Sprout: Using a Garden Metaphor to Visualize and Support Customizable and Collaborative Health Tracking

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Sprout: Using a Garden Metaphor to Visualize and Support Customizable and Collaborative Health Tracking

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Master of Science
in
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by Pape Sow Traoré

Guarini School of Graduate and Advanced Studies
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Hanover, New Hampshire
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Abstract

Self-tracking tools have become increasingly popular, especially with the advent of wearable technology and smartphone applications. However, traditional tracking tools often display data in a quantitative format that can be overwhelming and cause users to abandon their tracking efforts. Additionally, these tools typically provide a generic user experience and are designed from a single-user perspective, lacking external support. To overcome these limitations, we develop Sprout, a mobile data-tracking application that offers a more qualitative, customizable, and collaborative experience for health monitoring and management. Sprout uses a garden metaphor to visually represent health information and allows users to tailor their data experience by customizing data capture types and corresponding visual representation for each element. Furthermore, users in Sprout can collaborate to achieve community goals, unlocking new features for their gardens. We conduct a user study with 22 participants to investigate the impact of qualitative data visualization, customizability, and social support on users’ activity levels, goal attainment, engagement, and satisfaction with the self-tracking system. Our results suggest that qualitative visualization of data can help some users maintain their motivation to meet health-related goals, but a mix of quantitative and qualitative data is desired by some users. Customizability requires tailored features to help users develop a sense of ownership over time, and social features are a crucial motivator for users to achieve their health goals. However, tracking with strangers instead of friends can hinder user engagement due to the lack of connection.
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“And my success is not but through Allah. Upon him I have relied, and to Him I return.”

Quran 11:88
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1. Introduction

Personal informatics refers to a class of systems designed to assist users in tracking and reflecting on their personal data [19]. In recent years, the use of self-tracking technologies has experienced a significant surge, with these tools becoming increasingly integrated into various facets of individuals’ lives. Wearable technologies such as the Apple Watch, Fitbit, and smartphone applications have made it easier for individuals to monitor their health data in order to manage their well-being. Currently, there are approximately 350,000 health-related applications available worldwide, with nearly 90,000 introduced in 2020 alone [13]. In the United States, approximately 1 in 4 Americans use smart wearable devices, which translates to roughly 82 million people in 2022, and the total number of smart wearable users is projected to reach as high as 93 million by 2025 [16]. People track a range of data, including heart rate, exercise, sleep, and noise notifications, among others.

While self-tracking tools can be beneficial, they often have several limitations. Traditional tools display tracked data in a heavily quantitative format, relying on numbers, charts, and graphs. However, research has shown that this type of feedback can be overwhelming [12, 23], potentially leading to discomfort with the information revealed and prompting users to abandon their tracking efforts altogether [14]. Moreover, self-tracking tools provide a generic experience to all users, with everyone seeing the same data representation. Even metaphor-based visualizations translate the same data to the same visualizations on the interface for all users. Finally, current tools are frequently designed from a single-user perspective, with users tracking their progress without any outside support. Even tools that offer social features usually take the form of competition, rather than more collaborative approaches that involve engaging with data at a community level to achieve a shared goal.

To overcome the limitations of traditional self-tracking tools, we develop Sprout, a mobile data-tracking application that supports more qualitative, customizable, and collaborative experiences for health monitoring and management. To inform the initial design of Sprout, we conduct formative interviews with 8 participants to better understand their motivations for tracking, the tools they use to track, and their preferences for data visualizations. Based on our findings, we derive guiding design principles for the application. Sprout uses a garden metaphor to visually represent health information as various nature-related elements in the interface, such as flowers, animals, and weather. This approach offers more qualitative rep-
resentations of personal data. Moreover, our interface empowers users to tailor their data experience by enabling flexible customization of data capture types and corresponding visual representation for each element. This means that multiple users can assign the same information to different garden elements within the interface. In contrast to traditional social tracking tools that promote competition between users, users in Sprout collaborate to achieve community goals, allowing the community to unlock new features for its garden such as animated animals. To protect user privacy, Sprout makes all its aspects anonymous by default and lets users decide what they want to disclose. Our aim with Sprout is to investigate how the incorporation of qualitative data visualization, customizability, and social support influence users’ activity levels, goal attainment, engagement, and satisfaction with the self-tracking system.

We conduct a between-subjects user study with 22 participants who are not acquainted with each other, and we use customization and social features as variables, creating 4 experimental conditions where each condition either has both, one, or none of the variables. Participants are asked to select two pieces of data from the Apple Health application, map their chosen data to either their garden’s tree or flowers, and set and track their daily targets for 16 days. Our findings suggest that qualitative visualization of data can help some users sustain their motivation to meet their health-related goals, but it should not be seen as a replacement for quantitative data in all cases. Rather, some users desire a mix of both quantitative and qualitative data to better support their needs. Furthermore, our results indicate that customizability may require its features to be as tailored as possible to be effective in helping users develop a sense of ownership over time. Finally, our study suggests that social features are a crucial motivator for users to achieve their health goals. However, we found that tracking with strangers instead of friends can hinder user engagement with the system due to the lack of connection.
2. Related Work

In developing our approach, we consulted a variety of sources, including models of personal informatics, studies that have utilized quantitative or qualitative visualizations, and research on social tracking and data sharing. Specifically, we reviewed different models of personal informatics to better understand how they have been created and implemented in previous works. We also examined studies that have leveraged visualizations to communicate information to users, both qualitatively and quantitatively. Additionally, we explored research that has investigated collective tracking and data sharing in personal informatics contexts. By reviewing and synthesizing these various sources, we aimed to develop an approach that builds on prior work and addresses some of the limitations and challenges identified in the literature.

2.1. Personal Informatics

Personal informatics is a set of tools and systems that enable individuals to collect data about themselves for self-reflection and self-understanding. While the practice of collecting is not new, as it has been an innate human instinct since ancient times, the nature of what we collect has changed significantly over the years. Our ancestors collected artifacts like white crystals from other regions, as archaeologists have discovered from the Kalahari Desert [24]. Nowadays, people collect various items like old manuscripts, stamps, coins, sports memorabilia, and art. With the advent of the internet and sensor technologies, individuals can now collect information about themselves, such as their behaviors and habits, and use it to answer questions about their lives [20]. For example, by tracking their activities and daily mood, users can discover which activities positively or negatively impact them.

Various models have been introduced to explain how people select and use these personal informatics tools. A well-known model is Li et al.’s stage-based model of personal informatics systems [19]. Their study examined the problems encountered by users when interacting with self-tracking tools and how to make these systems more effective. The model consists of five stages: preparation, collection, integration, reflection, and action. Users decide on the self-tracking tool and the data to track during the preparation stage. In the collection stage, the data is observed and collected. In the integration stage, the collected data is aggregated and processed. It is essential to note that this stage assumes that the user may be tracking
multiple types of data. In the reflection stage, the processed data is presented to the user in a visual format. Finally, users decide what actions to undertake with their newfound knowledge in the action stage. The model also underscores the cascading nature of these stages; obstacles encountered in the initial phases can have a consequential effect on subsequent stages. For our research, this cascading property suggests that the way data is displayed to users in the reflection stage influences the actions they decide to carry in the action stage. Thus, it is critical to better support users’ self-reflection needs.

Although Li et al.’s model presents a structured approach to collecting and reflecting on personal data, it may not account for unexpected events that can occur in an individual’s life. The model assumes that users have a well-organized approach to tracking data, implying that they devote sufficient time to analyzing their data in the reflection stage before moving on to the action stage. However, unforeseen circumstances can arise, impacting the way users navigate between the stages identified in [19].

To fill this literature gap, Rooksby et al.’s [32] research explored how self-tracking tools become entangled in people’s daily lives. They defined five styles of personal tracking: 1) directive tracking is driven by a goal the user wants to achieve; 2) documentary tracking involves collecting data to create a narrative; 3) in diagnostic tracking, users try to find if there exists a correlation between many aspects of their lives; 4) collecting rewards involves tracking to score points; 5) and in fetishized tracking, users track out of curiosity, love for numbers, and interest in technology. Most study participants used more than one self-tracking tool and would access their information from different devices. These tools were intertwined and often tracked multiple facets of a user’s life. As the study notes, the use of tracked data appeared to be short-term, with very few participants still using the tools discussed during the first interview. Rooksby et al. dug deeper into the emotional impacts of tracking on users. Rather than being a superficial practice, tracking was directly tied to a participant’s self-esteem, sense of pride, and mental health. The authors characterize their observations and conclusions as lived informatics, conveying that “people are using information and finding its meaning in their day-to-day lives.”

Both Li et al. [19] and Rooksby et al.’s [32] work present a comprehensive view of the different tracking stages and styles. Other works in literature have focused more on studying users’ behaviors and needs during specific stages. Li et al.’s [20] work on self-reflection explored users’ needs while in the reflection stage. They determined six questions users ask when going through their data: status, history, goals, discrepancies, context, and factors. They derived
two main reflection phases: *Maintenance* and *Discovery*. The *Maintenance* phase mainly focuses on *discrepancies* and *status* questions. Users already know their goals and the factors affecting their behavior. In the *Discovery* phase, users do not know their goal, causing them to track different types of data to uncover answers and identify factors that influence their behavior. The main questions during this phase are *goals*, *factors*, *context*, and *history*. This phase supports Roosky’s argument that expecting people to track rationally is unreasonable. Logical tracking would involve identifying a specific goal in the preparation stage and starting data collection afterward. Instead, people start collecting data to find actionable goals, thus transitioning between the two phases.

The central concern of the research presented in this paper is about aiding people in the *reflection* stage, providing them with informative and engaging visualizations. In the next section, we discuss various works that have explored different data visualization methods.

### 2.2. Quantitative vs Qualitative Visualization

Most early research projects on self-tracking tools have focused on quantitative methods when displaying data. For example, Houston [11], Chick Clique [28], and Shakra [4] used pedometers to encourage users to increase their physical activity by incorporating data-sharing features. All three applications used numerical representations and graphs to show the user’s current step count, historical view, and statistics in groups. Recent studies on self-experimentation, such as SleepBandits [7] and TummyTrials [26], used the same numerical approach, using text representation to display sleep changes and food trigger patterns, respectively.

On the commercial side, fitness products such as Strava, Fitbit, Runkeeper, and Nike+ use representations based on graphs or statistical reports to track users’ levels of physical activity. All the applications mentioned above track quantitative data; hence, it is reasonable that their representation would also be quantitative in nature. However, it’s worth noting that even subjective data such as habits and moods are often displayed using quantitative representations. For example, Strides and Habit Tracker help users build a routine and use a grid-like representation of the data to keep users motivated. In addition, DailyBean and Daylio use charts to display users’ recorded mood flow.

While using numbers and charts works for some individuals, several studies [15, 25, 31] have shown that not everyone is a “*numbers person.*” Furthermore, this quantitative approach can overwhelm users [23, 12], especially novice self-trackers, and negatively affect their mental...
health. For example, Kelley et al. [17] studied self-tracking for students’ mental wellness. Their findings revealed the guilt, embarrassment, and disappointment students experience when the representation of their data reflects something negative about them. Therefore, providing alternative data visualizations is crucial when developing effective self-tracking tools.

Several research studies have examined alternative data visualization techniques such as qualitative representation. For example, Fish’n’Steps [21] used a pedometer to track a user’s daily step count, mapping the data to the emotional state and growth of a virtual fish inside a virtual tank. Depending on the user’s progress, the size of the fish would change along with its facial expression, becoming happy when enough progress had been made and sad otherwise. Ubifit [10] tracked a user’s physical activities and used a garden metaphor that blooms to display the data. Each type of flower represented a different physical activity, and recent and latest goal attainments were represented by varying the numbers, sizes, and colors of the displayed butterflies. Ubigreen [15] encouraged green transportation behavior by providing feedback on a user’s transportation activities. Feedback was provided by modifying either a virtual tree or a polar bear, growing leaves and apples on the tree or the bear’s iceberg as the user takes green actions. Finally, employing a narrative approach, WhoIsZuki [27] mapped a user’s physical activity data to a character’s progress in a multi-chapter story. Different chapter elements, such as birds, were shown with varying colors and sizes to depict activity type and duration, respectively. Qualitative data representation has been shown to increase motivation in meeting goals [15, 20], help plan activities, and provide feedback that is “approachable” and “non-confrontational” [27].

Despite being an alternative to quantitative representation, most of these studies provide a generic experience where all users see the same visualizations. In other words, the same pieces of data are mapped to the same visualization in the interface for all users. For instance, the same flowers mapped to the same activities in Ubifit, Ubigreen added the same types of elements to the tree, and WhoIsZuki had the same storyline plot for all participants. In fact, some users of Ubigreen have expressed a desire for greater diversity in the visual rewards offered by the platform, stating how the visuals were interesting initially but started being repetitive. A critical and unexplored question is whether allowing users to specify what data to track and how to map it to the interface can promote a more personally meaningful data experience. To the best of our knowledge, this question has been understudied. Our work builds on these research projects and open questions to contribute to the creation of rich and meaningful user experiences.
2.3. Tracking as a Social Practice

Socializing over shared interests and activities is part of human nature, and tracking is no exception to this rule. Although there is a significant emphasis on the 'self' in self-tracking, some connections to other people usually exist. Examples include showing progress to loved ones, competing with friends, and comparing oneself to others. Many studies have shown that social applications with data-sharing functionalities can effectively increase motivation to meet goals. For example, Consolvo et al. [11] found during their study, in which users tracked step count, that the experimental group with data-sharing features had a significantly higher chance of meeting their goal. Similarly, most participants in Fish’n’Steps [21] stated that sharing a tank with other participants was “a stimulating challenge and benchmarking mechanism,” thus increasing their motivation.

There are two primary approaches for incorporating social features into systems: competition and cooperation. A competition approach involves presenting a community’s data and ranking its members, allowing participants to compare themselves to others. For example, users in Houston [11] and [4] were able to compare their daily and average step counts to relative to other users. According to their findings, some users reported enjoying the competitive aspect of the applications, which in turn increased their motivation to use them. On the other hand, it’s important to note that the use of competition can also elicit negative feelings in some users. Some participants in Fish’n’Steps [21] considered competitiveness to be unnecessary and incompatible with the game’s overall theme. In cooperation, the collective data of all users within a group has an impact on the state of a shared element. Fish’n’Steps employed this approach by dropping the tank’s water level and gradually removing some of the tank’s decorations when one of the members made insufficient progress toward their goal. Lin et al. discovered that cooperation did not significantly impact a team’s performance when its members were anonymous; participants went out of their way to identify their team members. It is important to note that this was only possible because of the nature of the study; all participants worked for the same company and had known one another. Other studies [4, 11] have also used a similar approach: competition in a setting where participants knew each other. The question that naturally arises is whether making users anonymous in an environment where they are unfamiliar with another would positively affect the group’s performance and social interaction.

Further research has been conducted to compare the effects of competition and cooperation on users. For example, Peng and Hsieh [29] discovered that in a game-playing context, the
cooperative goal structure led to more effort from players than the competition goal structure. More importantly, playing with friends led to more commitment to in-game goals than playing with strangers in a cooperative goal structure. In addition, [3] found that participants in workout groups preferred exercising together, referring to this practice as cooperation. Finally, HealthyTogether [9] investigated how users perform in different gamification settings: cooperation, competition, or hybrid. Their findings revealed that users in the cooperation and hybrid groups outperformed the competition group; they significantly improved their physical activities. Moreover, participants in the cooperation group were socially more active than their counterparts, sending more messages to other members of their groups.

In the following section, we discuss interviews conducted with college students who have diverse tracking practices, and how their feedback was analyzed to inform the development of the prototype used in the subsequent field study.
3. Formative Interviews

The interviews were conducted to explore various aspects of students’ self-tracking, including their habits, behaviors, motivations, attitudes toward data sharing, and responses to our preliminary qualitative visualization designs. The insights gained from these interviews informed the design specifications for the development of a mobile application.

3.1. Visual Designs

One of the goals of this study is to provide an alternative method for data visualization that goes beyond traditional methods like numbers, graphs, and charts. By doing so, we aim to provide a more user-friendly and informative way to convey tracked information. Our study adopts a qualitative approach to data visualization, which is consistent with previous research [15, 21, 10]. These studies follow a similar pattern for visualization: data is depicted in the form of nature scenes and elements. For instance, Fish’n’Steps [21] uses fish inside of a fish tank, Ubifit [10] uses a garden scene with an assortment of flowers and butterflies, and Ubigreen [15] uses trees in one interface and a combination of polar bears and iceberg in the other. What we visualize, hear, or experience can significantly impact our mental, physical, and emotional state. Several studies in psychology have shown the positive effects of nature on well-being. Being close to nature or visualizing nature scenes has been shown to improve our health [34], enhance our psychological well-being [19, 6, 5], and evoke positive emotions [22].

Building on the studies above on qualitative representation and findings on the benefits of nature scenes, we came up with three designs for visual feedback, as shown in Figure 3.1: a garden, a pond, and a beach. It is important to note that these scenes represent the view of a single user and not a community view. Similar to designs from prior studies [15, 21, 27], each element in our scenes represents a piece of data the user is tracking. For example, in the garden, the four types of flowers could represent four different physical activities being tracked by the user, while the number of flowers could describe their weekly or monthly frequencies. However, our designs differ from prior studies by providing a shared element whose state is affected by the collective data of the group. All three scenes display a sun whose brightness varies based on the collective data. This feature ensures that users can become aware of the well-being of their group at a glance.
Figure 3.1. Three design concepts were shown to the interviewees. These designs depict a garden, a fish pond, and a beach. Each element in the scene represents a piece of data that is being tracked.

3.2. Participants

Through word of mouth, we recruited N=8 participants (4 female, 4 male, aged 20-24) who were all active students at Dartmouth College. Participants were in different stages of their academic life, with 2 being in their second year, 1 in their third year, 3 in their fourth and final year, and 2 graduate students. Participants did not have to meet any specific criteria to be part of the interviews. The initial plan was only to recruit people who were currently tracking or have tracked in the past. However, doing so would have prevented us from understanding the barriers that prevent certain groups from tracking. Moreover, we had yet to determine the specific target group for the field study. Therefore, some individual variations existed in the selected participants’ tracking practices. These span from people vehemently tracking to individuals without any desire to track personal data.

3.3. Procedure

Each participant was invited for an in-person interview which lasted between 20 and 45 minutes, with an average of 37 minutes. The interviewer started by giving an overview of the project and explained the goals of the interview. Next, participants signed a consent form, enabling us to record them. The interview consisted of two parts: data tracking and data visualization.
3.3.1. Data Tracking

Participants were asked questions about the following topics: current or past tracking experiences, motivations for tracking or not tracking, any behavior changes due to tracking, and the types of information they track or would consider tracking. Participants were given multiple handouts they could use when answering some of the questions. Next, users selected the data they track or would consider tracking by circling them on a list of data grouped into 16 categories and ranking them. This list was obtained from a study conducted by Abtahi et al. [1], which analyzed users’ motivations for non-digital forms of self-tracking, such as bullet journaling. Categories included mood and emotions, fitness and activity, finances, and health.

3.3.2. Data Visualization

During this phase, participants started by looking at the proposed three nature scenes for data visualization: garden, pond, and beach. Next, they answered questions related to the following topics: their first impression of the scenes, elements they would add or remove, and their opinion on being able to customize the scene (i.e., choosing what elements look like and personalize mapping between scene elements and tracked data). Then, participants ranked the three scenes based on personal view (i.e., only visualizing their data) and community view (i.e., combining user’s data with other people’s for visualization purposes). Finally, participants gave their perspectives on seeing other users’ data represented using metaphors and data privacy.
4. Interview Results

We transcribed the recordings of the interviews using a third-party tool and analyzed them by coding the responses. Instead of having a pre-determined coding scheme, we identified themes as we processed and analyzed the interview responses. However, during the analysis, we concentrated on the motivations for tracking, tracking tools used, what data people track, visualization preferences, and users’ perspectives on data sharing and privacy.

4.1. Motivations for Tracking

Participants expressed various reasons for tracking personal data. Most respondents started tracking personal information to change or maintain behavior. For example, P4 started tracking his sleeping pattern to improve his sleep quality. P7 collected his weight to ensure it aligned with his weight brackets for martial arts. P3 recorded his screen time to improve his productivity by identifying which social media platforms he spent the most time on. P2 wrote down her daily food intake to improve her eating habits. Another identified reason for tracking was reminder and reminiscence. For instance, P8 recorded daily actions or events she was grateful for and enjoyed the ability to go back and review the ones that made her happy. This is similar to P5, who used her tracking of life events as a “time capsule,” allowing her to reminisce on her wellness in earlier stages of her life. Additionally, two participants (P5, P8) recorded actions they needed to do, such as exercising or washing their hair, to avoid forgetfulness. Lastly, a few participants collected data out of curiosity or for pattern discovery. P3 tracked his number of steps to discover if there was a relationship between his tiredness and his daily walking distance. P1 tracked his eating, sleep, and exercise habits to identify any relationships between them.

Li et al. [20] also identified the three motivations mentioned above for tracking to understand the types of questions people ask about their data. Moreover, each motivation can be mapped to one of the five styles of tracking identified by Rooksby et al.’s [32]. Tracking to change or maintain behavior corresponds to directive tracking, collecting data for reminiscence is a sort of documentary tracking, and tracking to discover patterns and find correlations is similar to diagnostic tracking.

It is important to note that tracking was not the initial goal for some participants. In other
words, tracking resulted from external factors, such as acquiring a tool that happened to track data. For example, P2 started tracking her workout after she had acquired an Apple Watch. P6 used a similar approach when tracking his sleeping patterns. He mentioned that his sleep data was interesting to visualize initially, but then he gradually convinced himself that he needed the tracking to sleep better. Having a tool allowed him to become aware of his sleeping patterns. This tracking approach is closely related to Li et al.’s [20] Goal question, which describes tracking as a way to determine a goal and actionable steps one could take to achieve a desired outcome.

4.2. Tracking Barriers

The following barriers emerged from the analysis: negative sentiments, lack of accuracy, and input and output format.

The most common tracking barrier was the negative sentiments, such as guilt, that originated from looking at the data. When describing how her sleep data impacted her thoughts, P4 said: “I feel bad when I look at my graphs, and I see that I’ve slept five hours. And for the most part, other ones, I will have slept eight.” P6 recounted similar feelings when discussing his workout data, “it kind of makes me feel bad, especially when I haven’t been going to the gym as often. Because it’s like I just wasted an hour of my time on not very much.” Not only did tracking practices lead to feelings of guilt, but they also led to exhaustion, as P2 noted: “I think it was exhausting. It was exhausting to log my family’s food. If my mom made us food I didn’t want to be like one ounce of chicken, three potatoes. It was just so annoying that I got sick of it.”

A few participants cited the inaccurate representation of their life by their data. This came in the form of self-tracking tools displaying wrong information, as P4 experienced, “And it’ll be kind of annoying because it’s wrong. Obviously, sometimes, it’ll say that I slept like 10 minutes. And I know I didn’t sleep 10 minutes. So that’s like frustrating sometimes.” Aside from the display of wrong information, the lack of context was mentioned as another barrier. As P4 summarized: “…it oversimplifies. It’s one metric to describe me as person in that context… Like, I got 5000 steps today. But yeah, again, I completed my month’s work… it did not feel like a fair representation of my productivity.”

The last barrier mentioned by participants relates to the representation of the input and output. For example, P4 started tracking her mood but encountered difficulties understanding the data, describing it as “weird to read”. Two participants found it cumbersome to input precise calorie
values when tracking food, stating, “...then I also have to do all the mental math” (P6) and “…it kind of went from like down to the number to now just kind of keeping a general ballpark estimate in my head.” (P7).

It is important to stress that some of the barriers originate from the nature of the data being tracked. Modern smart devices can automatically track data such as steps and sleep; other data, such as mood and calorie intake, require manual input. Moreover, most identified barriers occur during one or both Li et al.’s [19] reflection stage (e.g., feeling of guilt, lack of context, and data being hard to interpret) and collection stage (e.g., having to enter the exact numbers for calories). This paper only focuses on barriers encountered by users during the reflection stage, more specifically, the feeling of guilt when visualizing data using quantitative representation.

4.3. Types of Data

We presented participants with a list of categories of data that people track obtained from [1]. Participants then selected within each category what data they would consider tracking or not and to explain the reasoning behind their choices.

![Figure 4.1. Frequency for each category of tracked information selected by participants. A category was counted towards a participant’s selection if they had picked at least one choice from that category.](image)

Reasons for tracking data included ease of tracking, physical benefits, goal achievements, and personal curiosity. Multiple participants selected some data because applications on their devices automatically collected them. These include finances (P5, P6), sleep (P3), and reading time (P6). Other participants picked data that they believed would benefit their physical health such as heart rate (P1), food consumption and calories (P1, P7), air quality (P3), bedtime routines.
Some participants selected data that would help them achieve their goals. Three participants (P3, P6, P8) tracked their events to prevent forgetfulness, P4 tracked resolutions for accountability, and P8 recorded what she was grateful for every day to remind herself to be more grateful. Lastly, some participants (P3, P6) wanted to track simply out of curiosity (e.g., dream tracking, personal goals).

Participants cited various reasons for not tracking specific data. The most common reason was that tracking those data could cause greater harm. Two participants (P2, P3) mentioned that they stopped tracking food-related data such as weight and calorie intake because they started to develop a toxic lifestyle. P4 cited her desire to track mental health but emphasized her unwillingness to view the data, fearing it would negatively affect her self-esteem. Another common reason was laziness. Examples include having to enter the data manually, such as calories (P8), and tracking an overwhelming number of data, such as hobbies (P2) and social connections (P5). Interestingly, three participants mentioned that screen time was something they would not be willing to track for different reasons. Two participants (P2, P7) stated that knowing that their screen time would not change their behavior. P7 justified his argument by explaining that the nature of his school work, which involved dealing with digital media, required extensive screen time. Similarly, P1 noted that screen time data is oversimplified and must be put into context: “you have been on the screen for 12 hours today. If you just look at that data, you would say that is really bad. Whereas no, I have been on the screen for 12 hours today, but I completed my month’s work. That is an objectively good thing.”

4.4. Data Visualization

After answering questions about their tracking practices, participants spent some time inspecting the designs of the nature scenes (i.e., the garden, pond, and beach) shown in Figure 3.1. We asked them to narrate their first impressions of each scene and answer follow-up questions on customization and data sharing and privacy.

4.4.1. Impressions of Nature Scenes

Most participants related to the garden due to its familiarity. For instance, two participants used the concept of growth to describe their impression of the garden, stating, “I associate garden with growth… it makes sense to me… I feel like trees and plants are things that can grow” (P2) and “you can build a garden by planting things… and when you grow more trees, that is
a good thing” (P6). Some participants used their life experiences to explain their preference for the garden. P5 mentioned how it reminded her of two farming video games she played. P7 stated that the idea of a community garden reminded him of community gardens he had visited during a trip to Germany. Participants appreciated the flexibility and modularity of the garden. They emphasized how the nature of the garden would help them compartmentalize the different data using flower and color customization (P7) and arrange elements in a way that showcases their priorities but still feels natural (P1).

A few participants also mentioned familiarity when describing their first impressions of the beach. Similar to some participants’ association of the garden’s trees and plants with growth, P8 also associated the beach’s palm tree and algae with growth. For P7, the beach was reminiscent of his childhood and the beach that was close to his home. However, some participants did not find the beach as relatable as the garden. The two main concerns mentioned were the lack of diversity in the scene and the peculiar idea of having multiple beaches together. The beach did not have as many potential elements as the garden, limiting the number of tracking options in a one-to-one mapping between the data and scene elements. Additionally, the notion of “a community of beaches” seemed somewhat strange to participants since it is widely uncommon. This lack of familiarity is reflected in participants’ scene rankings in Figure 4.2, where the beach has the lowest rank for the community view.

The pond was not as well-received as its two counterparts, especially for the single-user view. Participants found it challenging to relate to the scene, citing a lack of personal connection. Moreover, most of the concerns raised were related to customization. P2 noted how she could only think of changing the fish’s number, color, and size to show progress in the pond, none of

Figure 4.2. Participants ranked the three scenes based on single-user and community views. Participants mostly preferred the garden scene for both views.
which she found particularly interesting. Two participants (P3, P7) pointed out that the nature of the pond did not allow for an unlimited number of fish and that having different colored fish would make it difficult to compartmentalize.

Overall, the majority of participants preferred the garden scene and its related elements. Although customization was a key factor, the main differentiator was the familiarity and personal connection participants felt. They were more used to growing flowers than growing fish and more familiar with a community of gardens than a community of beaches or ponds. P6 best summarized this perspective: “I have never built a beach before. I have never built a pond before. But I have certainly built a garden before.”

4.4.2. Design Changes

After getting their impressions of the scenes, we asked participants for any design changes they would make or any features or functionalities they would like to incorporate. Several participants wanted the tracking and the designs to involve more social aspects. P4 suggested having the ability to share statistics with family and friends. P2 wanted a competitive platform where different users and groups would compete against each other. Another suggestion was letting users track multiple data at the same time to identify patterns. For example, P1 wanted to track exercises and sleep to see if one affected the other. Similarly, P4 wanted to know if there was a relationship between her bedtime, wake-up time, and sleep quality. Other suggestions included rewarding users for meeting goals to promote self-competition, making elements in the scene animated, and limiting the number of possible scene actions.

4.4.3. Customization

We were also interested in knowing participants’ overall perspectives on customization. Several participants said that having the ability to customize would enhance their tracking experience. They mentioned that it could create a sense of ownership and pride, thus, increasing their motivation to continue tracking. P6, on the other hand, described it as marginal and a source of extra work and preferred “the computer to do the work for me.” Although we asked about customizing characteristics of scene elements such as size, number, and colors, some participants focused more on data customization. P2, for example, highlighted the importance of letting users define success when tracking sensitive data such as weight and nutrition.
4.4.4. Data Sharing and Privacy

By and large, participants said that sharing their data would increase their motivation and engagement by creating a sense of community. For instance, P5 explained that the group challenges in Strava, a fitness social network application, made her feel connected to a broader community. P6 brought up the positive feelings she gets when other members recognize her efforts. For other participants, having knowledge of other people’s well-being or what they were tracking was enough to increase their engagement. Participants were mainly willing to share data with family and friends. However, they all mentioned that their willingness to share was directly related to how personally sensitive the data was. Sleep, exercises, and goals were used as examples of inconsequential data. On the other hand, they were warier in sharing data related to their mental health. They suggested that the application follow an opt-in model; the data should not be shared by default, and users should have the option to turn this feature on or off.
5. Sprout Application

Drawing on personal informatics models literature, data visualization techniques identified by prior self-tracking research on which we build, and the findings of our formative interviews, we created Sprout, an iOS self-tracking health application. The app builds on prior research by incorporating qualitative representation of data [21, 10, 27, 15] and social features [11, 21, 4, 28] and differs by adding customization to provide unique experiences to users. To store user data and analytics, Sprout heavily uses mobile development services offered by Firebase (e.g., Firestore, Cloud Functions and Messaging, Remote Config). The interfaces were designed using SwiftUI and SpriteKit to handle 2D graphics and animations.

5.1. Design Guidelines and Justifications

We present below the design guidelines that were followed to create Sprout. We also provide justifications for these choices using our findings from preliminary research and literature review.

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexibility</td>
<td>Application should support different styles of tracking</td>
</tr>
<tr>
<td>Customizability</td>
<td>Users should have the ability to determine what they want to track and how to see it</td>
</tr>
<tr>
<td>Familiarity</td>
<td>Design elements should be familiar to users</td>
</tr>
<tr>
<td>Passive Tracking</td>
<td>Data tracking should be automatic by default but flexible to allow manual input</td>
</tr>
<tr>
<td>Social Influence</td>
<td>Application should provide features that foster a sense of community among users</td>
</tr>
<tr>
<td>Privacy</td>
<td>All data representation and social features should be anonymous by default</td>
</tr>
</tbody>
</table>

5.1.1. Flexibility

Prior studies [32] have demonstrated the existence of different styles of tracking, such as tracking for goal achievement or progress documentation, and that users ask different questions about their data depending on their goals [20]. Our interviews revealed, in line with previous research, that users have diverse motivations and objectives for monitoring their personal data. To make Sprout flexible, we added features to support the following tracking styles identified by [32] directive, documentary, diagnostic, and collecting rewards.
5.1.2. Customizability

Our research addresses a key inquiry: how does the level of customizability, i.e., the extent to which users can personalize different aspects of the application, impact their self-tracking experience? Prior studies [19, 8] have emphasized the need for customizability, as most existing self-tracking tools provide a generic experience where all users track the same data and are provided with the same data representation. We designed Sprout to put users in control and enable them to decide what they want to track and see.

5.1.3. Familiarity

According to our formative interviews, participants displayed a preference towards the garden visualization due to its familiarity. The psychological phenomenon of favoring things that we have been frequently exposed to is commonly referred to as the mere-exposure effect [35]. Picking the known over the unknown reduces uncertainty (i.e., uncertainty reduction) and makes understanding and interpreting things we visualize easier (i.e., perceptual fluency). However, developing an attachment to familiar things could lead one to forgo other rich experiences. Nevertheless, we decided to use elements of the garden visualization because of the already established connection, with the aim of driving motivation and engagement.

5.1.4. Passive Tracking

Li et al.’s [19] outlined multiple barriers faced by users in the collection stage. One barrier identified during our preliminary interviews was related to active (i.e., self-reports) vs. passive (i.e., sensors) logging. Consistent with prior findings [19, 14], manually entering data can result in exhaustion and tracking abandonment. To address this, we chose to let users track data that can be automatically collected by their smartphones via the Apple’s Health app but still allows them to manually input the data if necessary.

5.1.5. Social Influence

Effective tracking tools require motivation as a crucial component. Previous research findings [11, 4, 21, 9, 2] have shown that social features (e.g., support, pressure, communication, competition, and cooperation) could positively influence users to stay motivated and achieve their goals. When deciding between cooperation and competition as the approach for our study, we opted for cooperation based on the findings of Chen et al. [9], who concluded that cooperation was more effective than hybrid and competitive approaches.
5.1.6. Privacy

Through our formative interviews, we discovered that users were willing to share their data depending on the type of information they were tracking. Specifically, we found that some data were more sensitive than others, influencing their level of comfort with sharing. We enforced user authentication to prioritize users’ privacy and made all social features anonymous by default. No special handling was needed for the tracked data since they were depicted using figurative elements, i.e., trees, flowers, and sun.

5.2. App Implementation and Features

The guidelines specified in Table 5.1 are heavily reflected in the implementation of Sprout. The design and development of the prototype were iterative; we engaged with some of the users who had participated in the formative interviews to gather feedback to enhance the application’s features. The sections below describe the main components and functionalities of the application. To provide examples in the following sections, we will use the example of a user tracking steps and sleep, with goals of 10,000 steps and 7 hours of sleep.

5.2.1. Authentication

5.2.1.1. Sign-up and login. During our preliminary tests, we identified that users preferred not to fill out forms for signing up and logging in. Having to enter the same credentials every time they wanted to login was a source of annoyance for them. Therefore, we streamlined both processes by relying on the user’s existing email account. When a user logs in to the application for the first time using their email account, their information (e.g., name, email, unique identifier) is fetched and used to create a new Sprout user. Ultimately, signing up and logging in follow the same interaction flow and do not require filling out forms.

5.2.2. Onboarding

5.2.2.1. Selecting experimental condition. The first step in this process is to select a group where each one represents a different experimental condition (these conditions will be discussed in later sections). Some subsequent screens during onboarding are hidden depending on which group the user belongs to.
5.2.2.2. **Selecting data to track.** The user selects which two data out of a list of four they would like to track, as shown in 5.1b. These four options (i.e., sleep, steps, walking and running distance, and workout time) can be automatically tracked by the *Apple Health* application and still allow users to manually input data entries. Based on the findings from our formative interviews, we narrowed down our options to these four categories. As illustrated in Figure 4.1, *Fitness & Activities* was the most preferred choice. Prior research on tracking motivations informed our decision-making when determining the number of data options that users would be permitted to select. Although only allowing one option would have sufficient for users
who only wanted to document their progress (i.e. documentary tracking), it would not have worked for users with a desire to connections between different aspects of their lives (i.e. diagnostic tracking). Our decision to limit the selections to two was driven by a desire to ensure consistency among future study participants and avoid burdening users with too many options.

5.2.2.3. Goal setting. We employ sliders to set daily goals for the two data options selected in the previous step, as shown in Figure 5.1c. Since our planned study would only last for two weeks, we opted for daily goals instead of weekly ones to provide users with greater granularity. Members of all groups can modify their daily targets later, as needed.

5.2.2.4. Selecting tree and flower type and color. Our goal is to empower users with the ability to personalize their gardens by selecting the style and color of their trees and flowers. We provide 8 types of trees and 3 types of flowers the user can choose from by scrolling horizontally, as shown in Figure 5.1d and 5.1f, respectively. After selecting a type for their tree or flower, the user is presented with 10 colors to choose from, as shown in 5.1e. Only users in the customization groups can pick their trees, flowers, and colors. Other users get the default choices chosen by the research team. To enhance the application, we assign whimsical names to the trees and flowers to make them more engaging and fun (Figure 5.2).

![Figure 5.2. Examples of trees and colors; the first word corresponds to the color](image)

5.2.2.5. Mapping data to scene elements. This feature differentiates our method from other existing tools. In this step, we let users determine the meaning of the tree and flower. They map each selected data to either the tree or the flower by dragging it to the empty slot corresponding to the desired garden element. Figure 5.1h shows an example of a user mapping their step count to their tree. This mapping means that progress towards their step count goal translates to gaining droplets that can be used to increase the height of their tree. If the step count was
Figure 5.3. This diagram illustrates the relationship between the user, the Health App, and third-party tracking applications. When a new entry is recorded through a third-party app, it is automatically transmitted to the Health app. Subsequently, the Health app notifies our application about any updates. Alternatively, entries can be directly inputted into the Health app without involving third-party apps.

mapped to flowers, then step count progress would have allocated seeds to grow more flowers in their garden. We will explain this mechanism in more detail in later sections.

5.2.2.6. Final steps. The last part of onboarding involves giving a name to one’s garden, which the user can change later. After onboarding, the user is redirected to their home screen, where they can start interacting with the various features of Sprout.

5.2.3. User Data and Progress

5.2.3.1. Data tracking and interaction with Apple Health. The current system can only track step count, sleep duration, workout duration, and walking & running distance. Sprout makes use of Apple’s HealthKit API to detect changes in the user’s data in the Health app and perform the appropriate updates. Picking the Health app as a source of health data was intentional. People often use third-party self-tracking applications. These apps can receive read-and-write access to the Health app. This access allows the Health app to be the central source of health data on iOS, containing all the data created by third-party applications. Therefore, Sprout users can continue using the tracking applications they are already using, and changes will be reflected in the Health app and subsequently in Sprout.

To detect changes, Sprout runs long-running queries that monitor changes in the Health app. Once a change is detected for data of interest (i.e., data has been saved or removed), an alert is sent to Sprout, instructing it to update the database and fetch the new updates. These queries run both in the foreground (i.e., the application is being used) and the background (i.e., the application is not being used). It is important to note that Sprout only updates the database
if the user opens the application; in other words, the app needs to be in the foreground for updates to occur.

Tracking certain data requires more configuration than others. For instance, steps and walking & running distances can be easily tracked by the Health app. On the other hand, tracking workout and sleep duration is more involved. For workout duration to be automatically tracked, the user needs to perform activities that sensors on the phone can detect. Activities such as weightlifting and cycling would most likely require manual input at the end of each session. The same applies to sleep; the user needs to set up their sleep schedule, though this only has to be configured once. To handle these cases, the user can manually edit entries via the Health app if they think their data is either missing or inaccurate. Users can only edit data for the current day and not previous ones. A day in the context of tracking any of the data listed above is defined as the time interval between 12:00 A.M. and 11:59 P.M. The only exception to this rule is sleep which has an interval between 10:00 PM and 9:59 PM. This time interval ensures that if a user goes to bed at 10:30 P.M., the 90 minutes between 10:30 P.M. and 12:00 A.M. are counted towards the following day.

5.2.3.2. Visualizing current progress. The dashboard allows users to get an overview of their current progress toward their daily goals. In Figure 5.4, the user has mapped their step count to their tree and sleep minutes to their flowers. They can visualize their current number of droplets, number of seeds, and their progress towards their steps and sleep goals for the current
day. Progress towards a goal is displayed using the actual value and a progress bar. Figure 5.4d shows that the user has completed 1000 steps and slept 5 hours the previous night.

5.2.3.3. Earning droplets and seeds. The Health app notifies Sprout of any changes concerning the data the user is tracking. If the user’s progress passes a threshold, some droplets or seeds are awarded, as shown in Figures 5.4b and 5.4c. The calculation is as follows: for every 5% progress users make toward their goal, they are awarded one item (i.e., droplet or seed). For example, in Figure 5.4, the user has a daily step count goal of 10,000 steps and completed 1000 steps. Since 5% of 10,000 steps is 500 steps, the user is awarded two droplets, as shown in Figures 5.4c.

5.2.4. User Garden

5.2.4.1. Growing trees and planting flowers. Users can grow trees and plant flowers in their gardens using the personal garden screen. Each user is limited to one tree but can have an unlimited number of flowers. The screen has a lock icon button that users can tap to toggle between different actions, as shown in Figure 5.5. To relocate the tree, users can press and hold while moving a finger across the grass after closing the lock. Opening the lock allows users to grow their tree or plant flowers.

![Growing tree and planting flowers in the garden](image)

(a) Closing lock and small moving tree (b) Opening lock; selecting droplets and growing tree size (c) Selecting seed and planting flowers

**Figure 5.5.** Growing tree and planting flowers in the garden

To grow their tree, users select the droplet icon by tapping it and then tap anywhere above
the tree to release a droplet. For growth to occur, contact must be made between the tree and the droplet; otherwise, users lose the droplet. To ensure that the tree’s size stays within the boundaries of the screen, we impose a size limit on its growth. Therefore, it is possible to have leftover droplets at the end of the day. Users revealed during preliminary testing that simply releasing a droplet was monotonous. We decided to make it more challenging by moving the tree horizontally at a constant speed when trying to release a droplet. Planting flowers follows a similar process; users first select the seed icon and tap anywhere on the green field to grow a flower at that location. Unlike the tree, no limits are imposed on the number of flowers users can plant. It is important to note that the garden resets every day at midnight. As a result, the tree returns to its minimum size and all the flowers disappear. This feature was added to ensure consistency between a user’s goals, which were set to be daily, and their progress toward those goals. Moreover, the garden contains other elements that contribute to its aesthetics, such as birds, clouds, and an animated dog.

5.2.5. Community

![Figure 5.6. The community garden at two different points in time. In the first one, the garden only contains the trees of its members. The flowers planted by users in their gardens also get added to the community garden and are distributed evenly](image)

5.2.5.1. *Group membership.* Users belong to a community where each member tracks two pieces of data. By default, all aspects of the community are anonymous; users’ names, the data they are tracking, and the exact values of their progress are all hidden. Figure 5.6 shows the layout of the community garden. Each plot is named after a user’s garden and contains
one tree and zero or more flowers. The tree’s height shows the owner’s current progress toward one of their goals. The flowers in a plot, however, do not necessarily belong to that user. To promote cooperation, all individual garden flowers created by community members are distributed evenly among group members, regardless of contribution.

5.2.5.2. Unlocking badges and features. When a community is created, certain features (e.g., clouds, animals, and birds) are initially hidden in both personal and community gardens. These features are represented by badges (as shown in Figure 5.7) and can only be unlocked by community members. Unlocking a badge requires reaching the minimum number of days specified for that badge, where the community’s goal completion rate (GCR) is 50% or higher. The GCR is calculated by dividing the total number of goals achieved by members for a given day by the total number of community goals. For example, if a community has 6 members and each is tracking 2 pieces of data, then the total number of community goals would be 12. If the members were only able to meet 7 goals for that day, then the GCR would be 58% (7/12). Users can unlock up to 10 badges or features as community members achieve their goals. Once a badge is unlocked, the corresponding feature becomes visible, and users can see a brief description of the badge, as shown in Figure 5.7. The days on which the GCR is at least 50% need not be consecutive, and a community is not penalized for failing to meet the 50% threshold.

5.2.5.3. Awareness of group progress. The community’s current goal completion rate (GCR) affects the state of the sun or moon in the personal garden. On any given day, as group members

![Figure 5.7](image-url)
complete their daily goals, the state of the shared element (i.e., sun or moon) gets brighter, as shown in Figure 5.8.

![Figure 5.8. State transition of the shared element in a user’s garden. The glanceable element allows users to see how the aspects of the community impact their personal garden. The shared element transitions from one state to another every time there is at least a 25% increase (i.e., 25%, 50%, 75%)](image)

5.2.5.4. Sending and receiving messages. People can use the messaging feature to send direct or community-wide messages. Tapping the paper plane icon at the top right displays a dialog that lets users select the type of message they would like to send (see Figure 5.9a). After selecting which message type, they are prompted to enter the content of the message, select the recipient in case of a direct message, and determine whether or not to make the message anonymous. The anonymous toggle is always on by default to minimize mistakes (see Figure 5.9b and 5.9d). Thus, the user must consciously decide to turn it off if they want to send a public message. Tapping the envelope icon displays a history of sent and received direct messages; tapping on the globe icon shows the community feed.

![Figure 5.9. The interaction flow for sending messages: tapping on the paper plane icon at the top right opens a dialog letting the user decide whether to send a direct or a community message. The user can select the recipient of a direct message. All messages are anonymous by default, but users can make their names visible.](image)
5.2.6. History

5.2.6.1. Viewing personal history. Users can visualize their progress over time by accessing the history screen (Figure 5.10a). Each row corresponds to a single day and contains the date, their goal, and a representation of their progress in figurative (see Figure 5.11) and numerical formats. Tapping on a row displays what the garden looked like for that particular day, as shown in Figure 5.10b. A legend is displayed at the bottom left corner to help users remember their initial mappings (e.g., the tree is mapped to steps). The legend’s droplet and seed icons represent the tree and the flowers, respectively. The droplet and seed icons in the legend symbolize the tree and flowers, respectively.

(a) Historical view of step count  (b) Selecting specific day  (c) The number of days where GCR was at least 50%

Figure 5.10. Screens that allow users to view their personal and community progress over time.

Figure 5.11. These faces represent progress toward a goal and are used for personal and community goals. They transition from sad to euphoric as progress is made.

5.2.6.2. Viewing community history. To view their community’s progress, users can navigate to the community history view shown in Figure 5.10c. This history is based on the community’s goal completion rate (GCR), i.e., the number of goals achieved on a given day by the community divided by the total number of community goals.
5.2.7. Other

5.2.7.1. Customization. Accessing the settings screen allows people to change the type and color of the tree and flower they selected during onboarding. Changes to the tree are automatically applied to the current tree in the garden; on the other hand, changes to flowers do not overwrite existing flowers, allowing the creation of a garden with various flower types and colors. Users can also edit their goals (i.e., increasing or decreasing the values), the name of the garden, and the background music. We provide a selection of five songs that users can iterate over.
5.2.7.2. *Push notifications.* The community platform sends users immediate notifications for direct messages and newly added content. Additionally, a daily notification is sent at 12:30 P.M. to motivate users towards achieving their gardening goals. The timing of this notification is deliberately chosen to provide users with enough time to complete their tasks after receiving the reminder. However, users do not have the option to modify the daily notification time. Whenever a community member achieves their goal, a notification is sent to all members. Lastly, at midnight, users receive daily notifications about their community’s badge achievements. These notifications help keep users engaged and informed, leading to an enhanced user experience.
6. Field Study

To test Sprout, we conducted a 2-week study to explore people’s use of the system and how qualitative representation, customization, and social interaction affected their engagement level, self-efficacy, and overall experience with the system.

It is important to note that the deployment of Sprout was not intended to test for behavior change, which is unrealistic in such a short study and not desirable when evaluating novel technologies in such early stages of HCI research [18]. The complex nature of behavior change requires researchers to conduct longitudinal studies to demonstrate the long-term effects of their system. Instead, we are more interested in better understanding the practicality of Sprout outside of a lab context, gauging people’s reactions to our novel design strategy (i.e., combining qualitative visualization with customization and social interaction), and discovering ways to improve the system.

6.1. Recruitment

We conducted recruitment at Dartmouth College and advertised the study for 2 weeks by placing posters around campus and sending messages on popular school Slack channels. Posters were strategically placed in high-traffic areas (e.g., libraries, cafeterias, and gyms) and stated that we were looking for iPhone users who were interested in tracking health data. People interested in the study completed a pre-study survey that asked them about their self-tracking practices and demographics. We later used responses from the survey to place participants in different study conditions. Participants did not have to be tracking any health-related data prior to the study. Upon completion of the study, they were compensated with a $20 gift card.

6.2. Setup and Method

We designed a between-subjects study with four conditions that varied the ability of participants to use the customization and social features of Sprout. In the groups with customization features (i.e., groups 0 and 2), members could edit different elements and functionalities of the application at any point during the study. Participants in the social condition (i.e., groups 0 and 1) could view their community, earn rewards, and send messages. Table 6.1 summarizes
the features that were available under the four different conditions.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Group 0</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Send direct and community messages</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Receive notifications about group goal achievement</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unlock community badges and features</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change type &amp; color of tree and flowers</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Change the garden name and background music</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Participants in a customization condition did not have to unlock features like their counterparts in the social condition; those features were already available to them from the beginning of the study.

In the pre-study questionnaire, we asked participants if they had tracked before, their interest in tracking health-related data, and their interest in using a tracking application with social features. We assigned all participants to one of the study conditions while considering their responses to the survey. Once people confirmed their participation in the study, we sent them an email with detailed instructions on setting up fitness tracking on the Apple Health app and invited them to schedule an onboarding session. Participants had a couple of days between their onboarding session and the official start of the study to become familiar with the application and report any issues. At the end of the study, we sent participants an exit survey and conducted an exit interview. Moreover, the application automatically collected app usage data during the two weeks. In the following subsections, we provide more information on the above components.

### 6.2.1. Onboarding

All onboarding sessions occurred within a week before the official start of the study. Participants who had confirmed their participation were invited to our lab. They started the session by confirming that their phones had the minimum required iOS version and downloading the Sprout application. Next, participants picked which two data to track and then set their daily goals. Based on their study condition, they could also customize their tree and flowers. In order to compare their activity level before and after the study, we asked participants also to provide their baseline data gathered before the onboarding. The baseline data consisted of the 16 days before the official start of the study. We then reviewed the user guide for the participant’s study condition. The user guide provided an overview of Sprout’s different components, such as activity tracking, growing one’s personal garden, customization, and social interaction.
6.2.2. Exit survey

Participants were sent an email two days after the conclusion of the study, inviting them to take part in an exit survey and schedule an optional exit interview. The survey included questions pertaining to their attitudes and behaviors towards their health following the intervention, as well as their overall reactions to the app.

6.2.3. Exit interview

Unlike onboarding, the exit interview took place online. Participants received a link to the virtual meeting after scheduling. The goal of the exit interview was to, among other things, collect participants’ overall experience with Sprout, get insights into how they used the app in their daily life, and understand their satisfaction with their level of activities, motivations to engage with the app, and overall reactions to the customization and social features. These interviews were recorded and then transcribed using a third-party application for analysis.

6.2.4. App data logs

We collected participants’ interactions with the application throughout the study. Examples of interaction events include screen views, messages sent, droplets and seeds earned, goal changes, and app customization. Each interaction contained information relevant to helping us answer our research questions. These data were late analyzed across the four different conditions.

6.3. Participants

After advertising the study, 57 people completed the screening survey; 28 people confirmed that they still wanted to participate. Out of the 28 respondents, 22 completed the 2-week study. Table 3 summarizes the demographics of participants.

The majority of participants were students; 16 were undergraduates and 5 were graduate students. One participant was a staff member at one of the school’s departments. 16 of the participants identified as female and 6 as male. All participants had done some sort of self-tracking prior to the study (e.g., phone application, smartwatch, paper journals). Participants varied their choices of data to track; 16 participants tracked steps, 14 tracked sleep, 7 tracked workouts, and 7 tracked walking and running distance. 8 participants tracked both steps and sleep,
making it the most popular data combination. At then end of the study, 17 participants agreed to fill out the optional exit survey and take part in the optional exit interview.

The pre-study survey asked participants to rate on a scale of 1 to 5 their interest in self-tracking health data and using a tracking application with social features. We used these responses to randomly assign participants to one of the four study conditions. Both group 0 (customization and social) and group 1 (social only) had 6 participants, and both group 2 (customization only) and group 3 (control condition) had 5 participants.
7. Study Results and Discussion

7.1. Effects and Experiences of Tracking with a Qualitative

7.1.1. Activity Levels

7.1.1.1. Trends in activity level. Throughout the study, participants logged a total of 1,335,616 discrete health-related activities, including steps (1,330,844 steps), sleep (1254 hours of sleep), workouts (3202 minutes of workouts), and walking and running distance (316 miles). Daily entries for goals ranged from 0 - 151 minutes for workouts, 0 - 12 hours for sleep, 0 - 12 miles for walking and running distance, and 0 - 30,000 steps for step count. Table 4 presents certain statistics derived from calculating the average value of each activity across all participants who monitored it.

<table>
<thead>
<tr>
<th>data</th>
<th>max average</th>
<th>min average</th>
<th>collective mean</th>
<th>collective median</th>
</tr>
</thead>
<tbody>
<tr>
<td>steps (count)</td>
<td>10447</td>
<td>1363</td>
<td>5198</td>
<td>4235</td>
</tr>
<tr>
<td>Walking &amp; running (mi)</td>
<td>4.9</td>
<td>0.7</td>
<td>2.8</td>
<td>2.6</td>
</tr>
<tr>
<td>Workouts (min)</td>
<td>52.3</td>
<td>5.7</td>
<td>28.6</td>
<td>29.8</td>
</tr>
<tr>
<td>Sleep (hrs)</td>
<td>8.1</td>
<td>1.05</td>
<td>5.5</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Several participants mentioned having trouble with their sleep data. Four participants (P6, P11, P12, P20) mentioned how their sleep data would get double counted. P6 had already been using an application different from Apple Health to track his sleep which caused the sleep data to appear twice in the Health app. For the other three participants, Apple Health would combine their ‘bedtime’ and ‘asleep time.’ We made sure to remove the duplicate entries before analyzing their data. The lowest sleep average presented in Table 4 (i.e. 1.05 hours) belonged to P13, who had difficulty interacting with the Apple Health app. She specifically mentioned being unable to set her sleep schedule and manually enter data.

We calculated the average activity level for each participant before and after the intervention and found that activity levels decreased across all four types of data. On average, step count levels decreased by 39%, walking and running decreased by 28%, sleep saw a 4% drop, and workouts dropped by 17%. However, the Wilcoxon Signed-rank test only showed a significant difference between the pre and post-averages of the step count level ($W = 3, Z = -3.36, p < 0.05$). To analyze the data further and identify possible trends related to these drops, we split
the baseline and data into individual weeks. Interestingly, the decrease in activity levels started during the baseline period, with all 4 types of data seeing a decrease between week 1 and week 2, as shown in Figure 7.1. However, the Wilcoxon Signed-rank only revealed a significant drop between week 1 and week 2 of the average step during the baseline period. The activity level averages of steps and walking & running distances followed a similar pattern; they steadily decreased during the 4 weeks. On the other hand, workout and sleep saw an increase in activity levels, though not statistically significant, between week 2 of the baseline and week 1 of the study for workout, and between week 1 of the baseline and week 3 of the study for sleep.

![Activity Level Before and After Study](image)

**Figure 7.1.** The average activity levels of each participant were computed and grouped by activity for all four weeks, with the initial two weeks being utilized to assess the effects of the intervention.

7.1.1.2. Activity level barriers. To add some context to the decrease in activity level, we asked participants about any extenuating circumstances that might have led to the overall low performance. Unsurprisingly, 8 participants mentioned school as being the main activity barrier. Participants reported having to do homework or study for exams for days (P3, P5, P6, P7, P8, P15, P22); “I brought myself away from thinking about health and exercise for a couple of days” (P3), “there was a good four or five day period where I was just like, I’m just gonna sacrifice to guarantee the grade” (P6), “there were at least 2 days where I didn’t check it at all. I think it was because of finals” (P15). Other reasons mentioned by participants include sickness (P12, P17, P19) and travelling (P22). Some participants had more specific reasons. For example, P9 did not carry her phone as often and mainly relied on her watch to track both her steps and workout during the day. She mentioned forgetting to put it on for a couple of days and how that might have affected her activity level. P1 was tracking her steps but had to use her bike to go to her classes for the first week of the study, resulting in low daily step counts. It is important to note that the study occurred during the last two weeks of the school term. During this period of the
term, students tend to be occupied with submitting their final assignments, taking last exams, and commencing preparation for their final exams, making it a notably busy time.

7.1.2. Use of Garden Motif

Here we present our findings regarding participants’ attitudes and reactions toward the qualitative nature of Sprout.

7.1.2.1. The use of qualitative visual motifs can create a fun and playful tracking experience. Overall, participants had a positive reaction to the garden motif. The post-study survey indicated that the majority of participants found the application fun (13/17), enjoyable (15/17), and entertaining (13/17). Participants highlighted different elements of the application they appreciated such as visualizing the different gardens in their community (P1, P5), seeing the animated animals in the garden (P3, P6, P20, P22), unlocking different garden elements (P7, P9, P11), seeing their progress depicted in the form of droplets and seeds (P22), changing the types and colors of their trees and flowers (P13, P15, P17), and planting trees and flowers (P8, P22). This suggests that by using metaphorical motifs in conjunction with animations, digital platforms can offer users an enjoyable tracking experience.

7.1.2.2. Incorporating qualitative motifs into tracking strategies has the potential to help participants sustain their motivation over time. In the exit survey, we asked participants about the likelihood that they would continue using the application after the end of the study. 47% of respondents said they were moderately likely (6 participants) or very likely (2 participants) to keep using the application. Most participants cited elements related to the garden metaphor as their favorite aspect of the application when asked, indicating a strong preference for this particular design choice; “My favorite aspect... was the act of planting the seeds and droplets in my garden. I found it satisfying” (P3); “I liked the idea of flowers and trees as a representations of our progress” (P12); “I enjoyed the game of dropping the water on the tree” (P9); “planting the seeds and watering the tree never felt like a chore or hassle” (P8); “I thought the interactiveness with the seeds and water was a nice feature” (P20).

7.1.2.3. Users desire qualitative representations of their data with some quantitative aspects. Although users reacted positively to the garden motif, 9 participants expressed difficulty visualizing their progress over time to identify trends. The current version of Sprout provides a
historical view in the form of a list, allowing users to scroll through to see previous data. Instead of this format, some participants (P1, P3, P8, P14) specifically requested the use of graphs and charts: "I like the idea of the flowers and the trees more. I think that appeals to more people. But again, it would be nice to have a historical view through a graph … a traditional graph." (P8). A few participants still wanted to include the aspects of the garden in the graphs, such as depicting the heights of the trees over time to imitate the slope of the graph (P1, P8). Interestingly, P22 still found Sprout to be too quantitative due to the use of numbers of droplets and seeds to depict progress: "I think one of the things that was interesting about the app was that it still gives you numbers in droplets and seeds, which I felt was a little bit distracting and almost like contrary what it should be" (P22). Personal tracking tools cannot be standardized as different users have different preferences, with some preferring quantitative or qualitative representations, while others desiring a combination of both. Hence, developers of self-tracking tools should aim to strike a balance by understanding the unique requirements of their audience. Nevertheless, there is potential for enhancing the qualitative aspect of the current tools through the implementation of animations, as proposed by P22.

7.1.2.4. Applications with different types of visualizations are used to support users' tracking experience. When creating Sprout, we anticipated that it would serve as the main visualization provider, pulling data from other applications when needed. We found during the exit interviews that some users saw it as something that would complement the tools they were already using; they saw it as a companion application and not a replacement. When asked if they wanted to inclusion of graphs and charts in Sprout, three participants (P7, P9, P22) said no because the Health app already provided the quantitative representation they needed; “Because what this app was to me was, I would have my health app and I would have my actual number health tracking on my watch. And then this app [Sprout] would be something fun that is a rough correlate to those numbers. So I don’t think the purpose should be to replace those numbers. This is a good argumentation of those numbers.” (P22). When creating digital tools, it’s important to consider that they might serve as a supplement to current tools and address particular requirements.

7.1.2.5. External factors can reduce the importance of the type of visualization. We hypothesized that the type of visualization impacts a user’s tracking experience. This hypothesis assumes that users have the time to reflect on their data. However, a few participants reported that the type of visualization did not matter to them because of the lack of time. For example, P17
mentioned that if she does not have time to think about her health goals, she will not have time to track and reflect on her data; “when I am super busy, [the visualization] does not really matter to me... I don’t even have time to use the app.”

7.1.2.6. Garden motif elements are used as live progress indicators, enabling users to plan for more activities when needed. The number of droplets, seeds, flowers, and seeds gained throughout the day allowed users to be aware of their progress their daily goals, allowing them to take action to meet their goals. For example, P15 said she would water her tree and plant flowers in the middle of the day but would notice the shortness of her tree and the bareness of her garden. These indicators allowed her to plan for more activities to meet her goals for the rest of her day; “That was a good indicator for me for the rest of the day to keep walking, to keep trying to reach those goals.” (P15). Digital tools can help users meet their goals by increasing their awareness of their daily progress. Bringing awareness does not always equate to just sending notifications; instead, these tools should find means to encourage willful interaction; the user should come to the app and not the other way around.

7.1.3. Impacts of Sprout on Users

In this section, we focus on the impacts of Sprout on users. These impacts relate to all aspects of the application, including the visualization, the community, and the customization.

7.1.3.1. Over time, users become more aware of their health-related activities. By simply monitoring their data, numerous users were able to gain insights into their health-related behaviors. As an example, P1 previously did not pay attention to her step count, but after using the application, she became more engaged with monitoring it. P7 assumed that she consistently reached 10,000 steps per day, but Sprout revealed that her actual step count was lower. Additionally, Sprout assisted four participants (P8, P12, P14, P17) in recognizing how school negatively affected their sleep patterns. Several participants noted that in addition to becoming more conscious of their health-related behaviors, they also began to scrutinize their actions more closely to determine what they were doing correctly or incorrectly. For example, when he met his step goal for a specific day, P14 would list activities he had performed for that day, such as walking to the gym or his physical therapist; he would then try to replicate those actions as much as possible. For P15, not meeting her goals enabled her to reflect on how she prioritized other aspects of her life such as school over her health.
7.1.3.2. The application became a source of motivation for certain users to meet their daily goals. In the exit survey, we asked participants about the usefulness of the application in motivating them to meet their daily targets. Of the 17 survey respondents, 16 reported finding it at least slightly useful, with 7 finding it moderately useful and 4 finding it quite useful. Participants reported multiple instances in which Sprout caused them to perform specific actions to meet their goals. The application motivated certain users to take additional walks. For instance, P1 and P5 opted for lengthier routes, P19 walked with her friends to increase her step count, and P11 stated that when she was near her step goal and it was close to midnight, she would take breaks from studying and walk around her building. Three participants (P3, P11, P14) reported that Sprout encouraged them to go to bed early. For P11 and P3, the motivation came from the anticipation of completing their sleep goal in the morning; “I would always be motivated to sleep, and then it’d be exciting to see the next morning if I met it” (P3). Other participants were motivated by the rewards provided by the app in the form of seeds and droplets. Earning instant rewards right after a workout motivated P8 to go to the gym more, while P12 increased her gym attendance because of her desire to earn more seeds.

7.1.3.3. Tracker enabled users to enhance their existing habits. As mentioned in previous examples, some participants had already established a regular routine of certain activities before the study. However, the addition of Sprout enabled them to reinforce their pre-existing routines. P9 mentioned her annoyance at forgetting to log her workouts since she took pleasure in reviewing her statistics. Using Sprout decreased the likelihood of her forgetting, as it created “another responsibility”.

**Figure 7.2.** The ratings of each barrier statement as reported in the onboarding survey.
7.1.3.4. Certain life events can take precedence over an individual’s health goals, making the latter relatively less important. The daily routine of a college student often involves numerous activities with strict time constraints. When faced with a situation where they must pick between finishing their homework or going for a walk to meet a goal, students usually pick the former. This is consistent with the feedback provided by our participants in the pre-study survey. Most commonly, participants felt that their busy schedule did not allow them to make time for healthy behaviors (68%) and that they are too busy after work to even bother (50%), as shown in Figure 7.2. Moreover, participants found the process of being or staying healthy difficult (91%), stressful (73%), inconvenient (78%), and depriving (61%). Participants also expressed similar feelings after the study. In particular, P5 would start her day by determining whether it would be busy with homework, and if yes, she would not try to meet her step goal. Meeting her goal was a priority for P7 only when she was to it, as her busy schedule did not allow her to focus on it throughout the day; “It’s just not happening today. It was just like, throw your hands up, because I had so many things to do...I can’t do this today.” P15 recalled a particular instance where she went for a five-minute walk before midnight only because she was close to meeting her goal; “…but then other days, if I check it and I’m like so far behind…what’s done is done, you know” (P15). We argue that this approach to tracking, namely an all-or-nothing approach, stems from the nature of goal setting. The heavy focus on setting and meeting goals hides the value of making simple progress over time. Personal informatics systems should be designed to allow users to see the value in any progress regardless of its magnitude. It’s worth noting that our position is not that goal setting is unimportant; numerous research have shown its effectiveness [30, 33]. Our argument is that users should be able to recognize the significance of making progress, even if they are unable to achieve their goals.

7.1.3.5. Intrinsic motivations may not always be enough. Although the exit survey results showed that a majority of respondents felt at least somewhat motivated by the application (16/17), some users felt that it did not help as much as other existing tools. In particular, P20 felt more motivated by the financial rewards provided by the step-tracking application she had been using: “I think I was already motivated by the other track where I’m getting paid to do those things.”

7.1.3.6. The extra motivation to meet goals can be harmful in some cases. The application was developed with the idea that users should perform more of an activity, such as getting more sleep, more steps, or more exercise. Some participants had already been active and the application provided extra motivation to forgo their daily responsibilities and meet their goals. For
instance, P9 was already an avid gymgoer before the study, causing her to exercise even when she had things to do; “But I tend to go to the gym, even though I don’t have time to go to the gym. And this app didn’t help that much. Because it was even more motivation to go to the gym, even though I don’t have time, which is not a bad problem to have. But doing it every day can be kind of be bad.” (P9). Self-tracking tools should accommodate not only people who need to perform more of an action or task but also those who need to perform less. In P20’s case, the ideal tool would allow her to track her rest days and be rewarded for them; she should not be punished for resting. P19 specifically asked for such feature: “one thing I also need to be better at is taking rest days. So I wonder if that could be treated almost as importantly; something I could track and not feel guilty about because I feel like a lot of other apps make me feel guilty about not being active every single day.”

7.1.3.7. Users continue using self-tracking tools for different various. We observed that several participants continued to log their activities even after the study’s conclusion, with some logs appearing up to 30 days later. Participants identified various reasons for their continued usage of Sprout. For instance, two participants were still curious about their data and enjoyed looking at the visual motifs; “I was gonna keep using it. At the very least it shows me how much sleep I’ve been getting in a nice fashion” (P14); “I liked using the app, I liked the flowers and I liked [adding] the droplets on my own tree, even though I knew there was no chance we were gonna get any more achievements” (P10). For other users (P3, P7, P14), using Sprout just became a daily routine; “I really liked it because it was still tracking the same things. Nothing changed really after the study. So it was like still part of my routine for the past couple of days” (P3). Another reason that came up repeatedly was the app’s notifications, especially the daily reminders to water the user’s tree (P8, P20), as well as notifications about group members achieving their goals. P17 continued to log her workouts after the study ended because she had more time, while P11 reported that the application kept her accountable and motivated her to continue completing her goals.

7.1.4. Goal Setting and Completion

Throughout the study, the daily targets were modified only seven times by five participants, with each user changing their targets a maximum of two times. These changes differed from the goals established during onboarding. Over a period of 16 days, each participant had two daily goals, resulting in a total of 32 achievable goals per participant. Considering the study had 22 participants, the total number of goals across all participants was 704. Overall, the users
were able to accomplish 33% of the total goals, with an average of 10 goals per participant and a standard deviation of 4.52. The number of goals achieved varied among participants, with some achieving as few as 3 goals, while others accomplished up to 19 goals.

![Percent Goal Achievement Rate Over Time](image)

**Figure 7.3.** For each day across all participants, we determined the ratio of achieved goals to the total number of goals that could have been accomplished.

During the first week of the study, participants achieved 34% of their set goals on average, while in the second week, they accomplished 32%, as shown in Figure 7.3. We observed no significant difference in the number of goals achieved by participants between these two weeks. Figure 7.3 illustrates that the daily percentage of goals achieved fluctuated between 30% and 40% for 11 days throughout the study. The first three days showed a continuous increase in the number of goals achieved, rising from 29% to 38%. This increase may be attributed to the novelty effect of the *Sprout* introduction. In contrast, the second week experienced a decline for four consecutive days, falling from 47% to around 20%

The sections below discuss findings related to elements that may impact the importance attach to their goals, perspectives on the ideal number of data to track, and the reasons users indicated for either changing or not changing their daily targets.

7.1.4.1. *Users place different levels of value on newly established goals versus goals they are attempting to maintain.* A few participants felt that the new habits they were trying to adopt were more critical than the ones they were going to sustain. P3 valued her sleep more because she was trying to adopt better sleeping habits. This is consistent with the number of times she met her daily targets; she met her sleep goal 7 times throughout the study while she never met her walking & running distance goal. Similarly, both P5 and P8 attached more importance to
their new goals; “I cared more about distance since that was a new one that I hadn’t ever tracked where for step count, I’ve been tracking for a long time” (P5). To better assist users in achieving both their current objectives and any new ones, digital tools should distinguish between these types of goals and offer suitable assistance.

7.1.4.2. The way data is logged impacts its perceived importance. In case the phone fails to detect certain activities, users had the option to manually input log entries for their health-related behaviors. The automatic tracking feature may lose its significance for some users as it operates in a passive manner. For instance, P6 felt he had a more active choice in his workout goal than sleep goal. This is somewhat similar to P9 who was more aware of her workout goal than her step goal because it was the one she had to actively enter the data for; “I have to log my workout minutes for them for the app load it. So usually, if it was the end of the day, and I forgot to log my workouts, that was the one that I needed to do better on when the steps was just like doing it in the background.” Being more aware of her workout goal made her make a plan for when she would go to the gym and when she would log her workout. The significance of this discovery lies in its contradiction to some of the findings from our initial interviews, which suggested that users favored automatic tracking by their devices. Nevertheless, the act of manually inputting data can enhance user awareness and the value they attach to their objectives.

7.1.4.3. Accuracy and consistency of the application’s output impact goal importance. Inaccurate and inconsistent information provided by tracking tools can decrease the importance users attach to their goals. Walking distance had more value for P7 because it felt more accurate and consistent, “it felt more accurate, because the number of steps, they would vary. It just didn’t feel like consistent, it didn’t feel accurate.” According to Epstein et al. [14], data quality issues are among the reasons why individuals discontinue tracking. Our study suggests that tracking abandonment caused by concerns over data quality may initially manifest as a decline in the perceived importance of a goal due to inaccuracies, followed by a loss of motivation to track progress towards that goal, and finally, complete abandonment of tracking for that specific objective. Therefore, it is imperative for digital tools to offer precise and consistent data representation to prevent users from abandoning tracking.

7.1.4.4. The importance of a goal varies based on context. For a few participants, the importance of a goal depended on the environment and context they were in. Two participants (P8, P14) emphasized the importance of their sleep goal because of the difficulty of getting enough sleep
during the school term. Moreover, P14 started to care more about his daily step count after surgery for his leg injury. This suggests that the importance of a goal fluctuates depending on what the user cares the most about at a given time.

7.1.4.5. Goal completion rate impacts users in different ways. Achieving their daily goals allows users to keep their motivation up during their tracking journey. The opposite is also true; not meeting daily targets can lead to a decrease in motivation. P8 admitted that Sprout was more useful for her sleep tracking, but she paid less attention to it because she was not meeting her goal. Conversely, P11 placed greater importance on her step goal than her sleep goal due to the difficulty of achieving it; meeting her step goal became a personal challenge.

7.1.4.6. Societal conventions impact goal-setting. Based on feedback from several participants, understanding how to set daily goals increases the perceived importance of those goals. During onboarding, we noticed that participants would sometimes set their daily goals to either arbitrary numbers or numbers commonly believed to be good ones. P15 tracked both step count and walking & running distance but she did not know a good daily goal for walking & running distance. She set her daily step goal to 10,000 steps because of the common belief that people should be taking 10,000 steps a day. As a result, her step count numbers had more meaning than walking & running distance numbers. Similarly, P3 recounted setting her sleep goal to 8 hours because she had seen on the internet that it was a healthy amount. This indicates that individuals incorporate external knowledge when setting their goals. Consequently, digital tools should furnish adequate information during the goal-setting process.

7.1.4.7. Attempting to track many goals simultaneously can make it difficult to complete them. We asked participants the ideal number of things they would track at the same time. Most of them (16/17) reported being willing to track at most five things, with the majority wanting to track either two or three things. Participants reported various reasons for not wanting a high number of things to track, such as being too busy during the day (P7, P8), the difficulty to give all of them the same level of importance (P1, P8, P12, P14), and feeling guilty when failing to meet one of them (P6). Interestingly, only one P15 said that she would only want to focus on one goal at a time. This contrasts with other participants who specifically mentioned they would not track only one piece of data because it makes it impossible to see the relationship between different aspects of one’s life (P1), and it might lead to one quitting tracking if not successful (P7). As users’ tracking preferences and requirements vary, the number of items they
choose to track fluctuates depending on the specific questions they seek to answer. Therefore, it is essential for digital tracking tools to provide users with the flexibility to select the number of items they wish to track, based on their individual needs.

7.1.4.8. Flexible goal-setting can allow users to align their tracking to their lifestyle. The application was designed in such a way that users could only set daily goals. This approach did not seem to work for participants who wanted greater flexibility. Specifically, they expressed a need to set goals using different frequencies such every week or every other day; “it would be nice to be able to set different kinds of goals rather than just a daily number, for instance, weekly mileage. I’m training for a marathon now and I have certain targets I have for every week, but not necessarily for every day” (P19); “we work out every other day. Your workout goal is only going to be met half the time… big part of workout is having rest days and you don’t really want to feel like you’re being penalized for taking a rest day” (P7). To help users achieve their health goals, digital tools must support customized goal setting. This means enabling users to set goals for different timeframes so that they can stay motivated and align their tracking settings with their lifestyle.

7.1.4.9. Forgetfulness can prevent some users from changing their daily targets. Some users simply forgot that the application gave them the ability to change their daily target. P17 mentioned that remembering would not have made her change it because she thought her daily goals were reasonable though she was not meeting them. Users tend to forget key features of the applications they use, and digital tools could help alleviate this problem by sending reminders when the context is appropriate.

7.1.4.10. Users perceive reducing their daily targets as a form of cheating. Several participants (P3, P6, P8) expressed their dissatisfaction with the concept of decreasing their daily goals solely to fulfill them; “that one would feel like cheating, because even though I was struggling to reach the goal. I didn’t think I should lower it because I know in myself that that is the amount of sleep that I want to try to get. So lowering it would just be for the sake of being more likely to reach that goal, and not for the sake of my health” (P8). We hypothesize that this problem might be a side effect of goal-setting. By setting daily goals, users create a test-like environment for themselves, where cheating is equivalent to changing the passing grade. This is also related to one of the main downsides of goal-setting; it creates this all-or-nothing mentality that prevents users from seeing the value in their progress no matter the magnitude. Conversely, a small
number of participants reduced their daily targets to ensure that they could attain them. As an illustration, P7 reduced her daily step goal due to a demanding school schedule, which made it challenging to meet her original target. She began to feel remorseful that her community was missing out on badges, prompting her to adjust her daily goals to ensure they were more attainable. Nevertheless, reducing the daily target of a goal may result in it becoming less challenging to accomplish. Certain users attribute greater value to accomplishing their goals when they set ambitious targets; “having my other goals be something that I couldn’t consistently meet unless I actively thought about or actively tried made it feel like a goal that I got to like working towards” (P10).

7.1.4.11. The need to stay consistent can prevent some users from changing their daily targets. Some participants valued the consistency of a goal more than any other of its aspect. To them, goals were not to be changed often; users should try to complete them no matter the cost; “No, why would you change it? You can’t make it easier for yourself over this goal. It just needs to be like a set goal and you just hit it every single day” (P11).

7.1.4.12. Users experience a disparity between their level of satisfaction after completing an activity and the lack of goal completion. One of the primary shortcomings of goal-setting is that it fails to provide a comprehensive understanding of user satisfaction. For example, P8 had a 9-hour sleep goal but described always feeling great after getting 7 or 8 hours of sleep. The same scenario occurred with his workout goal; his goal was 50 minutes but felt good after getting 35 or 40 minutes. These results show that setting goals does not mean that one has to consistently complete them. Personal informatics systems with goal-setting features could help users by allowing goal-setting to be more qualitative. For instance, instead of setting a daily workout goal of 60 minutes, one could set a goal of achieving a “good” workout. However, making goal-setting more qualitative might still be a bit abstract, hence the need to combine it with quantifiable metrics such as duration. Nevertheless, setting goals using a combination of qualitative and quantitative metrics would allow users to define what goal completion means in different contexts and environments.
7.2. Influence of Customizability and Social features on Health Behaviors, Attitudes, and User Engagement

Our study consisted of four different conditions where participants tracked different health-related behaviors. These variations in data to track make it difficult to do comparisons between the different conditions. Therefore, we decided to use the number of seeds and droplets as proxies to activity, interaction, and engagement levels. This approach allowed us to compare groups and measure the impacts of the intervention.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Social</th>
<th>No Social</th>
<th>Customization</th>
<th>No customization</th>
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</thead>
<tbody>
<tr>
<td>Total usage time(min)</td>
<td>425</td>
<td>141</td>
<td>255</td>
<td>311</td>
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<tr>
<td>Total usage time (mean)</td>
<td>35</td>
<td>28</td>
<td>23</td>
<td>52</td>
</tr>
<tr>
<td>User interaction (count)</td>
<td>2560</td>
<td>710</td>
<td>1193</td>
<td>2077</td>
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<tr>
<td>User interaction (mean)</td>
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<td>142</td>
<td>108</td>
<td>359</td>
</tr>
<tr>
<td>Seeds gained</td>
<td>3033</td>
<td>2016</td>
<td>2128</td>
<td>2921</td>
</tr>
<tr>
<td>Seeds used (count)</td>
<td>2893</td>
<td>1467</td>
<td>1724</td>
<td>2636</td>
</tr>
<tr>
<td>Seeds used (%)</td>
<td>95%</td>
<td>72.8%</td>
<td>81%</td>
<td>90.2%</td>
</tr>
<tr>
<td>Droplets gained</td>
<td>2713</td>
<td>1637</td>
<td>2461</td>
<td>1889</td>
</tr>
<tr>
<td>Droplets used (count)</td>
<td>1925</td>
<td>1069</td>
<td>1510</td>
<td>1483</td>
</tr>
<tr>
<td>Droplets used (%)</td>
<td>71%</td>
<td>65.3%</td>
<td>61%</td>
<td>78.5%</td>
</tr>
<tr>
<td>Goal achievement (count)</td>
<td>139</td>
<td>91</td>
<td>115</td>
<td>115</td>
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<tr>
<td>Goal achievement rate (%)</td>
<td>36%</td>
<td>28.4%</td>
<td>33%</td>
<td>33%</td>
</tr>
<tr>
<td>Screen views (count)</td>
<td>2020</td>
<td>322</td>
<td>890</td>
<td>1452</td>
</tr>
<tr>
<td>Screen views (mean)</td>
<td>168</td>
<td>32</td>
<td>81</td>
<td>132</td>
</tr>
</tbody>
</table>

7.2.1. Influence of customizability on activity levels, goal achievement, and user engagement

The customization features were used 26 times in total by 6 participants out of 11 (the number of participants in the customization condition). Surprisingly, customizability did not have a significant effect on participants’ health-related behaviors. Specifically, participants in the non-customization condition gained more seeds than participants in the customization condition, a 31% difference as shown in Table 7.2. However, participants in the customization group did gain more droplets, with a difference of 26%. However, we found no significant difference between the number of seeds and droplets between the customization and non-customization conditions, using the Mann-Whitney U test.

Regarding goals, participants who had the ability to customize their garden completed a nearly identical amount of goals compared to those without customizability features: 33% vs. 33%, respectively. This marginal difference was not statistically significant.
Customization did not significantly impact daily goal completion rates between the two conditions. In fact, there are five days where the two conditions have equal goal completion rates. 

Similarly, customization did not seem to have much of an impact on people’s engagement with the app, as shown in Figure 7.5. Participants in the non-customization condition had more usage time (311 minutes vs 244 minutes) and more interactions (2077 interactions vs 1192 interactions) with the application than users in the customization condition. Other engagements were also higher for participants in the non-customization groups; they used more seeds (90% vs. 81%), used more more droplets (79% vs. 61%), and viewed more screens (1452 views vs 890 views), as shown in Table 7.2; however, we found no significant difference. Moreover, we found no significant difference in the user engagement and motivation survey responses participants filled out after the study, using the Mann-Whitney U test.

We present below findings related to customization including reasons that may have contributed to the lack of significant impact during the study.

7.2.1.1. Some users prefer to stick with their default options. Participants in the customization condition had the opportunity to customize the types and colors of their tree and flowers
during onboarding. Users reported picking the options they liked the most at the beginning of the study (P3, P5, P6, P13); “it felt like a character customization type of thing, you choose your character at the beginning and that’s kind of guy that you roll with” (P6). These findings suggest that the effects of customization are difficult to measure in such a short study, namely a 2-week period. Although the study results (i.e. activity levels, goal achievements and user engagement) do not show any significant impact of customization, it would be premature to conclude it cannot play an important role in a user’s self-tracking journey. A longitudinal study should be done to thoroughly investigate the possible impacts of customizability.

7.2.1.2. Customization may not be a critical feature for everyone. They mentioned that it was not a feature they would use on a daily basis. For example, P3 likened changing colors to changing the wallpaper on her phone; it is something she does every month or so. P14 cared more about the consistency of his flowers and did not see the application as a platform he’d be on frequently. This is consistent with our earlier finding which showed how some users viewed Sprout as a companion application used to complement existing applications.

7.2.1.3. Lack of time can prevent users from personalizing their experience. This also accords with our earlier observations, which showed that lack of time as being a barrier for users; “But I do think for me is more like, if I have time, I would. Time is definitely a really important factor for me. If I have time, I can spend more time on thinking if I want to build a beautiful garden, design the tree, the color of the trees and type of tree” (P17). These findings highlight a key issue with self-tracking tools: while they can be effective in promoting healthier habits, they cannot directly provide users with more time. However, digital tools may still assist users in organizing their lives to make time for pursuing their health goals.

7.2.1.4. Users desire a reward system that allows them to unlock features. Participants in the customization conditions had all the customization features available to them at the start of the study; they did not have to unlock them. Surprisingly, this design may have resulted in customization being less appealing to users. By not having to work for the customization options, users may have felt less invested in the customization process. Talking about this issue P7 said: “I get the idea of having options and picking one that you like, but I also like the opposite side of that, not having options. You very much want to fight for them [the options] way more than just them being given to you.” When asked about the same topic, P1 said “I wish I could unlock new colors and then it would be more fun and exciting. And then you could see and say
.oh, wow, my trees, the new color that we all just unlocked.” This suggests that creators of personal informatics systems should carefully consider the design of their customization features, including how they are introduced and accessed, to ensure that they are both engaging and rewarding for users.

7.2.1.5. Social interaction is a sought-after element by users in their self-tracking journey. During the study, participants in the customization groups were using a version of the application that lacked social features, and were not informed about the existence of alternative versions that did include social features. Some of these participants expressed interest in having social aspects added to their version of the application; “Having some community aspect that isn’t comparing goals because that’s bad. But something along those lines, something to involve other people would be nice” (P14); “But I think really bringing in Yeah, just the social aspect would be motivating. And it’d be nice to be able to congratulate friends on meeting their goals” (P19).

7.2.2. Influence of social features on activity levels, goal achievement, and user engagement

Overall, participants with social features fared far better than those without. Specifically, participants in the social condition gained more seeds (40% difference) and droplets (50% difference), as shown in Table 7.2. However, we found no significant difference between number of seeds and droplets in either condition, using the Mann-Whitney U test.

![Figure 7.6. Participants with social features had a higher daily goal completion rate 12 days out of 16.](image)

Regarding goals, participants who received social features completed 36% of their goals on average, while participants without social features completed only 28.4% of their goals on average. Similar to the seeds and droplets gained, we found no significant difference.

Unlike customization, social features had a significant impact on people’s engagement with the application, as shown in Figure 7.7. In the social condition, participants spent more time...
on the app (425 min vs. 141 min), had more interactions with the app (2560 times vs. 710 times), and viewed more screens (2020 views vs. 322 views), and used more seeds (95% vs. 73%) and droplets (71% vs. 65%) as shown in Table 7.2. Using the Mann-Whitney U test, we found significant differences between the conditions’ usage time (U = 29.5, Z = 1.978, p < 0.05), number of interactions (U = 21, Z = 2.389, p < 0.05), and number of screen views (U = 3, Z = 3.726, p < 0.05), and user engagement survey score for both UES (U = 9, Z = 2.555, p < 0.05) and UTAUT (U = 12, Z = 2.261, p < 0.05). Analyzing qualitative data on people’s reactions to social features such as badges and community messages can provide insights into both the positive and negative effects of social conditions.

7.2.2.1. The lack of participation from group members can be a source of frustration. Unlocking new features required cooperation among group members; people had to rely on one another. A few participants complained that the same users were always active; “I feel like there’s usually a pattern of the same few trees are just not grown at all . . . in my group, there were only really three active users. And everyone else would just be like, oh, nothing’s happened” (P1). Some other participants harbored stronger emotions towards their inactive group members. For instance, P7 felt so frustrated that she would often have to calm herself down, “I was frustrated with them so much and I had to calm down. I’d be like, it’s not that deep . . . but it would just really upset when we wouldn’t hit the goals” (P7). Her frustration primarily stemmed from her perspective that humans are inherently independent creatures by nature; “…in health . . . your progress is your own, like nobody else can carry that for you. And you can’t rely on anybody else. But in this case, you do have to rely on other people to meet a communal goal” (P7). She would have preferred to work alone rather than with a group; “It is terrible. I hate it. Because I if it were me, I could
have gotten it done. I mean they were holding me back. That’s what it was. They were holding me back and that was so frustrating.” Like P7, P11 also experienced similar frustration with group members, perceiving that “they were not trying hard enough”. She expressed a preference for individual sports, citing how she did not like “to rely on other people to get things done.” These feedback suggest that incorporating social features can be an effective strategy for increasing user engagement in personal informatics systems. However, it is important to recognize that some users may prefer to track and achieve their goals independently. As demonstrated by the experiences of the participants mentioned earlier, personal informatics systems should cater to both social and individual preferences. By offering a range of features that accommodate different user needs, personal informatics systems can promote sustained engagement and ultimately lead to better health outcomes.

7.2.2.2. The lack of participation from group members can lead to tracking abandonment. When asked how likely they were to continue using the application, two participants expressed their willingness to continue but only if their community had active group members; “I’d like to keep using the app, but if I’m not with a community that uses it as well, then there isn’t really any motivation” (P7); “I would like to continue using it if I had others to use it with, but it looks like others in my community aren’t using it as much” (P9).

7.2.2.3. The ability to visualize the progress of other members is a desired feature among users. The only way for users to see the progress of a member is by looking at the size of their tree; the number of flowers in their was not useful because flowers were distributed equally among group members. As a result, participants had difficulty visualizing other members’ progress and they wanted other ways to visualize a specific member’s progress instead of just relying on the size of their tree (P7), more opportunities for interaction with individual gardens (P3, P7, P8), and to stop the reward sharing mechanism where all flowers are distributed among group members (P11). In an anecdote regarding the latter, P1 recounted taking over her community’s garden by planting her flowers; “And then another time, I went on a hike. So I think I had a ton of steps. And I was like, I just want to plant flowers and take over everyone’s garden.”

7.2.2.4. Complete anonymity may not always be the preference of users. The application provided full anonymity, revealing only the garden’s name of a fellow group member along with their chosen tree and color; they did not even know what other group members were tracking. As a consequence, this created a lack of personalized identity as participants noted; “there was
no individualizing factor... everyone’s just kind of the same” (P6), “it was just a little bit boring when you couldn’t see [who they were], because usually there is an avatar like a name or something, there’s usually some unique identification, right? There’s like a profile picture, there’s a description. But with these, it was just like a name” (P7), “maybe if you had an avatar… walking in their garden” (P8). Participants provided a number of recommendations to decrease the level of anonymity including ability to create of personalized avatars (P3), know what other people are tracking (P6), and share common interests (P3). One participant (P7) went as far as saying that she would have chosen to not be anonymous if we restarted the study; “If we restarted [the study] and I had the option, I probably would have chosen to not be anonymous. I would probably want to know who’s in the community and, I would want them to know who I was.” One participant mentioned that she would have used the app more if she had known the other members of her group, “I think if I did it with people I knew I would use it more often to achieve my goals” (P11). Participants’ feedback suggests that the level of anonymity provided by the application may have hindered their ability to relate to each other. This highlights the importance of incorporating user-controlled anonymity features in digital tools, where users can choose the amount of information they are willing to disclose. By giving users greater control over their privacy, personal informatics systems can facilitate more meaningful interactions while preserving users’ comfort levels.

7.2.2.5. *Earning rewards can serve as a motivating factor.* Seven participants in the social condition reported that the reward mechanism provided by the badges increased their motivation to meet their daily goals. Earning badges increased their motivation by providing a fun gameplay (P1, P3), creating an excitement to unlock new features (P3, P9), and creating a sense of responsibility to contribute to the community (P8, P11). As P8 put it: “[the badges] meant that you weren’t solely responsible. It meant that you would want to step up and help yourself and help the community so that more people could reap the rewards. So I like how it felt like teamwork to reach more badges and unlock more features.” P1 recounted having a change in attitude regarding the badges; “I was pretty doubtful of them at first, but it was actually fun to see. Sometimes we’d be really close and someone in the community would message [to encourage]. It definitely gave everyone something to move towards to.”

7.2.2.6. *Some users prefer cumulative rewards.* We were also interested in learning if participants had any suggestions or recommendations on the reward mechanism. Some of them recommended changing the frequency of the rewards, switching from daily to weekly rewards...
which would in turn eliminate the need to reset garden daily, which was something participants did not enjoy as much; “it bothered me that there wasn’t a cumulative garden. I thought I would get to design something big but that never happened. It was basically the same garden day in and day out” (P20).

7.2.2.7. The possibility of earning rewards can induce feelings of pressure and guilt. While earning rewards had its benefits, it was not entirely positive. Some participants reported feeling pressure and guilt while striving to complete their goals. Talking about this issue, P8 said: “I personally, sometimes would feel bad because I knew there like three nights in a row where like, I didn’t hit my sleep goal. I’m partly responsible for why my whole community is not going to get this dog house.” P6 recounted having similar feelings: “[it was] a bit of pressure if we didn’t unlock a badge and it was like 45% and you are like I could have been the one to push it over the edge.”

7.2.2.8. The possibility of earning rewards can become a frustrating aspect of a tracker. Some users associated earning badges with frustration towards other group members. These individuals were frustrated that the same members were consistently active and contributing to the community’s success. Members were frustrated by the unreliability of some peers, which made it challenging to achieve badge-earning goals; “[the badges] were the most motivating thing about the app but also the most frustrating, because it wasn’t something that I could do by myself. You know what I mean? I was like, why are you guys like this? you know, my community, they didn’t do it didn’t do anything…It was so frustrating. And that was very upsetting to me, because we’d be so close. Some days, we’d be like, 48% or something, and one person would have to do it, and they wouldn’t, and it would be so annoying. I’d be like, I want a dog so badly” (P7). One participant (P11) likened his experience to a typical school group project in which not all members contribute equally.

7.2.2.9. The level of communication between group members decreases over time. By the end of the study, participants in the social condition had exchanged a total of 20 messages, comprising both direct and community messages. During the study, participants sent a total of 19 group messages, with 15 of them sent within the first 6 days as seen in Figure 7.8. The daily number of community messages ranged from 0 to 5. Of the 11 individuals in the social condition, 6 sent messages to their respective groups. The number of group messages sent by participants using the messaging feature of the app ranged from 2 to 5.
7.2.2.10. **Sending direct messages to unknown individuals is generally not preferred by users.** The total of messages sent was throughout the study was 20. Surprisingly, only one direct message was sent during the entire study, with the remaining 19 messages being community messages. The number of messages sent by individuals who used the messaging feature ranged from 1 to 5. Some participants provided specific reasons for their hesitation to send direct messages, all of which were related to Sprout’s anonymity. For example, 6 participants cited the fact that other group members were strangers; “I didn’t know who those people were, why would I really need to do that [to message]?” (P1); “there wasn’t a rapport already built…we didn’t really have anything to talk about” (P7); “because it was anonymous, I didn’t see a reason to message one individual person” (P8), “there’s not that much to talk about, because you don’t really know them that well” (P9); “I wouldn’t feel comfortable doing that because I had no idea who it was” (P10); “…random people…we didn’t know anything about them” (P11). Similarly, some participants mentioned the absence of individualizing factors; “it felt like we were all almost like identical subunits of a bigger group ” (P8), “I didn’t know where people were at in their specific health journey” (P3). The feedback provided by users underscores the importance of personal informatics systems that enable users to connect with individuals they are already familiar with. The participants’ reluctance to send direct messages on Sprout due to anonymity suggests that users prefer to interact with people they already know or share some degree of familiarity with. An alternative approach could be to enable users who do not know each other to establish a rapport through the platform. Incorporating features that facilitate introductions and foster community could be an effective strategy for minimizing the impact of the lack of already established relationships in personal informatics systems.

![Figure 7.8](image)

**Figure 7.8.** The number of community messages sent over time decreases throughout the study
7.2.11. **The fear of being seen as odd can deter users from sending direct messages.** Even though the platform ensured complete anonymity, some users still experienced apprehension that they may be perceived as peculiar when sending direct messages to other members; “*I felt a little weird because I wondered how they were going to see it*” (P6); “*when you are the receiver, it’s great that someone reached out to me and wants to meet up. But as a sender, I thought that maybe they are going to be weird about it*” (P5).

7.2.12. **Group messages containing words of encouragement were the most commonly sent by users to other group members.** As indicated by the 19 group messages that were sent, participants showed a greater willingness for messaging within their groups rather than via direct messages. Messages of encouragement accounted for 47% of the total number of group messages sent. Other types of messages included congratulatory, informational and apologetic. Table 7.3 presents some quotes of the group messages that were sent during the study.

<table>
<thead>
<tr>
<th>Message Type</th>
<th>Example Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encouragement</td>
<td>“Come on guys we need one more goal (P6).</td>
</tr>
<tr>
<td></td>
<td>“We’re on the homestretch!! let’s get to 50%!” (P8)</td>
</tr>
<tr>
<td></td>
<td>“just need one more person to achieve one of their goals today-yall got this!” (P5)</td>
</tr>
<tr>
<td></td>
<td>“let’s go guys we need those badges” (P1)</td>
</tr>
<tr>
<td></td>
<td>“almost halfway to goals! keep walking, working out, stepping, etc!” (P8)</td>
</tr>
<tr>
<td></td>
<td>“1/3 of the way so far for today! keep it up” (P8)</td>
</tr>
<tr>
<td>Congratulatory</td>
<td>“Good job everyone! Woohoo we got cloud!” (P9)</td>
</tr>
<tr>
<td></td>
<td>“yay guys many goals completed today!” (P11)</td>
</tr>
<tr>
<td></td>
<td>“y’all we crushed this today” (P1)</td>
</tr>
<tr>
<td>Informational</td>
<td>“I just ran crazily around collis but step goal is complete!” (P11)</td>
</tr>
<tr>
<td></td>
<td>“just completed my goals for the day” (P5)</td>
</tr>
<tr>
<td></td>
<td>“it was daylight savings everyone add an extra hour to your sleep :)” (P1)</td>
</tr>
<tr>
<td>Apologetic</td>
<td>“Guys I forgot to log my workout before midnight. I’m so sorry.” (P6)</td>
</tr>
</tbody>
</table>

7.2.13. **The ability to communicate with group members can foster a sense of community.** We asked participants whether they experienced a sense of community, and if so, what factors contributed to it. A common theme that emerged from the responses to this question was that the ability to send messages to the group played a significant role in developing a sense of social connectedness. For example, P9 appreciated the support messages sent by her group members: “[I felt a sense of community] because of the community messages. I sent three messages but there are other people that sent some too. And if it was like 9pm and [the group message] says we are so close and you at this, it made me feel supported even though I did not know who it was.” P12 also credited the encouragement messages that people in her group would send as
contributing significantly to her sense of belonging, “[I felt a sense of community] because I was getting messages from them; they were cheering us up”. On the other hand, for some users, the ability to send messages had the opposite effect. Specifically, P3 perceived that the reduction in the number of messages created a more autonomous feel to the overall experience. As seen in Figure 7.8, the number of messages sent by participants did decrease over time. However, the sense of community experienced by some participants in the social condition may have played a crucial role in boosting their motivation to achieve both their personal and community goals. Digital tools can assist users in achieving their health goals by providing features that facilitate seamless communication with other users.

7.2.2.14. Despite an application having community features, some users can still feel disconnected from their group. Participants identified multiple reasons for this disconnection. Section 7.2.2.9 discusses the decrease in the number of group messages sent over time, while other reasons for this trend include the absence of a physical component (P6) and insufficient information about other group members (P7). More details on the latter issue are also provided in section 7.2.2.4 which talks about the impacts of the anonymous nature of the application on users.

7.2.2.15. Despite some users’ preference to track their progress with friends, they acknowledge both benefits and drawbacks when compared to tracking with strangers. This preference for tracking with friends stems from the issues users identified in sections 7.2.2.10 and 7.2.2.11. Participants highlighted several benefits of tracking with friends, including increased accountability due to a pre-existing community (P7, P14), more opportunities for interactions outside of the app (P7, P8), ease of connecting with friends rather than strangers (P11), and greater incentives to send direct messages (P5, P9, P12). Participants primarily identified the potential downside of tracking with friends as creating unhealthy comparison, highlighting a difference between comparing oneself to friends versus comparing oneself to strangers.
8. Limitations and Future Work

While our research sheds light on the effects of qualitative visualization, customizability, and social elements, it is crucial to acknowledge the limitations of our work and explore potential avenues for future research. First, the study’s duration and timing might have impacted the manner participants engaged with the application. It is essential to bear in mind that self-tracking can either be a short-term or long-term practice, with short-term tracking lasting many weeks or months. The limited duration of our study, which only lasted 16 days, might have created challenges in accurately measuring the impact of the intervention, particularly in relation to the customization aspect of the application. Solely analyzing the quantitative data might suggest that the ability to personalize the visual experience does not play a significant role in a user’s tracking experience. However, as we have found, customizability might not be a feature that people use on a daily basis, as most prefer to stick with their default choice until they feel the need to change it, which varies based on the user. As one participant put it, using the customization features is similar to changing one’s phone wallpaper, which is something users do not do frequently. Furthermore, the timing of our study may have also contributed to certain limitations in our results, as it was conducted during the final two weeks of the term, which are typically the busiest for students as they complete assignments and prepare for finals. While our qualitative results suggest that customizability has potential, longer studies are needed to accurately determine the impact of customizability on self-tracking.

Second, participants had limited customization options, as they could only change the types and colors of their trees and flowers. As a result, users were restricted when personalizing their garden, as other garden elements such as animated animals were not customizable. Our analysis revealed that limited engagement with the customization features could be attributed, in part, to a lack of options that appealed to all users. Specifically, some participants expressed dissatisfaction with the available choices for customizing their interface. To enhance users’ sense of ownership and engagement with the garden motif, future research should investigate different options for personalizing data visualizations.

Third, our study relied on users opening the application for their data to be automatically logged. While this helped us measure disengagement with the application, it also led to missed data points because some users forgot to open the application. Additionally, we did not allow for retroactive logging, which meant that data could only be logged for the current day. Al-
though the data might point to some users not meeting their daily goals, having those missed data points might have told us a different story. We took the missed logging into account during data analysis; however, it may be beneficial for future systems to incorporate automatic logging that does not rely on users opening the application and to support retroactive data logging.

Finally, our application offers a high level of anonymity, preserving users’ identities and the data they track. However, we also recognize that some users may feel a sense of disconnection from others when tracking their health behaviors with strangers. While our research has demonstrated that social features can positively impact activity levels and health behaviors, some participants have voiced concerns about the lack of connection and shared interests with unfamiliar tracking partners. While this gives an exciting opportunity to study the effects of social tracking with familiar individuals, it also raises the important question of how to balance users’ desire for connection with their need for privacy. Specifically, we must consider users who may be hesitant to share sensitive data such as mental health and medication.
9. Conclusion

This paper introduced Sprout, a novel mobile self-tracking application that uses a garden-themed qualitative visualization, customizable features, and social support to motivate users to meet their health-related goals. Our study aimed to investigate the impact of qualitative visualization, customizability, and peer support on activity levels, goal achievement, and user engagement in a self-tracking application. To achieve this, we conducted a two-week study with a cohort of 22 participants, comparing their usage of Sprout with and without social and customization features. By comparing the different groups, we were able to assess the specific effects of these features on user behavior and outcomes.

Our analysis revealed that users generally respond positively to the use of qualitative data visualizations while self-tracking, as it improves the overall user experience and helps sustain motivation towards achieving their goals. Despite the overall positive responses, some participants expressed a desire for a mix of both quantitative and qualitative representations of their data. Our findings suggest that qualitative data visualizations should not be seen as a replacement for quantitative data visualizations for all users. Instead, incorporating qualitative visualizations can enhance existing visualization techniques and provide users with a more personalized self-tracking experience. Unfortunately, our study did not find significant effects of customizability on user engagement or goal attainment. We believe that the lack of impact can be attributed to the limited range of customization features available in Sprout and the short duration of the study. The application’s current customization options may not have been sufficiently varied or tailored to the individual preferences of users, which could have limited their engagement with the app. Additionally, the two-week study period may not have been long enough for participants to fully explore and take advantage of the customization features. Future studies could explore the impact of more extensive and tailored customization options over a longer duration to better understand the potential benefits of customizability in self-tracking apps.

While the impact of social features on goal attainment was not statistically significant in our study, we found that they had a significant positive effect on user engagement. Participants who used Sprout with social features reported higher levels of motivation, accountability, and enjoyment compared to those who used the app without them. Despite the positive impact of social features on user engagement in our study, some participants reported experiencing neg-
ative effects. Specifically, some users mentioned feeling guilty when they did not contribute to the community goal. Moreover, frustration with inactive members and discomfort communicating with strangers were cited as reasons for disengagement with the social features. These negative experiences highlight the importance of balancing the benefits of social support with the potential drawbacks, and designing social features in ways that mitigate these negative effects.
Bibliography


[22] Ryan Lumber, Miles Richardson, and David Sheffield. "Beyond knowing nature: Contact, emotion, compassion, meaning, and beauty are pathways to nature connection". In: *PLoS ONE* 12.5 (2017), e0177186. DOI: 10.1371/journal.pone.0177186.


A. Formative Interviews

This project aims to create an interpersonal informatics tool that explores how visual metaphor and customizable data encoding can support collaborative health management. Our current audience is college students. We are currently user-testing informatics interfaces for an application that enables collection of health data from multiple users and visualizes that information in a metaphorical way. These interviews will provide vital user research that we need to validate/modify/reject assumptions we have made throughout the project, in order to refine our app to make it inclusive and useful for the users. The interview will be roughly 20-30 minutes long. The interviewer will ask you a list of questions and will take notes about your responses. The interviewer will also give you handouts and color pencils; they will instruct you what to do, but no answer is wrong!

Data Tracking

Q1. What is your current experience with tracking? Have you stopped? [If the interviewee does not track, skip to question 11]

Q2. What do you track? If not, what would you like to track? [interviewer will go through the Apple health app with the interviewee) (take notes of what the interviewee would track, if any)]

Q3. I would love to hear more about when you started self-tracking? And why did you decide to start?

Q4. Have you noticed any changes in your behavior as a result of your tracking practice?

Q5. Here is a list of trackable things that are not part of the Apple Healthkit; do any of these interest you? If so, which one? If not, why? [Provide another list of trackable things that are not part of HealthKit - check handout]

Q6. Please could you rank the things you said you track/would track? [Give ranking handout to interviewee]

Q7. You said that you don’t track- I would love to hear about why?

Q8. Would you be interested in tracking elements of your life? Why/ Why not?

Q9. What would you like to track in your life?

Data Visualization

Show the three designs for visualization. Explain our vision; mapping their data to elements in scenes, using a metaphor-based approach. Let the interviewee draw on the handouts.

Q1. What do you like?

Q2. What do you not like?

Q3. What would you change/remove/add?

Q4. What are your thoughts on being able to customize the scene ie. choosing what visuals you want to represent what you track?
Q5. Please rank the ‘personal view’ scenes 1-3 (favorite to least favorite)? Could you explain why?

Q6. Please can you rank the ‘community view’ scenes 1-3 (favorite to least favorite)? Could you explain why?

Q7. Can you think of other scenes (to display tracked data)?

Q8. What do you think about the community aspect of our idea? Ie. the ability to see other people’s scenes and/or interacting with them?

Q9. Do you have any data privacy concerns? If so, what are they?
B. Onboarding Guide

This interview will take about 45 minutes. There are no right or wrong answers to these questions; we are interested in knowing what you really think. You may refuse to answer any questions which you are uncomfortable answering. You may stop this interview at any time. The research team will protect any information you provide, which will be used only for research purposes and not reveal who you are. You will not be identified in any publication from this study. Before I start, may I audio record our conversation? The research team will protect the recordings and will only use them for later reference while organizing our study notes.

Goals & Motivations

Q1. Why do you track or want to track health?
Q2. Is there anything you have been tracking? What tools/app have you used (digital or physical tool)?
Q3. Is there anything that could motivate you to track your health more?
Q4. What do you dislike about tracking / What would make tracking less boring or more fun?

Aesthetic preferences

Q1. What was the your first impression of the app
Q2. What do you think about using trees and flowers instead of graphs to display data?

Social

Q1. With whom do you track? [Probes: self, spouse/partner, friends, child(ren), co-workers, etc.]
Q2. What do you think about the community aspect of our idea?
C. Offboarding Guide

Thank you for participating in our research study! I will now ask you several questions about your experience over the last few months. This interview will take approximately 45 minutes. There are no right or wrong answers to these questions; we are interested in knowing what you really think. Before I start, may I audio record our conversation? The research team will protect the recordings and will only use them for later reference while organizing our study notes.

Overall experience, including with our app

Q1. Were there any problems you encountered while using our app during the study?

Q2. Has there been anything particularly confusing while using the app? What have you disliked about your experience with the app?

Q3. Has there been anything you found delightful while using the app? What have you liked about your experience with the app?

Q4. Did the app remind you of any other app, technology, or non-digital experience you’ve used/had in the past?

Garden Display

Q1. What was it like to see your activity status and goals being visualized through a garden metaphor/image? Would you have ever preferred to see more traditional charts and graphs of your data vs. the more artistic visualization?

Q2. Would you be receptive to keeping this sort of image as your wallpaper? Why or why not?

Q3. [for participants in the social condition]
   1. Did you like having the community interfaces and features? Why or why not? (e.g. badges, unlocking community features, community messages)
   2. Did you feel a sense of community with the other people who were tracking with you?
   3. What was it like doing it with a group of people that you did not know (essentially strangers)?
   4. Would you prefer to do it with friends or people who you do know in real life? Why or why not? If so, who might you like to track with?
   5. Did you have any concerns about privacy when tracking in this sort of social environment?

Q4. [for participants in the customization condition]
   1. Did you use the customization features?
   2. [If yes] what prompted you to customize? Did you find changing those features compelling (tree & flower, color)? What would you have liked to customize instead?
3. [If no] why not? Did you forget you could change things? What would have made customization more appealing?

**Q5. [for participants who kept tracking after the official end of the study]**

- I noticed that you continued to open the app and even meet some goals after the study officially ended, which was really cool to see! Can you describe what motivated you to keep using the app even though it was not technically required anymore?

**Motivation with health behavior**

**Q1.** Were these new healthy behaviors you were hoping to adopt? Or something you were already doing and committed to?

- [For new behaviors] In what ways did the app help you begin these new habits?
- [For existing behaviors] In what ways did the app help you stick with these habits?

**Goal achievement**

**Q1.** How did you pick what goals to set?

- Was one of these goals more important to you than the other? How so?
- If you could pick the number of behaviors / goals to track, how many would you prefer? (Just 1? 2 like in the study? 3? more?)

**Q2.** Did you change your goals over the course of the study?

- [If yes] Why did you change your goals? Please elaborate (what triggered you to change a goal, under what circumstances did you change your goal, etc).
- [If no] Why not? Did you ever think about changing your goals, to be either harder or easier? Please explain.

**Q3.** Were there any specific moments where the app helped motivate you to complete your goals?

**Q4.** Are you satisfied with your performance towards achieving your goals?

**Participant-specific questions**

**Q1.** [Reference the list here for any interesting/unusual/etc behaviors each specific participant exhibited during the study that we want to inquire about during the interview.]

**In-app usage**

**Q1.** When did you use the app? Did you start to build a routine around using the app (e.g., checking before bed?)

**Q2.** Did you ever need to manually add activities (rather than having the app automatically track X and Y)? Why?
Q3. How could the app have been better for you? [Potential prompts: features, functions, services you wish the app to have.]

Q4. Potential prompts: features, functions, services you wish the app to have.

Q5. Has there been anything about using the app that you found particularly motivating?

Q6. What do you feel about the notifications from the app? (e.g. Daily reminder to check app, when group member achieved their goal, end-of-day summary)

**Extenuating events during the study**

Q1. Did any events take place over the study period that may have impacted your behavior (caused you to X/Y more or less)? [Can prompt about: heavy school work / exams, sporting events, travel]

**Social**

Q1. Did a friend, family member, coworker, stranger, or anyone else ever notice you using the app or ask you about the Sprout garden?

Q2. Any other noteworthy interpersonal experiences you had related to the app?

**Wrap-up**

Q1. Those are all the questions I have for you. Is there anything about healthy behavior that you would like to mention that we haven’t not covered so far but you’d like to tell us?

Q2. Anything else about your experience with the app you’d like to tell us?

Q3. Anything else you would like to share with me?

Thanks! This is the end of the interview.