Exploring the Relationship Between Mood and Smartphone Use Through Data Physicalisation

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ABSTRACT

This study explores how emotional state and phone usage influence one another, through the design and deployment of interactive probes. A series of physical probes was designed to enable self-reported, reflective data about smartphone usage behaviour and emotional well-being. The first probe invited participants to log their emotional state before and after phone use and indicate their intention. Through three in-context deployments, the experience was iteratively refined and transitioned from data collection to a reflective behaviour intervention.

The final design called *'Intentree', is* a data physicalisation that visualises phone use and invites reflection on behaviour. The usage is presented as leaves and flowers in various colours and sizes, mirroring the users' emotion and length of usage. When the user activates their phones, the branch lights up requesting reflection. This project blends personal narratives, embodied interaction and self-driven meaning-making in a playful, tangible form.

Keywords
Smartphone use; Mental health; Mood; Self-regulation; Emotional Reflection; Data Physicalization

INTRODUCTION

As smartphones become increasingly embedded in daily routines, they are not just tools for communication but also spaces where emotions play out. Emotions play a central role in shaping human behaviour. Our emotions arise from what we experience in the world, and in turn, they influence how we behave and interact with our surroundings [12].

From doomscrolling during stress to checking messages out of habit, phone use often reflects more than utility. Smartphone usage frequently affects how people feel, but emotions can also shape how and when they use their phones [13]. Despite this, most digital well-being tools focus on tracking usage metrics such as screen time or frequency, overlooking the emotional context in which these behaviours occur.

Why Physical Probes?
We chose to explore this relationship through a physical probe and applying the Data-enabled Design 8-loop [18] instead of surveys or apps. This way the focus shifted from the screen to the user's environment, putting the emphasis on in-context data-gathering and insights. This allowed us to combine self-reporting through data physicalisation, turning invisible phone habits into visible, tangible patterns.

Design Principles
Our design approach was motivated by the desire to support self-awareness through ambient, embodied interaction rather than through metrics or feedback alone. The twelve design principles proposed by Funk et al. [7] guided our process across all stages. Throughout the design-process we highlighted how key principles informed our decisions in each step from early exploration to the final intervention.

Figure 1. Close-up of intervention design, Intentree

Contextual and informed exploration
The project unfolded in two phases. In the first phase, contextual exploration, we asked: What is the relationship between phone use and emotional state in everyday life? To explore this, we designed and iteratively deployed a tangible data probe that allowed users to log their emotions before and after phone use and reflect on their motivations.

In the second phase, the informed exploration, our research question became: How can a tangible data physicalisation support emotional reflection on smartphone use in everyday life? Here, we designed a reflective artifact that visualises phone use and mood through the placement of coloured and sized components, encouraging ambient awareness through physical interaction.

Reflection as an intervention design

Reflection is recognised in HCI as a powerful catalyst for self-insight and behaviour change [1]. By encouraging users to revisit their actions and feelings, reflection supports growth, learning, and more conscious decision-making. In this study, physical probes and data physicalisation acted as reflection mechanisms. The process of logging emotions and seeing them visualised through interactive artifact created moments of pause and self-awareness.

Target Users and Use Context

The focus of this study was on university students aged 20 to 25 years old as our target users. As younger adults are among the highest smartphone users and are more prone to problematic or emotionally driven phone use. Research has shown that younger age is a significant predictor of problematic social media and smartphone engagement [3].

The context was the home-environment where personal habits, emotions, and routines unfold most naturally. To ground our exploration, we developed a persona 'Jolly Jane' a 25-year-old MSc student whose phone use reflects common patterns like frequent checking, stress-driven scrolling, and a desire for better digital habits.

Jolly Jane

About him

Phone Usage Patterns:
- Most-used apps: Instagram, WhatsApp, Duolingo, YouTube, Netflix
- Usage duration per day: 5-6 hours, frequent checking
- When & why he use phone:
  - During study breaks (dopamine hit)
  - To manage stress/anxiety
  - Bonding with family and friends
  - As a tool for productivity (calendars, reminders, to-do apps)

- Age: 25
- Address: Eindhoven, Netherlands
- MSc Human-Technology Interaction Student

Pain points:
- Feels guilty after doomscrolling for 1+ hour
- Always scrolling at phone before go to bed
- Notifications interrupt focus
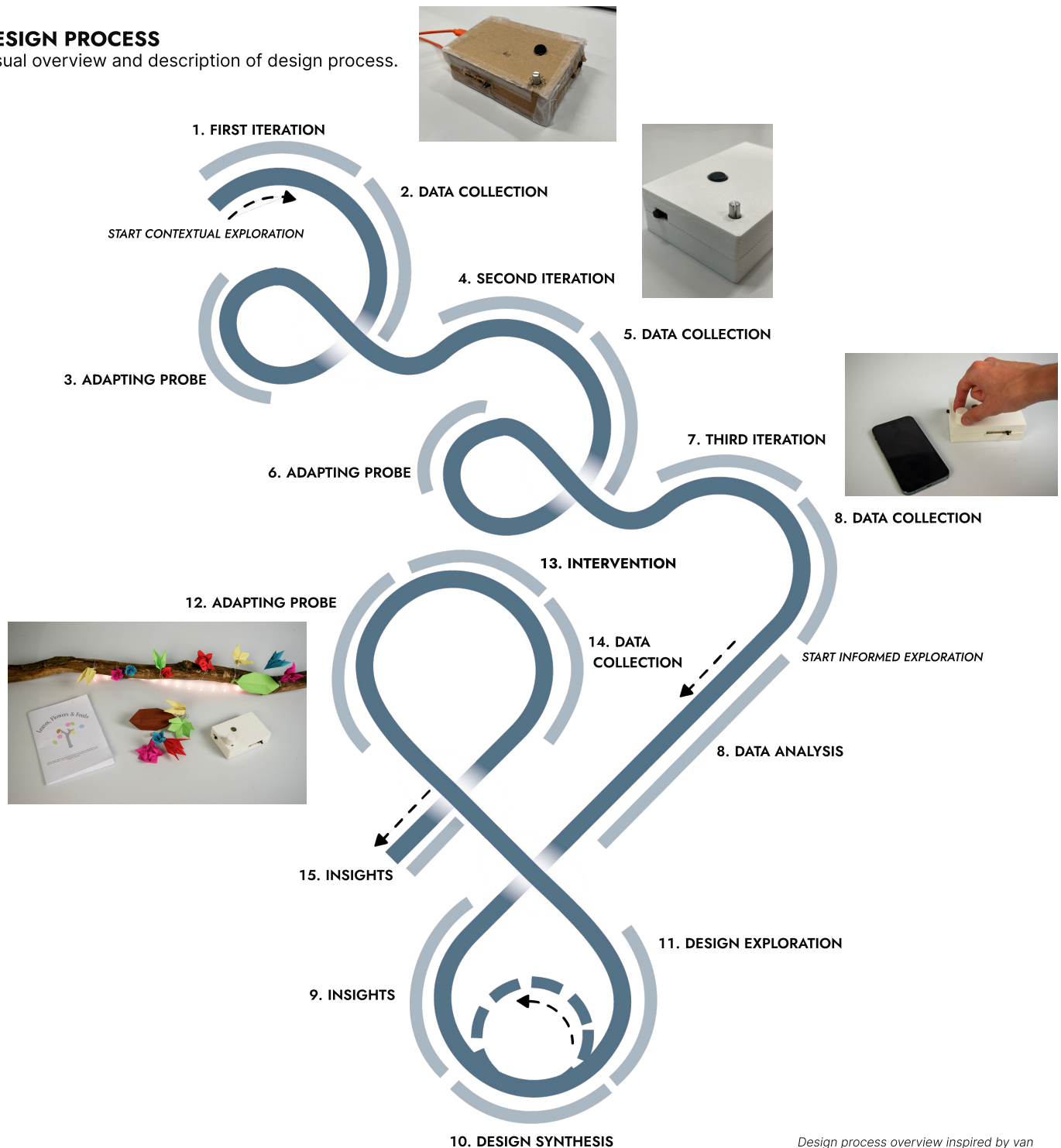- Feels screen time is high but lacks discipline to reduce it.

Goals:
- wants to build better digital habits
- feel less addicted to phone
- want to make reflections on phone usage patterns

Figure 2. Persona Jolly Jane

DESIGN PROCESS
Visual overview and description of design process.

1. FIRST ITERATION

2. DATA COLLECTION

START CONTEXTUAL EXPLORATION

4. SECOND ITERATION

5. DATA COLLECTION

3. ADAPTING PROBE

7. THIRD ITERATION

6. ADAPTING PROBE

8. DATA COLLECTION

13. INTERVENTION

12. ADAPTING PROBE

14. DATA COLLECTION

START INFORMED EXPLORATION

8. DATA ANALYSIS

15. INSIGHTS

11. DESIGN EXPLORATION

9. INSIGHTS

10. DESIGN SYNTHESIS

Design process overview inspired by van Kollenburg & Bogers 8-shape model [3]

CONTEXTUAL EXPLORATION

We started this study by investigating how people used their phones in emotionally charged moments and whether they were aware of that connection. Instead of tracking screen time, we focused on the emotional and situational: how people feel, why they reach for their phone, and whether that use is intentional or habitual. The research question during this phase was:

Could we design a tool that surfaces emotional patterns in phone use, rather than just measure time?

To explore this, three iterations were completed using the top part of the DED 8-loop: deploying probes in context, collecting data, and adapting the design. Finally, insights from this step were used to inspire the informed exploration phase of the study.

What data were we interested in?

The first iteration of our probe aimed to make an invisible habit visible by capturing how participants felt before and after using their phone, why they used it, and whether that use was intentional. Simple time markers were used, to observe patterns in duration and timing. A tangible analog probe was used instead of a phone-based tracker, as screen-time tools offer little emotional insight. Physical interaction encouraged users to slow down and reflect on their mood and motivation. The probe was placed in the home to naturally blend into daily routines.

First data probe design

The data probe operated through a custom-built data collection device that was build on an ESP32 microcontroller and powered by a power bank. The data collection process began when participants activated a physical switch while using their phone. The participants then interacted with the rotary encoder knob to indicate their intended reason for using their phone, selecting from predefined categories on the probe itself. Before and after smartphone use, participants self-assessed their emotional state through a Likert-scale slider on the side of the probe. Additionally, a realisation button allowed participants to flag moments when they realise unintentional phone use or when their actual usage differt from their initially indicated purpose. Once the switch activated the probe, collected data flowed seamlessly through OOCSI [5] to be stored in a DataFoundry [6] database.

> **Principle 3. Deep contextual data**
> Involving a few participants allowed us to gather rich contextual data about their smartphone use and emotional state.

Adapting the probe

After analysing the data and conducting a brief interview with the participant, valuable insights were gained on how the probe should be adapted for future deployments. One key insights was that the probe had to be more intuitive and less obstructive to use, because now each time participants used their phone, they needed to perform many steps. The 'realisation button' (to be pressed when participant realised their phone use deviated from the set intention) was too obstructive and did not provide valuable data.

> **Principle 8. Use technology consciously and transparent**
> To minimise burden on the participant, we immediately adapted the probe to be more intuitive and obstructive to use.
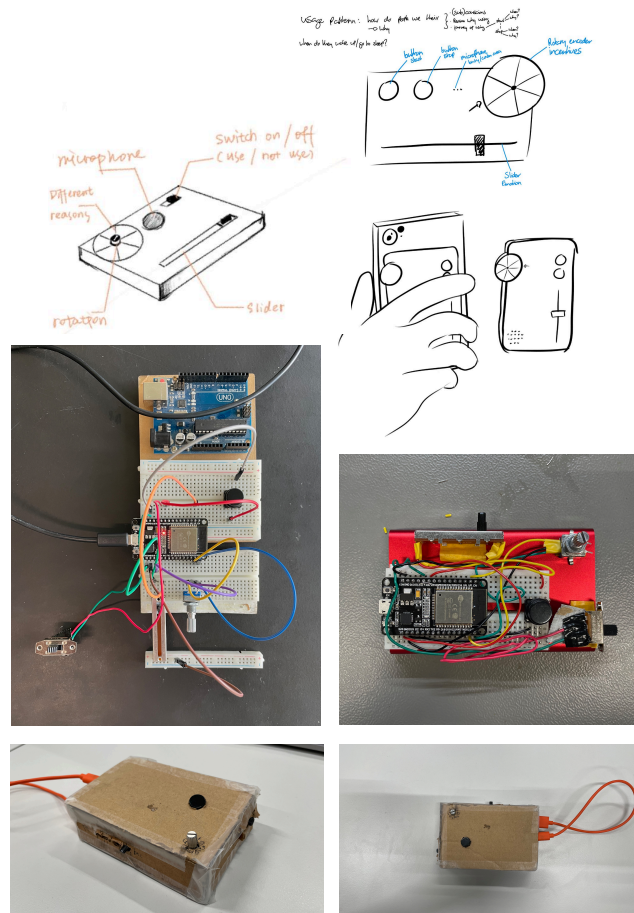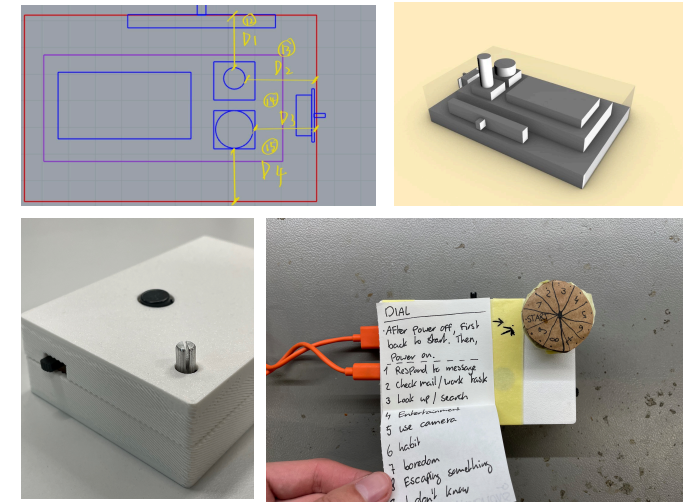

Figure 4. Collage of first iteration

Figure 3. Collage of second iteration

> **Principle 5. In constant contact with the context**
> **Principle 6. Design with data in real-time**
> Through short iterative loops, we were able to gather feedback quickly and implement it, working with participants to improve the probes.

Second iteration

For the second iteration we deployed with the same participant to test if and how the probe improved after adaptation. For this iteration the interactions with the probe were simplified, to reduce friction in everyday use. The realisation button was removed, as it was difficult to interpret reliably and made the process feel unnecessarily complex.

Moving away from the lo-fi prototype in the first iteration, and improve protection of the electronics during deployment, a 3D printed casing was made. The casing was modular, so that elements could be added or removed in later deployments and no unnessecary waste was produced.

Adapting the probe

Analysing the data from this deployment, some elements of the probe were producing some unusable data-points. The rotary encoder knob produced inconsistent data, and the home Wi-Fi connection was unstable, meaning the probe was not always connected. These elements had to be evaluated and altered in the next iteration, to make sure the third probe provided trustworthy insights.

Third iteration

After the previous deployments, we conducted our final iteration over a longer period of time. A Telegram bot was set up to send automated surveys each time the probe was used. This was done to gain immediate and broader understanding of the qualitative, subjective data. The automation through DataFoundry is a perfect example of how data streams can complement each other. The short survey includes questions such as: Have you used your phone intentionally? Do you feel that your phone use has contributed to your current mood? These answers complemented the probe data during the data-interview, gaining deeper in-context insights. See appendix A for the ESP32 microcontroller python code.

Data collection

The probe collected data through four channels. First, it detected when the participant turned on their phone. Using the rotary encoder knob, participants then indicated why they were using their phone. Before and after phone use, the emotional mood could be indicated using the slider. Once the probe was switched off, an automated survey is sent. All this data provides a complete picture of each participant's phone use, enabling analysis of the relationship between emotional mood and phone use.

Improved UX: visual feedback (blue light) when probe is connected. No more lost data because of connection issues.

Principle 2. Qualitative and quantitative data

During these first deployments, both qualitative and quantitative data are combined to gain a broad insight of the context.

Figure 5. Data flow visualization of third iteration

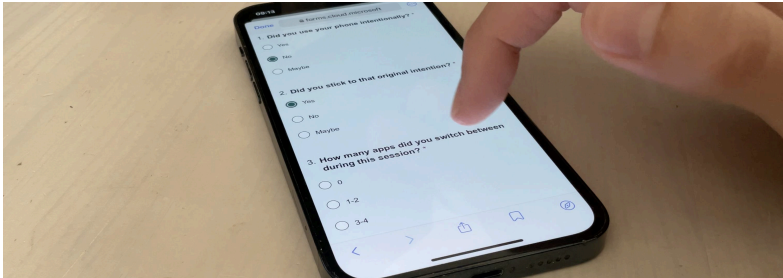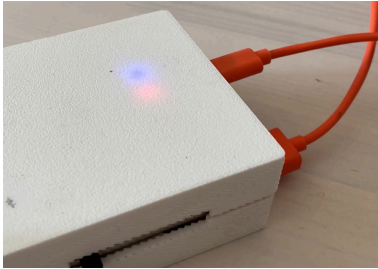| ☐ Column 1	≡ Label	≡ Emoji	≡ Category type	≡ Description
1	Respond to Message		Communication task	You intended to reply or react to a message or app notification
2	Check Email / Work Task		Productivity task	You planned to do something work or school related (e.g., calendar, email)
3	Look Up Info / Search		Information seeking	You needed to find something out (e.g., directions, fact-check, etc.)
4	Entertainment / Media		Leisure task	You wanted music, a podcast, a video, or to play a game
5	Habit / No Specific Reason		Habitual use	You opened your phone automatically out of habit or muscle memory
6	Boredom		Emotional use	You were idle or restless and wanted something to do
7	Avoiding Something / Escaping		Emotional avoidance	You used your phone to escape stress, anxiety, or a task you're avoiding
8	External Cue / Notification Triggered Me		External trigger	You picked it up only because something pinged or lit up
9	I Don't Know	?	Fallback / uncertainty	You aren't sure or can't describe the reason clearly

Principle 1. Design with stories and anecdotes

The survey in this iteration delves deeper into contextual data through narratives. These are collected directly and not afterwards (e.g. during an interview) to provide real and rich insights.
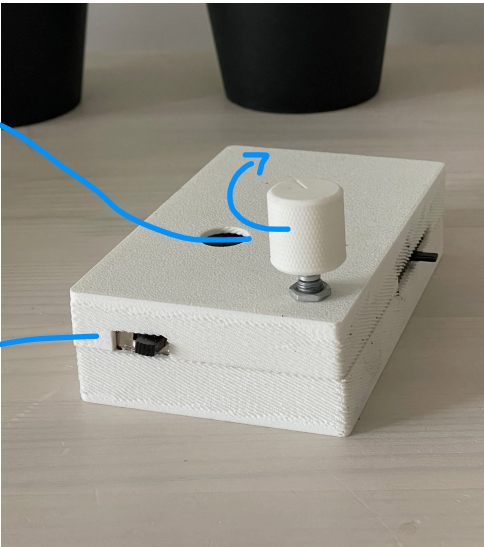
Principle 7. Modular and reusable

The modular probe components are reused throughout the process to ensure that data collection needs are always met. We also modified the plastic housing of the probe throughout the process to make it last as long as possible.

PARTICIPANTS

Participant	ID
P1 🐶	u8572d5c39f534ea3
P2 🐘	uc2a7d1360c3447b1
P3 🐱	ua6ffe4e41...
P4 🐻	u139d74f5e...

```
1  // retrieve id of first participant in project
2  // var pid = participants[0].participant_id;
3  var pid1 = participants[2].participant_id;
4  var pid3 = participants[3].participant_id;
5
6
7  // send a Telegram message to this participant and turn the
8  if(data.button < 1) {
9    DF.telegramParticipant(pid3, "Hi, XXX! Here's a short surv
10   DF.telegramParticipant(pid1, "Message sent! https://form
11 }
```

Principle 9. Automation
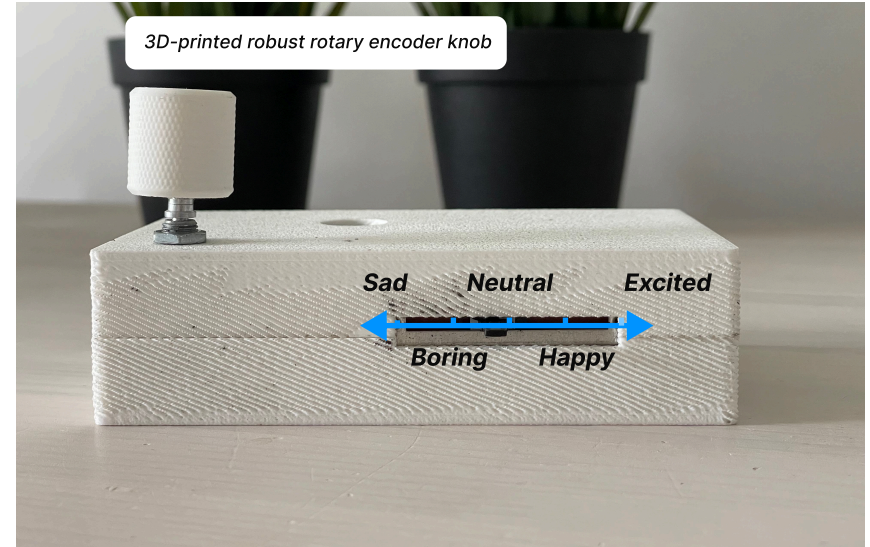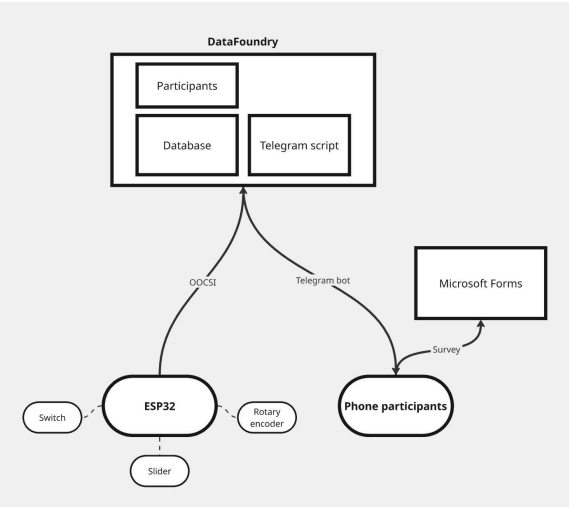
Using a script in DataFoundry, surveys are automatically sent to participants, ensuring a seamlessly connected experience for the participant.

3D-printed robust rotary encoder knob

Sad   Neutral   Excited
Boring   Happy

Insights into context, behaviour and experience

The results presented below are based on data collected during the third deployment of the probe(see appendix D). To enrich the findings, follow-up data-interviews were conducted with participants. Tables and graphs were made for further analysis based on the DataFoundry graph (Figure 6). Specifically, to clarify the emotional spectrum within the slider, the following value ranges are defined: sad (0–819), boring (820–1638), neutral (1639–2457), happy (2458–3276), and excited (3277–4100).
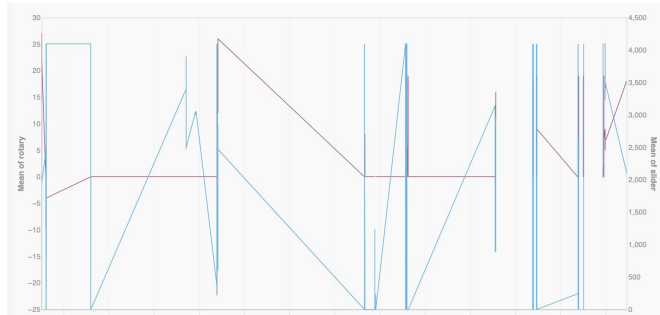

Figure 6. Graph of raw data collected by probe

Quantitative data

The influence of emotional state on phone usage

The table (table 1) indicates a clear relationship between participants' emotional states and the phone use. Specifically, participants with a low emotional state (for example sad or boring) tended to use their phones for a longer duration (up to 26 minutes), while those in a positive state (excited or happy) engaged with their phones for shorter periods (as little as 2 minutes). This suggests that individuals may use their phones as a coping mechanism or a way to regulate their emotions when feeling low (sad).

In contrast, when individuals are already in a good mood, they may have less need or motivation to engage with their devices for extended periods. Therefore, the emotional state before phone use may significantly shape the user's behaviour and level of engagement with the device.

Interestingly, participants who began in a relatively positive or neutral emotional state consistently rated the phone's emotional impact as high (score = 5–6). This may indicate that individuals who were already emotionally stable or positive were more aware of emotional shifts or more sensitive to emotional reinforcement from digital interactions. In contrast, participants who started in a low emotional state gave lower ratings (score = 3), suggesting a weaker perceived influence of phone use on their emotions.

The influence of phone usage on emotional state

The impact of phone usage on emotional states varies depending on the reason for usage. According to the data, intentional usage such as responding to messages tends to result in stable or slightly improved emotional states, as indicated by minimal or positive Δ Emotion values. This type of usage may involve meaningful communication, which supports emotional well-being.

In contrast, entertainment and media use show the most variation in emotional outcomes. Some participants experienced a significant emotional change in emotional state (e.g., Δ Emotion = +2047) (due to the good news by a phone call), while others experienced a decline (Δ Emotion = -207). This inconsistency suggests that media consumption can have both uplifting and potentially harmful emotional effects, likely depending on content and individual context.

Overall, phone usage can both reflect and influence emotional states. Intentional and communicative use appears more emotionally stable or positive, while passive or media-driven usage leads to more variable and less predictable emotional outcomes.

Figure 9. Graph between phone usage reason and the impact of mobile phones on emotions
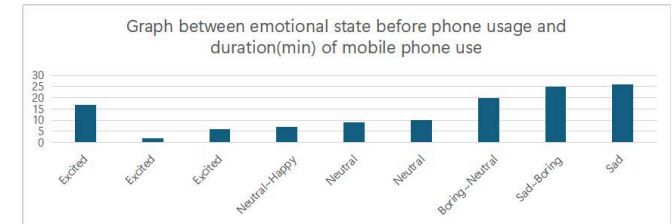

Table 1. Participant complete data-set

Figure 7. Graph between emotional state before phone usage andduuration(min) of mobile phone use

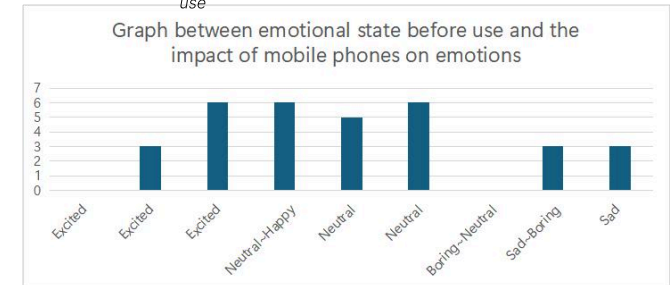*Figure 8. Graph between emotional state before use and theimpact of mobile phones on emotions*
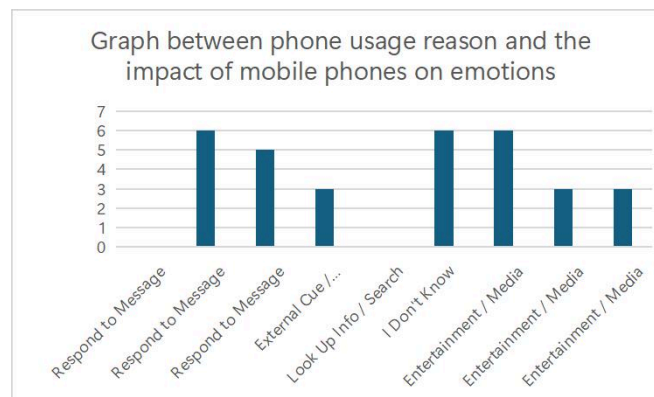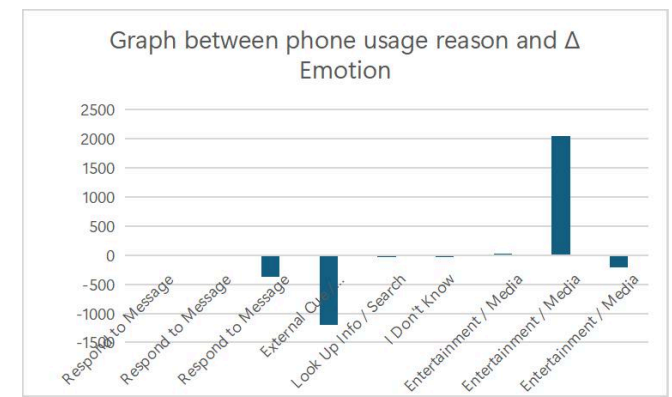

Figure 10. Graph between phone usage reason and ΔEmotion

Qualitative data

Relationship with mobile phones

Participants showed mixed feelings about their phones. Participant 1 described it as a *"two-fold"*: essential for organizing work and school tasks, but also a distraction, especially through social media. They noted that "scrolling for hours through videos I don't care about" negatively affects their mood, but they felt unable to delete the apps because of lack of control and emotional dependency.

Participant 2 showed an improved relationship with her phone. "I have deleted platforms like YouTube and Instagram to avoid passive scrolling." She also explained she will use such apps only with clear intentions. However, she mentioned recently reactivating Instagram was "not so good," showing that self-control can easily be disrupted.

Emotional impact of phone Use

Participants reported that phone use, especially involving social media, often had a negative emotional effect. Participant 1 mentioned using their phone as a way to escape when feeling stressed, but described the result as "feeling empty inside" afterward. They also noted that excessive scrolling led to procrastination and "feeling worse" about tasks left undone.

While Participant 2 acknowledging that phone use sometimes helps to "get your mind off stress," they emphasised that when usage became a habit, it often led to feeling worse. They noted that "the message you're receiving needs to be very positive to really lift your mood," Participant 2 recalled "I got good news on my phone this afternoon and that made me happy," suggesting that digital interactions tend to influence emotions more negatively unless actively positive.

Both participants expressed that phone use, particularly unintentional or passive use, can contribute to mood decline, distraction, and emotional fatigue, especially when used during times of stress, tiredness, or low motivation.

Strategies for Managing Phone Use

To manage phone usage, participants also adopted structural strategies to limit access to distracting content. One participant mentioned using two separate phones, one of which was reserved for more relaxing, non-distracting use. However, she noted that this method was not always effective due to practical limitations, such as forgetting to charge the second phone. Another participant described activating "work mode", which blocks access to most apps except essentials like mail, calendar, news, and music. They used this mode when they "need to get stuff done" and viewed it as a coping mechanism to focus, reducing the chance of getting drawn into distracting content.

In addition, both participants reported efforts to regain control over their phone usage through increased awareness and intentionality. Participant 1 expressed a desire to "be more aware of when and how much I use my phone," suggesting strategies like enabling grayscale mode or disabling apps to reduce impulsive use. They also reflected on the probe itself as a potential intervention, stating that if they had used it every time they picked up the phone, "I would have used my phone less," though they found it "a bit too invasive" for frequent use.

DISCUSSION OF CONTEXTUAL EXPLORATION

The relationship between phone usage and emotion

According to the findings, users experiencing more positive emotions tend to have shorter and more intentional phone usage. In contrast, individuals in a negative emotional state are more likely to engage in longer, less purposeful phone use.

Moreover, users with more positive emotions demonstrate a higher awareness of how their phone usage affects them, suggesting a stronger sense of self-regulation.

Regarding the impact of phone usage on emotions, the data shows that intentional usage does not significantly influence users' emotional state. Instead, it is negative moods (e.g., sadness) that appear to trigger longer and more passive or unintentional usage, rather than being a consequence of it.

Design insights

Intentional Use Leads to More Positive Emotional Outcomes

Participants who used their phones for clear purposes experienced more emotionally stable(neutral) or even positive outcomes(happy, excited). In contrast, passive or habit-driven use, especially triggered by external cues, often led to emotional decline. Design should support goal-oriented interactions and help users stay aligned with their original intent.

Restrictive Features Alone Are Not Sustainable

While users reported that blocking apps or activating "work mode" helped reduce usage, might leading to compensate later with increased screen time, especially when awareness was low. This suggests that restriction mechanisms must be paired with tools that cultivate reflective awareness, rather than relying solely on blocking access.

Emotional Awareness is essential

Users often lack awareness of their emotional state whenpicking up their phones. Our data shows that phone use initiated in low emotional states tends to last longer and result in more negative emotional outcomes. Therefore, design should aim to encourage brief moments of emotional self-check before or during phone interaction to foster intentional use. This indicates an opportunity for design to scaffold long-term habits by reinforcing users' own goals and providing gentle, ongoing support.

Next step

Building on these insights, we shifted our focus to explore how design could intervene in this emotionally driven pattern of phone use.

While emotional states clearly shape usage behaviours, the reverse impact remains limited, particularly when phone interaction lacks intentionality. This gap raises a critical question: how might we foster more reflective, emotionally aware usage in everyday life? To address this, our second research question emerges:

How can tangible data physicalisation support emotional reflection on smartphone use in everyday life?

This next phase focuses on designing and testing an intervention that encourage users phone usage reflection, fostering behavioural change.

> **Principle 1. Design with stories and anecdotes**
>
> Focusing on participants' stories with their phones, we collected thick and unique data of phone usage

> **Principle 3. Favour deep, contextual data over wide, big data.**
>
> Only a small number of participants was involved in the deployment and interviews, offering the opportunity of more detailed and personal insights. During the interview, we focused on contextual information such as the stories behind answers, instead of general answers and could ask more directed questions.

INFORMED EXPLORATION

With the gathered data in the contextual exploration phase, the next phase of informed exploration started. In this phase the intervention design was created, to further explore user behaviour and test the effectiveness of a designed intervention.

Design synthesis

The result of the last iteration within the contextual exploration formed the first step of the informed exploration. The insights from this step were that intentional use of the smartphone lead to more positive emotions. Secondly, it was found that restrictive features were temporarily effective, but often lead to compensation later in the day. Finally, emotional awareness while picking up the smartphone was essential to help people control their usage. Based on these conclusions a mind-map was created to illustrate what an effective design intervention should entail, based on this data gathered in previous steps.
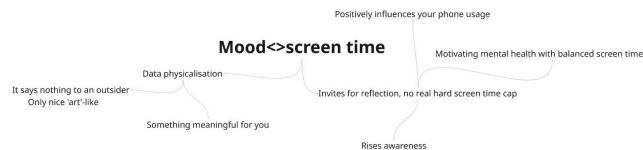
Figure x. - Mind-map of design criteria based on insights of iteration 3.

Principle 11. Use data awareness in creative design process

The data found in the previous iteration on mood and emotion was not directly implemented into the design. It was chosen to cover this topic by inviting the user to reflect on their own mood and identify elements of the design to represent their mood. Without defining what a 'good' or 'bad' emotion was, predetermining which element should represent which emotion.

The choice was made to create a data physicalisation, which was private yet meaningful to the user. The person using the design would have full control over the visualisation of the data, to create this very personal and private way of representing data. The design should also support intentional use of the smartphone, by offering a visual representation of use during the day or week and in this way raise awareness about usage. Furthermore, to counter the effects of restrictive features, the design should focus on reflecting on own behaviour. This should also add to raising awareness and creating a more positive relationship with the Smartphone.

Principle 8. Use technology conciously and be transparant and critical about applied data practices.

To avoid exposing the participant by spilling privacy sensitive data about mood in the form of a data physicalisation, the data represented was by choice of the participant self. The objective data about use, was measured by a switch also controlled by the participant. This way, it was clear what of this data was shared with the researchers and when. No unnessecary technology was added. All of the data gathered would be discussed with the participant at the end of deployment, to again support transparency.

Designerly explorations with data

Based on the course lecture introducing data physicalisation and showing examples, additional existing designs were gathered to analyse (Figure 11). From this, some elements were isolated, which formed design criteria. This included a design that was interactive and used shapes and forms that represented data, without immediately revealing what data. The interactions should be simple steps and easy-to-learn to not overcomplicate using your smartphone while still being inviting to the user. Also, the design was an artifact that could be placed in the context (the home-environment) without bothering the user or standing out too much. By again using principle 8 using technology consciously and only where necessary, and additionally principle 4 putting emphasis on visualising data in a way understandable to the user.

Principle 4. Visualize data in ways understandable and transparant for the participants

As the data physicalisation was designed by the user themselves, this created a safe and transparent way of visualizing data. They themselves understood what it meant and could explain this later on to the researchers. The objective data was presented in a understandable way, later on in the data-interview.

Implementing the data points found in the previous iterations, the team individually brainstormed and made sketches (figure 12). When discussing those in the team, one idea was picked that entailed the design criteria set before hand to further investigate and iterate on. This concept was a tree which could be decorated by the user with flowers and leaves representing their emotional state and length of their smartphone usage (figure 13). Again using the probe separately while using their smartphone same as in previous steps, the tree would gently remind them to reflect on their usage, by lighting up. To guide the user in the reflective process, questions were asked while interacting with the tree and decorative elements.

To determine how the design would behave in context, the team again individually brainstormed on the functionalities. They asked themselves questions like: what would I do if I used this design? What would my friend do if I gave this design to them? How do we see usage of this design in long-term? This resulted in several storyboards which were finally merged through discussion within the team, into a final design: 'IntenTree".

Principle 12. Shift perspective as needed

To create the storyboards and further investigate the functionalities of the design for this iteration loop, the team members were encouraged to shift perspectives. During this individual activity, they asked themselves the questions mentioned above and shifted multiple times between the in-context perspective and designer-perspective on the design.
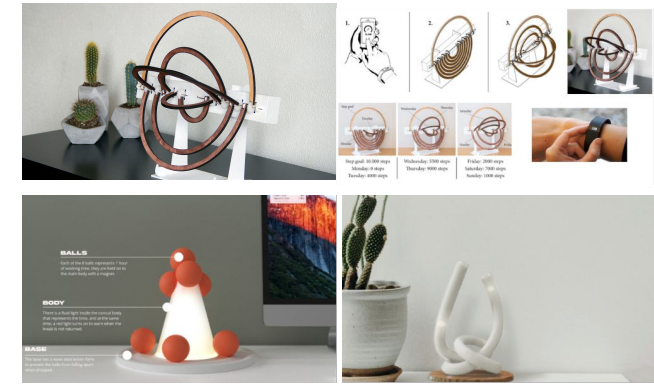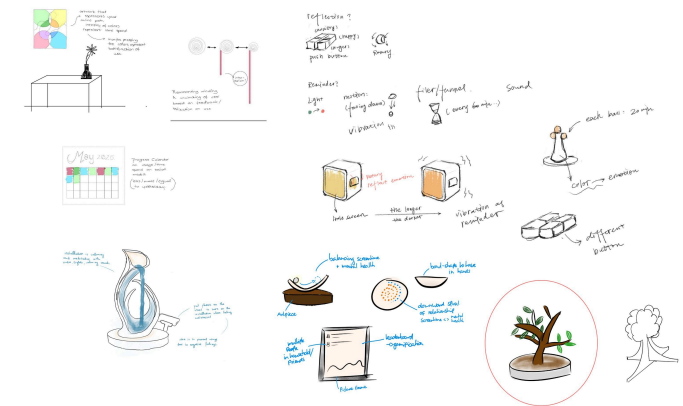
Figure 11. Inspirational projects [9, 14, 15]

Figure 12. Sketches from brainstorming session
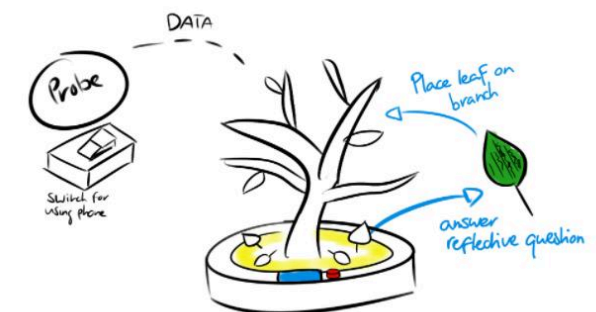
Figure 13. Basic layout of the chosen design

1. Storyboards

Ask participant Where do she/he usually use phone during interviews

Place pressure sensor on the seat

After 30 minutes, the device lights up to remind the user that reflection is about to begin.

Question shown on screen

Each shape and color represent a reason/feeling

chose the color&shape

weekly leaves collection and reflection questionnaire
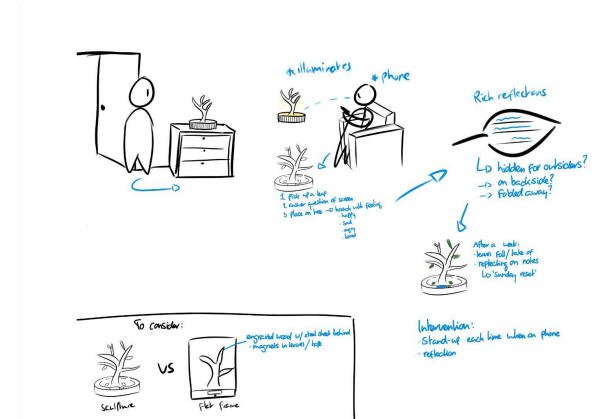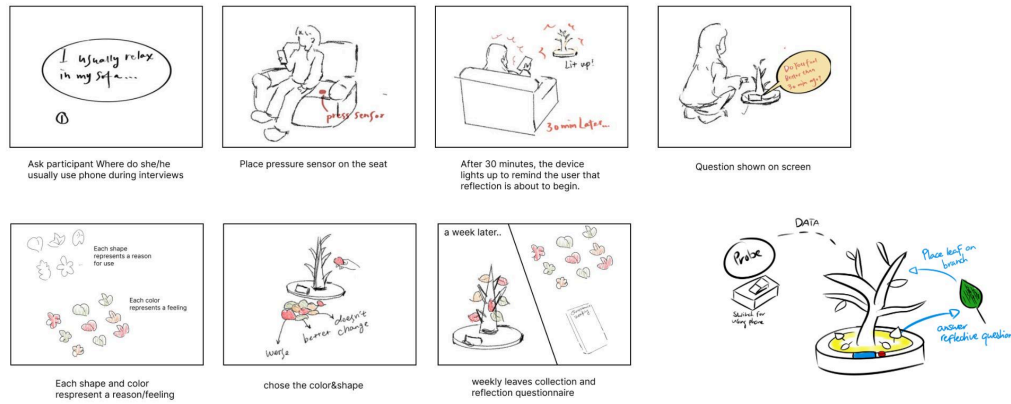
2. Merged storyboard & intended data gathering

The user pushes the button on the tree model

The user picks a leaf or flower representing their feelings, the size represents their smartphone usage.

After attaching the leaf or flower they fill in the reflection journal

User is home

The user wants to reflect on their behavior/emotion but did not switch the button

The user interacts with the tree

When using their smartphone they flip a switch on the probe

After 30 minutes OR when user flips the switch within 30 minutes = the tree lights up

The user does not interact with the tree

The tree dims the light, but stays on

At the end of the week the user reflects on their choice of leaves past week

data from probe (button/slider)

data from chat-bot (daily reminder)

data from leaf/flower choice

data from reflection journal

time spend on smartphone

Photo of the tree per day

size of leaf/flower

color and type of leaf/flower

emotion

usage

notes

3. Inspiration for further design

Figure 14. Collage of inspiration [17, 16, 10, 11, 8, 4, 2]

Prototype situated in the everyday life

The designed prototype '*IntenTree*' consisted of three parts:

1. **A real branch with paper decorations**
This branch was taken from nature to somewhat replicate the feeling of a tree. Lights were added to one side of the branch, which were triggered by a switch to invite the user to interact with the design (see appendix B for the code). Additionally, multiple origami flowers and leaves of various colours and sizes were folded and attached to a metal wire. This way, they could easily be attached t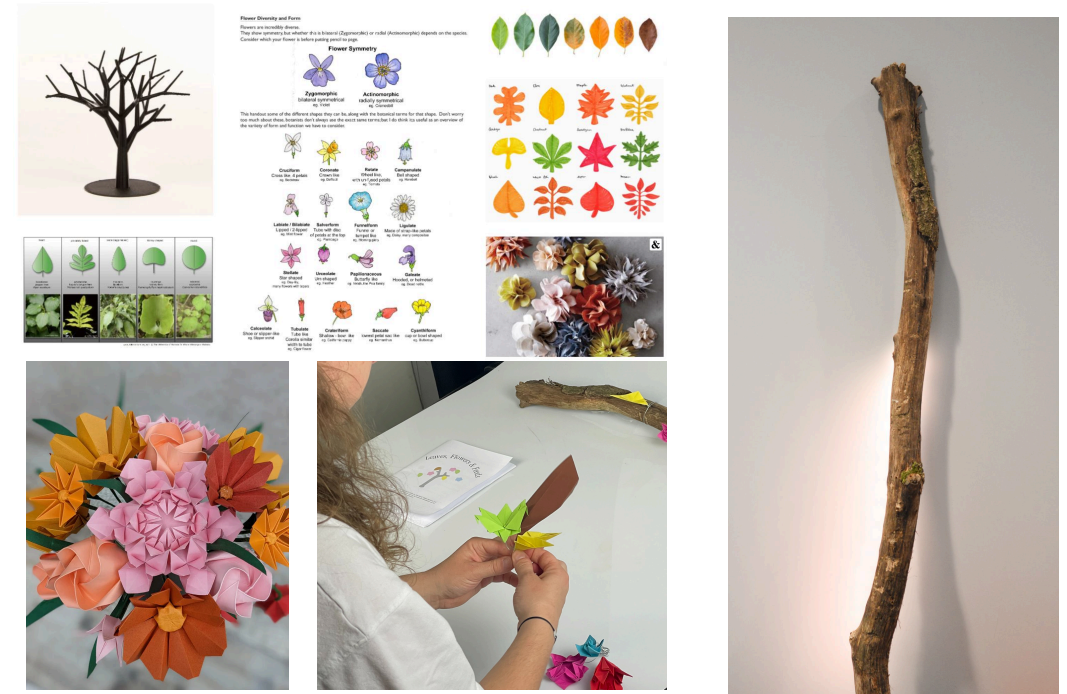o the branch. The bright colours and various shapes of the decorations, were intended to welcome the participant into reflecting.

2. **A portable probe**
The probe was used as switch, so that the participant could indicate when they used their phone and collect usage data. The probe also activated the lights on the branch after use (see appendix C for the code).

> **Principle 7. Use modular & reusable**
> The probe designed for the past iterations was already multi-functional and adapted multiple time throughout the process. For this design a switch was needed to track usage data and the probe could be reused again, simply by eliminating other functionalities and use it as a switch.

3. **A reflection-journal booklet**
In the booklet the participant could indicate what type and size of decoration they picked. It also asked how the participant was feeling and how the smartphone was used to make them more aware of their mood and intent. The remaining questions had a more open character by providing an empty box for the answer, so the participant could journal and express themselves more if they wanted to.

Deployment
The participant took '*IntenTree*' home to place the branch at home in the room they spend the most time in while awake, and preferably in sight. They were asked to turn the control on the probe whenever they were using their smartphone, and turn it off whenever they stopped using it. After using the probe, and terminating smartphone use, the tree lit up. The participant had the choice to reflect on their behaviour or ignore the cue.

If they choose to reflect, they picked a flower or leaf in the size of their usage: small, medium or large respectively representing brief, normal or long usage. The choice of flower or leaf was up to the participant, and not pre-designated to give them the creative freedom to express themselves. Whenever a flower of leaf was added to the branch, the participant was instructed to fill in the reflection booklet. The booklet guided them through their choice to reflect on their smartphone usage, behaviour and mood. At the end of the day, the participant was asked to share a photo of their branch with the researchers.

After deployment of a couple of days, the participant took 'IntenTree' as a whole back to the researchers. Together they discussed the choice of decorations and the usage data which was recorded by the probe in a data-interview.

Collecting data

Quantitative data
As mentioned before, the data probe from the contextual exploration was reused, but solely to track when participants used their phone. The size of the flower or leaf represented the perceived time spent on their smartphone, so the chosen flower or leaf was an subjective representation. The relationship between screen time, flower or leaf, colour, and actual screen time was discussed during the data-interview.

Qualitative data
As mentioned earlier, the participant sent a picture of the branch to the researchers each day. This allowed the researchers to track the progress of the reflections. Personal interpretations of flower or leaf choices, colours and types were gathered through reflection journal. As well as the emotions, usage and notes associated with them (see sppendix E).

Interview
After deployment, a semi-structured interview was conducted to get feedback and insights of the design. Focusing on the artfact and its influence on the participants, quantitative and qualitative data was collected. This data was then combined to create a table with a mixture of quantitative and qualitative data, so that patterns could be recognized (table 2).

Time / Date	Size	Color	How do you feel?	Reason	My phone felt like	Why?
17/06; 22:35	Medium	Pink	Bored	Entertainment/Media	A friend	I watched a show i love
23:06	Large	Brown	Happy	Look up info / Search	A teacher	I looked up a tutorial
18/06; 11:20	Medium	Blue	Happy	Respond to message	A friend	I responded to a message of a friend
13:25	Large	Green	Bored	Entertainment/Media	A hug	I came home after a long day at school
12:05	Small	Yellow	Happy	Respond to message	A friend	I went out to play soccer on a small pitch with my friends
15:10	Large	Yellow	Stress	Respond to message	A colleague	Stressed for a group deadline tonight
19.06 / 00:01	Medium	Yellow	Relieved	Respond to message	A boss	Just texted my group I handed in the report
00:25	Small	Blue	Tired	Entertainment/Media	A friend	Watched netflix before going to bed

Table 2. Combined quantitative and qualitative data

Insights into context, behaviour and experience

Quantitative data
In this small dataset, most phone interactions were linked to feelings of happiness, boredom, or relief. Additionally, the phone was often perceived as a *"friend" or "hug"*, offering emotional comfort or casual connection. However, when emotions like stress or relief were involved, the phone became a *"colleague"* or *"boss"* representing responsibility and task management. The data-set also included what type of leaf or flower was connected to emotions and type of interactions with their smartphone. Visualising the connection between these datapoints did not lead to repetitive or recognisable patterns (figure 15).
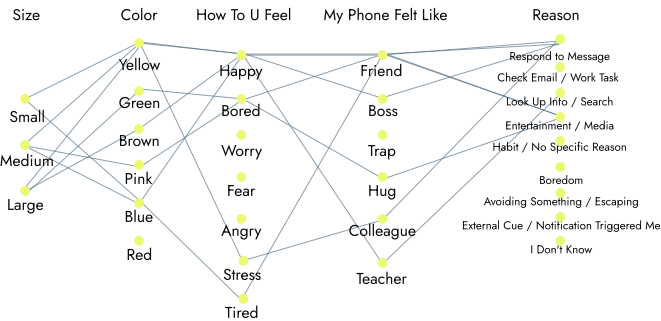

Figure 15. Data visualization of data-set from reflection-booklet

Qualitative data

The artifact

1. Ease of use
The simplicity of the artifact was appreciated. It was noted that it was *"very low maintenance，flip the switch and press the button when you're done"*, and *"found it easy to remember to use it."*. The low-effort interaction supported consistent use in daily life. Beyond functionality, the artifact evoked a mindful moment. One user described it as feeling *"like a meditation"*, and another as *"nice for a weekly reflection to give you more awareness"*. The tangible engagement helped creating a pause from digital life.

2. Routine misalignment
One participant noted a practical limitation due to where the design was located in their home. They placed it opposite to the bed, making the visual feedback less effective: *"I had to stand up to check if it was lit up"*. This highlights the importance of clear instructions to participants by specifying good physical placement of the design. As this would have prevented this misalignment with the context and routine of the participant.

3. Probe Use Insight
Although using the probe required just *"flipping the switch"*, it was used less consistently than the artifact. One participant reported using it *"every time it lit up"* but admitted they *"didn't use the probe every time"* they used the phone. This suggests that even low-effort probes can be overlooked if they do not align with users' phone habits, highlighting a gap between passive awareness and active self-reporting.

4. Long-term Engagement Challenges
Despite initial interest, concerns emerged about sustained impact. As one participant reflected: *"in the long term it will lose the actual benefits you get from it"*. This highlights that when the interaction and reflective experience stay the same without variation, users may gradually disengage, reducing the artifact's long-term impact.

Reflection on Emotional State and Phone Use

1. Meaning of size and colour
Participants appropriated the artifact's open-ended visual system as a space for personal expression. While colours were not assigned fixed meanings, they were selected to reflect the emotion I associated with that instance of phone use. This illustrates how the lack of predefined coding encouraged participants to customise their own logic in the moment. Similarly, the size of the leaves was used to represent perceived phone use rather than actual time spent on the phone: *"If it was just a quick check, I'd go for a small one"*. This may suggest that offering room for interpretation may be more effective in supporting self-reflection than static measurement systems.

2. Reflection
The artifact facilitated subtle ambient reflection rather than explicit behavioural change. One participant noted *"I wouldn't say I saw some pattern with my mood, but just seeing the tree fill up kind of made me realise how often I grab my phone without thinking"*. The growing number of leaves acted as a simple reminder, helping users notice their phone habits. The artifact may have had a subtly influenced behaviour. Participants did not consciously intend to change their habits but still felt they used their phone less, stating for example: *"I didn't explicitly think about"* and *" I didn't use my phone that much"*. The variety in visual input encouraged recognition of each phone use moment: *"each leaf I added represented a time I used my phone (...) different size and colour made it something unique"*. Pairing the visual act with writing *"made me more aware of that moment"*, deepening the reflection. Together, the artifact and booklet worked as a reflective loop, where placing a decoration and writing about it made users reflect more on their phone use.

DISCUSSION

Looking back to the second research question, to encourage the reflection, the intervention design was suggested to be:

(1)Keep simple: The simplicity of the interaction design supported continued engagement in everyday life. Participants described the artifact as "low maintenance" and "easy to remember to use," suggesting that minimal-effort interactions can lower the barrier for consistent self-tracking and reflection.

(2)Be open-ended: The open-ended nature of the visual system, specifically the absence of predefined meanings for colour, encouraged participants to assign personal significance to each interaction. This allowed the artifact to function not merely as a tracking device, but as an expressive emotional diary, enabling flexible and personalised forms of reflection.

(3)Have ambient feedback: The effectiveness of ambient feedback was found to be closely linked to its physical placement. One participant reported that placing the artifact in a less visible location reduced its reflective impact, emphasising the importance of spatial alignment and visibility in the design of ambient systems.

(4)Influence in a sub-conscious way: The artifact influenced participants' behaviour in subconscious ways. Although users did not report immediate behaviour change, they noted a shift in awareness, describing how the visual accumulation of leaves helped them recognise unconscious phone use habits without requiring active analysis.

(5)Be tangible: Combining the tangible interaction (placing a leaf) with a written reflection task (in a booklet) deepened the reflective experience. Participants noted that the act of writing made them more aware of each phone use moment, suggesting that layering modalities of reflection, visual, physical, and textual, can enhance self-awareness over time.
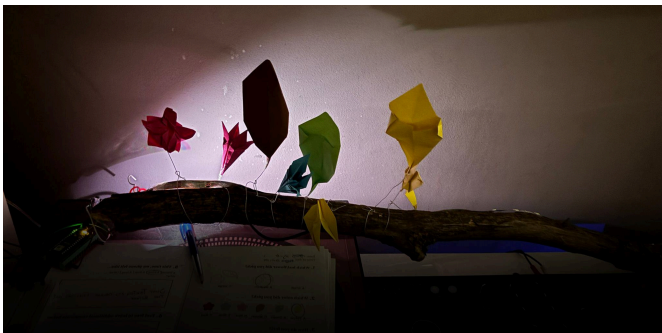

Figure 16. Intervention design during in-context deployment

LIMITATIONS AND FUTURE WORK

In this section, the limitations of the project are described and reflected on. Additionally, it presents potential ideas for future iterations.

Limitations

Although only a small number of participants were involved, it did enable the collection of rich contextual data and active engagement. Also, the duration of the study was limited, whereas a longer study would potentially reveal long-term behavioural patterns and changes in habits. Manual activation of the data probe when using a smartphone likely resulted in an incomplete data collection, as the participants may have forgotten to activate the probe.

Future work

Future work would focus on automating the collection of data from reflection journals, Sunday reflections and the participant interviews with the research team. This would result in a more attuned and automated system. This could involve a mobile app that automatically generates outputs from the input data streams (see figure 17).

CONCLUSION

This project, the Intentree, contribute to Data-enabled Design by using reflection, self-assessment and self-reporting data to make participants more aware of their smartphone use and emotional state. By following the Data-enabled Design 8-loop and the 12 design principles, this study answered two research questions to deeply explore the context of emotion and phone usage.
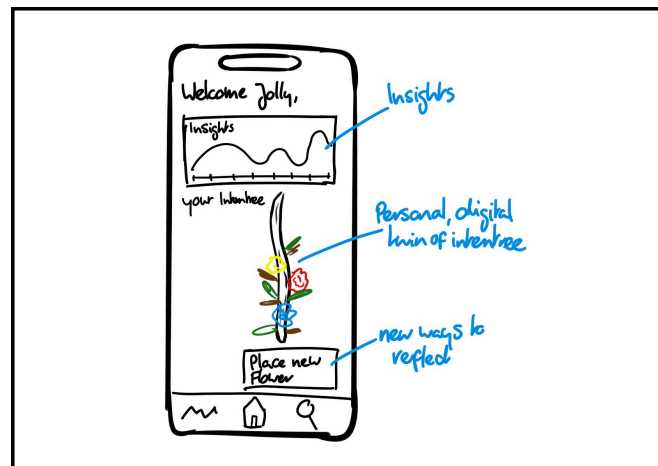

Figure 17. First sketch of future mobile app

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APPENDIX A - ESP CODE (CONTEXTUAL)

```python
import network
from oocsi import OOCSI
import time
import secrets

from rotary_irq_esp import RotaryIRQ
from machine import ADC, Pin
import machine

wlan = network.WLAN(network.STA_IF)

def connectWifi():
    wlan.active(True)
    if not wlan.isconnected():
        print('connecting to network...')
        wlan.connect(secrets.ssid, secrets.wifipass)
        while not wlan.isconnected():
            pass
    print('connected:', wlan.ifconfig())

connectWifi()

# Connect to OOCSI
o = OOCSI('DED-Team7_ESP', 'hello.oocsi.net')

# Rotary encoder
r = RotaryIRQ(
    pin_num_clk=22,
    pin_num_dt=23,
    reverse=True,
    incr=1,
    range_mode=RotaryIRQ.RANGE_UNBOUNDED,
    pull_up=True,
    half_step=False,
)

# Input
slider = ADC(Pin(36))
slider.atten(ADC.ATTN_11DB)
switch = Pin(14, Pin.IN, Pin.PULL_UP)

# Previous states
last_rotary = 0
last_slider = slider.read()
last_switch_state = switch.value()
last_send_time = time.ticks_ms()
message_sent = False

led = machine.Pin(2, machine.Pin.OUT)
try:
    # Connection check
    o.send('DED-Team7_Channel', {'status': 'connected'})
    led.value(1)
except Exception as e:
    print('OOCSI not connected:', e)
    led.value(0)

while True:

    rotary_value = r.value() % 20
    slider_value = slider.read()
    switch_state = switch.value()
    current_time = time.ticks_ms()

    if last_switch_state == 0 and switch_state == 1 and not message_sent:
        message = {
            'button': 0,
        }
        o.send('DED-Team7_Channel', message)
        print(message)
        message_sent = True


    elif switch_state == 0:
        if time.ticks_diff(current_time, last_send_time) >= 1000:
            last_send_time = current_time
            message = {
                'rotary': rotary_value,
                'slider': slider_value,
                'switch': switch_state,
            }
            o.send('DED-Team7_Channel', message)
            print(message)
        message_sent = False

    last_switch_state = switch_state
    time.sleep(0.1)
```

APPENDIX B - ESP 1 CODE (INTERVENTION)

```python
import machine
import neopixel
import network
import time
from oocsi import OOCSI

# WiFi Setup
wlan = network.WLAN(network.STA_IF)
def connectWifi():
    wlan.active(True)
    if not wlan.isconnected():
        print('Connecting to network...')
        wlan.connect(secrets.ssid, secrets.wifipass)
        while not wlan.isconnected():
            pass
    print('Connected:', wlan.ifconfig())
connectWifi()

# Configuration
num_leds = 30
pin = machine.Pin(5)
brightness = 0.5
np = neopixel.NeoPixel(pin, num_leds, bpp=4)
r, g, b, w = 255, 147, 41, 0

# State tracking
current_led_index = 0
delay_active = False
delay_start_time = 0

# Button setup
button = machine.Pin(6, machine.Pin.IN,
machine.Pin.PULL_UP)
button_pressed = False

def turn_on_leds(n):
    np.fill((0, 0, 0, 0))
    np.write()
    for i in range(n):
        np[i] = (
            int(r * brightness),
            int(g * brightness),
            int(b * brightness),
            int(w * brightness)
        )
        np.write()
        time.sleep(0.5)

def turn_off_leds():
    np.fill((0, 0, 0, 0))
    np.write()
```

```python
# Handle OOCSI message
def handleDirectMessage(sender, recipient, event):
    global delay_active, delay_start_time
    print("Received message:", event)

    if 'switch' in event:
        if event['switch'] == 1 and not delay_active:
            delay_active = True
            delay_start_time = time.ticks_ms()

        elif event['switch'] == 0 and delay_active:
            print("Delay canceled due to switch=0")
            delay_active = False

# Setup OOCSI
o = OOCSI('DED-Team7_ESP2', 'hello.oocsi.net')
o.subscribe('DED-Team7_Channel', handleDirectMessage)

# Connection LED
led = machine.Pin(48, machine.Pin.OUT)
try:
    o.send('DED-Team7_Channel', {'status': 'connected'})
    led.value(1)
except Exception as e:
    print('OOCSI not connected:', e)
    led.value(0)

turn_off_leds()
turn_on_leds(18)
```

APPENDIX C - ESP 2 CODE (INTERVENTION)

```python
import network
import time
import secrets
from oocsi import OOCSI
from machine import Pin

# WiFi connect
wlan = network.WLAN(network.STA_IF)
wlan.active(True)
if not wlan.isconnected():
    print('Connecting...')
    wlan.connect(secrets.ssid, secrets.wifipass)
    while not wlan.isconnected():
        pass
print('Connected:', wlan.ifconfig())

# OOCSI connect
led = Pin(2, Pin.OUT)
try:
    o = OOCSI('DED-Team7_ESP', 'hello.oocsi.net')
    o.send('DED-Team7_Channel', {'status': 'connected'})
    led.value(1)
except Exception as e:
    print('OOCSI not connected:', e)
    led.value(0)

# Button setup
switch = Pin(14, Pin.IN, Pin.PULL_UP)
last_state = switch.value()
message_sent1 = False
message_sent2 = False

while True:
    state = switch.value()

    # Detect release and send message only once
    if last_state == 1 and state == 0 and not message_sent1:
        o.send('DED-Team7_Channel', {'switch': 1})
        print('Sent switch=1')
        message_sent1 = True
        message_sent2 = False

    # Reset flag when button is held down
    if state == 1 and not message_sent2:
        o.send('DED-Team7_Channel', {'switch': 0})
        print('Sent switch=0')
        message_sent1 = False
        message_sent2 = True

    last_state = state
    time.sleep(2)
```

APPENDIX D. CONTEXTUAL EXPLORATION QUOTES

How would you describe your general relationship with your phone?
→ (e.g., mostly practical, mostly social, something you use to relax?)

Are there specific times or situations where you're more likely to use social media or scroll aimlessly?
→ (e.g., bedtime, during breaks, while eating, etc.)

How intentional do you feel your phone use is, overall?

Are there any specific apps that consistently affect your mood - positively or negatively?

Do you ever find yourself switching between apps frequently? What tends to trigger that?

Do you feel like you're in control of how and when you use your phone?

If you could change one thing about your relationship with your phone, what would it be?

In general, how do you think your emotions influence when and how you use your phone?

Have you noticed patterns in how your mood changes after using your phone?

Can you recall a recent example where using your phone made you feel better or worse?

You rated one session with a 3 out of 7 for how much it cont. Can you recall what felt different in that
In most sessions, you said you used your phone intentionally and stuck to your goal. What helps you stay intentional in your phone use?

There was one session where you answered "Maybe" to both using your phone intentionally and sticking to the intention. Can you tell me what happened there?

You often used your phone while lying down or eating. Do you think your body position or activity affects how you use your phone or how you feel afterward?

How would you describe your general relationship with your phone?

P1: Two fold (two sides): phone is really important for work and school because i arrange a lot of things with it, but there is also other side that is social media and gets me distracted which i don't like but i can't delete the apps. For example, on instagram i want to see my friends pictures but then i end up scrolling for hours through videos i dont care about affects my mood.

P2: Better than before. I've for context, I've tried to limit the not useful things for my phone, so I've already a time ago **deleted YouTube and Insta.**
To not scroll every time on those and only can access it when I'm literally take action to that. But I reactivated Insta and that was not so good.

Are there specific times or situations where you're more likely to use social media or scroll aimlessly?

p1: Tiktok but i permanently deleted it from my phone, insta reel i cnat delete because of friends, it could be both positively and negatively, reading news and articles is also smth i do a lot and that affects my mood positively because i want to be informed

p2: Sometimes but usually not really i think but it does happen. I stay committed to 1 or two apps
Not always, sometimes i **get lost a bit in** how much i use it and in time and when i finish i am like did i really watch youtube videos for an hour

P2:"Often open it intentionally **but i also get pretty lost sometimes in reels and tiktok;** intention is always to text someone or check smth but end up scrolling"

P2:
I want to be more aware of when i use my phone and how much i use my phone; have some way of telling me when to stop or invasively stop like greyscale or disable apps

I got good news on my phone this afternoon and that made me happy not sure if it was the phone or the message

---

Have you noticed patterns in how your mood changes after using your phone?

P1: When i am really **stressed i** use soc media to escape and i am not really aware but i do that too, it gets my mind of it and afterwards **i feel empty inside**

P2: but it does sometimes get your mind off of the thing you were stressing about, it gives you time to relax and think about the stress.

P1: In the end you do feel less good because you wasted time and you had a lot of things wyou wanted to do but u didn't because you scrolled

P1: I want to **be more aware of when i use my phone and how much i use my phone;** have some way of telling me when to stop or inva stop like greyscale disable apps

P1: "You become aware when u need to reflect on it. I don't think it affected how i behaved, i was aware but i didn't use the probe everytime i picked my phone because it was a bit too invasive. If i had used th eprobe everytime i would have used my phone less"

P2: **The time that it really was only habit in a bad way.** It influenced that **I felt worse.** Like oh, I need to do stuff, but I can't do it because every time get distracting and then take the phone.

P1: And **I think it's the phone more easily influences towards a bad, bad moose than a good mood.**

P2: Also, **when your message that you're receiving is good or bad.** It's more often to really influence in **a negative way** instead of **a positive message needs to be very positive to really lift up your mood.**

P1: Example for procrastination: i wanted to record a song but i didn't do it because i was scrolling through tiktok and that worsened my mood

P2:
And for **now that that's is better because I take it more intentionally,** it has less influence on my mood. Except when like for work or just for yourself, you're checking e-mail or app. In that case, when the message is kind of negative, it can still influence you, of course.

Specifically, due to use info. **When I wanted to sleep and still use my phone**, that won't. And then to the to the worse kind of.

P2: I was very tired. Then the call was kind of hot, **samely difficult.** And then I was just laying down. I want what's the entertainment but also wanted to sleep.
And that doesn't go together. And yeah, in combination with my leg at the moment, my mood is not the best always.
So that is why the mood stays there quite low.

P2: **Actually the other way around.** The first night, yeah, that was very interesting. But the first night. So that was Monday. You have two instead of three because they were set. Like, try to get at least three times in there.

I have **two phones** and I have his own one so I can still access kind of in the relaxing times. So like when you take a book or or genghisol I could take that phone.
But I every time forget the charges and then I want to check something.

i have workmode on half of my apps i cannot use i can only use mail, calendar, news and music and i can't really get distracted. I always use it when i need to get stuff done. It is easy to open the app and get stuck in it so it is my coping mechanism to foicus

Reflection on the artifact

How can a tangible data physicalization support emotional reflection on smartphone use in everyday life?

it was actually nice and relatively easy to use, apart from **filling out the booklet was very low maintenance,** flip switch and press button when ur done so that was nice. the light wasn't annoying

found it easy to remember to use it

apart from the tieing of the leaves not very natural to the routine

it felt very natural, like a meditation

it's nice for a weekly reflection to give you more awareness

but in the long term it will lose the actual benefits you get from it.

the location of keeping the artifact: on the shelf opposite of bed

it was annoying, my desk is on the other side of the room i didn't have a good view of my tree, i had to stand up to check if it was lit up

Ignore the signal moment: it didn't lit up if i switched off the probe before 90 secs

Probe was harder than artifact: it was just flipping the switch. i used it every time it lit up but i didn't use the probe every time i used my phone, but i used it most of the times i userd my phone

Booklet

influence of artifact on phone use: maybe subconsciously a bit i didn't explicitly think about oh im not gonna yse my phone so it might have had smrh to do with the artefasct bnecause i didnt use my phone that much.

Emotional and phone use reflection

Did the artifact help you notice any patterns in your emotional state or phone use?

the leaves and flowers: it made me reflect on it because each leaf i added represented a time i used my phone, different size and color made it something unique if you write something in the booklet after it makes you more aware of that moment

booklet was necessary addition otherwise it would have been less meaningful

i liked question 5, cause it made it in more metaphorical way explain the realtionship with my phone, made me reflect in a new way, gave me new perspective on what u use ur phone for

color of flowers: I didn't assign fixed meanings to the colors, but I chose them based on how they felt in the moment. It still reflected the emotion I associated with that instance of phone use

size: it wasn't super precise, but it gave me a way to express how much I felt I used my phone. Like if it was just a quick check, I'd go for a small one.

maybe a little, **I didn't really sit down and analyse it or anything,** but I did **start to notice that I was putting leaves** on **mostly after scrolling randomly or out of boredom.**

I **wouldn't say I saw some pattern** with my mood, but j**ust seeing the tree fill up** kind of **made me realise how often I grab my phone without thinking.**

1. How did it feel to use the artifact over the last few days?
2. it was actually nice and relatively easy to use, apart from filling out the booklet was very low maintenance, flip switch and press button when ur done so that was nice. the light wasn't annoying
3. Where did you usually keep the artifact, and why?
4. on the shelf opposite of my bed
5. Did you find it easy or difficult to remember to use the artifact? Why?
6. foudn it easy to remember, i was just flipping the switch. i used it every time it lit up but i didn't use the probe every time i used my phone, i used it most of the times i userd my phone
7. Did it become part of your routine, or did it feel like a disruption?
8. apart from the tieing of the leaves not very natural to the routine it felt very natural
9. Did the artefact's presence influence your decision to use your phone at all?
10. maybe subconsciously a bit i didn't explicitly think about oh im not gonna yse my phone so it might have had smrh to do with the artefasct bnecause i didnt use my phone that much.

1. How did you decide which color to assign to each emotion?
2. no logical meaning, i just picked a random color, i do love the aesthetic tho, i chose them based on their aesthetic
3. Did you feel that the size of the leaf or flower represented your phone use accurately?
4. it wasn't super precise, but it gave me a way to express how much I felt I used my phone.
5. Looking at your tree now, what kind of story do you think it tells about your past few days?
6. it made me reflect on it because each leaf i added represented a time i used my phone, different size and color made it something unique if you write smth in the booklet after it makes you more aware of that moment
7. How did it feel to fill out the booklet each time the artefact lit up?
8. it was annoying, my desk is on the other side of the room i didn't have a good view of my tree, i had to stand up to check if it was lit up
9. Did writing things down add something that the artefact alone didn't?
10. booklet was necessary addition otherwise it would have been less meaningful
11. Were there any prompts or questions in the booklet that felt especially helpful (or not helpful)?
12. i liked question 5, cause it made it in more metaphorical way explain the realtionship with my phone, made me reflect in a new way, gave me new perspective on what u use ur phone for

1. Did the artefact help you notice any patterns in your emotional state or phone use?
2. not sure
3. Did you ever ignore the tree's signal? Why do you think that happened?
4. it didn't lit up if i switched off the probe before 90 secs
5. Would you want to keep something like this in your room/space long-term? Why or why not?
6. it's nice for a weekly reflection to give you more awareness but in the long term it will lose the actual benefits you get from it.