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IE403 Human Computer Interaction

Final Project Report

Course Project:

Behavioural UI Design for Smartphone Charging and Carbon Emissions

Group 7

Members:

Ansh Garg (202201343)
Kalp Shah (202201457)
Dev Joshi (202201405)

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1 Goal of the Project

The aim of this project is to understand how everyday smartphone usage contributes to carbon emissions and how people think about this impact. In particular, we focus on:

- Awareness of carbon emissions and the idea of a "carbon footprint" among general users.
- How people use their smartphones in daily life, including their charging behaviour and upgrade patterns.
- How actual charging data from smartphones can be used to understand and visualise real charging habits.
- Designing a behavioural user interface (UI) that can gently nudge users towards more sustainable charging practices.

The broader goal is to connect concepts from Human–Computer Interaction (HCI) with environmental sustainability. By combining qualitative data (interviews and questionnaires) with quantitative data (charging logs from a mobile app), we want to identify opportunities where UI design can help users:

- Become more aware of the carbon footprint of their devices, and
- Gradually change their behaviour without feeling forced or overloaded.

In the later stages of the project, this understanding will be used to design and prototype a behavioural UI, followed by basic user testing and evaluation.

2 Task A: User Interaction Study (Qualitative)

2.1 Data Collection Methodology

For Task A, we conducted a small user study using a semi-structured questionnaire focused on:

- Awareness and understanding of the term "carbon footprint",
- Awareness of the carbon footprint of smartphones specifically,
- Personal behaviour and lifestyle related to smartphone use, upgrading and charging.

Each group member interacted with multiple participants. In total, we collected responses from **15 participants**. The questions were asked in an informal, conversational way, but the same core set of 15 questions was used for everyone to keep the data comparable.

2.2 Demographics of Participants

The 15 participants were a mix of:

- Undergraduate students (B.Tech),
- Postgraduate students (M.Tech, MBA),
- PhD scholars,
- College faculty members (Assistant/Associate Professors),
- Working professionals (e.g., software engineer, designer),
- Non-technical participants (homemaker, small shop owner, auto-rickshaw driver, retired employee).

This gave us a mix of age groups, education levels and digital usage patterns, which helped us see how awareness and behaviour may differ across user types.

2.3 Qualitative Analysis and Affinity Diagram

All the responses were written down and then analysed using a basic **affinity diagram** technique. We clustered similar responses together on sticky notes (or their digital equivalent) and grouped them into higher-level themes.

Major clusters that emerged:

- **Cluster 1: Basic awareness of "carbon footprint"**
  Many participants had heard of the term, usually from school, TV, social media, or news. However, the understanding was often broad ("pollution caused by our actions") rather than specific to digital devices.
- **Cluster 2: Very low awareness of smartphone-specific carbon footprint**
  While people agreed that electricity use and manufacturing must have "some impact", only a few participants had thought specifically about smartphones having their own carbon footprint (including production, data centres and charging).
- **Cluster 3: High dependence on smartphones in daily life**
  Most participants described their phone as "very important" for communication, studies, work, navigation, and entertainment. For students and professionals, it is almost central to both academic and work routines.
- **Cluster 4: Charging habits**
  Common behaviours included:

  - Charging once or twice per day,
  - Charging mostly at night or in the evening,
  - Plugging in around 20–40% battery level,
  - Often charging up close to 90–100%.

  Only a few people mentioned consciously avoiding 100% charging or using battery saver modes.

- **Cluster 5: Upgrading and device lifetime**
  Some participants upgrade roughly every 2–3 years (performance or camera as main reasons), while others keep their phone until it stops working. Old phones are usually kept as backup, given to relatives, or occasionally exchanged/sold.

- **Cluster 6: Sustainable behaviour (low and uneven)**
  A few participants reported using dark mode, power saver, or consciously reducing screen time and streaming. However, most did not connect these habits with environmental impact; they did it more for battery life or personal convenience.

2.4 Key Observations from Task A

From the affinity diagram and qualitative analysis, we observed:

- Awareness of carbon footprint exists at a general level, but is rarely connected to digital behaviour.
- Charging and upgrade habits are driven by convenience and performance, not sustainability.
- There is potential for a behavioural UI that:
  - Makes the invisible impact visible (e.g., by showing carbon-related feedback),
  - Suggests small, practical changes (e.g., optimal charging range, avoiding overcharging),
  - Fits into existing habits instead of forcing completely new routines.

3 Task B: App-Based Charging Behaviour Data (Quantitative)

3.1 Data Collection Methodology

For Task B, we used the mobile application provided by the instructor to log actual charging events from smartphones. The app records:

- The type of event: `power_connected` or `power_disconnected`,
- The battery percentage at the time of the event,
- The date, time and timezone.

We collected data from **5 Android phones**. For each phone, the app data was exported as a CSV file. Each `power_connected` event marks the *start* of a charging session, and each `power_disconnected` event marks the *end* of that session. We paired these events in order to compute:

- Battery percentage at the start of charging,
- Battery percentage at the end of charging,
- Number of charging sessions per phone.

3.2 Demographics of Phone Users

The 5 phones belonged to different types of users, overlapping with the participants in Task A:

- Two B.Tech students,
- One postgraduate student,
- One working professional (software engineer),
- One non-technical user (family member / homemaker type profile).

3.3 Duration and Dataset Description

The app data was collected over:

21 October 2025 to 31 October 2025 (11 days)

Across these 11 days, we found:

- **109 charging sessions** across all 5 phones.

Table 1: Charging statistics for each phone over 11 days

Phone	Sessions	Avg Start	Median Start	Avg End	Median End
Phone 1	24	33.3%	36%	87.2%	92%
Phone 2	27	33.1%	29%	93.0%	99%
Phone 3	15	37.4%	38%	97.0%	100%
Phone 4	23	29.1%	26%	93.0%	95%
Phone 5	20	34.2%	36%	90.3%	95%
Overall	**109**	**33.1%**	**33%**	**91.8%**	**96%**

3.4 Quantitative Analysis of Charging Behaviour

For each phone, we computed:

- Number of charging sessions,
- Average and median battery percentage at the start of charging,
- Average and median battery percentage at the end of charging.

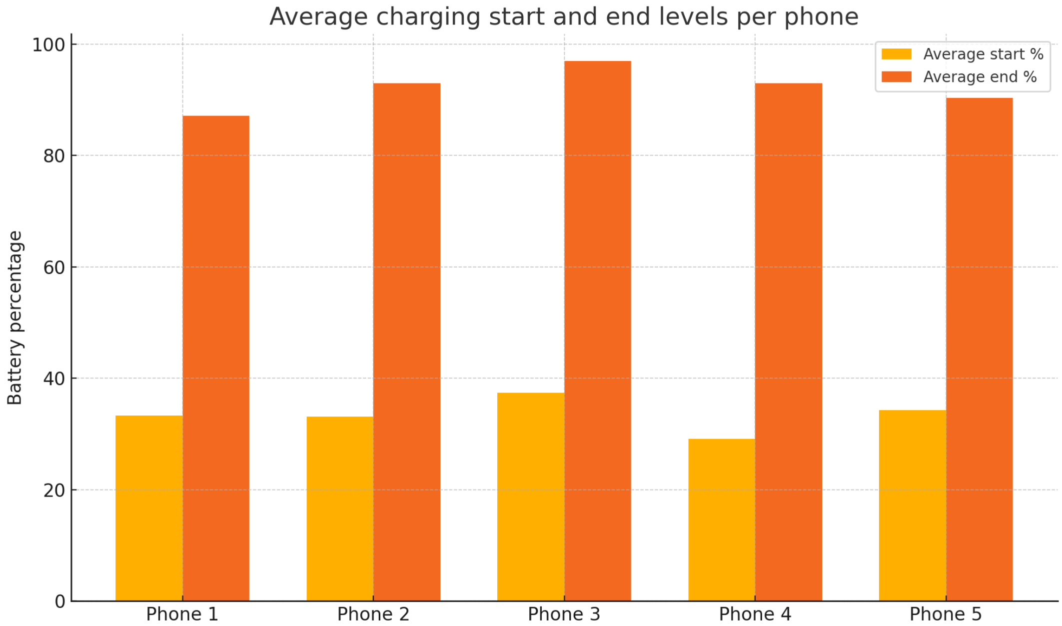

Figure 1: Average battery percentage at the start and end of charging for each phone.

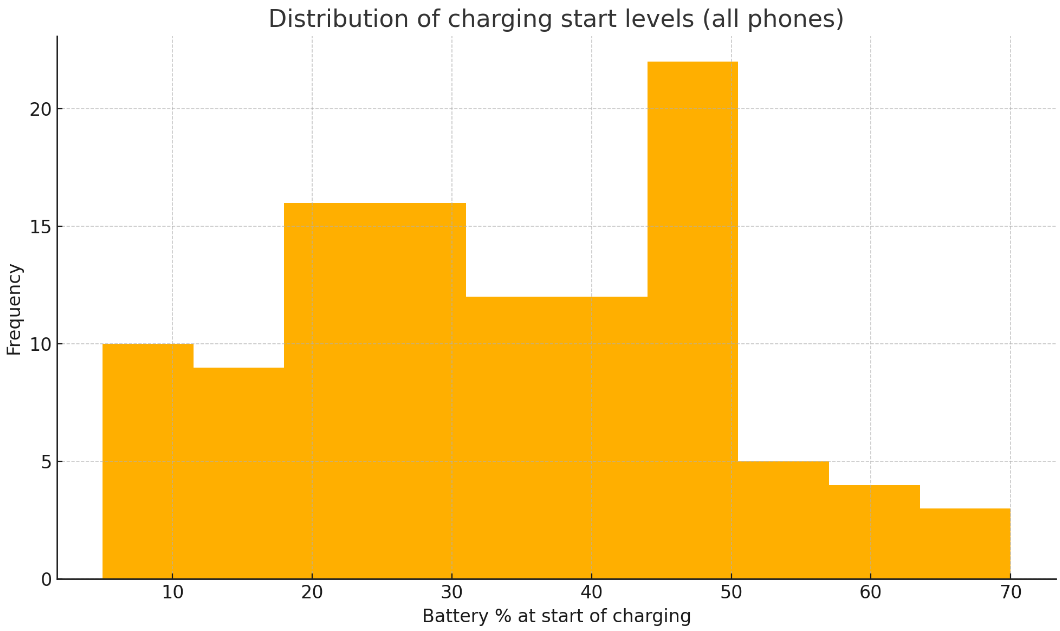

Figure 2: Distribution of battery percentage at the start of charging (all phones combined).

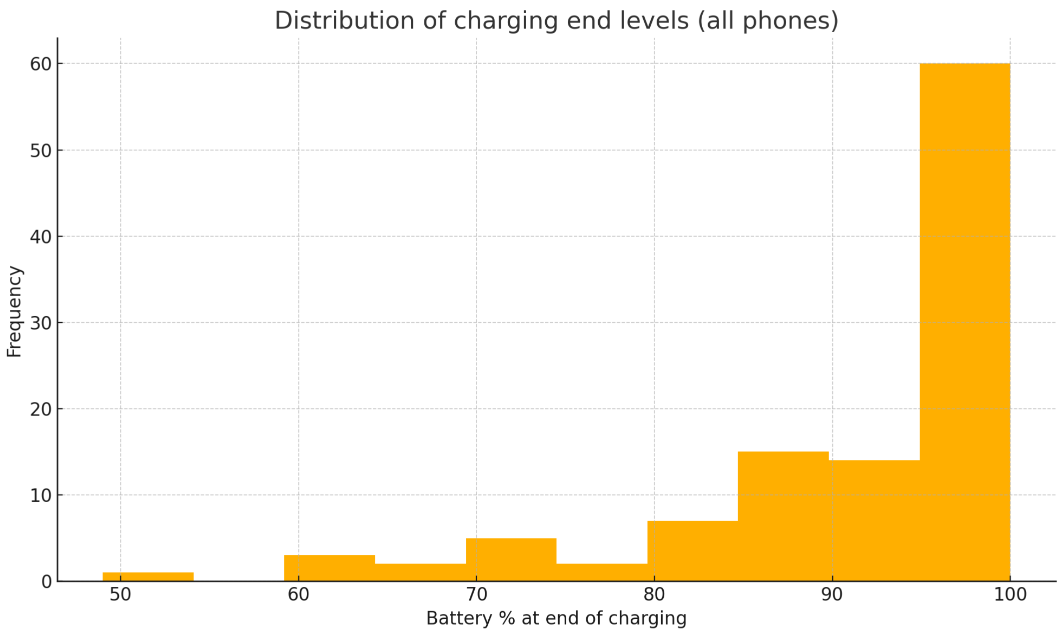

Figure 3: Distribution of battery percentage at the end of charging (all phones combined).

From the combined data:

- **Average starting percentage:** around **33%**.
- **Median starting percentage: 33%**.
- **Average ending percentage:** around **91.8%**.

- **Median ending percentage: 96%**.

This means that users typically plug in their phones when the battery is roughly one-third full and unplug when it is close to full, often above 90%.

3.5 Key Findings from Task B

Linking back to the questions mentioned in the project brief:

1. **How many times did users charge their phones?**
   Over the 11 days, each user charged their phone on average about **2 times per day**. Some phones (e.g., heavy users) had slightly more sessions (up to ∼2.45 per day), while lighter users had around 1.3–1.8 sessions per day.

2. **What was the minimum charge on average (or median) before plugging in?**
   Considering all phones together, the **average starting battery level** was about **33.1%**, and the **median starting level** was **33%**. This matches the qualitative impression that users "start worrying" somewhere around 20–40% battery.

3. **What was the average maximum charge before unplugging?**
   On average, users unplugged at around **91.8%** battery, with a **median ending level of 96%**. For some phones, the median end level was at or near **100%**, meaning many sessions involved fully charging the device.

4. **Overall charging behaviour from app data**
   The app data confirms a pattern of:

   - Frequent charging (roughly twice a day),
   - Charging from roughly one-third battery to near full,
   - A general tendency to keep the phone battery high (above 90%).

3.6 Connecting Task A and Task B

The quantitative app data supports and strengthens our qualitative observations:

- People do not usually think about the environmental impact, but their charging patterns (frequent top-ups to high percentages) are very consistent.

- Many users charge at night or during convenient windows, which explains why charging goes up to 90–100% even if it is not always necessary.

- This behaviour can be targeted by a behavioural UI that:

- Gives subtle notifications when the phone is in a "good enough" range (e.g., 80–85%),
- Visualises how avoiding unnecessary full charges can reduce energy use and carbon emissions over time.

4 Prototype Design

As part of the project, we created both paper prototypes and digital prototypes of the behavioural UI concept named **GreenCharge**. The goal of this prototype was to demonstrate how charging behaviour, carbon emissions, and sustainable tips can be communicated effectively through a simple mobile interface.

The prototypes include:

- A **Dashboard screen** showing CO_2 estimates and median plug/unplug behaviour.
- A **Charging Log screen** showing the history of charging events with carbon emissions in grams (g).
- A **Tips screen** showing recommended sustainable actions such as charging within 20–80%, enabling battery saver, and reducing video streaming.

4.1 Paper Prototype Screens

Below are the hand-drawn versions of the prototype screens created during the ideation phase.

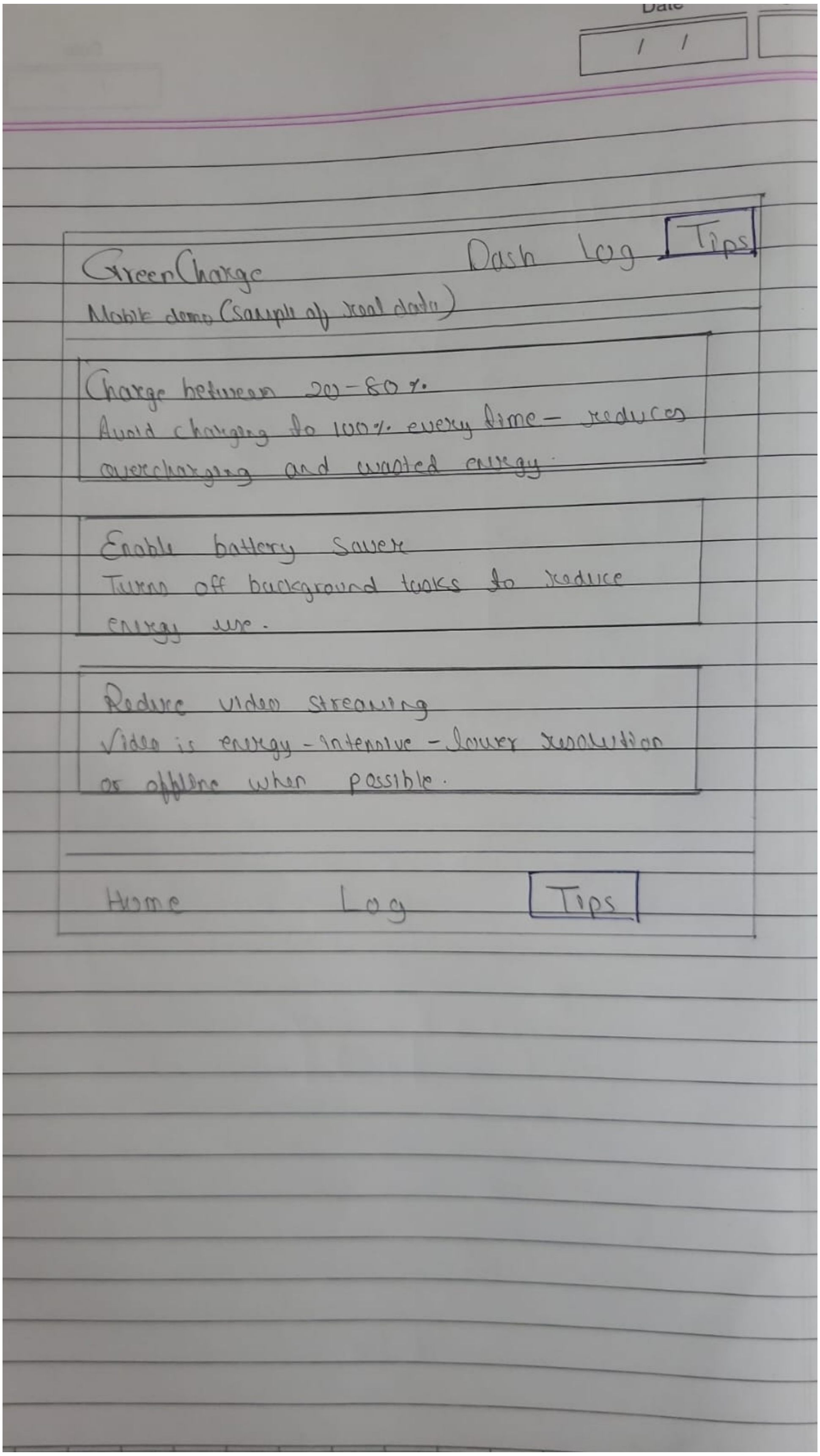

Figure 4: Paper prototype: Tips screen

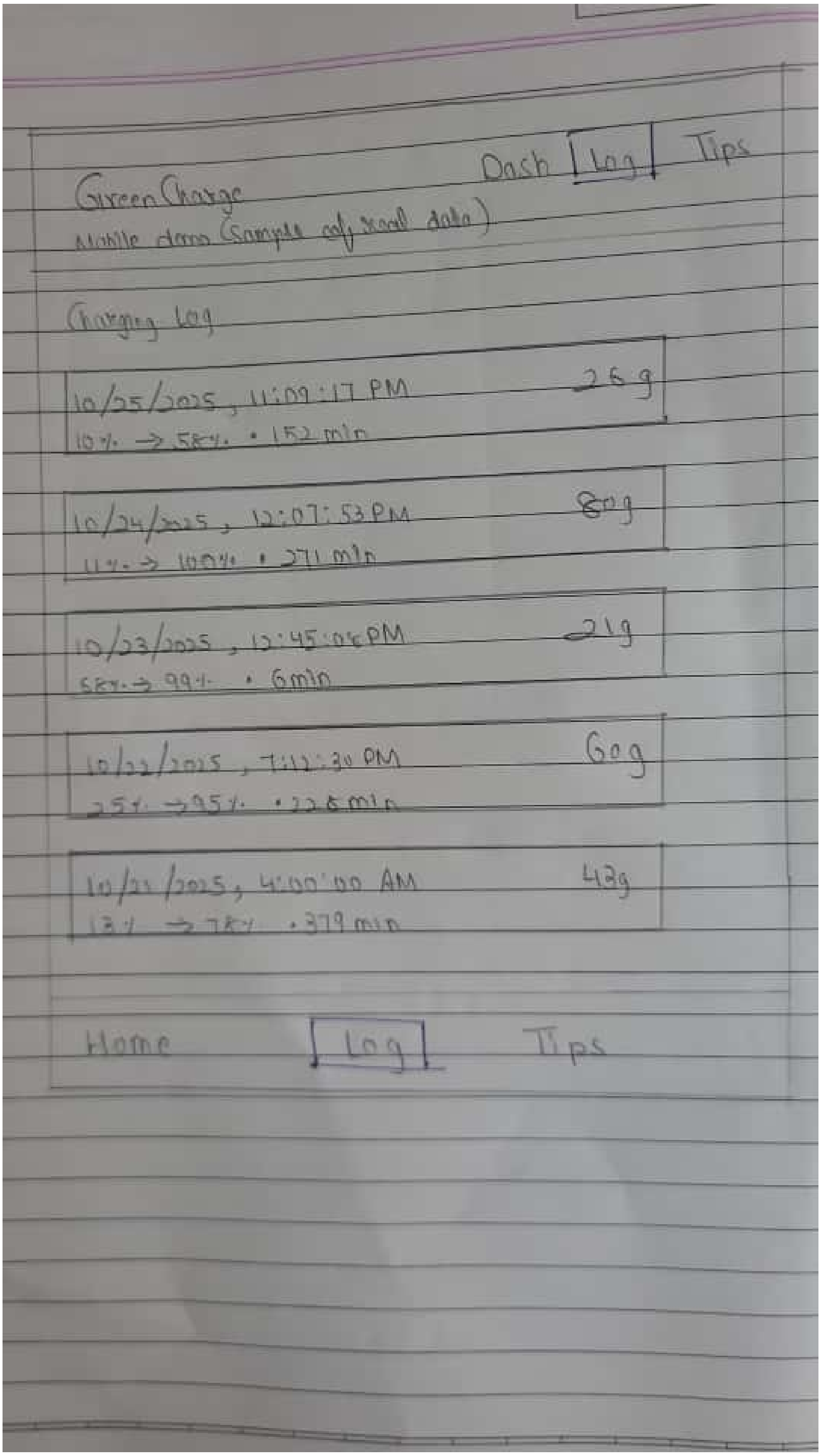

Figure 5: Paper prototype: Charging Log screen

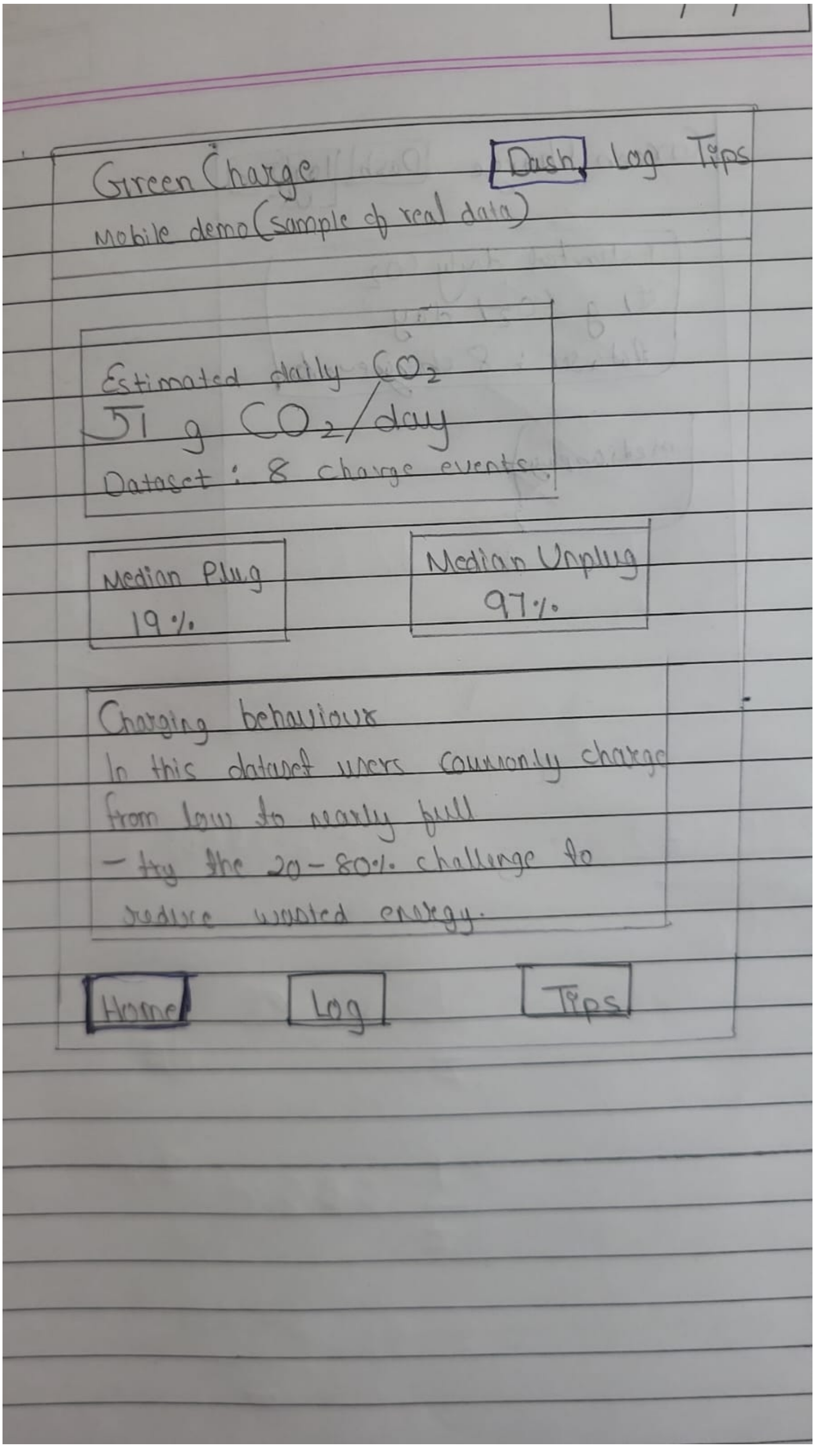

Figure 6: Paper prototype: Dashboard screen

4.2 Digital Prototype Screens

We also created cleaner digital mock-ups to better visualise the UI layout and interactions.

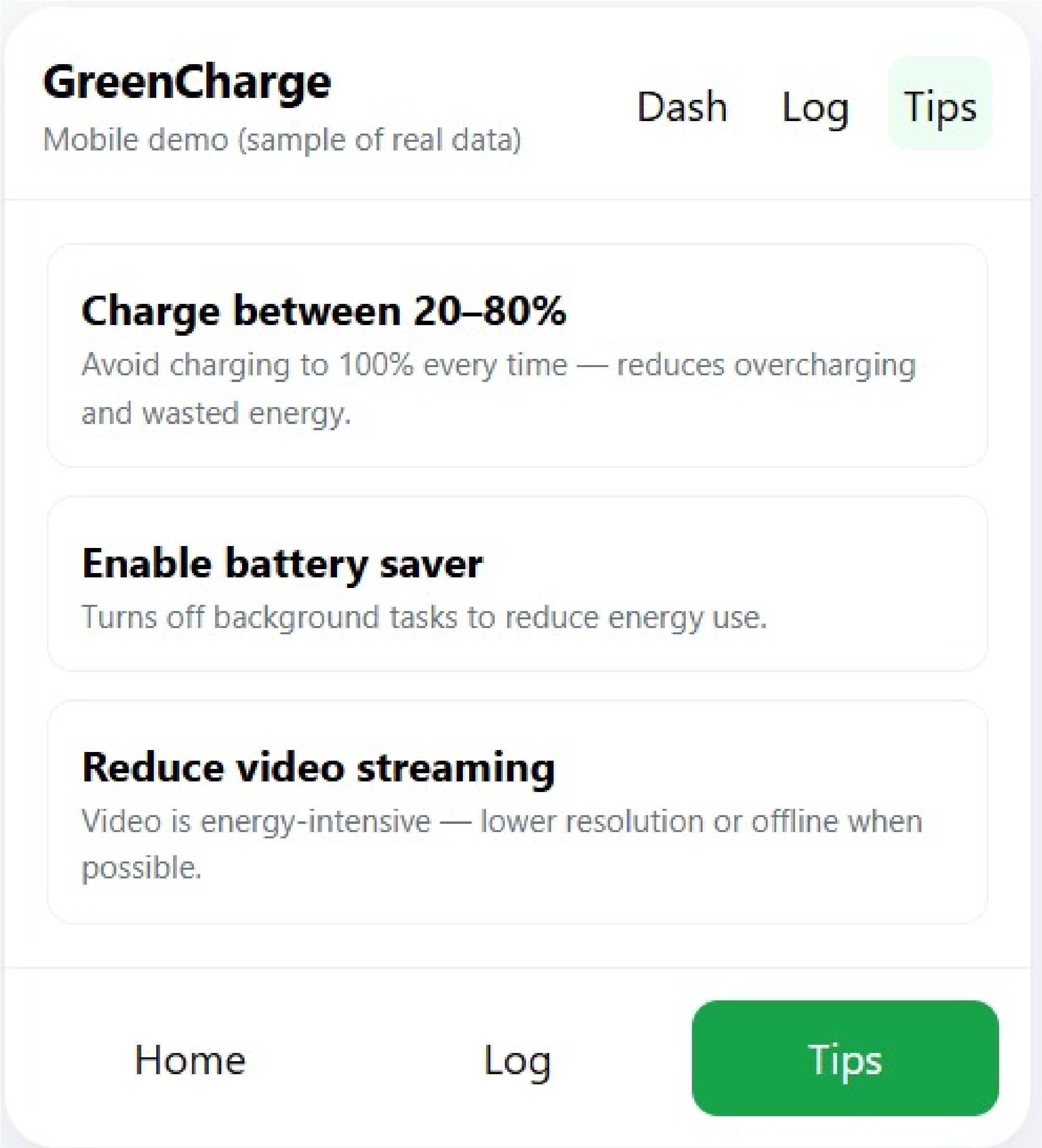

Figure 7: Digital prototype: Tips screen

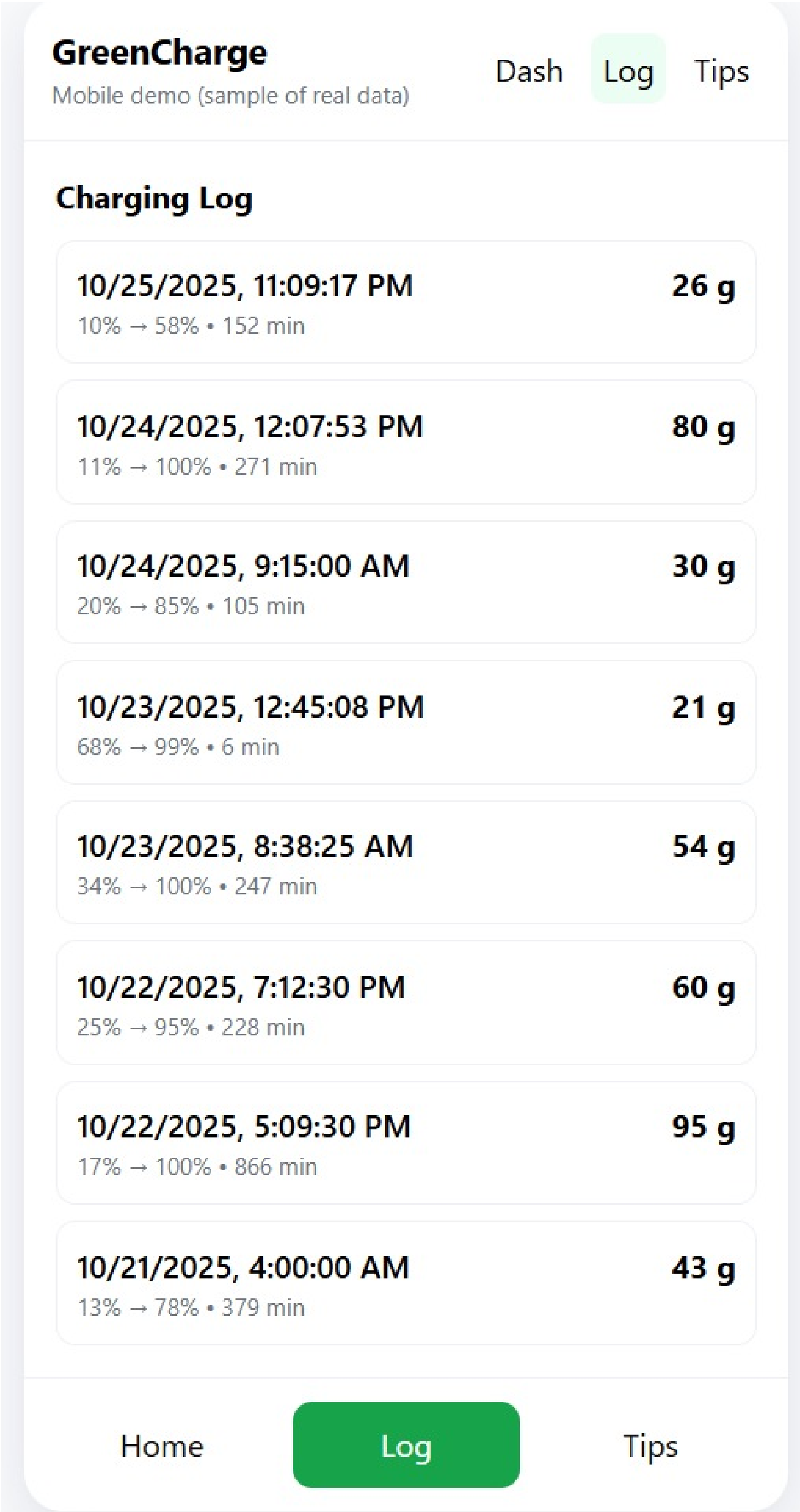

Figure 8: Digital prototype: Charging Log screen

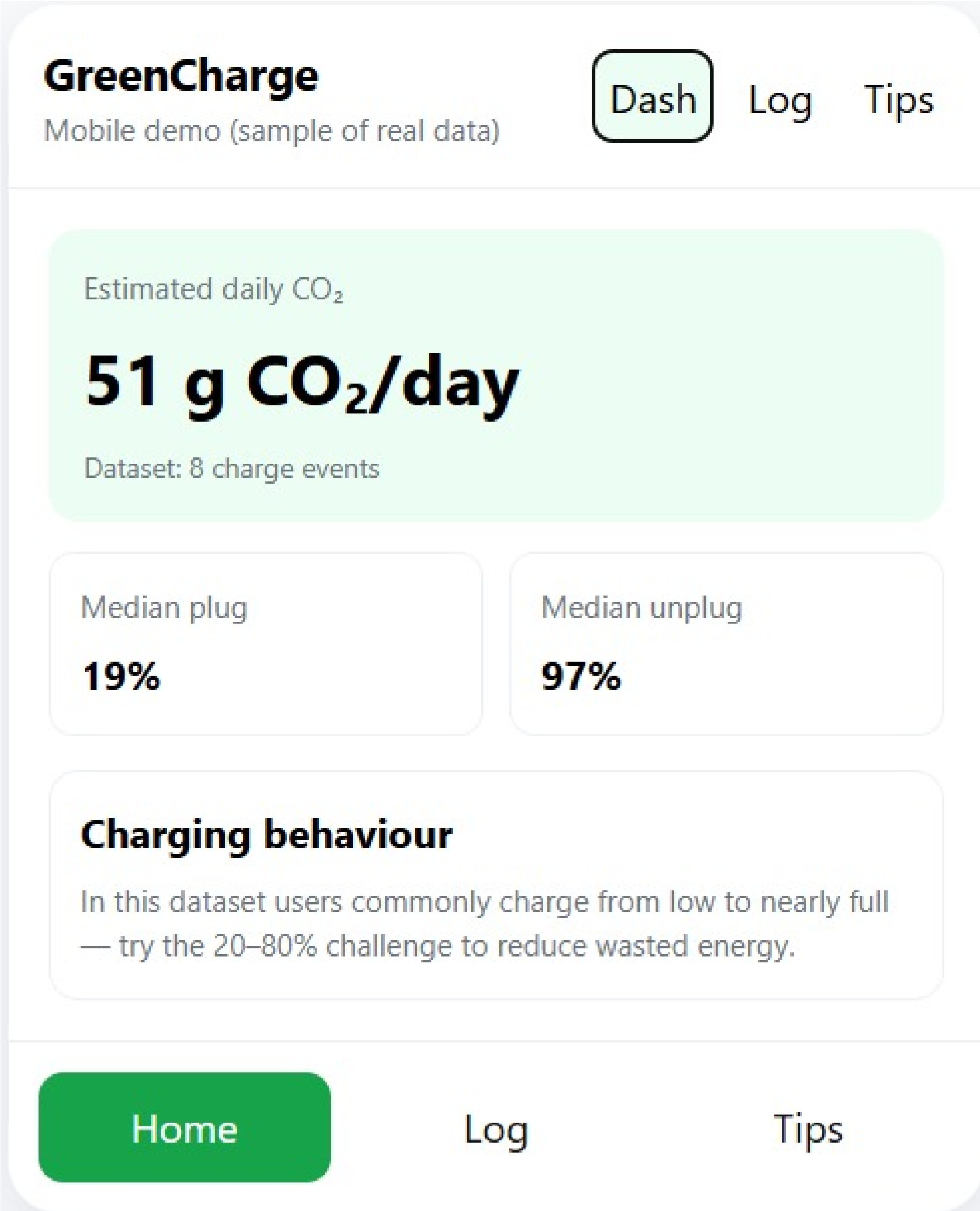

Figure 9: Digital prototype: Dashboard screen

5 Discussion

5.1 Challenges Faced During the Project

Throughout the project, we encountered several practical and methodological challenges:

- **Recruiting participants:** Many students and professionals were busy, so getting them to sit for a 10–15 minute questionnaire required multiple follow-ups.
- **Clarifying the concept of carbon footprint:** Several participants did not fully understand what "smartphone carbon footprint" meant. We had to simplify the explanation without influencing their responses.
- **Data cleaning:** The CSV data from the charging app had many entries where timestamps were close or repeated. Matching `power_connected` and `power_disconnected` events required careful processing.
- **Prototype decisions:** Choosing what information to show (e.g., CO_2, start/end battery percentages, charging behaviour) without making the UI cluttered was a design challenge.
- **Balancing simplicity and accuracy:** We wanted the prototype to show meaningful insights, but not overwhelm users with technical information.

5.2 Why People Did Not Agree to Install the App

During data collection, several participants showed hesitation or refused to install the logging app. Their reasons were consistent across groups:

- **Privacy concerns:** Many people were worried that the app might track more than just charging events — such as location, usage patterns, or personal files.
- **Fear of battery drain:** Ironically, some users thought the app itself would consume battery and reduce performance.
- **Skepticism:** Some did not trust unfamiliar apps and feared malware, data leaks, or unnecessary background processes.
- **Limited storage:** A few participants said their phones were already low on storage and did not want to install additional apps.
- **Not interested in environmental data:** A few people bluntly stated that they didn't care enough about carbon footprint data to install a new app.

5.3 Main Concerns Reported

When specifically asked, participants highlighted the following concerns:

- **Data security:** “Will this app read my personal data or track my activity?”
- **Background running:** “If it runs all the time, it might slow down my phone.”
- **Phone performance:** “Will it heat up my phone while logging events?”
- **Unknown developer trust:** “Is this app safe? Is it from a verified source?”

These insights helped us refine the design direction — the UI should clearly communicate transparency, privacy, and minimal resource usage.

6 Contributions

The project work was divided equally among all three group members. Each member contributed to both the qualitative and quantitative parts of the study, as well as to the design and documentation. The contributions are summarised below:

Ansh Garg (202201343)

- Collected **5 questionnaire responses** from students and faculty members.
- Helped in organising the responses and participating in the **affinity diagram** clustering.
- Processed the charging dataset from two phones and contributed to the calculation of average start/end percentages.
- Created the **digital prototype screens** for the Dashboard and Log pages.
- Coordinated the structuring of the final project report and integrated all sections into the LaTeX document.

Kalp Shah (202201457)

- Collected **5 questionnaire responses** from postgraduate students and working professionals.
- Assisted in analysing user behaviour trends identified in the interviews.
- Processed the charging dataset for one of the phones and reviewed the correctness of the event pairing (plug/unplug).

- Created the **paper prototype sketches** for the Tips screen and the Log screen.
- Helped refine the discussion points, especially the challenges and reasons participants were hesitant to install the app.

Dev Joshi (202201405)

- Collected **5 questionnaire responses** from non-technical users and general participants.
- Contributed to the grouping and naming of clusters in the **affinity diagram**.
- Processed the charging dataset for two phones, verified the computed statistics, and assisted in generating the graphs.
- Worked on the **paper prototype sketches** for the Dashboard screen and participated in the digital prototype review.
- Assisted in writing the explanation of Task B, especially the interpretation of the quantitative findings.

Overall, all group members contributed proportionately to data collection, analysis, design, and report preparation.