Université Grenoble Alpes - ENSIMAG

Reducing Anxiety in Health Data Tracking : Exploring Data Physicalization as an Alternative to Screen-Based Visualization

Authors: Benedia Sirine & Dahmane Ryma

Supervisors : Céline Coutrix & Vincent Lambert

Abstract

Health tracking applications provide valuable insights but can induce stress through precise numerical feedback. This project explores data physicalization as a calmer alternative, we conducted a preliminary survey (N=22) and a withn subjects user study (N=10) comparing a physical flower prototype with a traditional mobile dashboard. Results show that **60% of participants preferred the flower**, with stress scores **60% lower** (M=1.1 vs M=2.7). Remarkably, **90% felt least stressed with the flower** and **90% felt most judged by the dashboard**. Qualitative analysis reveals that participants perceived the flower as "calming" and "meaningful". These findings suggest that ambient physical displays offer a healthier approach to personal data visualization, supporting the shift from "quantified self" to "qualitative self".

Keywords : Human-Computer Interactions, data physicalization, calm technology, health tracking, quantified self, ambient displays, IoT

1 Introduction

Health tracking applications like Apple health, Google fit, and Samsung health have transformed personal health monitoring; with over 500 million users worldwide tracking steps, sleep, and calories, these tools have become integral to daily life. However, interfaces built around precise numbers and color coded progress bars can trigger guilt and anxiety when users fail to meet targets

Our preliminary survey revealed concerning patterns : one participant noted *"It makes you feel like you haven't achieved your goals"* while another reported stopping app usage entirely due to stress. This raises our central research question :

> **RQ :** *How can data physicalization reduce anxiety associated with health data tracking while maintaining user awareness of personal health metrics ?*

Data physicalisation (the practice of encoding data into physical form) offers a promising alternative. Unlike screen based notifications that demand immediate attention and provoke comparaison, physical representations can integrate seamlessly into living spaces, providing ambient awareness without digital urgency. This approach aligns with Weiser and Brown's "calm technology" principles [1], which advocate for designs that inform without overwhelming

In this project, we present ***Fitness flower***, a mechanical flower that physically represents daily step count through its opening states. We conducted a within subjects study (N=10) comparing this prototype with a traditional mobile dashboard, measuring anxiety, stress, and user experience across both conditions.

2 Related work

The "quantified self" movement has popularized personal data tracking, but research highlights its psychological costs. Etkin [3] demonstrated that measurement can reduce intrinsic motivation and trigger obsessive checking behaviors. The red/green color coding common in health apps creates binary success/failure framing that amplifies negative emotions.

Weiser and Brown [1] introduced "calm technology" as a design philosophy where technology engages periferal rather than focal attention. The Ambient Orb [4] exemplifie this: a glowing sphere providing awareness without demanding interaction.

Jansen et al. [2] define data physicalisation as "a physical artifact whose geometry or material properties encode data". Unlike screens, physical representations leverage spatial and material properties. However, limited research explores physicalization for personal health tracking, a gap our work addresses.

3 Preliminary survey (N=22)

We surveyed 22 participants aged 14-29 (M=22.6) to understand tracking behaviors.

Current behavior : 72.7% use tracking apps (Apple health 50%, Google fit 25%). Most tracked : steps (81.8%), screen time (59.1%), sleep (31.8%)

Emotional responses : 22.7% reported feeling "failure" from low scores, **13.6%** stopped using apps due to anxiety. One participant noted: *"It makes you feel like you haven't achieved your goals"*

Interest in alternatives : 77.3% expressed interest in physical objects displaying data artistically. Preferred locations : bedroom (45%), desk (23%), living room (32%).

4 Fitness flower : design & implementation

Based on survey insights, we designed *fitness flower*, a physical data sculpture representing step count through a- blooming flower metaphor.

Design concept. We chose a flower metaphor for several reasons : (1) blooming is universally understood as positive and healthy, (2) the transformation occurs slowly and silently, aligning with calm technology, and (3) flowers are aesthetically acceptable in domestic environments

- **morphing shape :** the flower transitions from a closed bud (0% of goal) to full bloom (100% goal reached)
- **ambient feedback :** movement is slow and silent, designed for peripheral vision
- **abstraction :** no numbers displayed, removing the "micro punishment" of seeing low counts
- **positive framing :** A closed flower is neutral, not a failure state like seeing a notification on phone saying it was a failure

The mechanical design was adapted from an open-source model on Printables[1]. The prototype was 3D-printed at our university's FabLab MASTIC using PLA filament

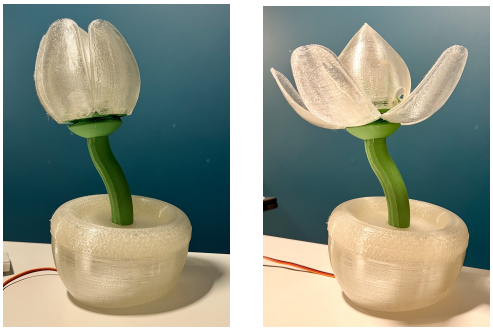

Figure 1: Fitness flower in closed state (left = few steps taken) and fully open state (right = daily goal reached)

System architecture. The system follows a standard IoT architecture connecting personal cloud data to a physical actuator. The pipeline consists of 4 main components (Figure 2) :

1. **Data collection :** Google fit app on the user's smartphone continuously records step data
2. **Backend processing :** python server hosted on Render.com queries the Google fit API every 10 minutes
3. **Message transport :** the calculated servo angle is published to an MQTT broker (HiveMQ) via SSL-encrypted connection
4. **Physical actuation :** the ESP32 microcontroller receives the message and adjusts the servo motor position

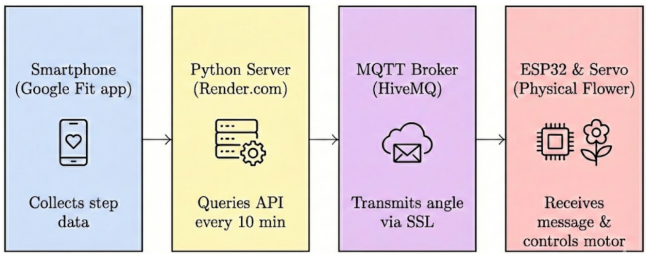

Figure 2: End to end IoT data pipeline from smartphone to physical flower

Technical implementation. The hardware consists of an ESP32 DevKit V1 microcontroller with integrated WiFi, an SG90 micro servo motor (180° rotation), and a 3D-printed rack-and-pinion mechanism. The prototype is powered via USB-C connected to a wall outlet. On the software side, we use Python/Flask for OAuth 2.0 authentication with Google fit API and Google Cloud for token storage, while the embedded code (C++/Arduino) handles WiFi setup and MQTT communication. Users enroll through a simple web interface (see Appendix A for details).

Data mapping : We implemented a linear mapping strategy from step count to servo angle :

$$\text{Angle} = \min\left(180, \frac{\text{Current Steps}}{\text{Step Goal}} \times 180\right)$$

The default goal is 6000 steps. When the user exceeds the goal, the flower remains fully open, reinforcing accomplishment without encouraging infinite optimization. The mapping updates every 10 minutes, creating smooth, barely perceptible transitions throughout the day.

[1] https://www.printables.com/model/134028-blooming-flower-remix/comments

5 User study

Participants. We recruited 10 participants (6 female, 4 male) aged 21-27 (M=23.3, SD=1.8). All were students or researchers in computer science, electronics, or related fields at our university. Participants were selected based on : (1) willingness to use Google fit for step tracking during the study period, (2) interest in health tracking, and (3) availability for the 8 day study period.

Conditions

Physical flower : participants placed fitness flower in their chosen location (desk, bedroom or living room) and used it as their primary step tracking interface
Digital dashboard : participants used the standard Google fit mobile application, which displays step count, progress bars, daily/weekly graphs, and color coded goal indicators

Study design

We employed a **within subjects crossover design** to control for individual differences while allowing direct comparaison between the two conditions described above. Participants were randomly assigned to two groups :

- **Group A (n=5):** flower (week 1) → dashboard (week 2)
- **Group B (n=5):** dashboard (week 1) → flower (week 2)

Each condition lasted 4 days, with evaluation questionnaires administered on day 0 (baseline), day 4 (week 1 evaluation), and day 8 (final comparative evaluation).

Measures

All items used 7 point likert scales, key constructs included :
Anxiety : stress, judgment, pressure, overwhelmed, calm.
Reflection : optimization, Well-being reflection, behavioral influence.
UX : pleasant, creative, understandable, easy to learn.
Qualitative : open ended questions about experience and emotional responses.

Procedure

Day 0 : initial questionnaire (demographics, tracking habits, baseline anxiety). Participants received the flower or app based on group assignment.
Days 1-3 : first condition usage. Participants integrated the system into daily life.
Day 4 : week 1 evaluation questionnaire. Systems swapped between conditions.
Days 5-7 : second condition usage.
Day 8 : final comparative questionnaire including direct preference questions and qualitative feedback.

6 Results

Overall system preference. After experiencing both systems, participants showed a clear preference for the physical flower (Table 1) :

Preference	N	%
physical flower[1]	6	**60%**
digital dashboard[2]	2	20%
both are equal	1	10%
neither	1	10%

Table 1: Overall system preference distribution (N=10)

Comparative questions. The final questionnaire included direct comparative questions revealing stark differences (Table 2) :

Question	Flower	Dashboard
felt *least* stressed	**90%**[3]	0%
felt *most* judged	0%	**90%**[4]
recommend to friend	**60%**	10%
encouraged wellbeing reflection	**80%**	10%
pushed to optimize numbers	10%	**80%**

Table 2: Direct comparison questions (remaining % = "same" or "neither")

These results demonstrate that the flower was percieved as less stressful and less judgmental, while the dashboard was associated with optimization of performances

Anxiety and stress metrics. The flower showed consistently lower anxiety scores across all metrics (Table 3). Most notably, **stress was reduced by 60%** (1.1 vs 2.7) with the flower compared to the dashboard.

[1] Orange highlighting indicates flower-related results
[2] Blue highlighting indicates dashboard-related results
[3] Green highlighting indicates positive/desirable outcomes
[4] Red highlighting indicates negative/undesirable outcomes

Metric	Flower	App	Δ
stress	**1.1**	2.7	**-1.6**
felt judged	1.6	2.7	-1.1
pressure to perform	2.2	3.6	-1.4
felt calm/soothing	**5.0**	4.0	**+1.0**

Table 3: Anxiety metrics comparison (1-7 scale). Lower is better for stress metrics; higher is better for calm. Green indicates the better performing system.

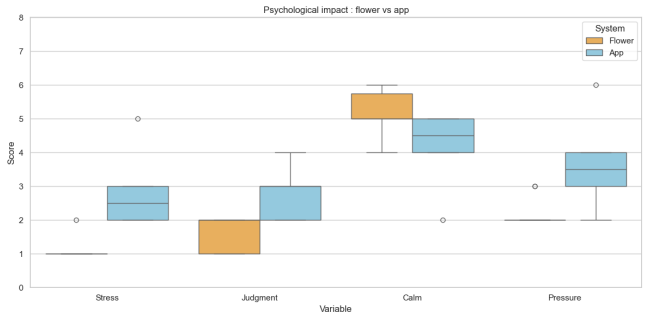

Figure 3: Psychological impact comparison : flower vs app across stress, judgment, calm and pressure dimensions

User experience metrics. Both systems were equally usable and understandable, but the flower was rated significantly more **creative** (+3.4 points) and more **pleasant** (+1.1) (Table 4). This substantial creativity gap suggests the flower offers a refreshing alternative to conventional tracking interfaces. The full UX comparison visualization is available in Appendix B.

UX Dimension	Flower	App	Δ
pleasant	**6**	4.9	+1.1
Creative	**6.2**	2.8	**+3.4**
understandable	5.9	**6.1**	-0.2
easy to learn	**6.0**	5.9	+0.1
interesting	**5.8**	4.9	+0.9

Table 4: UX scores (1-7 scale, higher is better). Green indicates the better performing system for each metric.

Adoption and behavioral impact

Long-term intention: When asked "Would you be willing to use the flower daily for several months?", 60% responded "yes, definitely", 30% "probably yes", and only 10% declined. This indicates strong potential for sustained adoption.

Hybrid system interest: 80% expressed interest in a hybrid system combining the flower with an optional minimal app for occasional precise checks (60% "very interested", 20% "maybe"), suggesting users value both ambient awareness and on-demand precision.

Behavioral changes: 40% reported walking more during the study, 10% walked less (feeling less pressure), and 50% reported no change. This suggests the flower maintains awareness without creating obsessive optimization behaviors.

7 Qualitative analysis

Thematic analysis of open ended responses revealed rich insights into participants' experiences with both systems.

Anxiety reduction with the flower. The most prominent theme was the flower's calming effect. P01 noted that *"the flower's ambient nature reduced my anxiety, I prefer the calm approach even if I miss some details"*, while P04 found it *"more gentle"* after experiencing *"the dashboard's constant pressure"*. P03 similarly described the flower as making *"tracking feel positive"* compared to the *"stressful"* dashboard.

Calm technology in practice. Participants explicitly recognized calm technology principles. P10 stated that *"the flower embodies calm technology principles beautifully"* and *"innovates meaningfully"*. P09 and P06 shared similar views, emphasizing the flower's *"ability to inform without demanding attention"* and its embodiment of *"calm technology principles"*.

Emotional response to goal failure. A critical difference emerged in processing unmet goals. With the flower, participants reported neutral or mild reactions: P01 felt *"small disappointment but not as harsh as seeing a red bar"*, P03 felt *"neutral"*, and P05 *"didn't care much"*. In contrast, dashboard users experienced stronger negative emotions: P02 felt *"frustrated"* by *"the red color"*, P04 immediately *"started planning how to catch up"*, and P10 noted *"the visual representation of failure is quite direct"*.

Perception of the flower in living space. Participants developed meaningful relationships with the flower, describing it as a *"decorative object that became meaningful"* (P01), a *"companion that communicates without words"* (P09), and *"an elegant HCI artifact"* (P10). P07 noted it evolved from *"a gadget"* to *"a weather indicator for my activity"*. Notably, P03 mentioned *"family loved it, my mom wants one for herself"*, suggesting appeal beyond tech-savvy users.

Dashboard advantages (minority view). Two participants preferred the dashboard for its

precision. P02 stated *"I prefer having precise data"* despite acknowledging the flower's aesthetic appeal, while P08 valued *"the dashboard's data richness"* from an engineering perspective. Both acknowledged the flower's stress-reducing benefits, suggesting a trade-off between precision and emotional wellbeing.

Desire for hybrid approach. Several participants suggested combining both systems. P07 noted *"I see value in both"* and suggested adding *"option to tap the flower to see exact number on a small hidden display"*.

Improvement suggestions. Participants provided constructive feedback: LED colors for additional data like sleep or screen time (4 mentions), companion app for occasional precise checks (3 mentions), battery operation for mobility (2 mentions), and personalization options (2 mentions).

8 Discussion

From quantified to qualitative self. Our results strongly support a paradigm shift from the "quantified self" to what we term the "qualitative self". The flower's deliberate ambiguity removes the "micro punishment" of seeing precise low numbers. As P05 captured: *"The closed flower didn't make me feel bad"* compared to the dashboard where *"the red color made me feel like I failed"* (P02). The 60% reduction in stress and 90% agreement that the flower was "least stressful" suggest that for **general wellness tracking**, ambient abstract representations are more appropriate than precise numerical dashboards. This aligns with Etkin's [3] finding that measurement can undermine intrinsic motivation.

Validation of calm technology principles. Our prototype successfully embodied Weiser and Brown's calm technology principles [1]: participants glanced at the flower naturally without interrupting activities (peripheral attention), the flower informed without demanding interaction (ambient awareness), and participants described it as "decorative" and "meaningful" (seamless integration). The emotional connections developed ("companion", "communicates without words") suggest successful integration into daily life beyond mere functionality.

Design implications. Our findings suggest guidelines for calm health tracking: (1) use metaphors over numbers, (2) design for peripheral attention, (3) frame feedback positively, (4) consider hybrid approaches for users wanting occasional precision, and (5) prioritize aesthetics for domestic environments.

Limitations. Several factors constrain our finding's generalizability. First, our sample size (N=10) limits statistical power and the ability to detect smaller effects. Second, the short study duration (8 days) may not capture long-term habituation effects or whether the novelty wears off over time. Third, all participants were students in technical fields (computer science, electronics), which may not represent general users who are less comfortable with technology. Fourth, **participants were recruited from our personal networks** (friends, classmates, colleagues), which introduces potential bias, they may have been more positive toward our prototype due to social desirability or wanting to support our project. This self-selection bias means our results should be interpreted with caution. Finally, technical limitations including servo motor noise and the requirement for constant power connection reduce ecological validity for real-world deployment.

Future work. Future directions include longitudinal studies (4-8 weeks) to assess sustained effects, multi-modal physicalization (LED colors for sleep), silent actuation mechanisms (shape memory alloys), testing with diverse populations beyond technical fields, and recruitment of participants with no prior relationship to the researchers.

9 Conclusion

We presented *fitness flower*, a data physicalization system transforming daily step count into the blooming of a mechanical flower. Our within subjects study (N=10) comparing this prototype with a traditional mobile dashboard yielded compelling evidence for calm technology approaches in health tracking :

1. **60% reduced stress :** flower (M=1.1) vs dashboard (M=2.7)
2. **90% felt least stressed** with the flower
3. **90% felt most judged** by the dashboard
4. **60% preferred** the flower overall; **90%** would use it long-term
5. The flower was perceived as **calming** and **non-judgmentall**
6. **Creativity rating** was +3.4 points highr than the dashboard

These findings support the shift from "quantified self" to "qualitative self", suggesting that for general wellness tracking, physical ambient displays offer a healthier alternative to anxiety-inducing numerical interfaces. As P10 eloquently summarized : *"the flower represents what self-tracking could become. Less about numbers, more about awareness and gentle motivation"*

References

[1] Weiser, M., & Brown, J. S. (1996). Designing Calm Technology. *PowerGrid Journal*

[2] Jansen, Y., Dragicevic, P., Isenberg, P., Alexander, J., Karnik, A., Kildal, J., Subramanian, S., & Hornbæk, K. (2015). Opportunities and challenges for data physicalization. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15)*

[3] Etkin, J. (2016). The hidden cost of personal quantification. *Journal of Consumer Research*, 42(6)

[4] Mankoff, J., Dey, A. K., Hsieh, G., Kientz, J., Lederer, S., & Ames, M. (2003). Heuristic evaluation of ambient displays. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '03)*

A Technical implementation details

A.1 Hardware components

Microcontroller : ESP32 DevKit V1, chosen for its integrated WiFi and bluetooth capabilities, low power consumption, and Arduino IDE compatibility.

Actuator : SG90 micro servo motor (180° rotation range), providing smooth movement for the petal mechanism

Mechanism : 3D-printed rack-and-pinion system converting rotational servo motion into linear petal expansion. The structure uses PLA filament for lightweight yet sturdy assembly

Power : The prototype is powered via a USB-C cable connected to the ESP32, housed in a 3D-printed enclosure and plugged into a standard wall outlet.

A.2 Software stack

Server side (Python/Flask): OAuth 2.0 authentication with Google fit API, Google Cloud for token storage, cron-job triggers every 10 minutes.

Embedded (C++/Arduino): WiFiManager library for captive portal Wi-Fi setup, PubSubClient library for MQTT communication, SSL/TLS encryption for secure broker connection.

A.3 Web interface for user enrollment

Users connect their Google fit account to their flower through a simple web interface (Figure 4). The enrollment process consists of three steps :

1. User connects the flower to power and joins its Wi-Fi access point ("Fleur_Setup")
2. User enters home Wi-Fi credentials via captive portal
3. User visits the web application, authenticates with Google, and enters their flower's unique ID (example: "FLOWER_01")

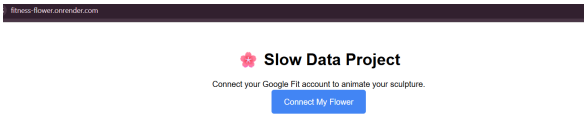

Figure 4: Web enrollment interface allowing users to link their Google fit account to their physical flower

B UX comparison visualization

Figure 5 provides a visual representation of the UX metrics comparison between the flower and dashboard systems, complementing Table 4 in the main text

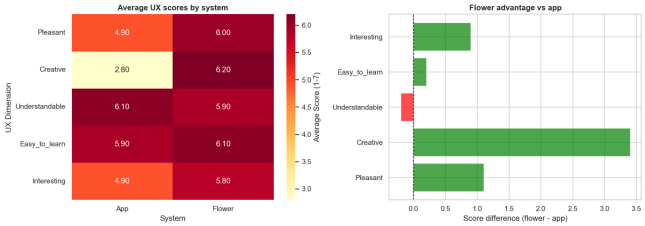

Figure 5: UX comparison heatmap showing the flower's significant advantage in creativity (+3.4) and pleasantness (+1.1), while both systems performed similarly on understandability and ease of learning

C Study materials

Questionnaires used in this study :

- Q0 - general public survey: `https://forms.gle/4KZLrRVQ3ryJa7xi6`
- Q1 - initial questionnaire (Day 0): `https://forms.gle/5MzgomJrfvDCGYMU6`
- Q2 - week 1 evaluation (Day 4): `https://forms.gle/yLVErHyFyaKQ9g9S6`
- Q3 - final evaluation (Day 8): `https://forms.gle/PdVjm5L2TdMUXZyMA`

Flower design source : `https://www.printables.com/model/134028-blooming-flower-remix/comments`

Data & analysis code : `https://github.com/serinebnd/Fitness-Flower`