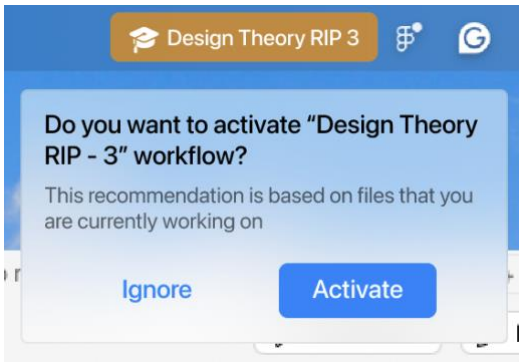
Improvement 1 – proactive way to trigger/switch to a workflow mode automatically

Automatic triggering/switching of a workflow mode is based on the following parameters:

1. Opening a file associated with a workflow

2. Creating a new file with a name similar to other file names in a workflow
3. Collaborating with a set of people associated with a workflow

Proactively turning on a workflow
If the user does any of the above-mentioned actions, the user will be prompted to enter the relevant workflow by showing the following popup from the menu bar.

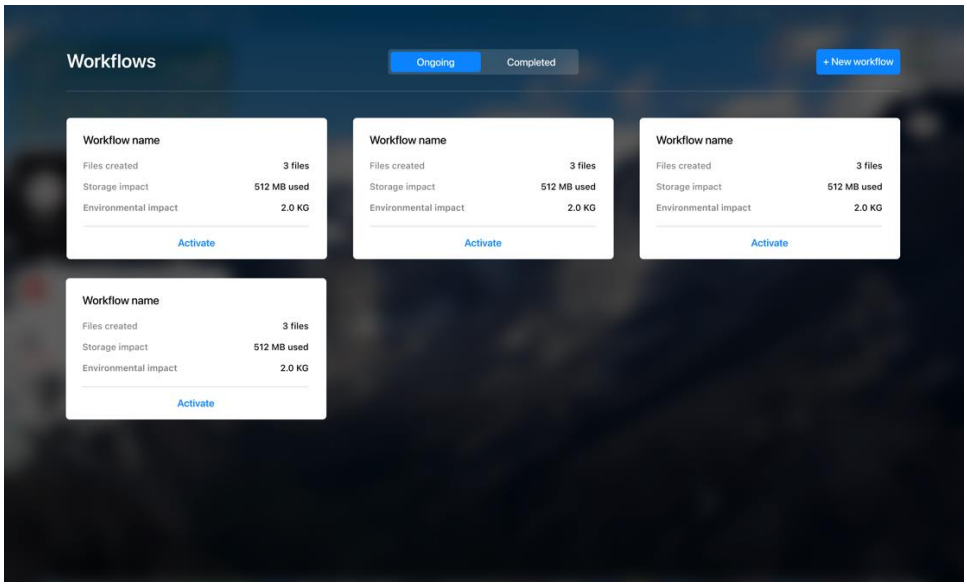


Proactively switching to a different workflow
Based on the above-mentioned parameter, if the operating system detects the user has switched to a different workflow, the menu bar notifies the user of the impending change in workflow and provides the user with an option to dismiss the change. If the user does not dismiss the impending action, workflow changes automatically.

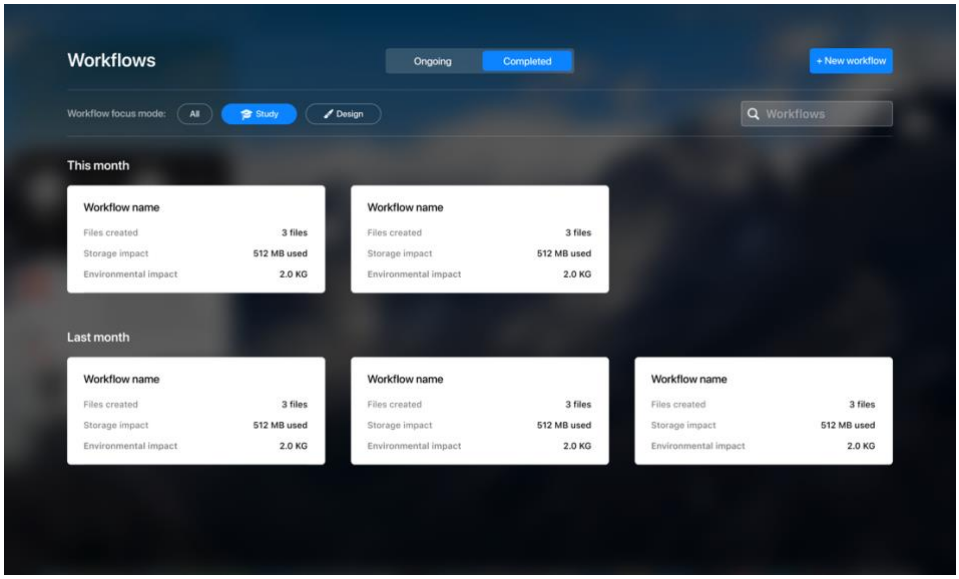
Improvements 2 & 3 – Decoupling workflow mode from the focus feature and introducing a way to access completed workflows

A new icon/feature has been introduced in the dock to reveal ongoing and completed workflows.

Clicking on the above-mentioned icon will open the following overlay in the OS, revealing the user's ongoing and completed workflows.

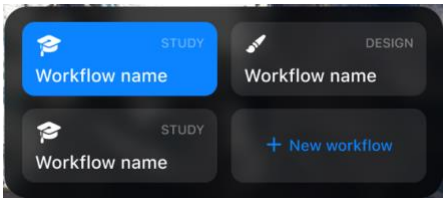


Workflow overlay showing the user's ongoing workflows.



Workflow overlay showing the user's past/completed workflows.

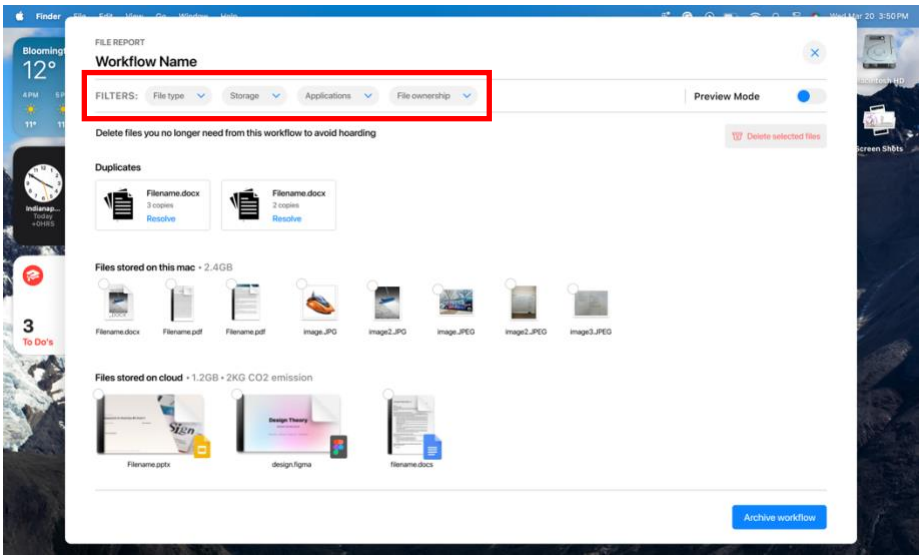
Additionally, there is also a desktop widget for quick and easy access to workflows.



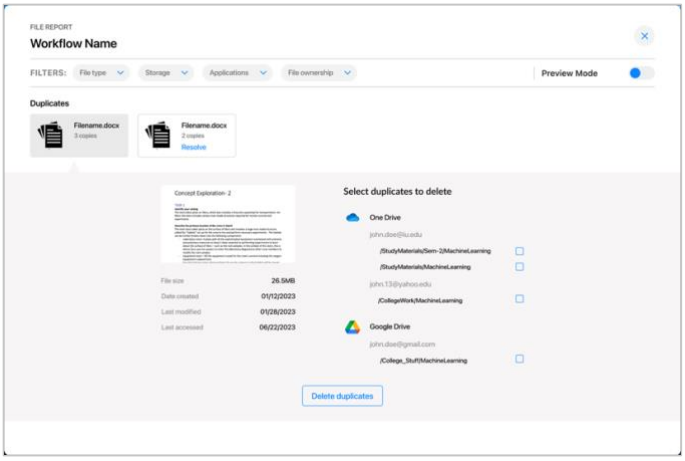
Improvement 4 – Improving the robustness of the file review system

Advanced filters are added to help users shortlist files based on the following:

1. File types (images, docs, PDFs, etc.)
2. Storage type (files stored locally or on the cloud)
3. Files generated from a specific application
4. File ownership (files that are completely owned by the user or shared)



Additionally, duplicate files are detected, and the file manager provides an easy way to see all the duplicates and delete the unwanted copies.



Reflections

Looking back, I am amazed (and proud of myself) by the wide range of solutions that were synthesized over the last 2 semesters. Each solution took a different approach to problem solving, but interestingly it was the problem statement that ultimately evolved.

One of the things that stood out to me last semester was the dramatic change in solutions from Sprint 1 to Sprint 2 after tailoring the design for my target audience (students) based on extensive research that was missing in the 1st Sprint as also pointed out during midterm crits. This made me realize the importance of properly understanding the audience that I am designing for.

Looking back, I don't think I was broad enough during the research phase. Initially, my objective was to only encourage users to regularly delete files from cloud storage, and I was naïve in thinking habit change would be the answer to this. I failed to dig deeper and find the root cause of the problem. Trisha helped me understand that I should be solving for data hoarding (the root cause), the implication of which will be reduced cloud storage utilization, ultimately helping my original goal of reducing the environmental impact of cloud storage. This taught me the importance of looking from different perspectives.

I also realized the limitations of user interviews during the contextual inquiry I performed as part of the 3rd Sprint. I got way more insights from contextual inquiry than I did from the previous 2 interviews, as I was able to see participants' cloud organization behaviors and ask questions on the go, revealing new insights that I might have not uncovered with interviews.

I think research is something I need to work on. I got stuck during the research phase and I thought there was nothing more to uncover. Moving forward, I will take a closer look at the relationships in an interconnected problem space and be broader during research. On the contrary, I think I did a good job with ideation that is showcased by 3 radically different solutions.

Appendix

Sprint 1

Initial problem space research

The MIT Press Reader. (2022, February 22). *The staggering ecological impacts of computation and the cloud*. https://thereader.mitpress.mit.edu/the-staggering-ecological-impacts-of-computation-and-the-cloud/

IET. (n.d.). *Dirty Data*. https://www.theiet.org/media/press-releases/press-releases-2021/press-releases-2021-october-december/26-october-2021-dirty-data

Research papers

Froehlich, J., Findlater, L., & Landay, J. (2010). The design of eco-feedback technology. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. https://doi.org/10.1145/1753326.1753629

Pakravan, M. H., & MacCarty, N. (2020). What motivates behavior change? analyzing user intentions to adopt clean technologies in low-resource settings using the theory of planned behavior. Energies, 13(11), 3021. https://doi.org/10.3390/en13113021

Turaga, R. M., Howarth, R. B., & Borsuk, M. E. (2010). Pro-environmental behavior. Annals of the New York Academy of Sciences, 1185(1), 211–224. https://doi.org/10.1111/j.1749-6632.2009.05163.x

Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1987). Analysis and synthesis of research on Responsible Environmental Behavior: A meta-analysis. The Journal of Environmental Education, 18(2), 1–8. https://doi.org/10.1080/00958964.1987.9943482

Pinder, C., Vermeulen, J., Cowan, B. R., & Beale, R. (2018). Digital behavior change interventions to break and form habits. ACM Transactions on Computer-Human Interaction, 25(3), 1–66. https://doi.org/10.1145/3196830

Garbi, A., Malamou, A., Michas, N., Pontikas, Z., Doulamis, N., Protopapadakis, E., Mikkelsen, T. N., Kanellakis, K., & Baradat, J.-L. (2019). BENEFFICE: Behaviour change, consumption monitoring, and analytics with complementary currency rewards. Sustainable

Places 2019. https://doi.org/10.3390/proceedings2019020012

Interview protocol

Introduction

Hi! I am Samarth – a second-year MS Human-Computer Interaction student at The Luddy School of Informatics. I am currently working on my capstone project focused on cultivating sustainable cloud storage behavior. I am conducting a user interview to understand user's behavior toward managing their cloud storage. You are not obliged to answer all the questions and you can also stop the interview if required.

Permissions

Before we get started, I would like to have your permission to record this interview. Everything you say will remain confidential and will only be used in the context of this project. Do I have your permission to record?

Questions

1. How do you typically use a cloud storage platform? Which cloud storage platforms do you use?
2. Do you have any idea how much data you store on the cloud (this includes images, emails & text messages)?
3. How do you decide whether you want to save a file locally on your computer or on the cloud?
4. Have you ever purchased additional cloud storage? (set the context for files as anything stored on the cloud including emails, messages, photos, etc.)
    a. If yes:
        i. How much extra storage did you buy?
        ii. Did you consider reviewing files currently in your cloud to delete unwanted files to free up some space?
        iii. How big was the price factor in your decision to buy additional storage?
    b. If no:
        i. Is it because you did not require additional storage, or did you delete unwanted files?
5. Has there ever been a situation when you proactively reviewed and deleted unwanted files from your cloud storage?
    a. If yes:,
        i. What factors influenced your decision to delete unwanted files from your cloud storage?
        ii. How did you review and delete files?
        iii. Did you find the process to be easy?
        iv. Are there any tools/features you would like to see in your cloud storage platform to make this process easier?
6. Are you aware of the environmental impacts of cloud storage?
    a. If yes:

i. <Skip to question 6>

b. If no: <Briefly talk about the environmental impact of cloud storage. Maybe show something as a visual aid to help them visualize the problem>

7. Now that you are aware of the environmental impact
    a. Would you be mindful to avoid hoarding unwanted files?
        i. If yes:
            1. what made you environmentally conscious?
            2. Do you see any barriers/concerns that might hinder you from regularly reviewing/deleting files?
        ii. If no:
            1. can you elaborate on why you wouldn't want to contribute to reducing the environmental impact by changing your cloud storage behavior?
            2. Would you be more inclined to follow this behavior if it was incentivized?
                a. If yes, what type of incentives would you prefer?
8. I would like to know if you are a working professional to understand a bit more about the data handling process at your organization:
    a. If yes:
        i. Are there any measures taken at your workplace to delete unwanted files?
        ii. Suppose you think a file created by you at your organization is no longer needed, do you have the authority to delete it? Are there any barriers to this?

Conclude

9. Is there anything you would like to add to this conversation?
10. Do you have any questions for me?

11. Thank you so much for your valuable time. This information will be extremely valuable as I start to think of design solutions for this problem. Take care!

Sprint 2

Research papers

William Odom Indiana University at Bloomington, Odom, W., Bloomington, I. U. at, James Pierce Indiana University at Bloomington, Pierce, J., Erik Stolterman Indiana University at Bloomington, Stolterman, E., Eli Blevis Indiana University at Bloomington, Blevis, E., University, B. Y., Research, M., University, C. M., Calgary, U. of, & Metrics, O. M. A. (2009, April 1). Understanding why we preserve some things and discard others in the context of interaction design: Proceedings of the SIGCHI conference on human factors in computing systems. ACM Conferences. https://dl.acm.org/doi/10.1145/1518701.1518862

University, R. G. C. M., Gulotta, R., University, C. M., University, W. O. C. M., Odom, W., University, J. F. C. M., Forlizzi, J., University, H. F. C. M., Faste, H., Inria, University, G., Aarhus, U. of, & Metrics, O. M. A. (2013, April 1). Digital artifacts as Legacy: Proceedings of the SIGCHI conference on human factors in computing systems. ACM Conferences. https://dl.acm.org/doi/10.1145/2470654.2466240

Bristol, C. P. U. of, Preist, C., Bristol, U. of, Bristol, D. S. U. of, Schien, D., Bloomington, E. B. I. U., Blevis, E., Bloomington, I. U., Yahoo, University of Maryland / National Park Service, Michigan, U. of, Microsoft, Iowa, U. of, & Metrics, O. M. A. (2016, May 1). Understanding and mitigating the effects of device and cloud service design decisions on the environmental footprint of Digital Infrastructure: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems. ACM Conferences. https://dl.acm.org/doi/10.1145/2858036.2858378

Digital Carbon Footprint Awareness among digital natives: An ... - ntnu. (n.d.). https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/2985003/919-Article%2bText-2210-1-10-20211115.pdf?sequence=1

[PDF] Data Hoarding and information clutter: The impact on cost, life ... (n.d.-b). https://www.semanticscholar.org/paper/DATA-HOARDING-AND-INFORMATION-CLUTTER%3A-THE-IMPACT-GormleyGormley/eb57d170798356e6e559b60816be0ad846b2b9e5

Interview Protocol (v2)

Introduction

Hi! I am Samarth – a second-year MS Human-Computer Interaction student at The Luddy School of Informatics. I am currently working on my capstone project focused on cultivating sustainable cloud storage behavior. I am conducting a user interview to understand user's behavior toward managing their cloud storage. You are not obliged to answer all the questions and you can also stop the interview if required.

Permissions

Before we get started, I would like to have your permission to record this interview. Everything you say will remain confidential and will only be used in the context of this project. Do I have your permission to record?

TOPIC 1 (Understanding user behavior)

Describe your use of cloud storage on a daily basis (coursework, personal life, collaborative projects, etc.)

1. What cloud storage services are you using?
2. Have you upgraded your cloud storage space? How important was the price factor?
3. What types of files do you generate the most?

4. What type of files do you typically store on the cloud?
5. Do you actively manage and delete files in your cloud storage? Why or why not?
    a. If yes – How often do you clean up your cloud storage?
    b. If not – What encourages you to continue hoarding data?

TOPIC 2 (Challenges & Motivations)

What challenges do you face when it comes to deleting files on your cloud storage?

1. How do you determine whether a file is "unwanted" or not? What are the factors that influence this decision? (both in your academic and personal life)
2. What type of files do you categorize as "unwanted" but don't want to delete them? And why?
    a. Follow-up: Are there any emotional or sentimental attachments to your files that make it challenging to delete them?
3. What would motivate you to review and delete unwanted files on a regular basis?

TOPIC 3

How important is environmental sustainability to your daily life, including your digital practices?

1. How familiar are you with the negative environmental impact of cloud storage? What are your thoughts?

CONCLUSION

1. Is there anything you would like to add to this conversation?
2. Do you have any questions for me?

Thank you so much for your valuable time. This information will be extremely valuable as I start to think of design solutions for this problem. Thank you!

Sprint 3

Research Papers

Sweeten, G., Sillence, E., & Neave, N. (2018). Digital hoarding behaviours: Underlying motivations and potential negative consequences. *Computers inHuman Behavior*, *85*, 54–60. https://doi.org/10.1016/j.chb.2018.03.031

Sedera, D., Lokuge, S., & Grover, V. (2022). Modern-day hoarding: A model for understanding and measuring digital hoarding. *Information & Management*, *59*(8), 103700. https://doi.org/10.1016/j.im.2022.103700

Is digital hoarding a mental disorder? development of a construct for ... (n.d.). https://www.researchgate.net/publication/327098318_Is_Digital_Hoarding_a_Mental_Disorder_Development_of_a_Construct_for_Digital_Hoarding_for_Future_IS_Research