TÉCNICO LISBOA

DAN & Danny: Self-Tracking for Managing Well-Being in College Settings

João Raimundo Nogueira

Thesis to obtain the Master of Science Degree in

Information Systems and Computer Engineering

Supervisor: Prof. Hugo Miguel Aleixo Albuquerque Nicolau

Examination Committee

Chairperson: Prof. David Manuel Martins de Matos
Supervisor: Prof. Hugo Miguel Aleixo Albuquerque Nicolau
Member of the Committee: Prof. Augusto Emanuel Abreu Esteves

January 2021

Acknowledgments

Before anyone else, a special thanks to my Dad for the countless hours we spent soldering, desoldering, and soldering everything back again. Thank you for your help and for advising me. Without you, this project would not be possible. I would like to thank all my family for being there and helping me throughout these years, for their understanding, caring, support, and for helping me deal with all the stressful situations.

I want to thank my dissertation supervisor Prof. Hugo Nicolau for all the support, guidance, and motivation that made this project possible and which I am really proud of. Thank you for trusting me and for all the opportunities which helped me grow as a person. This work was supported by FCT through the project ARCADE (PTDC/CCI-COM/30274/2017).

I would like to acknowledge NAPE for their help throughout this thesis, for their insights and knowledge, and for helping me recruit students for my user studies. With that in mind, I would also like to thank everyone that participated in my user research and my final user study.

Last but not least, I want to thank all my friends and colleagues that helped me grow as a person and were always there for me when I needed them.

To each and every one of you – Thank you.

Abstract

Students who enter college face challenges that can negatively influence their well-being. Furthermore, college students are amongst the least likely to consult health professionals during an emotional crisis. The problems students face and lack of help-seeking, means they often manage their well-being by themselves, which can lead to further complications. Latest approaches leverage user-generated data to infer well-being issues, yet there is a lack of solutions that support the students' needs and allow collaboration with stakeholders. Additionally, these tools focus on quantitative data, lacking context and privacy provided by written qualitative data. Following the trend of Personal Informatics, we propose digitally augmented notebooks for students to self-track well-being. With that in mind, we created a flexible system to attend various needs, offering feedback through visualizations that can be shared with stakeholders. These tools should help college students manage their well-being by increasing their self-awareness and self-reflection and by easing data-sharing and help-seeking. Finally, we conducted a study to assess the effectiveness and acceptability of our approach. Furthermore, we also provide an analysis of well-being among college students. Findings show that stress, productivity, and sleep are the most impacted dimensions, mainly caused by an excessive workload. These problems are exacerbated by poor help-seeking behaviours. Participants confirmed that our approach helped manage their well-being by increasing self-awareness. Nevertheless, acceptability issues indicate some users prefer a digital-only approach, and we were not able to evaluate the value of data-sharing. There is also an opportunity to add functionalities to ease problem-solving and goal-setting techniques.

Keywords

Self-tracking; Self-awareness; Self-reflection; Help-seeking; College; Well-being

Resumo

Estudantes que entram na faculdade enfrentam desafios que podem influenciar negativamente o seu bem-estar. Além disso, estudantes universitários estão entre os que menos consultam profissionais de saúde durante uma crise emocional. Os problemas que os alunos enfrentam e a falta de procura de ajuda significa que normalmente são eles que gerem o seu bem-estar. As abordagens mais recentes aproveitam os dados gerados por utilizadores para inferir problemas de bem-estar, mas faltam soluções que correspondam às necessidades dos alunos e permitam a colaboração com entidades interessadas. Adicionalmente, essas ferramentas focam-se em dados quantitativos, perdendo o contexto e privacidade oferecidos por dados qualitativos escritos. Seguindo a tendência de Personal Informatics, propomos cadernos digitalmente aumentados para automonitorização do bem-estar. Com isso em mente, criámos um sistema para atender várias necessidades, oferecendo feedback a partir de visualizações que podem ser partilhadas com outros. Estas ferramentas deverão ajudar estudantes universitários a gerir o seu bem-estar, aumentando a sua autoconsciência e autorreflexão, e facilitando a partilha de dados e procura de ajuda. Conduzimos um estudo para avaliar a eficácia e aceitabilidade da abordagem e para analisar o bem-estar entre estudantes universitários. Resultados mostram que stress, produtividade e sono são as dimensões mais impactadas, causado principalmente por carga excessiva de trabalho. Estes problemas complicam-se devido a comportamentos inadequados de procura de ajuda. Os participantes confirmaram que a nossa abordagem ajudou a gerir o bem-estar, aumentando a sua autoconsciência. No entanto, problemas de aceitabilidade indicam que alguns preferem uma abordagem exclusivamente digital, e não fomos capazes de avaliar o valor da partilha de dados.

Palavras Chave

Automonitorização; Autoconsciência; Autorreflexão; Procura de ajuda; Faculdade; Bem-estar

Contents

1 Introduction **1**

1.1 Problem . . . 3

1.2 Approach . . . 4

1.3 Contributions . . . 4

1.4 Paper Submission . . . 5

1.5 Document Structure . . . 5

2 Related Work **7**

2.1 Background . . . 9

2.2 Personal Informatics and Quantified Self . . . 10

2.2.1 mHealth . . . 11

2.2.2 Back to Analogue . . . 13

2.2.3 Reducing Capture Burden . . . 14

2.3 Digital Phenotyping . . . 15

2.4 Leveraging Social Media . . . 17

2.5 Discussion . . . 21

2.5.1 Passive vs Active . . . 21

2.5.2 Analogue vs Digital . . . 22

2.5.3 Data collected . . . 22

2.5.4 Capture Burden . . . 22

2.5.5 Information Visualization and Feedback . . . 23

2.5.6 Sharing & Privacy . . . 23

2.5.7 Conclusion . . . 23

3 User Research **25**

3.1 Cultural Probe . . . 27

3.1.1 Materials & Activities . . . 27

3.1.2 Participants . . . 28

3.1.3 Procedure . . . 28

3.1.4 Findings . . . 28
3.1.5 Discussion . . . 33
3.2 Data, Sharing & Privacy . . . 33
3.2.1 Toolkit Design Process . . . 33
3.2.2 Using the Participatory Toolkit . . . 37
3.2.3 Findings . . . 37
3.2.4 Discussion . . . 42
4 DAN and Danny **45**
4.1 Approach . . . 47
4.2 Architecture . . . 48
4.2.1 DAN - Digitally Augmented Notebook . . . 48
4.2.2 Danny - Mobile Application . . . 48
4.3 DAN - Digitally Augmented Notebook . . . 49
4.3.1 Features . . . 49
4.3.2 Prototype Iterations . . . 50
4.3.3 Hardware Circuit . . . 51
4.3.4 3D Model . . . 53
4.3.5 Arduino Code . . . 53
4.4 Danny - Mobile Application . . . 56
4.4.1 Features . . . 56
4.4.2 Architecture . . . 57
4.4.3 Navigation Flow . . . 58
4.4.4 Information Visualizations . . . 59
4.4.5 Sharing and Privacy . . . 62
4.4.6 Engagement . . . 63
4.5 Communication Layer . . . 64
4.5.1 Communication protocol . . . 64
4.5.2 Background Work . . . 65
5 User Study **67**
5.1 Research Questions . . . 69
5.2 Method . . . 70
5.2.1 Participants . . . 70
5.2.2 Apparatus . . . 70
5.2.3 Procedure . . . 71
5.2.4 Data Collection & Analysis . . . 73

5.3 Findings . . . 74
5.3.1 Acceptability . . . 74
5.3.2 Effectiveness . . . 77
5.3.3 Well-being in College . . . 78
5.4 Limitations . . . 80
5.5 Discussion . . . 80

6 Conclusions and Future Work **83**

A Studies' Interview Guides **93**
A.1 Cultural Probe - Interview Guide . . . 94
A.1.1 Materials & Activities . . . 94
A.1.2 Other Themes . . . 95
A.2 User Study - Interview Guide . . . 96
A.2.1 Acceptability . . . 96
A.2.2 Effectiveness . . . 97
A.2.3 Well-being in College . . . 97

B Cultural Probe - Envelopes **99**

C Toolkit - Data Type Cards **105**

List of Figures

2.1 The OmniTrack interface. A list of existing trackers are shown on the Trackers tab (a), where people click the ”Edit” button to open the Edit Tracker page (b) for modifying the trackers. The automatic triggers are listed on the Triggers tab (c), and the external services are listed on the Services tab (d). 12

2.2 HEED: The states for activity reporting. 15

2.3 StudentLife app, sensing and analytics system architecture. 18

2.4 Surveying the participant's mood (left) and emotion (right). 19

2.5 Paper prototypes. 1) A prototype for on-campus clinicians. 2) Prototype for campus administrators. 20

3.1 Cultural probe[1] materials used for user research. 27

3.2 Toolkit overview: (1) Data Type Cards; (2) Yes, No and Maybe Tokens; (3) Scenario Card; (4) Sharing Methods. 34

3.3 Toolkit overview: (Left) Main Board and Stakeholders; (Right) Emotion Chart and Numbered Tokens. 35

4.1 Solution architecture. DAN (left) syncs data through BLE with the mobile application (right). 48

4.2 DAN's digital augmentation 49

4.3 DAN's prototypes: (1) Original; (2) First; (3) Final. 50

4.4 DAN's main circuit 52

4.5 DAN's 3D model 53

4.6 Application architecture 57

4.7 App's main flow: (1) Welcome (2) Home; (3) Trackers; (4) Profile. 58

4.8 App's dialogs: (1) Add Tracker (2) Select ratings; (3) List of ratings; (4) Rating. 59

4.9 Visualizations: (1) Line Chart; (2) Horizontal Bar Chart; (3) (Monthly mode only) Bar Chart; (4) Multi-line Chart; (5) Horizontal Stacked Chart; (6) Radial Chart. 60

4.10 Sharing mechanism: (1) PDF selection; (2) Range & Data selection; (3) PDF generation; (4) PDF. 62
4.11 Engagement strategies: (1) Weekly; (2) Counters; (3) Achievements; (4) Example achievement. 63
4.12 Communication flow 64

List of Tables

2.1 Smartphone sensors previously used in digital phenotyping research. 16
2.2 Self reports previously used in digital phenotyping research. 16
2.3 Comparison between the related work explored in the previous sections. 21

5.1 Usage logs 74

List of Algorithms

4.1 Setup 54
4.2 Loop 55

Acronyms

ASD	Autism spectrum disorder
BLE	Bluetooth Low Energy
CAD	Computer-Aided Design
EEPROM	Electrically-Erasable Programmable Read-Only Memory
EMA	Ecological momentary assessment
ENEE	Estudantes com Necessidades Educativas Especiais
ESM	Experience sampling method
FIFO	First In First Out
GATT	Generic Attribute Profile
I2C	Inter-Integrated Circuit
IST	Instituto Superior Técnico
LCD	Liquid Crystal Display
MTU	Maximum Transmission Unit
MWI	Mental Well-being Index
NAPE	Núcleo de Apoio ao Estudante
PDF	Portable Document Format
PEOU	Perceived Ease of Use
PU	Perceived Usefulness
PTSD	Post-traumatic stress disorder
RTC	Real-time Clock
TAM	Technology Acceptance Model
USB	Universal Serial Bus

1

Introduction

Contents

1.1 Problem 3
1.2 Approach 4
1.3 Contributions 4
1.4 Paper Submission 5
1.5 Document Structure 5

Well-being is what most people seek in life. In a general way, it is the lack of problems, which includes having good physical and mental health, and high life satisfaction.

Among the education milestones, the transition from high school to university is often overlooked, but students who enter a college setting are faced with new challenges that might influence their well-being. For example, the academic workload, peer pressure, social and extracurricular activities, and the overall pressure of graduating are all factors that might induce instabilities to the students' well-being [1–6]. The diverse college population means that students vary in their ability to cope with these challenges, and some of them face far more barriers than others. Furthermore, it is also relevant to notice that a college campus *"encompasses a socially and geographically cohesive, situated community, where poor mental health of an individual student can have spillover effects on others"* [7]. Thus, it is of paramount importance to create solutions to monitor and maintain the students' overall well-being.

1.1 Problem

Students' mental health and well-being is already an international concern [6], and it has been widely recognized that there exists a college mental health crisis [1–6]. Anxiety, depression, eating disorders and suicidal tendencies are some of the most common disturbances present among students [5]. Although mental health problems are the primary issue, the diverse student population means that some may face additional and unexpected obstacles. These factors may have significant implications towards academic success, productivity, substance use, and social relationships [3].

Additionally, college students are also among those least likely to consult health professionals during an emotional crisis [8]. Hunt et al. [3] state that this happens due to lack of time, privacy concerns, lack of emotional openness, lack of a perceived need for help, and scepticism about treatment effectiveness. Another important obstacle is the stigma associated with mental health problems and help-seeking [9].

The wide variety of problems that college students face, which are exacerbated by their help-seeking behaviours, means that students often have to manage their well-being by themselves. Not only is this prejudicial for the students——as they do not realize the full extent of their issues——but also for other important stakeholders, such as college staff or the student's family, who are not able to fully understand and monitor the students' well-being.

Recent approaches focus on utilizing user-generated data to infer well-being issues [4, 7, 10]. This data is not only actively and passively collected but might also involve social media content. However, these approaches are limited as there is a lack of solutions that can support the different needs of students in a college setting, and which can be used in collaboration by both students and stakeholders. Furthermore, these tools focus mostly on quantitative data in digital form that lacks the context and privacy provided by qualitative data in paper-based solutions.

1.2 Approach

Following the trend of Personal Informatics and the Quantified Self, our approach focuses on developing a self-tracking tool dedicated to students in a college setting. Our objective is to increase students' awareness regarding their well-being and facilitate help-seeking behaviours.

While a digital approach might be more appropriate for quantitative data and overall better for data management [11], paper diaries are more suited for qualitative data and may raise fewer privacy concerns since this data is kept offline. Paper diaries, which are dedicated and usually private tools for self-reporting, are easy to start and use, portable and robust [12, 13]. As such, we propose to **augment a paper diary allowing both analogue and digital input, and build a bridge between qualitative and quantitative data.**

In order to preserve the original flexibility of notebooks, our tool will be structure-free and even allow practices of bullet journaling [14]—to build student-specific trackers. Students will be able to engage in ecological momentary assessments by rating well-being related measures. Justifications and context for such answers can be written on the same diary.

Additionally, we propose a companion mobile application to visualize the data generated by the student. With such visualizations, we intend to increase students' self-awareness and facilitate problem-solving and goal-oriented techniques. Only students have access to their own data but they are also able to share it with stakeholders such as college counsellors, health professionals, family and even other peers. Furthermore, this feature should facilitate the student's help-seeking behaviours in order to get the necessary support and feedback.

By leveraging this system, we aim to offer tools to help students and other stakeholders identify, discuss and work towards solving well-being issues.

1.3 Contributions

With this dissertation, we intend to provide a self-tracking system with the necessary features to allow students and other stakeholders **to monitor and identify well-being instabilities in college settings.** We highlight the following contributions:

1. Two user research studies that offer insights regarding self-tracking in college settings, and the definition of guidelines for the development of self-tracking tools for students.
2. Development of a flexible self-tracking tool that bridges analogue and digital data coupled with a mobile application for data visualization and sharing to increase self -awareness and -reflection.
3. Validation of the acceptability and effectiveness of said tools, and an analysis of college students' well-being issues, their causes, and implications.

1.4 Paper Submission

Additionally, by leveraging the work done throughout this dissertation, we also contribute with a paper submission for CHI 2021: Late-Breaking Work[1].

1.5 Document Structure

In Chapter 2, we showcase different perspectives and tools that focus on leveraging user-generated data. We split this section into three different approaches: (1) Personal Informatics, (2) Digital Phenotyping, (3) Social Media, and conclude this chapter with a discussion of all the related work explored. In Chapter 3 we present our user research that includes two different studies. In Chapter 4 we start by stating our approach which takes into account the related work and our user research. After presenting our design goals and system architecture, we showcase our self-tracking tools: (1) DAN - Digitally Augmented Notebook, and (2) Danny - companion mobile app. In Chapter 5 we present our user study where we state our proposition, research questions and method. We conclude this section by showcasing and discussing our findings. Finally, we finish this document with a conclusion on Chapter 6.

[1] https://chi2021.acm.org/for-authors/presenting/late-breaking-work

2

Related Work

Contents

2.1 Background 9
2.2 Personal Informatics and Quantified Self 10
2.3 Digital Phenotyping 15
2.4 Leveraging Social Media 17
2.5 Discussion 21

In this chapter, we explore relevant work regarding various approaches that may help monitor and identify issues with students' well-being. Firstly, in the next section, we will set the background of some techniques that are often implemented in the tools we explore throughout this chapter.

2.1 Background

In clinical practice, the assessment of symptoms is usually done retrospectively and is often impacted by recall bias—systematic errors present in patients' assessments. These are introduced by processes of autobiographical memory and cause differences in accuracy or completeness. These errors can be further deteriorated by patients' dysfunctional attitudes about themselves and their surroundings.

Experience sampling method (ESM) and Ecological momentary assessment (EMA) are two of the most common research tools used to overcome these issues. ESM (Psychology) consists in asking individuals to provide systematic self-reports at random moments [15]. EMA (Medicine) involves repeated sampling of individuals' current behaviours and experiences in real-time, and in their natural environments [16]. These two approaches originated from different research contexts, and although they have much in common (i.e collection of self-reports), they originally had some differences. The ESM was created to measure people's internal affective states and relevant activities, and data recording has generally been signal-contingent (i.e. at random signals during the day). EMAs focus more on the individual's behaviours and usually rely on physiological measures or health-related questions. Additionally, data recording is often event-contingent, where individuals self-report the data right after specific events. Despite the differences, the two concepts are often used together or interchangeable.

Trull et al. [17] study the uses and corresponding advantages and disadvantages of these methods. Both ESM and EMA can be conducted with a variety of tools, including paper and electronic diaries. While electronic diaries usually have time-stamps associated with the self-reports, paper diaries have the disadvantage of allowing "back-filling". With analogue approaches, participants may not self-report at the proposed schedule, and save it for a later time. Both ESM and EMA collect momentary ratings which make them relevant for the assessment of moods, thoughts, symptoms, or behaviours, which are all aspects that are likely to change over time [17]. Besides minimizing the recall bias, these strategies provide a picture of the individuals' moment-to-moment state in their natural environments. As Trull et al. [17] state, *"such an understanding is necessary in order to provide an accurate evaluation of the relevant clinical problems, to recommend appropriate treatment or intervention, and ultimately to adequately evaluate treatment response"*.

In the following sections, we showcase various works that leverage different types of user-generated data (including data collected from ESM and EMA) that can give meaningful insights about the state of students' well-being.

2.2 Personal Informatics and Quantified Self

Personal Informatics, also known as Quantified Self, refers to the school of thought that uses technology to collect data on different aspects of the daily lives of people [18]. Users can use self-tracking tools to help increase self-reflection and self-knowledge in order to understand themselves, to self-monitor chronic diseases or to motivate for changing behaviours [18].

Kelley et al. [4] explored the important role of self-tracking in promoting mental wellness. They contributed with two studies to understand self-tracking techniques in student populations and their role in managing stress and mental wellness. The first study was aimed to understand student health professional perspectives regarding assessment (of data), communication (with students) and self-care planning. It allowed the authors to understand the importance of different types of self-tracked data in different scenarios. The second study was conducted on 297 students, and it included questions about general (and their own) self-tracking practices and sharing habits. It showcases what data students are self-tracking, their motivations and if it helps them achieve their end-goals.

The first study clarified that it is complex to standardize self-tracking tools as different scenarios require distinct data to be collected. Regarding stress and mental health, data such as exercise, sleep quantity, class attendance, academic workload, bedtime and depression scale were considered advantageous for health professionals. Additionally, the second study revealed that 90% of the participants already engage in self-tracking practices, with some of them being previously diagnosed with a chronic and/or mental illness. Out of all the participants, only one student tracked mood, as the rest tend to track more quantitative measures since most tools are better suited for that purpose. The motivations that led them to enrol in these practices are: to improve health, change behaviours and track specific goals. Students responded positively regarding sharing self-tracked data with family, healthcare professionals and friends, with the most common reason for the latter being: *"I want to help others by sharing my experiences"*. Furthermore, most of the participants agreed that sharing data with healthcare providers facilitates the overall clinical process. However, it should be highlighted that both studies exhibited opinions that self-tracking is not always beneficial and can worsen the state of the student. Students may become stressed and obsessed, and some practices promote negative health behaviours. Additionally, the authors state that a self-tracking tool should offer healthy recommendations on what to track.

Both studies showed results that can be helpful for the design of future self-tracking technologies and highlight the need for flexibility to increase adoption and effectiveness.

2.2.1 mHealth

Personal Informatics technologies include mobile applications that support the collection of personal data for different uses. We will explore self-tracking systems which offer self-reflection, flexibility, and an open architecture for sharing.

MoodRhythm [19, 20] was developed for tracking and supporting daily rhythms. It focuses but is not limited to patients diagnosed with Bipolar Disorder. The *MoodRhythm* system includes an app where patients can track different activities and set daily targets, and which also collects passive data regarding sleep and social activity patterns. Besides the app, there is a web dashboard with visualizations to support clinician-patient communication. The system developed by Voida et al. [20] could have broader applicability for students, yet it still has limited functionality. The app and dashboard combined might allow not only users but other important stakeholders to identify problems regarding well-being.

While *MoodRhythm* focuses on helping patients maintain a consistent activity rhythm, *Monarca* [21] allows bipolar patients to self-track factors associated with mood swings (e.g. sleep levels, adherence to prescribed medication regimens, and activity levels). The system focuses on providing feedback through visualizations and from clinicians—through a built-in trigger and notification feature. Bardam et al. [21] developed *Monarca* while aiming to fix the disadvantages of paper-based mood forms. They conducted a study where the app had high (87%) and similar compliance to paper-based forms. However, the app relied on obtrusive alarms to alert the user to assess new data. Regarding the collected data, some participants were not always satisfied with the available items and the text entry (qualitative data) was not used.

In a college setting, the student population has different needs that make flexibility an important factor when designing tools for this context. Kim et al. [22] had that in mind when developing *Omnitrack*, which provides the tools to create personalized self-tracking experiences that fit everyone's needs. Kim et al. [22] noted that users tend to abandon them after some time because (1) tracking apps imposed heavy tracking burden by asking to fill in too many mandatory fields for each entry or (2) existing tracking apps did not support their tracking needs. *Omnitrack* leverages a semi-automated tracking approach [23] combining manual and automated tracking. To further lessen the burden of inserting manual data, the app allows for easy access to shortcuts. The app includes four sections: Trackers, Triggers, Services and Visualizations. Users can create customized trackers by choosing their own data inputs and even incorporate external services from tracking devices. Users can also set triggers to automatically retrieve data at specific moments. Lastly, the app offers a dashboard with visualizations that are recommended according to the trackers created. The deployment study provided some insights into what the users want to track and how did they manage to do it using *Omnitrack*. The obvious advantage of this app is its flexibility as it can be adapted to different case scenarios and can integrate different origins of data in one place. The first problem that was evident in the deployment study is the learning curve that comes

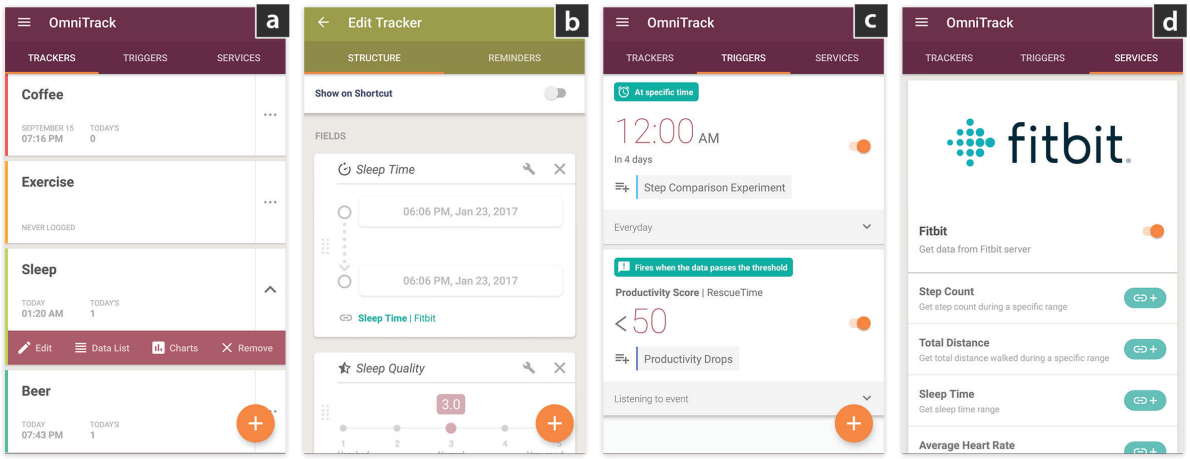


Figure 2.1: The OmniTrack interface. A list of existing trackers are shown on the Trackers tab (a), where people click the ”Edit” button to open the Edit Tracker page (b) for modifying the trackers. The automatic triggers are listed on the Triggers tab (c), and the external services are listed on the Services tab (d).

with using this app. Many users might have trouble configuring their own trackers and there is also a possibility of high battery consumption when trying to track too much information. There is also room for improvement in the Visualizations section of the app, which is important as better visualizations can contribute to better analysis. Although it was not already implemented, this app can also be improved with sharing capabilities.

Kim et al. [24] later leveraged *Omnitrack* for adolescents with Autism spectrum disorder (ASD) where participants were invited to design customized trackers. Their findings showed that flexible self-tracking helped adolescents with ASD to deal with their behavioural challenges, understand and regulate their emotions, discover how to improve their well-being, and leverage data mediated communication with their family.

Also relevant for college settings is the work of Harari et al. [25]. They leveraged different smartphone self-tracking applications to evaluate student's interest and compliance. In order to do so, they conducted three sensing studies which shared the following features: (1) participants' use of smartphones as a self-tracking tool, (2) the ability to self-track using passive sensing and active logging, and (3) the incentive of personalized feedback based on participants' self-tracking data. Those who enrolled in these studies were offered different incentives. The first study offered course credits, the second monetary compensation depending on their participation, and the third a wearable device for the top performers. Findings exhibited three dimensions of self-tracking motivations: productivity and health behaviours, well-being and daily activities, and social life on campus. These studies also evidence that an effective recruitment strategy can be achieved by providing personalized feedback combined with other incentives.

2.2.2 Back to Analogue

Electronic-based approaches, such as the previously explored, can automate data capture, provide contextual data like timestamps [12], and reduce data management burden [11, 26]. Furthermore, while it seems that electronic solutions are preferred to paper diaries, Dale et al. [27] stated that there might exist a publication bias. Having that in mind, we showcase three paper-based solutions in order to understand the reasons behind choosing analogue over digital inputs.

Vega et al. [26] discussed some of the problems that arise with the use of technology and the advantages of paper-based solutions. For all of the requirements they had at the beginning of the study, a paper-based approach was the most suited. Such requirements were for the solution to be (1) Independent, (2) Accessible, (3) Frictionless. The final symptom-tracking notebooks were flexible and customized for each of the participants. The notebook was structured in order to allow the answers to be automatically encoded but, because of that, it had trouble dealing with input errors and extra information that the users wrote. Other advantages (comparing to their previous prototypes) were that it had a small learning curve and users could analyze their data.

Lee et al. [28] also leverage a structured analogue approach as they introduce the *MindNavigator* workshop. *MindNavigator* was designed to explore the landscape of students' stress and implement personalized interventions for stress management. In this workshop, students were introduced to the *MindNavigator* Worksheet, which used Cognitive Behavioral Therapy [29] as the basis of the design to allow (1) recognizing stressors, (2) changing perceptions, and/or (3) adopting alternative behaviours. The *MindNavigator* Worksheet allowed the user to build a stress profile, recognize stressors and underlying emotions, set goals, and plan, track and revise their strategies. The worksheet offered a structure that can help the overall process of stress management and behavioural change but does not focus on the easing self-tracking. Participants did not use other self-tracking solutions and only wrote short descriptions of their experiences and emotions on the worksheet.

Ayobi et al. [14] explored Bullet Journaling[1] for flexible and mindful self-tracking. The main idea behind the paper is whether or not the new trend of bullet journaling offers the needed flexibility for self-tracking while being effective as other technologies. The authors outline two design directions for flexible and mindful self-tracking. Firstly, they defend the use of pencil and paper for self-tracking but agree with digitally extending it with additional values. They also say that we should support digital self-tracking as a mindful design practice and, to not focus only on passive automation and predefined presentations of data. Bullet journaling indeed offers enough flexibility for different scenarios while being able to maintain a structure. However, it has some limitations because it requires a large amount of motivation and engagement from the users. The paper shows many examples of bullet journals that prove them to work as: Habit Trackers, Mood Trackers, and Symptom Trackers. The structure of the journals make their data

[1] https://bulletjournal.com/

easy to read and to analyze. It also creates a two-way bridge between the analogue and digital world, as users put digital data on their journals but also share them online with peers. Another downside is that designing and using bullet journals has a learning curve, which can result in a low number of users adopting this technique. Ayobi extends his studies of bullet journaling to inform the design of personal informatics technologies for unpredictable chronic conditions [30]. He has analyzed paper bullet journal photos in order to find how people with multiple sclerosis use them as a self-care practice. With his findings, he emphasizes the need for mindful and flexible self-tracking technologies.

2.2.3 Reducing Capture Burden

Besides flexibility, there is also a need to reduce the capture burden that comes with using these tools for in-situ self-tracking [31]. Both digital and analogue approaches may suffer from a high capture burden which can lead to users abandoning the tools. Vega et al. [26] explored different prototypes to achieve better compliance for patients diagnosed with Parkinson. Tools like *Omnitrack* [22] and *SleepTight* [32] already explored the use of mobile widgets to reduce the burden and increase the compliance rate.

When developing *SleepTight*, Choe et al. [32] studied ways to reduce the capture burden of manual tracking while leveraging its benefits. Engaging in self-tracking increases awareness and provides a timely reflection on the data collected. Having this in mind, they state that *"an obtrusive, high burden recording device—such as a manual tracking tool—can augment this positive, therapeutic behaviour change"*. They explore enhancing manual tracking by developing a tool that supports easy and flexible manual capture of various behaviours. They had three design goals throughout the development of *SleepTight*. The first goal was to allow individuals to capture both target behaviours and factors that influence such behaviours. The second was to reduce the capture burden of manual tracking, and the last goal was to offer feedback to promote self-reflection. The results showed that the widgets reduce the steps to manual tracking, and also serve as visual reminders to help the user track their behaviours. However, the widgets are not scalable and also might make people anxious.

Ferrario et al. [33] leveraged the use of light data by developing *SnAPP*. With the proposed system, the users can press a physical button, which is inserted in the audio jack, to send a positive (one click) or a negative (double click) signal to the app. This was mostly used to capture mood states. Additionally, users can use the visualizations showed on the app for self-reflection. This system reduces the capture burden, but the light data might not be enough to detect problems with the user's well-being.

Larsen et al. [34] had a similar approach when developing a one-button wearable. This button was used to track the occurrence of PTSD-related symptoms, and the data collected turned out to be valuable in complementing the therapeutic process. The system was used by a patient to track only one symptom (previously chosen by a therapist) and offered a minimized capture burden. However, a single button is very limited because it can only track one symptom and the input is binary (symptom or no symptom).

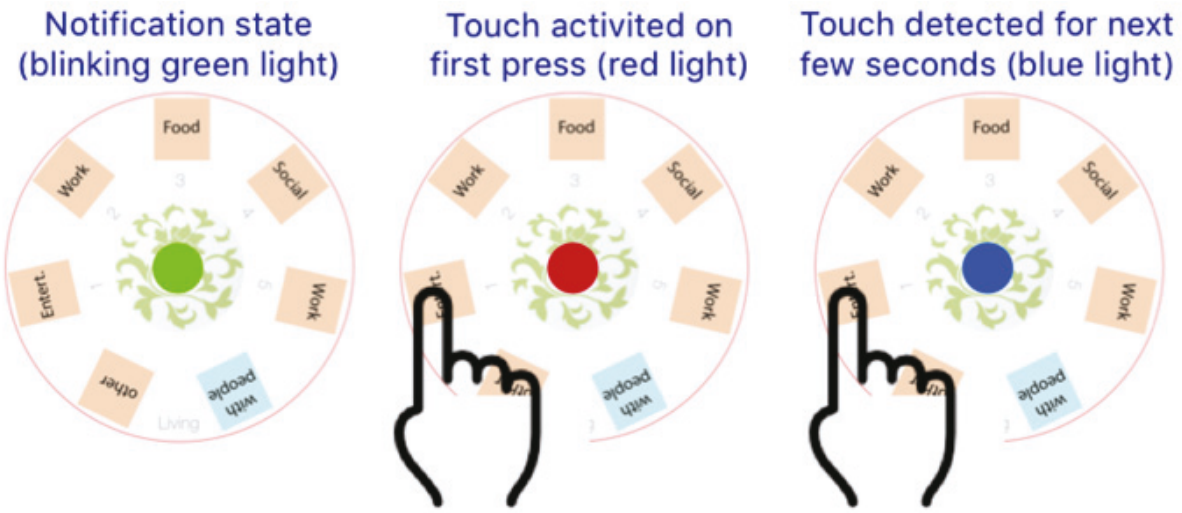


Figure 2.2: HEED: The states for activity reporting.

Adams et al. [35] solve the latter problem by developing a pressure-based tangible user interface for self-reporting pain. *Keepi* allows users to report different levels of pain by pressing it with a different intensity. This tool is unobtrusive and users felt that it was intuitive to use. Furthermore, one participant pointed out the need for clear feedback to reduce worry about accidental or failed recording. As people have different strengths, the pressure needed to report high levels of pain might be subjective and should be adapted to each individual.

Also in the context of reducing the capture burden, Paruthi et al. [36, 37] proposed *HEED* as a dedicated unobtrusive and distributed self-reporting device. They showcased two advantages of dedicated devices for reporting. First, the devices being distributed in the user's environment serves as a reminder for self-reporting. Secondly, it requires less preparation time than the typical self-reporting mobiles applications. The HEED devices have a seven-point touch interface that can be fully customizable for different contexts and to report multiple aspects (Figure 2.2). They conducted a study with *HEED* devices and an equivalent mobile application. Results showed that the use of the *HEED* devices depended on how convenient where their placements. If the participants were on the go, they found the mobile app to be more convenient. Some participants felt that the mobile is associated with stress-inducing activities and preferred the devices. It was also pointed out that these devices might lead to increased self-awareness.

2.3 Digital Phenotyping

In this section, we explore a more specific form of health surveillance technology usually referred to as Digital Phenotyping. In Psychiatry, this term is defined as the use of digital technology to measure the extended phenotype [38]. Torous et al. [39] refer to it as the *"moment-by-moment quantification of*

Table 2.1: Smartphone sensors previously used in digital phenotyping research.

Sensor	Description
Accel./Activity	Movement of device and person
App Use	App launches, installs, etc.
Battery	Battery level and charging
Bluetooth	Devices seen, plus status
Call Logs	Calls made and received
Camera	Raw images, num photos taken, etc.
Keyboard/Ui	Event counts, potentially keylogging
Light	Light levels detected
Location	Geographical coordinates of device
Microphone	Sound recordings, decibels, etc.
Screen	Screen stats (on/off)
SMS/Email	Messages sent and received
Web History	Websites visited

Table 2.2: Self reports previously used in digital phenotyping research.

Survey	Description
PHQ9	Depression and low mood scale
GAD7	Generalised Anxiety Disorder Scale
WEMWBS	Mental Well-being Scale

the individual-level human phenotype in-situ using data from smartphones and other personal digital devices". Additionally, they state that the data collected from smartphone sensors is ideal for capturing social and behavioural aspects of psychiatric and neurological diseases.

Rooksby et al. [6] reviewed Digital Phenotyping as an approach to monitor and analyze mental health and well-being. They explore its use in a university context and the overall acceptability among students. They state four different uses of this approach: (1) Monitoring students known to be at risk or with pre-diagnosed disorder; (2) Monitoring students to identify those who may be at risk and requiring help; (3) Monitoring the student body as a whole in order to measure well-being and inform policy and service provision; (4) Monitoring students for research purposes.

The forms of data collected in digital phenotyping can be seen in Tables 2.1 and 2.2. The first table regards mobile phone passive generated data which is different from personal self-tracked data (discussed in Section 2.2), as it is more "raw" and might not mean anything to end-users. *MoodRhythm* [20] uses this kind of data to support users who find self-tracking challenging. *MoodBook* [40] also leverages these forms of data to detect active and passive social media usage. *Monarca* [21] similarly uses sensors to detect physical and social activity. Another form of data also popular in this approach is the use of self-reports, such as the ones present in Table 2.2. These questionnaires are often intended to provide information that can be compared with the rest of the data.

Rooksby et al. [6] ran focus groups to discuss the data used and what it might seek to infer. After that, some of the students were asked to start tracking data (only the forms of data that they consented)

using an application. The students agreed there was a need for more technologies that can help them recognize signs and symptoms. One of the problems referenced was that the tracking app and EMAs were not enough to fix the problems and there was a need for a third-party service behind the app, but that might lead to less information being shared. Furthermore, some forms of data raised privacy concerns and students felt reluctant to share them. Additionally, students also questioned the relevancy of some of the data tracked. Regarding the self-report questionnaires, the participants were concerned with side effects like making them worry unnecessarily and cause negative thoughts and feelings. One suggestion was the use of more abstract mood tracking or even bullet journaling.

One of the discussed digital phenotyping studies by Rooksby et al. [6] was the *StudenLife* project by Wang et al. [10]. Figure 2.3 describes the design of the *StudentLife* system. The authors developed a continuous sensing app which collected most of the data present in Table 2.1, and then analyzed said data using behavioural classifiers for activity, conversation, sleep and location. The app also integrated *MobileEMA* to deliver photographic affect meter questions, pop-up EMAs and scheduled EMAs to evaluate mental well-being measures. The data was collected from students enrolled in a computer science class and incentives such as T-shirts and phones were given to promote compliance and data quality. Privacy was also an important concern as they anonymized the students' identity and made sure their data was not exposed to third-parties.

The results of the project show different correlations between the collected data and students' mental well-being and academic performance outcomes. However, as Rooksby et al. [6] pointed out, this project did not explore the students' perspectives and overall acceptability. Wang et al. [10] also reference the importance of providing feedback to students and other stakeholders as they can act upon the collected data.

2.4 Leveraging Social Media

Recent research has shown the usability of social media as another form of passive sensing, which is usually used together with the previously explored origins of data (EMAs, self-tracked data and smartphone sensors). Saha et al. [41] states that social media, as sensed data, is low-cost, large-scale, non-intrusive to collect, and can reveal patterns of mood, behaviour, cognition, psychological states and social aspects. The following approaches leverage social media as a "sensor" to assess well-being.

Lee et al. [42] leveraged whether the data collected from tracking users' online activity can infer the individual's real-word psychological mood. The conducted a study targeted to university students as they are more likely to maintain a frequent interaction with social networks. The ground truth was collected via experience sampling—students were prompted once a day to answer two questions (Figure 2.4), one to record the general mood and the other to assess emotional state (two-dimensional grid with

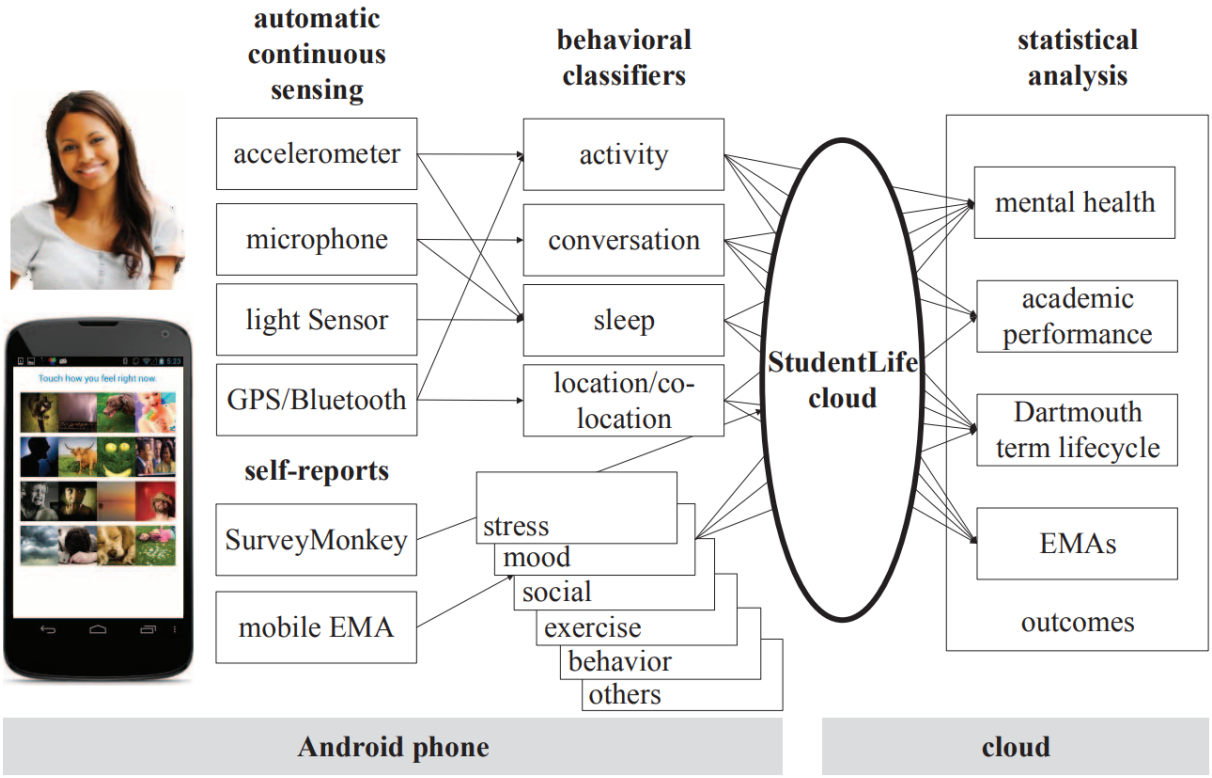


Figure 2.3: StudentLife app, sensing and analytics system architecture.

valance and arousal). The online activity data that was collected included Facebook's posts, likes and comments, and Twitter's tweets, replies and retweets. Based on this data, Lee et al. were able to detect mood changes within a window of 7 days for 61% of the participants. They trained two classifiers, one to detect whether there was a correlation between the online activity and the individuals' mood, and the second to assess whether the correlation was positive or negative. Their work shows evidence that people are diverse regarding their social media usage (i.e. non-existent or different correlations with mood). Therefore social media data might not be suitable for assessing mood.

According to Saha et al. [41], the previous study design is challenging to scale. With that in mind, they propose a slightly different approach which examines how large-scale social media data can leverage small samples of EMAs to build a mood instability classifier. Saha et al. [41] developed *CampusLife* to infer mood instability, which can be seen as an extension to the already discussed *StudentLife* project [10]. Besides the passive data and EMAs already discussed in the previous section, Saha et al. [41] collected social media data from some of the participants. This data was collected from Facebook and Twitter, and the authors concluded that it enhanced the inferential capabilities. Similarly to *StudentLife*, this study had concerns with privacy and depended on incentives to gather reliable data.

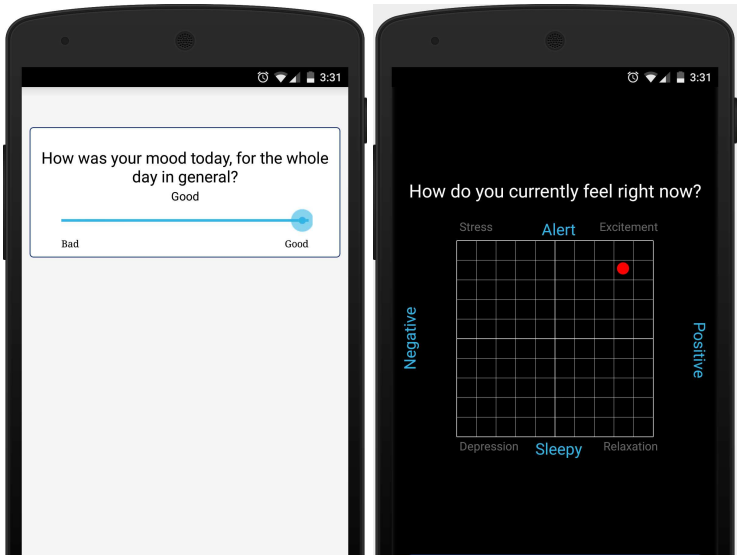


Figure 2.4: Surveying the participant's mood (left) and emotion (right).

Bagroy et al. [43] also leveraged the use of social media for analyzing the mental well-being of college populations. By using data from college communities in Reddit[2], the authors built and evaluated a transfer learning-based classification approach that could detect mental health expressions with 97% accuracy. Bagroy et al. [43] propose a Mental Well-being Index (MWI) for College Campuses. Besides being able to show meaningful temporal patterns, this index also allowed to find relationships between itself and different university attributes (size, prestige, demographics). Students often use social media to express their issues, but this information presents challenges when it comes to analysing it and gaining meaningful insights about students well-being. This index can be highly beneficial to colleges to gain an overall mental health measure and possibly act upon it, by allocating services and strategies to support students. The MWI focuses on the collective mental well-being on campus, and while it has its use, it does not allow to identify specific students that might require more assistance. This index might be further improved with more social media data but it can lead to ethical issues.

Moodbook [40], just like other projects showcased in Section 2.3, uses a mix of passive data collected from mobile board sensors and active data from EMAs. With passive data, the app detects social media usage and, as social networks are partly used for communication, they also use the keyboard sensed data to distinguish between active and passive social media usage. The application also captures their mood—before and after each social media use—with a Photographic Affect Meter, instead of the most common approach which is to collect the ground truth sparsely (i.e. daily or weekly). By combining these forms of data, *Moodbook* can infer the user's mood through social media interaction patterns. The frontend of the app comprises three different elements. The first shows the social media usage duration coupled with the mood assessments. The second element illustrates the amount of the

[2]https://www.reddit.com/

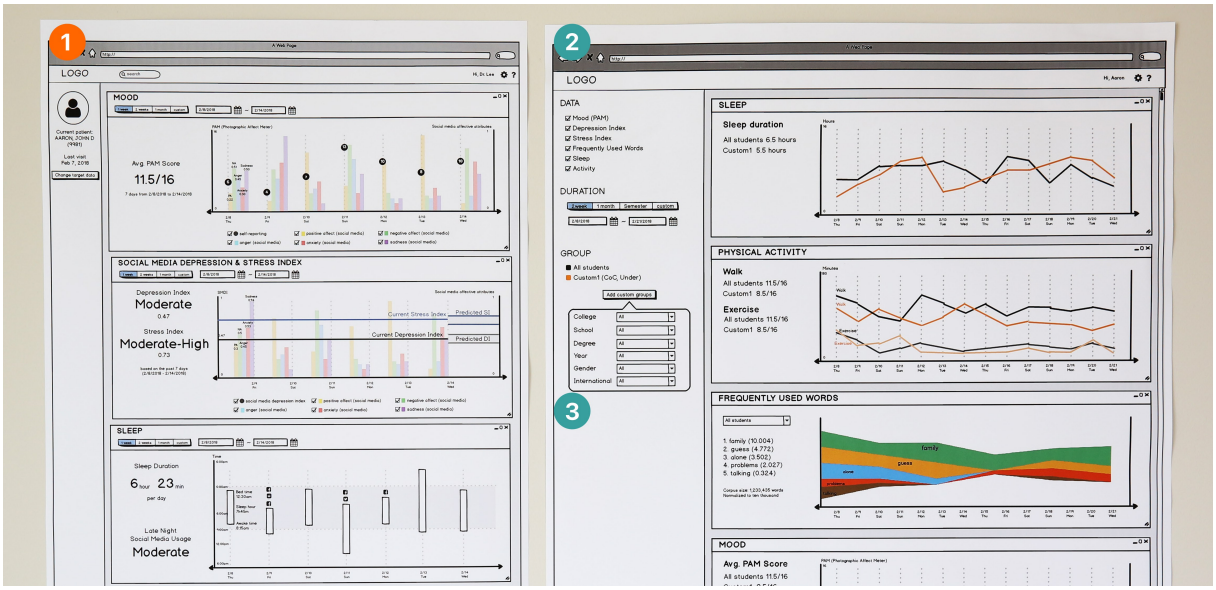


Figure 2.5: Paper prototypes. 1) A prototype for on-campus clinicians. 2) Prototype for campus administrators.

user's online activity (passive or active), and the third displays a summary of the collected data. The application provides feedback to the user and, with consent, sends data to researchers for analysis.

Yoo et al. [7] explored the use of student's social media data in addition to self-tracked data, as research has already proved this data can provide in-situ insights about students' well being [7]. The purpose of this work was to design a dashboard for campus stakeholders to visualize student's data, and consequently improve their work practices around students' well-being. To design the dashboard, Yoo et al. [7] conducted two studies with campus administrators and on-campus clinicians. The first study concluded both groups had an interest in self-tracking data, with on-campus clinicians expressing they already had experience in gaining insights from such data. Both groups were sceptical concerning the use of social media data. Campus administrators see no benefits that justify its use. The clinicians also do not encourage it but do not deny its usefulness.

As different stakeholders value different information, Yoo et al. [7] developed two prototype dashboards, one for each of the study groups. The dashboard for on-campus clinicians focuses on single-patient visualization, while the one for administrators had aggregated data and abstracted visualizations. Both groups confirmed that the interface has the potential to improve their work practices around students well-being. However, while social media can complement self-tracking data, it is not easily interpreted, and there is a belief that such data does not reflect the actual student. One other problem of designing these dashboards is to select and present the most useful information that allows for a better and more straightforward interpretation. Dashboards like these also depend on the consent of students to share their data, and the lack of information can often create bias and mislead who is analysing it. Furthermore, it also raises ethical concerns about privacy, confidentiality and liability.

		Input			Data					
	Focus	Analogue/Digital	Passive	Active	Quantitative	Qualitative	Self-tracked	Raw Sensor Data	Social Media	Shared
Adams [35]	Pain	D		√	√		√			
Ayobi [14]	Flexible	A		√	√	√	√			√
Bagroy [43]	Well-being	D	√			√			√	√
Bardam [21]	Mood	D	√	√	√	√	√	√		√
Choe [32]	Sleep	D		√	√		√			
Ferrario [33]	Anxiety	D		√	√		√			
Harari (1) [25]	Behaviours	D	√	√	√	√	√			√
Harari (2) [25]	Well-being	D	√	√	√	√	√			√
Harari (3) [25]	Behaviours	D	√	√	√	√	√			√
Kim [22]	Flexible	D	√	√	√	√	√			
Larsen [34]	Symptom	D		√	√		√			√
Lee [42]	Mood	D	√	√	√	√	√		√	√
Lee [28]	Stress	A		√	√	√	√			√
Paruthi [36]	Flexible	D		√	√		√			
Rooksby [6]	Mental Health	D	√	√	√		√	√		√
Saha [41]	Mood	D	√	√	√	√	√	√	√	√
Vega [26]	Parkinson	A		√	√		√			√
Voida [20]	Mood	D	√	√	√	√	√	√		√
Wang [10]	Mental Health	D	√	√		√	√	√		√
Yoo [7]	Mental Health	D	√	√	√	√	√		√	√
Zhang [40]	Mood	D	√	√	√		√	√	√	

Table 2.3: Comparison between the related work explored in the previous sections.

2.5 Discussion

In this section, we state the conclusions we gathered from the works explored. In order to ease the comparison between the different articles, we also built Table 2.3.

2.5.1 Passive vs Active

The work explored in this chapter either uses active sensing (i.e. manual tracking), passive sensing (automatic tracking), or a combination of both (semi-automated tracking). Passive sensors have the advantage of reducing capture burden and allowing users to track data which would not be possible manually. The drawback of automatic tracking is that people might be less engaged and aware of the collected data [32]. Manual tracking, even though it requires more motivation and has a higher capture burden, it also raises the users' awareness [32], which is one objective of self-tracking approaches. Semi-automated tracking [23] balances the advantages and drawbacks of both types of data-sensing.

2.5.2 Analogue vs Digital

The lack of paper-based solutions can be explained by the clear advantages of electronic devices. Electronic approaches allow a better experience with data treatment and analysis [11], they can offer more contextual data such as time-stamps and location [12], and can increase compliance through signalling [44]. Nonetheless, there are drawbacks of digital solutions and possible improvements for analogue approaches. The mobile phone is often associated with stressful activities and users might avoid using them [36]. Mobile apps for self-tracking remind people that they are being monitored and therefore change how they interact with those solutions [45]. Devices that are dedicated for self-tracking have the advantage of reminding the user to self-track and requiring less preparation time [36]. Ayobi et al. [14] leverages bullet journaling because *"prior works suggest that people abandon consumer health technologies over time because of a lack of personally meaningful insights, and switch to paper notebooks to avoid unintended effects and to overcome technological boundaries"* [14]. Vega et al. [26] eases data treatment by giving a specific structure to notebooks which allows translation into digital data, but does not allow descriptive data. It is also important to note that, while we are achieving greater equivalence regarding computer and paper-tasks [11], users write faster on paper [11] which might be relevant for qualitative data input. Paper diaries are also easy to start and use, cheap, portable and robust [12, 13].

2.5.3 Data collected

Quantitative data is the most common and easily tracked data as it can be tracked passively. However, this data alone may require context, which can be provided by subjective and descriptive data. Leveraging a combination of quantitative and qualitative data may be the best solution. Social media data was leveraged to assess well-being and to correlate with other types of data. Nonetheless, conclusions show that not every individual uses social media in the same way [42], and this data might not represent their well-being [7]. The raw sensor data leveraged in the digital phenotyping approaches complements [20, 40] and correlates [10] with other types of data. Nonetheless, users do not find this data relevant [6] and further data treatment is needed to be presentable to individuals so they can act upon it [10]. Flexibility to support different data is an important requirement [14, 22] and there is a clear need for it in a solution dedicated for students in a college setting.

2.5.4 Capture Burden

Reducing the capture burden is vital for better and more prolonged compliance [31]. We have already discussed how passive sensors lead to a lesser capture burden but we have also showcased different solutions that can improve the burden of manual tracking [22, 32–34, 36].

2.5.5 Information Visualization and Feedback

The way we visualize the data we generate is relevant to increase self-awareness and to improve the reflection upon such data. However, some solutions were only designed for stakeholders [6, 7, 43] and not for students to reflect on the data. Visualizations are one of the forms of providing feedback for the users, and so it is important to focus on how we present the data in order to offer meaningful insights and reduce the analysis time.

2.5.6 Sharing & Privacy

Sharing the data with therapists, health professionals, family and peers might also improve the feedback and motivation. Some authors [4, 14, 28] reference social sharing as a way to get social support and connect with others in similar situations. However, sharing personal data raises concerns related with privacy and ethics, and the more delicate the data is, the more skeptical people feel about sharing it. Social media and raw sensor data used in some of the works are examples of delicate data that users prefer not to share [6, 7, 10, 41]. Students would share their information [4] but solutions should offer full control to the user, so he/she chooses what to share and knows how the data is being used.

2.5.7 Conclusion

After reviewing and discussing the related work, we highlight the following: (1) opportunity of leveraging a combination of analogue and digital inputs, (2) importance of flexibility on self-tracking tools, (3) advantages of sharing and the need to preserve users' privacy, and (4) importance of balancing the advantages of active tracking and the capture burden that comes with it. Finally, we also conclude that there is a lack of tools that are properly designed for college students and which can be used in collaboration with other stakeholders.

3

User Research

Contents

3.1 Cultural Probe 27

3.2 Data, Sharing & Privacy 33

Figure 3.1: Cultural probe[1] materials used for user research.

In this chapter, we showcase two studies that were done throughout this dissertation. Firstly, we conducted a study that leveraged cultural probes and allowed us to better understand the potential of self-tracking among college students. We also contribute with a study that explores, in a college setting, the importance of different types of data, sharing such data, and potential privacy concerns.

3.1 Cultural Probe

At the beginning of this thesis, we designed a cultural probe (Fig. 3.1) with the intent of leveraging the concept of tracking well-being and gathering opinions for a better understanding of our target audience.

3.1.1 Materials & Activities

The cultural probes were designed for a duration of two months and contained the following materials and activities:

1. **Instructions sheet** - contains information on how to use the materials.
2. **Campus map and stickers** - with the use of coloured stickers, where each colour corresponds to a rating (i.e. green = 4 = positive well-being, yellow = 3, blue = 2, red = 1 = poor well-being), the student should classify their overall well-being each day.

[1] A qualitative research technique used to understand the end-user, to gather opinions and inspire new ideas.

3. **Calendar and stickers** - once again using the coloured stickers, the student should mark different locations that he/she associates with a different level of well-being (e.g. stressful locations).

4. **Eight themed envelopes** - each envelope should be open periodically, and it contains a question and a challenge for the student. The content of these envelopes can be found in Appendix B.

5. **Diary** - the diary can be used for justifications regarding the stickers' placement and to answer the questions and challenges. Regardless, the student can also use it as a regular diary.

3.1.2 Participants

With the help of NAPE (Núcleo de Apoio ao Estudante), we sent out invites for IST students to join our study. The contacted students either had special educational needs (i.e. ENEE - Estudantes com Necessidades Educativas Especiais) or were being advised by NAPE's services. Throughout the months of November and December, four students enrolled in our study.

3.1.3 Procedure

We conducted a first meeting with each participant where we showcased our project and presented the cultural probes. After about two months, we scheduled and conducted a semi-structured interview with each student. Besides retrieving the materials, we questioned the participants to gather opinions regarding **well-being** (e.g. *What factors did they consider when rating their well-being?*), **self-tracking** (e.g. *What are the main difficulties when engaging in self-tracking practices?*), **help-seeking** (e.g. *Does having access to this kind of data lead to help-seeking?*), and **data-sharing** (e.g. *Would they share the data they collected?*). Finally, we recorded and transcribed each of these sessions and conducted a thematic analysis. The full interview guide can be found in Appendix A.

3.1.4 Findings

After analyzing the transcriptions, in this section, we showcase the main findings of this study.

Materials & Activities

The calendar proved to be the most successful activity in this cultural probe as participants found the task to be easy and enlightening. They all stated they were able to detect patterns in their well-being and correlate them with events in their lives.

> *"Looking back two months, I can really get an idea of how I really felt. If it was not for this, I would not have a slight idea of how I feel throughout the days." - P4*

"Possibly, I can even predict what my state will be according to future events... There is a pattern I have noticed that before tests, sometimes there are reds, and suddenly it goes to green." - P4

Interestingly enough, one student agreed that the data loses value if it is not coupled with justifications and context.

"Without justifications, it can be a bit complicated. If I had to talk with someone and I could remember why did I put each of them..." - P1

We asked which dimensions of their well-being did they consider for their assessments, and although they had different factors between them, they all referenced either stress or anxiety. One participant also stated that most of the factors he considered were connect in some way.

"They end up being connected to each other... If I am not productive, it ends up causing me stress." - P1

Each participant admitted that they back-filled their tracking at least one time while they did not create a habit. However, they thought it did not have much of an impact on their assessments.

"Of course something was lost, but I do not think it affected much." - P4

Finally, we asked whether participants would keep doing this type of self-tracking, to which they responded very positively. Additionally, they all said it would be preferable to have a dedicated approach because they would easily forget to use an application.

"Before this, I had already tried applications. I would try one day or two, and then I would forget... I think it is better if it is a dedicated tool. A phone is kind of an all-in-one, and this would be more valuable if we have a dedicated thing for it." - P4

"I actually preferred the paper instead of an application. I had already used an application, and I have so many applications on my phone ... one more daily notification reminding me to do this, it would become annoying. I would just delete the notification, and after two weeks, I would uninstall the application." - P1

"Either paper or an application, although I would likely forget to use the application." - P3

Participants did not see much value on the Campus map and said it was a one-time-only exercise as their opinions did not change much, although one student switched one sticker during the interview. Furthermore, participants based their evaluation on the memories and feelings they associated with each location.

"I placed a yellow circle on Social [Canteen] because it is the place where I usually do not like to eat, and when I went there, we were always running and I did not have my friend group defined. Meanwhile, on gardens ... because these are places where I usually go to have a break and rest ... in those locations I placed green circles." - P1

Overall, students appreciated the envelopes and the approached themes because it forced them to reflect on important subjects.

"I enjoyed it because there were subjects that I had not thought about. So, when I had to write, I developed more what I was thinking, and at the same time, I was noticing it." - P2

"I thought they were interesting for their nature but also because of the logic sequence I noticed. Throughout the month, I realized the theme followed something that was happening." - P4

Nevertheless, some of the participants found the exercise time-consuming as they had difficulties answering some of the questions.

"For some of the questions, I had not a developed opinion, and I had to think for a bit before writing, it was not immediate." - P2

Out of the four students, only one had used a diary and even started using a bullet journal during this study. Overall, students did not write much in the diary as it requires time, motivation, and building a habit out of it. Nevertheless, all students agreed on the objective of using diaries and did not deny its value.

"The idea I got is that it is like looking back and thinking while writing helps organize the ideas and understanding what sometimes can be more influencing our well-being." - P1

Self-tracking

All participants had tried or currently engage in self-tracking with either smartbands or mobile applications to track steps, distance, heart rate, calories, and nutrients. Some of their experiences were very short because it was time-consuming, they were not able to create a habit, or the application ended up not helping them reach their objectives.

"I tracked everything that I ate, and it would say the calories, nutrients, and everything more. It was nice, but it was too much work." - P1

"I started tracking my sleep cycles with applications that see in what sleep phase you are in and try to wake you up at the right moment, but I did not find one that woke me up at the right time and so, I uninstalled it." - P1

One participant referenced the main problem of passive tracking and admitted that active tracking has an increased value.

> *"I have a smartwatch, and it does it all. It tracks calories, steps, heart rate, and everything is registered, but I also do not go check it out, I do not see the purpose... [In active tracking], for each result, you have to be aware of it. It is not something that records itself automatically, and you have to be aware of it, which makes it more effective." - P2*

Nevertheless, some participants also stated that active self-tracking has an increased capture-burden, which can negatively impact its acceptability.

> *"When self-tracking is active, it implies that a person has to dispense a little of their day to record something, and either things are pretty easy, or that person might not have enough will." - P4*

Data-sharing

Every participant saw value in sharing self-tracked data with health professionals such as doctors, psychiatrists, and psychologists.

> *"It might be the easiest way for a psychologist to analyze someone, it is information that a person gives and that he/she is not even processing the information that might help." - P1*

Out of the four participants, only one raised privacy concerns regarding information being used out of the intended context.

> *"One thing that worries me with these devices is if my data is going to be shared with companies for other purposes such as advertising." - P4*

Well-being

Although not every participant was equally affected, everyone agreed that college negatively affects students' overall well-being, where stress was the most referenced problem. This was either caused by excessive workload, peer-pressure (*"the mentality of a person is affected by the people that surround them"*), pressure from their families, or also the pressure that is implied by college (i.e. graduating, having good grades and finding a job).

> *"Being a student implies spending much time working, studying, and that leaves little time to reflect, to internalize the feelings. I believe that can accumulate and manifest in some way. I consider that students usually do not reveal much of their well-being and let it advance forward until one day something might happen, it might burst." - P4*

Two of the participants said they were not as affected by these issues and suggested two strategies to avoid further implications.

> *"Maybe when we put things in perspective, for example, writing, understanding how this day went better or worst, and if it was more or less productive, it allows us to understand that we are not doing things with the right strategy." - P1*

> *"...to be able to maintain our well-being a little stronger, we distance ourselves from that burn-out, and I think we sacrifice a bit our college responsibilities." - P3*

Help-seeking

When we asked the students whether they believed young-adults avoided seeking help, three of them agreed with that statement. They said they tend to save everything for themselves and try to solve their issues alone either because they convince themselves they can manage such issues or because they do not feel comfortable sharing with others.

> *"Over the years, I have been building this idea that I have to be careful sharing this information with other people because of what they can do with such information. I think it is that idea, that fear that stops me from seeking help sooner." - P4*

These same participants admitted they usually do not seek help, but they were glad that someone offered it to them.

> *"I think I was lucky because if they had not introduced me to NAPE, I would probably never went there, and I do not really know where I would be right now if I had not admitted I could receive help." - P4*

Additionally, one student pointed out that such help-seeking behaviors can have further repercussions in the future.

> *"...if nothing is done, in a few generations, this spreads to a global context... Now, it is starting, and if we do not reinforce this idea of help-seeking, this can turn out to be a bigger problem in the future for the people that become adults." - P4*

Only one participant did not agree that college students avoid seeking help. He stated that mental health is already a popular theme that people openly discuss, but he admits there is a need for more effective help.

> *"I do not think I believe in that... I have friends that sought the help of psychologists and that are being followed by psychologists. I think, by default, when people think that it can help them, they search for help but there is not much available that at least seems effective." - P1*

3.1.5 Discussion

Overall, participants seemed to enjoy the activities we proposed with this cultural probe as it helped them reflect on different subjects and increased their awareness regarding their well-being. Self-tracking was well accepted among these students and exposed the value of leveraging such approaches in a college setting. Although some students shared past failed experiences, it helped us elicit and confirm some design guidelines, such as the value of a dedicated tool and active self-tracking. One participant also referenced the importance of adding justifications to light-data such as the stickers. While the calendar helped them be more aware of their well-being and allowed them to highlight patterns, participants did not value the spatial data (i.e. campus map). This information might be useful to leverage by aggregating the data of multiple students, but it does not seem worth tracking during a long period of time. Furthermore, participants saw the value and were open to share self-tracked data, but it was also evident that reducing privacy concerns should be a design goal for future self-tracking tools. Lastly, the acceptability regarding the use of a diary proved to be very subjective and, although participants understood its value, the capture burden might be an important concern.

The insights that the participants shared with us regarding well-being and help-seeking gave us further proof of the ongoing problem among college students. Participants agreed that college was negatively impacting students' well-being, and they referenced stress as the main issue. Furthermore, since these students admitted they do not usually seek help but were glad when someone offered it, there is also a need to facilitate and encourage help-seeking and sharing of valuable information.

3.2 Data, Sharing & Privacy

Although we found self-tracking to be well-accepted among college students, collecting and sharing user-generated data raises privacy concerns. That mostly happens considering such data may be used outside the user's original purpose. With this study, we intend to better understand user perspectives on the data that self-tracking tools should collect, their intentions and objectives about sharing such data, and their emotions if their expectations are not met. Taking inspiration from the work of F. Hamidi et al. [46], to ease conversations regarding user preferences and expectations, we propose a participatory activities toolkit.

3.2.1 Toolkit Design Process

To get a comprehensive understanding of college students' perspectives, we designed a toolkit that includes materials and activities which should elicit opinions regarding the various components of self-tracking. With that in mind, we propose activities that expose students' views concerning the most

Figure 3.2: Toolkit overview: (1) Data Type Cards; (2) Yes, No and Maybe Tokens; (3) Scenario Card; (4) Sharing Methods.

valued types of data, their perceived usefulness and intention to share their data, and their preferences regarding the sharing process. Finally, just as F. Hamidi et al. [46] proposed, we also intend to catalogue how students feel when their expectations are not fulfilled.

Materials

The final toolkit includes the following materials:

1. **Scenario Card** - a single card that summarizes the functionality and objective of a hypothetical self-tracking tool with the following description: *"A self-tracking tool with passive and active collection of data, for students to monitor their well-being and share with other stakeholders"*.

2. **Data Type Cards** - Coloured cards that represent types of data and which could be collected by the self-tracking tool. We grouped these cards into eight dimensions of well-being, where each was represented by a different shade of blue. Besides the dimension and title of the data type, we also included a banner that indicates whether the data is qualitative, quantitative, or a rating. We made a total of fifty-eight data type cards that can be found in Appendix C. We also included blank cards in case participants wanted to use other data types.

3. **Yes, No and Maybe Tokens** - three types of circular coloured tokens: (1) Green - YES; (2) Red - NO; and (3) Yellow - MAYBE.

4. **Sharing Methods** - three sets of coloured cards with different data sharing mechanisms: (1) Real-time (purple) - the data is shared in real-time; (2) Systematic (orange) - the data is shared periodically (e.g. monthly); and (3) On-demand (cyan) - the data is shared only when the user intends to.

Figure 3.3: Toolkit overview: (Left) Main Board and Stakeholders; (Right) Emotion Chart and Numbered Tokens.

5. **Main board and Stakeholders** - An 11x12 table where the first column includes ten types of stakeholders (i.e. people who may be interested in students' data) such as family, friends, professors, mentors, campus counsellors, campus administrators, medical professionals, psychologists/psychiatrists, governments, and researchers. The ten following columns (2-11) are where the data type cards (first row) and Yes/No/Maybe tokens should be placed. Finally, the last column includes slots for the sharing methods cards.

6. **Emotion Chart** - a Valence/Arousal chart with annotations on its axis. The chart did not include examples of emotions in order to not bias the user.

7. **Numbered Tokens** - ten circular tokens with a number from one to ten.

Activities

The toolkit includes a series of four activities that use the materials previously described. Before the activities began, we started by reading the description written on the scenario card. We also asked the participant to read it, and we made sure they fully understood the functionality and objective of the self-tracking tool.

Activity 1: What data should the tool collect? We first asked the participant to select the data types they expected the tool to collect. The participant should then choose ten data type cards that they think are more important to be collected. Each card was to be placed on a different column on the main board. We also allowed the participants to add alternative data types using blank cards. Furthermore, we asked them to justify each one of their choices.

Activity 2: Who should access my data? We then requested the participant to choose, for each of the ten data types chosen, who (i.e. which stakeholders) should access this data. By using the tokens,

they placed a *"YES"*, *"MAYBE"* or *"NO"* on each of the cells on the main board, representing a pair (data type, stakeholder). Again, we asked them to elaborate on why they would share each data type with each stakeholder. Since this activity was the most time-consuming, we allowed the participants to explain their reasoning for each data type (i.e. each column) or each stakeholder (i.e. each row), rather than justifying every single token.

Activity 3: How should the data be shared? To complete the main board, we asked the participant how they expect their data to be shared with the different stakeholders. We gave them the cards which represent the sharing types, and they placed one of them for each stakeholder (i.e. each row of the main board). We finished this activity by asking the participants to elaborate on each choice they made.

Activity 4: How would I feel if my expectations are not met? In this last activity, the participant speculated on how they would feel if the previously stated expectations—on the first three activities—were not fulfilled. After explaining and giving examples on how to use the Valence/Arousal chart, we asked the participant to place the numbered tokens where each represents a row on the main board (i.e. a stakeholder). If the participant chose not to share a data type with a stakeholder, we would ask them how they feel if it was otherwise shared. Furthermore, if a participant expected to share their data only on-demand, we would ask what would their emotion be if such data was shared in real-time. In this activity, we once again asked the participants to explain their reasoning.

Remote Participatory Activity

Since this study took place after the outbreak of COVID-19, we had to adapt our procedure to the new conditions. Our approach to solving this problem was to digitize the materials and, therefore, the activities. Since the COVID-19 pandemic increased the popularity of board/card games, we took advantage of a simulator for tabletop games. In Tabletop Simulator[2] you can *"Create your own original games, import custom assets, automate games with scripting..."*. By leveraging this simulator's features, we created custom assets for the materials previously described and arranged them in a table. We used two boards: a main one for the first three activities and another with the Arousal/Valence emotion chart. We grouped the data type cards into categories, added three bags with the Yes/No/Maybe tokens, and three more bags with the different types of sharing. On top of the emotions board, we added ten numbered tokens to be placed on the chart. To conduct the activities, we gave the participant control of our computer—which had the game installed—using Parsec, a tool to stream games for users to play together. Using the mouse and some useful hotkeys (e.g. Alt - zoom on an object), the participants were able to perform all the activities.

[2] https://www.tabletopsimulator.com/

3.2.2 Using the Participatory Toolkit

We used the developed toolkit to facilitate discussion around college students' perspectives regarding self-tracking and sharing data for their well-being. In this section, we showcase information concerning the participants and the procedures for data collection and analysis.

Participants

We recruited eight participants, between the ages of 18 to 25, who were IST students. Once again, this was only possible with the help of NAPE, which invited students who were ENEE or were being advised by NAPE's services.

Interview Procedures

After recruiting participants, we conducted eight semi-structured interviews through a video-call on Zoom[3]. We started these sessions by presenting the theme of this dissertation, which included showcasing the problem, explaining self-tracking, and revealing our proposal. We next explained the objective of this study and described what they were going to do throughout the session. Finally, we proceeded with the four activities described in the previous section.

Data Collection and Analysis

We recorded and transcribed each session, and although some of the recordings got corrupted, we still managed to take some notes from them. Tabletop Simulator also allowed us to save the sessions' final state, allowing us to further analyze their decisions and correlate the data with the transcriptions. Lastly, we conducted an iterative thematic analysis.

3.2.3 Findings

Activity 1: What data should the tool collect?

Overall, our findings from this activity suggest that students tend to value similar types of data but resort to some that are more specific due to personal motives. One of the most recurrent themes was the importance of productivity among college students. For this purpose, participants mainly chose the number of hours being productive and ratings associated with productivity levels. While for some the number of hours was a valid indicator of productivity, others preferred the use of ratings because as one stated: *"I can work ten hours and be unproductive, but in the next day I can work 2 hours and still be more productive than those 10 hours"*. Furthermore, some participants chose both data types so

[3]https://zoom.us/

one can complement the other. While one participant selected grades as a measure to track because it is closely related to his well-being state, another raised concerns about having them as the primary objective and suggests healthier goals related to productivity.

> *"Having grades as the main objective can bring us down, especially as college students. I think we should focus on more concrete objectives: 'I am going to study these hours for this class', more than: 'I want to finish with a 16 or 18', because sometimes it is out of our reach." - P2*

Out of all the participants, only one did not select data related to productivity because it previously harmed her well-being.

> *"There was a time I thought productivity was super important, but meanwhile, I started having anxiety due to that, so I already changed my mindset." - P1*

In order to preserve their well-being, participants suggested students should balance workload with social and creative activities. Once again, their preferences regarding the type of data that should represent these dimensions were diverse. While some chose quantitative metrics such as time spent socializing and exercising creative habits, others preferred ratings as an objective measure to evaluate the quality of those activities. Additionally, two participants preferred note-taking to track these dimensions because ratings can be too vague to represent complex situations.

> *"I think it [tracking creative habits] is an interesting thing because it is good for a person's mental health." - P2*

> *"After all, since we have so much work to do and we also want to rest, we end up losing the notion of time we spend or not with our friends and family." - P5*

Another theme that was repeatedly discussed was the emotional dimension of well-being. Participants stated that stress and anxiety were recurrent among college students and that these are measures that are beneficial for them to track. Additionally, three participants referenced the importance of monitoring addictions and its negative impact on well-being, and some preferred tracking more general measures such as mood and emotions.

> *"I do not know any college student who does not suffer from stress, meanwhile there are also those we suffer from anxiety." - P2*

Regarding these emotional measures, participants either preferred assessing ratings or taking notes, while the latter provides the much-needed context. Nevertheless, two participants suggested combining both types of data, as distinct situations require different amounts of context.

"[Quantitative measures] remove a lot of context and might be more confusing. How a person is feeling always has associated context, and if we remove that context, I think important information is lost. I can have [both data types] and evaluate emotions with ratings... and then, on my mood notes, I could explain better." - P8

Besides the emotional aspect of well-being, participants also emphasized the importance of tracking the physical dimension. For this purpose, they mostly chose quantitative metrics and ratings to monitor their sleep, exercise and nutrition. While the latter was less common, all participants stated that these three aspects have significant implications for their well-being. In this case, note-taking was only chosen for tracking exercise and eating habits.

"Because that is the basis of everything, in other words, nothing can be done throughout the day if a person did not sleep correctly." - P4

"I think exercising is fundamental. Even if a person does not enjoy it much, I think it is important." - P2

Lastly, while not as common, participants also found it useful to track their financial situation, self-esteem and quality of surroundings because these aspects significantly impact their overall well-being.

Still regarding this activity, one student insisted on selecting pairs of data because they provide further context. These pairs were either metrics with ratings because he states metrics can be too subjective, or ratings with note-taking.

"When choosing these pairs of metrics and ratings, I am also thinking that note-taking can be more useful in particular cases. It is more for exceptional situations where it might be useful to have more context if something goes wrong." - P8

Activity 2: Who should access my data?

In this activity, we were able to elicit perspectives regarding students' willingness to share the data they selected in the previous phase. Although participants' opinions were different because some were more open to sharing than others, we were able to detect recurrent themes.

Their willingness to share was mostly influenced by the perceived usefulness of sharing their data. This was recurrent across all stakeholders because although some participants saw more value than others, everyone agreed that sharing their data to these third-parties always has some usefulness. Whether it was for professional help from counsellors, doctors and psychologists, or statistics for college administrators, government and researchers, participants agreed on the importance of data-sharing.

"I would give doctors and psychologists access to everything because they are the ones who can really do something with it and help me." - P8

"I would say yes to all of this. For example, for those in college administration can have an idea of their students' statistics and their levels of well-being, and can use those metrics to support their decisions." - P4

Nonetheless, most participants would not share data types if that information did not seem useful for the end-goals they had in mind.

"For a physical doctor, I just do not consider essential or necessary for him to know how is my social life and how I feel [emotionally]." - P8

Despite the perceived usefulness, most participants raised some type of concerns regarding the privacy of their data. When the stakeholder in question was personally related to them, some participants stated possible drawbacks, such as additional pressure from more controlling families (e.g. when there is a lack of productivity) and concerns that may arise when people compare themselves with friends.

"In my case, if I share this data with my family, they will judge me. It can be additional external pressure, hence the maybe." - P4

"I think there can be a system of comparison between people and that might increase levels of stress." - P4

Additionally, when the stakeholders in question were more distant, such as college administrators and government, while some participants did not worry as much because the data would be used for statistics, others showed concerns regarding the use of their data for other purposes.

"It is always a risk you take. Any information that I extract out of me is information that I lost to the world." - P8

Lastly, besides detecting a pattern in the participants' choices, we questioned them regarding the influence that the type of data (i.e. Metrics vs Ratings vs Notes) has on their decision to share. Even though there was one student that would share any data in whichever form, all participants agreed on a preference order regarding the three types. While their disposition for sharing ratings or more quantitative metrics was similar, the former was preferred as it is less specific and raises fewer privacy concerns. Lastly, participants were less willing to share qualitative data as it is more private and involves more detail. Furthermore, a participant referenced that this was exacerbated by the existing stigma regarding mental health.

"Generally speaking, people are less willing to share qualitative data because they think it is too private. For example, mental health is a theme that involves stigma and people are ashamed of talking about it..." - P1

"Qualitative is what bothers me the most to share because it is the highest degree of precision of my information. Quantitative data is intermediate... and then ratings are the easiest data to share." - P8

Activity 3: How should the data be shared?

In the third activity, participants expressed different opinions about how they would prefer to share their data with the various stakeholders. While one participant was comfortable sharing the data in real-time with most of the third-parties, the remaining only chose such option with stakeholders that can provide more immediate help, such as their close family and friends, and their psychologists/psychiatrists. Nevertheless, one participant never selected the real-time method because there was no need to give that much control to someone else besides him.

"Regarding the family, data should be shared in real-time since they are the first who can act to improve the student's well-being. It is the front line... In the same way, our friends." - P4

"Usually, people who are followed by a psychologist, they are regularly attended... and when something is not right, it can also be easier to be accompanied." - P2

Regarding the preferences between the on-demand and the systematic methods, participants had two different perspectives. Some of them stated that it was useful to systematically share their information in order to be more readily supported. Nevertheless, the participants sometimes said there was no need to share the data so frequently and that the on-demand method would be enough. One participant also preferred this method for the stakeholders that were more close to his personal life.

"Those were I chose systematically were the ones where it is worth to have a periodicity for when the data is analyzed." - P2

"I do not have a problem, but I think it might not be necessary to receive that many reports." - P1

Activity 4: How would I feel if my expectations are not met?

Since some participants were very open about their data and the way they would share it, in this activity, we asked them how they would feel if the application did not allow to share their data as they expected. Although most expressed an indifference, their emotion was more intense if they had increased perceived usefulness, such as the value of sharing their data with a psychologist.

"It is sad because it would be a facilitation... Never had it, so it did not change my life, but I would be a bit sad because I created expectations that something would change, but it did not." - P3

When we asked how they would feel if their expectations were not met and if stakeholders gained more control than they wanted to give, we had different perspectives which took into account how distant the stakeholders were. While some participants felt angrier when third-parties such as the government and campus administrators had more control, others were worried about their data if their close family and friends had increased access. This feeling was further intensified due to their data being shared in real-time.

> *"I would be angrier than if it was with my family because they are people I do not know." - P2*

> *"It is a negative feeling because it is an intrusion of privacy, and an unnecessary one if it does not inform politics of change." - P4*

> *"Both my parents and my friends... if they would use the application to control me in real-time, I would be a bit mad. I would feel too controlled, but I would not feel as much controlled if it was with doctors or other stakeholders that, like me, have other hundreds." - P3*

One participant further explored this duality by stating:

> *"While there are things that if they know, it will disturb me less because they are closer to me and we are more comfortable, there are things that are more prejudicial if they know, exactly because we are close." - P8*

Nevertheless, when participants thought their data would be used in a more aggregated way, such as governments, college administrators and researchers, they felt indifference towards giving more or less control. They justify this feeling by stating that the third-party involved would have access to multiple users' data and would not discriminate an individual.

> *"It could not be any more indifferent. With so much people, they would not care." - P2*

3.2.4 Discussion

With this study, we were able to get a deeper understanding of college students' perspectives regarding self-tracking tools. Our findings from the first activity indicate that even tough participants agreed on which well-being' dimensions should be tracked, their preferences regarding types of data are very diverse. There was no clear favourite between quantitative and qualitative measures, as participants concurred that different case scenarios require different information. Such was most evident when participants preferred the use of qualitative data for the emotional part of their well-being and quantitative measures for the physical aspects. This enforces what we already know from the related work explored, that self-tracking tools need to be flexible enough to support diverse configurations and data inputs. Additionally, our findings suggest that combining different types of data is appreciated by college students,

as most of the times they offer distinct value. While metrics are often not enough to evaluate some aspects of well-being due to the lack of objectivity (i.e. a higher number of working hours might not mean higher productivity), ratings offer more accurate information but offer even less detail. Furthermore, both these types of quantitative data often lack relevant context which can be supported by descriptive qualitative data.

The results of this study's second activity mostly show that students perceive sharing data as a useful tool to manage their well-being. Nevertheless, they feel threatened when their data might be used for a different purpose regardless of their intentions. Another important finding was that their willingness to share is related to the data types (i.e. metrics vs ratings vs notes) since they are more likely to share information that offers less detail. From this, we can confirm that there is an opportunity to couple quantitative data, which lacks context but is more likely to be shared, with qualitative data, which offers the needed context but can remain in control of the user. The participants' choices in the third activity indicate a preference for having more control over how their data is shared. While the on-demand option was also popular, students often chose to systematically share their data to decrease the sharing burden while not giving up total control of their information. By doing so, it reduces the feeling of being monitored. Real-time data sharing was a rare choice as it increases privacy concerns and is only slightly more useful in specific scenarios. The findings from the second and third activities suggest participants' expectations regarding what and how data should be shared vary according to their end-goal and with whom they are sharing. We propose that self-tracking tools take these perspectives into account, and if they include a sharing mechanism, such feature should offer users as much control as possible, not only regarding the selection of data but also control of how it is shared.

Regarding the last activity, findings indicate that students have strong emotions not only when they lose control of what data is shared and how it is shared, but also when they build expectations, which are not met, regarding the usefulness of sharing their data. If self-tracking tools leverage these findings and fulfil college students' expectations, there is a higher chance of acceptance and long-term engagement. Furthermore, this means that self-tracking tools should be flexible enough to support different data types and offer a customizable sharing experience to reduce privacy concerns and meet the users' demands.

4

DAN and Danny

Contents

4.1 Approach 47
4.2 Architecture 48
4.3 DAN - Digitally Augmented Notebook 49
4.4 Danny - Mobile Application 56
4.5 Communication Layer 64

Having in mind the related work and user research previously explored, in this section, we describe our approach, design goals and objectives. After showcasing our approach and architecture, we give a detailed description of the design and development process of the tools we created.

4.1 Approach

Following the trend of Personal Informatics and the Quantified Self, our approach consists in developing a self-tracking system built for students in a college setting. Our tool aims to increase the student's awareness regarding their well-being and facilitate help-seeking behaviours.

Self-tracking Tool. Taking into account the related work explored in the previous section, we gathered the necessary requirements for our self-tracking tool. We propose a **dedicated** solution which is **flexible** enough for all students' necessities and has a **balanced capture burden**. In order to further increase student's self-awareness, our tool relies on **active assessments (EMAs)**. Considering the advantages and drawbacks of both analogue and digital approaches, we propose to **digitally augment a notebook** and, by doing so, we allow both types of input and leverage the advantages of each approach. Additionally, the augmentation we propose allows users to select and rate well-being related measures. Students can use the diaries as they intend, such as writing justifications and contextual data or even engage in bullet journaling practices. With this tool, we expect users to be able to input descriptive data coupled with self-assessed ratings and, therefore, building a bridge between qualitative and quantitative data.

Visualizations. We propose to create a companion App linked with the self-tracking tool in the interest of increasing awareness and promoting reflection. Furthermore, this application focuses on providing accessible visualizations that are easily perceived and understood, giving meaningful insights back to the student.

Sharing. Besides the feedback provided by the visualizations, students should also be allowed to effortlessly share their data with others in order to gain further feedback. The user can select which information to include and generates a static anonymous snapshot of their visualizations. Therefore, we are able to preserve users' privacy as they have full control of which data is shared, and do not feel like they are being monitored because this data is static.

User-centered design. It is important to emphasize that the design and development of our system will be user-centered as we maintain a close connection with potential users to receive feedback throughout the entire process. Furthermore, in our user research studies, we will always showcase our current approach and discuss possible drawbacks and improvements.

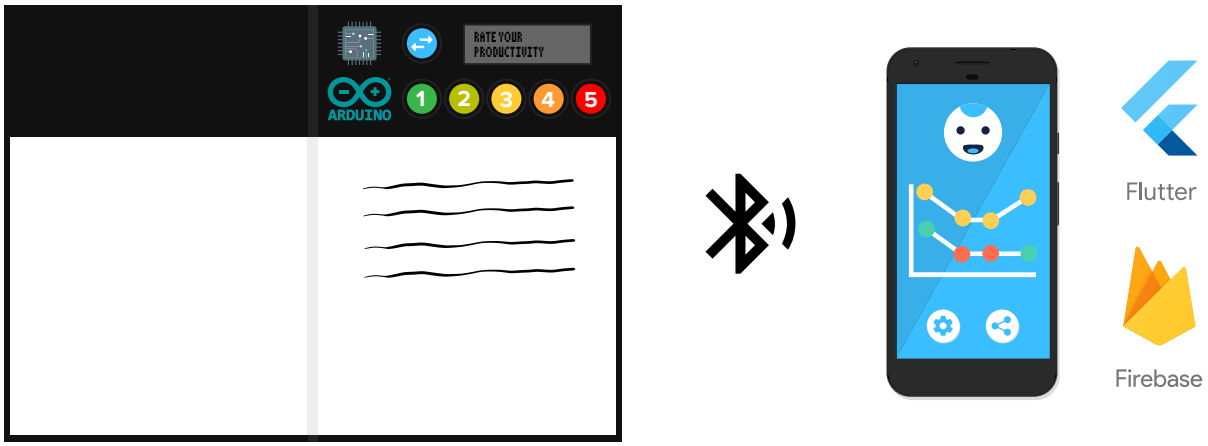


Figure 4.1: Solution architecture. DAN (left) syncs data through BLE with the mobile application (right).

Objectives. With this system, we aim to provide the tools to help students and other stakeholders identify, discuss, and work towards solving well-being issues. Our solution should increase the students' awareness regarding their well-being and facilitate help-seeking behaviours.

4.2 Architecture

After defining our approach, we can now present our system architecture, as seen in Figure 4.1, which is divided into two components: Digitally Augmented Notebook (DAN) and the Student's Companion App (Danny). In this section, we explore both these parts and how they interact with each other.

4.2.1 DAN - Digitally Augmented Notebook

DAN is a dedicated self-tracking tool based on a regular notebook and can be used as a diary for analogue input. We propose an Arduino-based augmentation that consists in the addition of five buttons and an LCD with a button to allow users to select and rate well-being related measures. Each assessment is stored in DAN and then synced through Bluetooth Low Energy (BLE) with the App if the phone is nearby.

4.2.2 Danny - Mobile Application

DAN's users also have access to a companion mobile application that serves as a medium to configure the tracked measures and to visualize the data collected. Within this App, students are able to visualize different idioms that use the collected data and give meaningful insights about their well-being. This application also houses a sharing mechanism that should ease help-seeking behaviours. Such feature allows users to select which data to include in the snapshot and generates a PDF that can be shared with anyone the user wants.

Figure 4.2: DAN's digital augmentation

4.3 DAN - Digitally Augmented Notebook

DAN is a dedicated portable self-tracking tool that focuses on active assessments (EMAs). The purpose of this device is to offer the means for users to collect data regarding their well-being. Based on a regular notebook, it can be used as a diary or for bullet journaling practices. The digital augmentation allows DAN to support digital input in the form of ratings. DAN lets users make assessments on their well-being by rating meaningful factors and writing down further contextual data.

4.3.1 Features

Bearing in mind the explored related work and our user research, we selected a group of design guidelines that we wanted our tool to follow. We consider the following features as the main contributions of our self-tracking tool:

Digital & Analogue – By allowing both digital and analogue data collection, we leverage the advantages of both approaches and offer a **balanced capture burden**. The ratings can be easily captured and analyzed but might provide insufficient insights (i.e. they do not provide context). The analogue data, although it involves a higher capture burden, it offers the much-needed context for the digital data. This functionality enables users to bridge the gap between quantitative (ratings) and qualitative (personal notes) data by creating a link between digital and analogue data collection.

Digital Augmentation – Although our objective was to digitally augment a notebook, we did not want to drastically change the usual experience a user has with a notebook. Our digital augmentation includes the addition of a small LCD, a button to interact with it, and a group of five buttons where each one represents a different rating. This grants users the ability to select a specific aspect of their well-being and rate it accordingly.

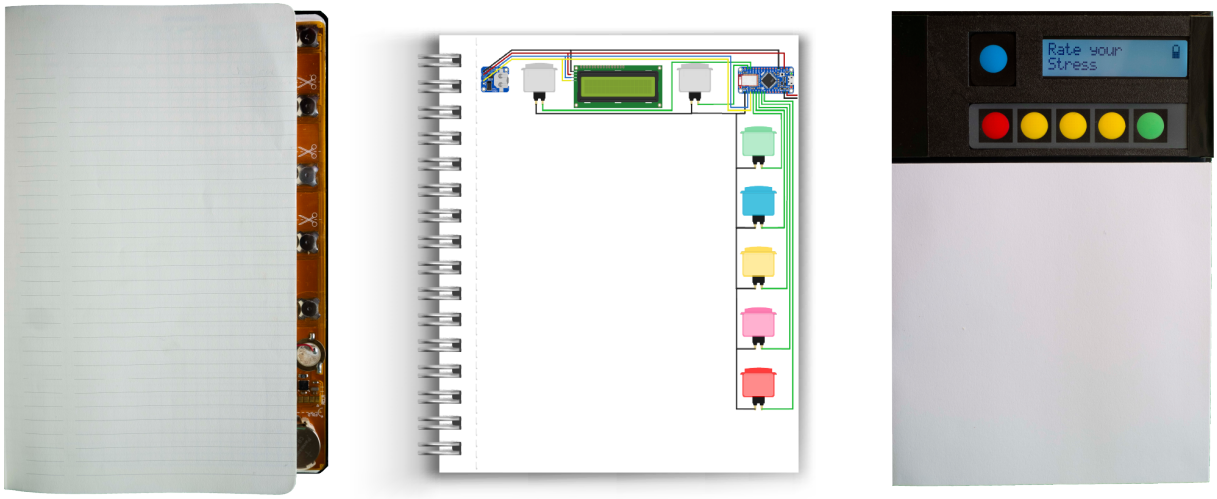


Figure 4.3: DAN's prototypes: (1) Original; (2) First; (3) Final.

Dedicated for Self-tracking – Furthermore, it also means that this device is a tool dedicated solely for self-tracking. We hope that this helps the user to focus and to stay away from further distractions while they reflect and input their data. Additionally, having a dedicated tool such as DAN can serve as a reminder for engaging in self-tracking assessments.

Portability – Another one of DAN's main characteristics is its portability, which is a relevant in-situ self-tracking approach to reduce the recall bias. We preserve the notebooks form factor, allowing the user to easily carry it and not requiring any external ports (e.g. charging USB port).

Active data capture – We also chose to focus on active data collection because, while it might impact the capture burden, we see an increased advantage as it promotes more self-awareness and self-reflection.

Flexibility – A notebook is already the most flexible tool when it comes to analogue data capture. From simple text annotations to complex structures used in bullet journaling, it is clear that a notebook does not constraint users' strategies. With that in mind, we also want to offer a flexible experience for digital data capture. Even though our tool collects only light-data, it enables users to adapt the tool for their needs by configuring the aspects which they believe mostly impact their well-being.

4.3.2 Prototype Iterations

In this section, we explore DAN's evolution by showcasing the different prototype iterations, which can be seen in Figure 4.3, their limitations and proposed solutions.

Original prototype. The original prototype we had in our possession only included a strip of five buttons, a real-time clock, a memory to store the ratings, and a coin battery to power the system. To transfer the data from the device, the user would have to manually sync the data using specific software.

First prototype. We identified a set of problems with the original prototype which conflicted with the previously decided design guidelines. The importance of flexibility led us to add an LCD screen and two buttons to interact with it, which allows associating the ratings with different measures instead of a single one. The previous prototype also introduces a burden regarding the collection of the data from the device. Adding Bluetooth communication enables us to offer real-time synchronization of the user's data with their phone. Having a more robust system, we also decided to add a charging circuit and a battery with higher capacity. Nevertheless, all these changes increased the weight and cost of the device, and reduced the amount of space where users can write.

Final prototype. The final changes implemented were mostly related to the device's form factor. After collecting feedback from potential users, it was evident that the previous design could negatively impact their experience. By placing the buttons on the right side of the notebook, we introduced conflicts with the user's hand movement while he/she would write in the notebook pages. This limitation could lead to involuntary input by miss-clicking the buttons and discomfort regarding hand movement. In order to avoid such issues, we decided to abandon the "L" shaped approach and move the buttons under the LCD. Such meant having all the hardware in a rectangular-shaped box on top of the notebook, leaving enough space to have square-shaped pages on the notebook.

4.3.3 Hardware Circuit

Throughout this section, we discuss our hardware choices and explain the different functionalities of the DAN's circuit.

The **main circuit**, which is represented in Figure 4.4, includes the following components:

- DFRobot Beetle BLE[1]
- Gravity: 2C Arduino LCD Module[2]
- Gravity: I2C RTC Module[3]
- 5x membrane buttons[4]
- Single membrane button

[1] https://www.dfrobot.com/product-1259.html
[2] https://www.dfrobot.com/product-1722.html
[3] https://www.dfrobot.com/product-1600.html
[4] https://www.aliexpress.com/item/32950089685.html

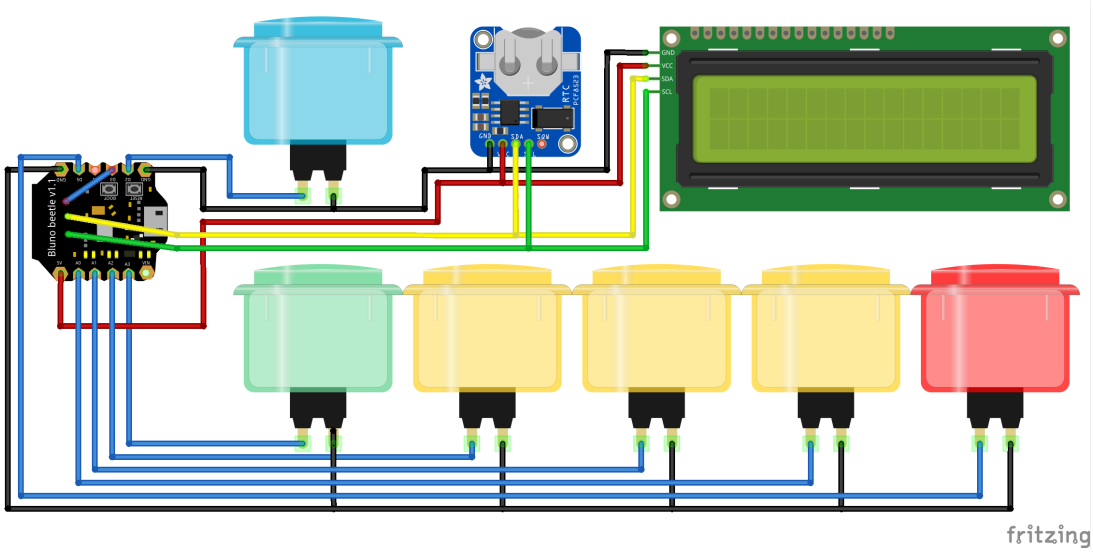


Figure 4.4: DAN's main circuit

Considering our requirements regarding the form-factor and BLE support, we opted for Beetle BLE as our Arduino board. This board includes an I2C interface and eight pins, two of which also serve as interruption pins. The five membrane buttons (i.e. buttons to input ratings) are connected to input pins while the single button is connected to an interrupt pin to allow users to wake their . Furthermore, we also connect the RX pin (i.e. the pin that receives serial and Bluetooth data) to the other available interruption pin enabling us to send interruptions through Bluetooth communication. Lastly, we daisy-chain and connect the LCD and RTC through I2C communication protocol. This allows us to display text on the LCD and use the RTC to collect timestamps when the user selects a rating.

Connected to the Arduino, we have a **charging circuit** which is composed of:

- Polymer Lithium Ion Battery - 3.7v 1500mAh[5]
- TP4056 Charging Module[6]
- Wireless Charging Module 5V/1A[7]
- USB to TTL Cable[8]
- 5V USB Charger

The rechargeable battery should power our system through two days of usage, and its charging and discharging are mediated by the TP4056. Furthermore, this battery can be wirelessly charged through the inductive module that is connected to the 5V charger through USB.

[5]https://www.aliexpress.com/item/33002448419.html
[6]https://www.amazon.co.uk/TP4056-Lithium-Charging-Protection-Function/dp/B07BSVS842/
[7]https://www.dfrobot.com/product-1284.html
[8]https://www.dfrobot.com/product-1277.html

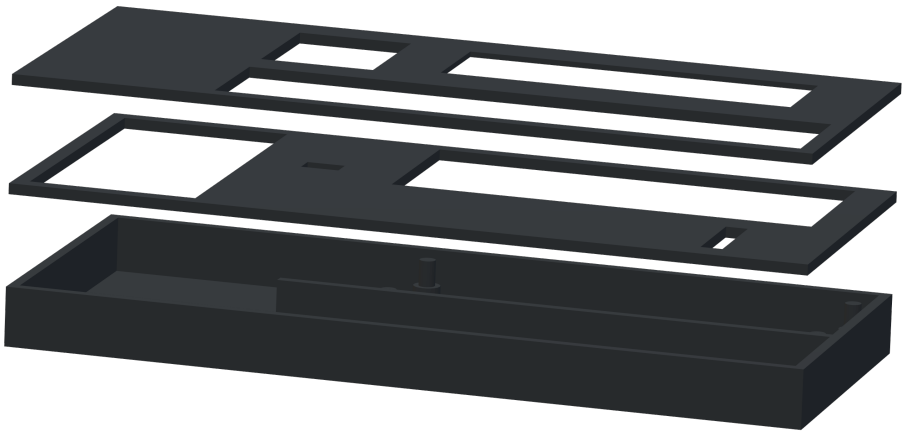


Figure 4.5: DAN's 3D model

4.3.4 3D Model

In order to create the housing for the entirety of our circuit, we decided to design and print a 3D model. To create such model, we leveraged Thinkercad[9] - an online easy-to-use 3D CAD design tool. Since we were not able to have access to a 3D printer, we took advantage of an online 3D printing service[10]. This service allowed us to upload our 3D models and choose parameters such as the printing material, quality and filling. Our selection included black PLA, a detail of 0.2mm, and 100% filling in order to provide a robust structure.

4.3.5 Arduino Code

Lastly, in this section, we present the most relevant segments of the program that we uploaded to our Arduino. Our code has two main functions: **(1) Setup -** the Arduino's startup routine; **(2) Loop -** the function that is repeatedly executed. The structure of these functions is represented in the Algorithm 4.1 and 4.2, respectively.

Configuration Backup

In order to provide a better user experience, we make sure the trackers that they configure are not lost when the device runs out of battery. This is possible by leveraging the EEPROM (i.e. Electrically-Erasable Programmable Read-Only Memory) present on Beetle, which allows us to save small amounts of data that are not lost when the device loses power. When the device's battery reaches a low level, we initiate the backup process that writes the trackers separated by commas and wrapped in a *START* and *END* character (i.e. *"<"* and *">"*). Since EEPROM has a limited number of writes, we save a flag

[9] https://www.tinkercad.com
[10] www.impressao3dportugal.pt/

Algorithm 4.1: Setup

```
begin
    restoreBackup()
    initializeComms()
    initializeLCD()
    initializeRTC()
    initializeButtons()
    initializeControlVariables()
    if noConfig() then
        lcdPrint("No trackers configured")
    else
        lcdPrint("Select the tracker to rate")
```

that controls whether we already backed up the current configuration. When the Arduino powers up, it executes the setup function and, if available, it restores the previously saved backup.

Ratings Stack

When a user inputs a valid rating, we save the tracker assessed, the timestamp, and the rating itself. This data is then pushed into a FIFO stack that pops a rating if DAN successfully sends it to the application. Nevertheless, the Arduino has limited memory, which only allows us to save ten ratings. In case the user reaches this limit, we present a warning message asking them to synchronize their ratings with our App.

Battery Control

Arduino has an internal voltage reference which allows us to calculate the current voltage of the battery. By doing so, we can estimate its current capacity and present it to the user by showing custom characters on the LCD. Thus, users can better plan the charging of the device, so it has enough battery when they need to assess their well-being.

Sleep

In order to save battery and provide a longer runtime without charging, we implemented a sleep method for our components. This method is triggered by either low battery warning or a timeout, which happens if there is no activity in the last 20 seconds. This routine includes the following steps: (1) Turn off LCD; (2) Dispose of I2C communications; and (3) Power down Arduino processor. If the device is in a sleep state, it can be woken up by either pressing the LCD button or by receiving data through Bluetooth.

Algorithm 4.2: Loop

```
begin
    if lowBattery() then
        lcdPrint("Low Battery Please Charge")
        if not backedUp then
            backupConfig()
            backedUp ⟵ true
        sleep()
    else
        if not sendingRatings and not receivingConfig then
            if incomingData() then
                token ⟵ readData()
                updateCommsState(token)
        doComms()
        if waitingForInput and not backgroundMode then
            if ratingButtonPressed() then
                updateLastActivity()
                saveRating()
                waitingForInput ⟵ false
                lcdPrint("Your rating was registered")
            if trackerButtonPressed() then
                changeTracker()
                lcdPrint("Rate your trackerX")
        else
            if noActivity() then
                sleep()
```

4.4 Danny - Mobile Application

Danny is an engaging application that should be installed on the smartphones of DAN's users. Furthermore, the App communicates with the respective DAN allowing it to gather user-generated data. Danny not only serves as a medium to collect the self-tracked data but also to configure DAN. This App promotes self -awareness and -reflection by presenting information visualizations and allowing users to share their data with other stakeholders.

4.4.1 Features

Bearing in mind the related work explored and our user research, we also gathered, for this application, a set of design guidelines. We consider the following features as the main contributions of our companion application.

Trackers & Recommendations – Throughout our application, we utilize the concept of a Tracker. Trackers are nothing more than a measure/aspect that impacts the overall well-being of a person. Still, with flexibility in mind, our App allows users to set up their custom trackers while also offering a variety of recommendations aimed at college students.

Meaningful Insights – It is of paramount importance to present users with meaningful insights that can be easily interpreted. By consuming the data which the user collects, our application is capable of generating various visualizations that promote self -awareness and -reflection. Users can leverage these charts to pinpoint changes and their causes, to find possible correlations, and to track the evolution of their well-being (e.g. to follow the progress regarding a previously set goal).

Sharing Mechanism – On this App, users are also allowed to effortlessly share their idioms and data with others in order to gain further feedback. Additionally, to maintain users' sense of privacy, we give them as much control as possible over the sharing process. The user can choose which visualizations they want to include, generating a static snapshot, which can then be shared with third-parties.

Engaging – One of our goals is to mitigate problems regarding the abandonment rate of our tools. Thus, throughout our App, we leverage gamification elements such as unlockable achievements and other techniques to preserve user engagement and promote re-engagement.

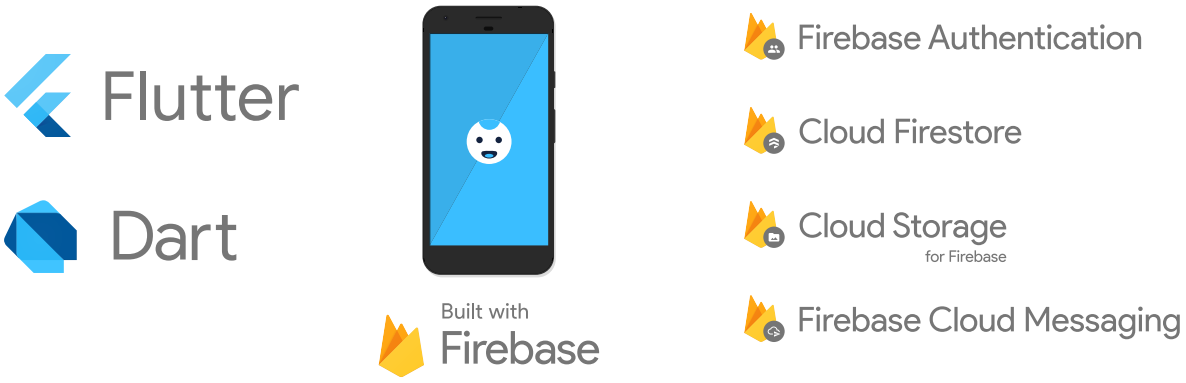


Figure 4.6: Application architecture

4.4.2 Architecture

To develop our application, we decided to leverage a cross-platform framework in order to build both Android and iOS apps from a single codebase. We decided to use Flutter[11], *"Google's UI toolkit for building beautiful, natively compiled applications for mobile, web, and desktop from a single codebase"*. Flutter's performance, usability, and rising popularity convinced us it would be the best option to develop our application. Coupled with Flutter, we also utilized Firebase[12], a Google's platform that provides the infrastructure we require to build this application. We resorted to the following Firebase services:

- **Authentication - grants users the ability to create an account and log into different devices.** This allows our App to securely save user data in the cloud and provide the same experience across all of the user's devices.

- **Cloud Firestore - a scalable NoSQL database that can store and sync data.** We mainly use Firestore to save user details, such as their personal information, trackers and ratings, and gamification data. Furthermore, we also used this database to store the recommended trackers and the achievements that can be unlocked while using the App.

- **Cloud Storage - allows us to store user-generated content**. It includes profile pictures, images associated with ratings, and the PDFs which they generate through our App.

- **Cloud Messaging - Firebase Cloud Messaging is a cross-platform messaging solution.** Through this service, we can send push notifications to our users to either alert them regarding changes on the App or to drive further engagement.

[11] https://flutter.dev/
[12] https://firebase.google.com

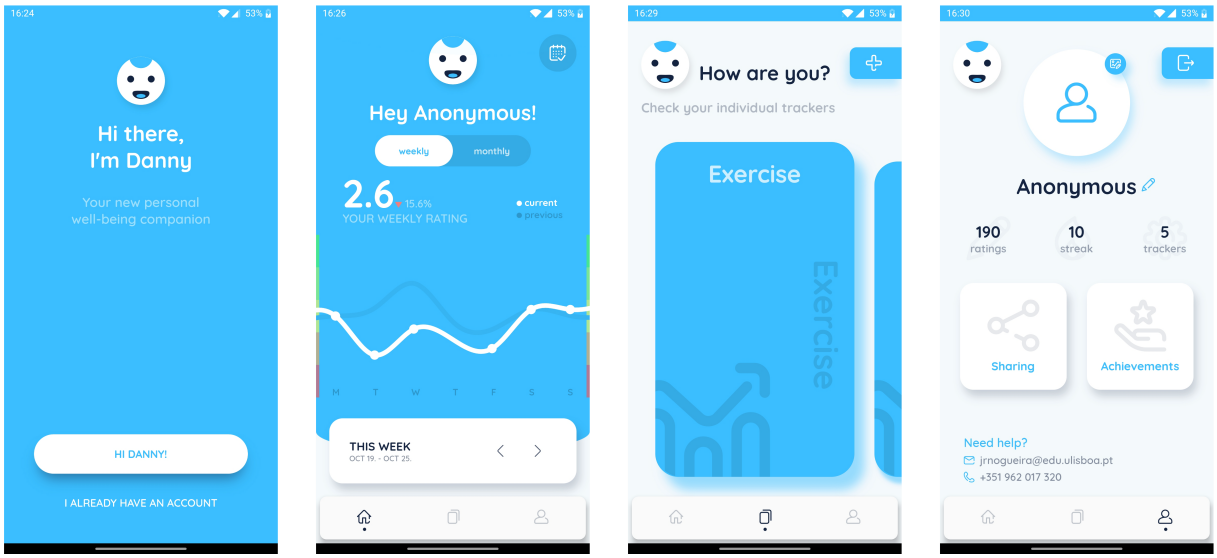


Figure 4.7: App's main flow: (1) Welcome (2) Home; (3) Trackers; (4) Profile.

4.4.3 Navigation Flow

In this section, we showcase the navigation flow of our mobile application. At first, when a new user opens our App (i.e. not logged in), they are presented with a welcome screen. At this stage, the user can either log in with their previously created account or follow the onboarding steps. Before prompting the user to register an account, we present a series of screens that showcase and briefly explain the main features of our App.

When a user logs into our App, they enter the main screen, which includes three tabs:

1. **Home** - The main objective of this screen is to **present the user's well-being data**. For this purpose, the home screen includes a **series of visualizations which aggregate all the ratings a user collects**. Here, users can also **access their ratings** by either clicking on the data points of the line chart or on the calendar view. This enables users to delete unwanted ratings and add images that can be linked with previously assessed ratings.

2. **Trackers** - On this screen, users can **configure their trackers and access the data of each one.** In order to add a Tracker, a dialog is shown giving users the ability to create their **custom trackers** or select from our **recommended list**. The following set of recommended trackers was built taking into account our user research: (1) Anxiety; (2) Exercise; (3) Mood; (4) Motivation; (5) Nutrition; (6) Productivity; (7) Sleep; (8) Social; (9) Stress; (10) Surroundings; and (11) Symptom. Furthermore, by clicking on one of the preconfigured trackers, users can access **information visualizations regarding the respective tracker's data**.

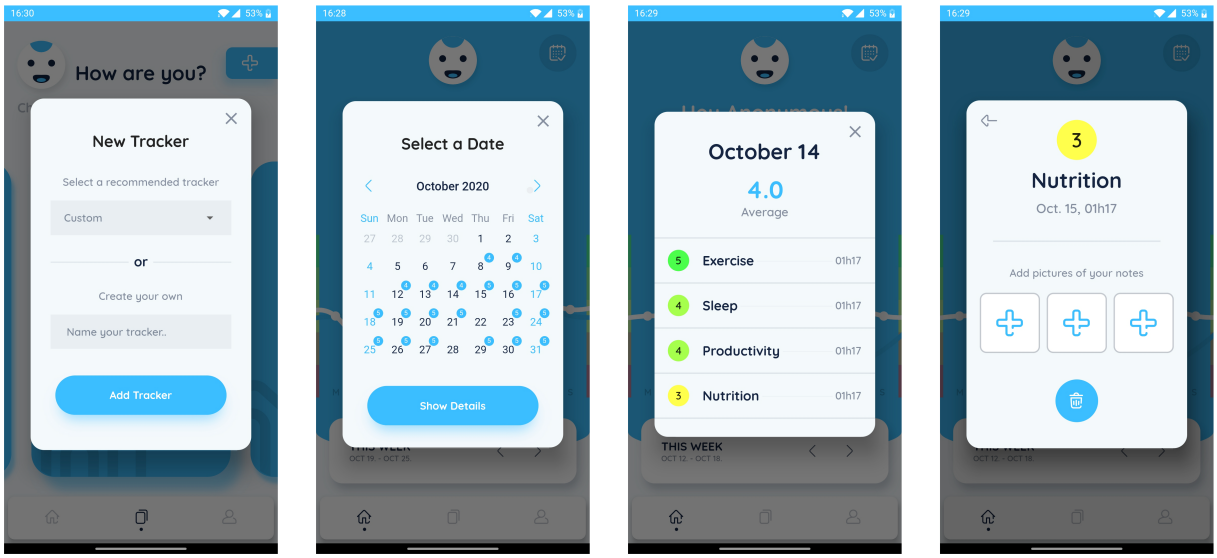


Figure 4.8: App's dialogs: (1) Add Tracker (2) Select ratings; (3) List of ratings; (4) Rating.

3. **Profile** - This screen presents **users' personal information** such as their username and photo, while also allowing them to change said details. Beneath that information, we also include counters regarding **user's activity**, which will be further explained in the Engagement section. Lastly, on this screen, users can also access the **sharing feature** and a list of **unlockable achievements**.

4.4.4 Information Visualizations

The main objective of this application is to consume user-generated data and offer insights in the form of information visualizations. In this section, we explore the vast offer of idioms (Figure 4.9) present on our application, including their marks (i.e. the graphical elements that represent the data) and channels (i.e. how the appearance of such elements is controlled), the tasks users can perform on them, and the questions they can answer.

We can split our visualizations into two groups: **(1) tracker data**, which leverages the ratings of a specific tracker to build idioms, and **(2) aggregated data**, which takes into account all of the ratings generated by the user, regardless of the tracker. Together with our visualizations, we offer tools that enable the user to select a specific time range. They can do this by selecting either the weekly or monthly mode and also by iterating over weeks/months.

Tracker data

Users can access the following idioms through the Trackers screen by clicking on one of the cards which represent the configured trackers.

Figure 4.9: Visualizations: (1) Line Chart; (2) Horizontal Bar Chart; (3) (Monthly mode only) Bar Chart; (4) Multi-line Chart; (5) Horizontal Stacked Chart; (6) Radial Chart.

1. Line Chart

Marks: (1) Point (Weekly mode only); **(2)** Line - connects the different points.

Channels: (1 & 2) The position of each point is defined by two coordinates. The x is the day of the week/month and the y is the average of the ratings of a day (i.e. the higher the average, the further away from axis the point/line is); **(3)** While a white line represents the current data selected, a less opaque line represents the data from the previous week/month.

Tasks: (1) Explore and compare changes in ratings throughout a week/month - Does my productivity improve at the end of the week? **(2)** Compare (average) ratings between the current week/month and the previous on - e.g. Did I improve my sleep since last week? Does my stress follow a specific trend throughout both weeks?

2. Horizontal Bar Chart

Mark: Bar.

Channels: (1) 5 positions, one for each type of rating; **(2)** Length is proportional to the number of ratings (i.e. more ratings leads to a larger bar).

Task: Explore ratings' distribution on a week/month - e.g. What are the most common ratings?

3. (Monthly mode only) Bar Chart

Mark: Bar.

Channels: (1) 7 positions, one for each day of the week; **(2)** Bar is proportional to the average of all the ratings assessed on that weekday (i.e. higher average leads to a larger bar).

Task: Compare averages of ratings on all weekdays - e.g. Am I more stressed on Mondays?

Aggregated data

These idioms can all be found on the Home screen of our application. Some of them are similar to the ones above but aggregate all of the ratings generated.

1. **Line Chart** - Same as the one described in the previous section but takes into account all trackers.

   Tasks: (1) Explore and compare changes in ratings throughout a week - Does my well-being improve at the end of the week? (2) Compare (average) ratings between the current week/-month and the previous one - e.g. Did I improve my well-being since last week? Does my well-being follow a specific trend throughout both weeks?

2. **Radial Chart**

   Mark: Radial Bar.

   Channels: (1) One position for each tracker, ordered from worst (inside) to best (outside); **(2)** Bar is proportional to the average of all ratings of the tracker (i.e. higher average leads to a larger bar).

   Task: Compare average of ratings of different trackers - e.g. What is more negatively impacting my well-being?

3. **Horizontal Stacked Bar Chart**

   Mark: Bar.

   Channels: (1) One for each day tracker; **(2)** Each stacked bar can have 5 portions with colours from green to red. Each colour represents a type of rating; **(3)** Bar is proportional to the number of ratings (i.e. more ratings leads to a larger bar).

   Task: Explore and compare distributions of ratings on a week/month among the different trackers - e.g. What is the tracker with more ratings with a 1 (red)?

4. **Multi-line Chart**

   Mark: Line.

   Channels: (1 & 2) The position of each point is defined by two coordinates. The x is the day of the week/month and the y is the average of the ratings of a day (i.e. the higher the average, the further away from axis the point/line is); **(3)** Each tracker has a line with a different colour.

   Task: Explore the evolution of each tracker's ratings and search for possible correlations - e.g. Does my productivity increase if I sleep better?

5. **(Monthly only) Bar Chart** - Same as the one in the previous section but leverages all trackers.

   Task: Compare average of ratings on different weekdays - e.g. Is my well-being worse on Mondays or on Fridays?

Figure 4.10: Sharing mechanism: (1) PDF selection; (2) Range & Data selection; (3) PDF generation; (4) PDF.

4.4.5 Sharing and Privacy

As previously stated, our App should provide a sharing mechanism, as seen in Figure 4.10, that offers users as much control as possible while also respecting their privacy. Said feature can be accessed through the Profile screen, where users can either share a previously created PDF or generate a new one. The generation process allows the user to select the time range and data to be included, before assembling and saving the PDF file.

1. **Range Selection** - Firstly, the user can select whether they want to share a week or a full month of data. After choosing the granularity, the user is prompted to select the specific week/month they wish to include in the PDF.

2. **Data Selection** - The second step allows the user to toggle what trackers they want to include in their PDF. There is also an option to choose the aggregated data (i.e. Well-Being) that is shown on the Home screen. Each dimension a user toggles in this step generates a single page in the PDF.

3. **PDF Construction** - Lastly, in this phase, the App will start iterating over the different charts and translate them into images. After collecting all the data, we assemble the PDF and save it into a local file, which is also synced with the user's online storage so it can be accessed on different devices.

The application stores the last two generated PDFs. Users can select either one and share them through other Apps installed on their smartphones, such as email and messaging Apps.

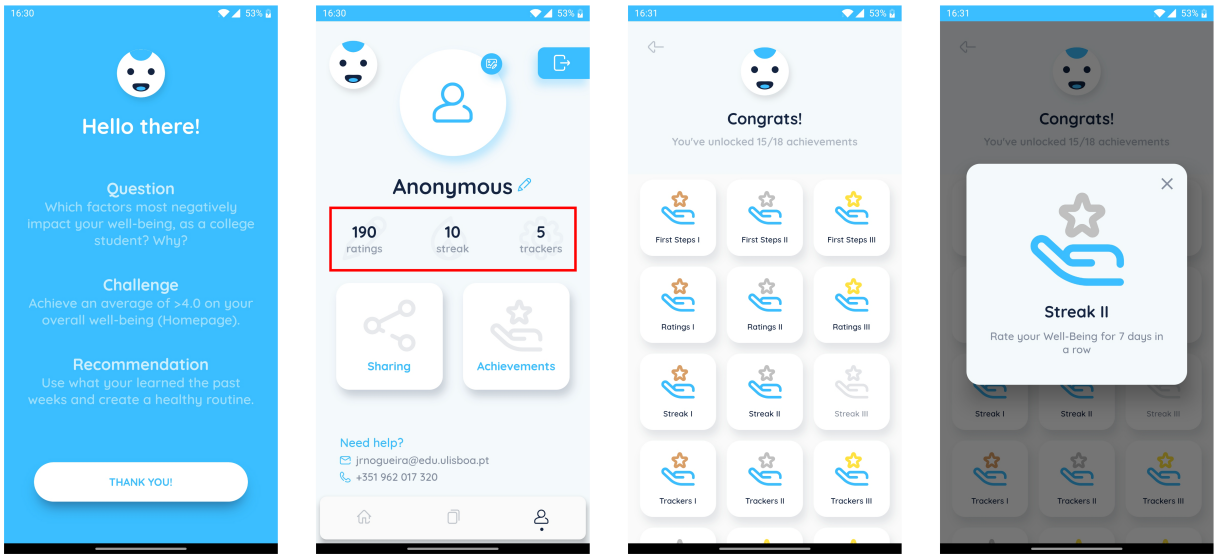


Figure 4.11: Engagement strategies: (1) Weekly; (2) Counters; (3) Achievements; (4) Example achievement.

4.4.6 Engagement

Lastly, in this section, we present our strategies to increase user engagement.

Weeklies

Similar to the envelopes we included in our Cultural Probe, we propose an extra screen on our App, which should refresh on a weekly basis. A Weekly includes a question to be reflected upon, a challenge to raise user engagement and promote goal-setting techniques, and a helpful recommendation for such practices. This screen can be accessed by clicking on Danny at any point in the App. A list of example weeklies can be found in Chapter 5.

Gamification

In order to further increase user engagement, we also leveraged gamification elements. On the Profile screen, we include counters for the number of ratings, the number of consecutive days with ratings, and the number of trackers. Using these counters and other information regarding the user's activity, we can create different achievements that a user can earn (e.g. *"Rate your well-being for seven days in a row"*).

Push Notifications

Finally, our application supports push notifications that can be used to strengthen user engagement. Examples of this would be notifying users about a new Weekly or reminding them to self-track their well-being.

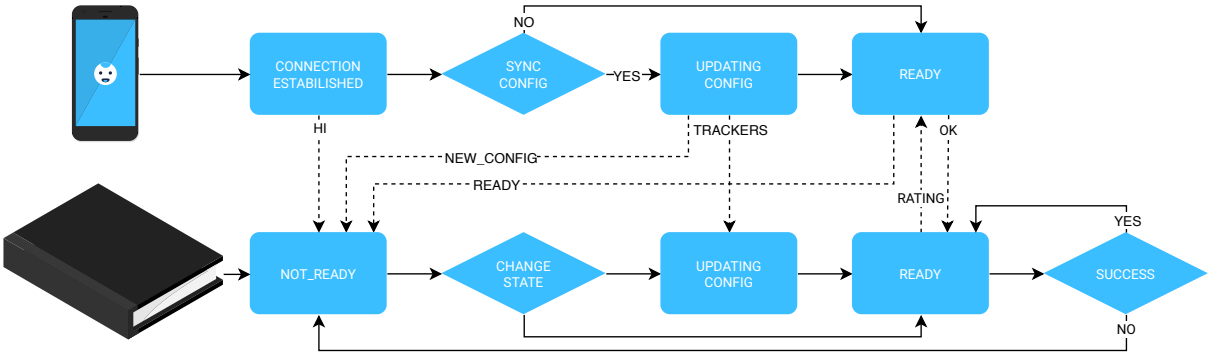


Figure 4.12: Communication flow

4.5 Communication Layer

As previously mentioned, our tools rely on BLE communication to not only synchronize trackers' configurations but also to collect the ratings introduced by the user. In this section, we explore the communication processes (Figure 4.12) that take place and allow our tools to function properly. We also dive into the background work that takes place while DAN and Danny are not actively being used.

4.5.1 Communication protocol

Before establishing a connection with DAN, our mobile application starts by listening to changes in the Bluetooth's state (i.e. Enabled or Disabled). As soon as Bluetooth is available, Danny starts a peripheral search filtering only the devices which have a specific GATT service[13] that is proprietary to Beetle BLE. As soon as a DAN is discovered, our application attempts to establish a connection and, if successful, initiates communications.

After establishing a connection with DAN, our mobile application checks whether it already synced (or not) the current tracker configuration. This verification is managed by a flag that is saved into the App's local data and updates whenever the user changes their configuration or when a new one is successfully synced. Depending on this flag, Danny sends a **HI** token followed by a **NEW_CONFIG** or **READY** token. Danny remains listening to changes in tracker configuration and sends a **NEW_CONFIG** token if necessary. On the notebook side, DAN consumes these tokens and changes its state accordingly. Summarizing, the communication between DAN and Danny can be in one of these three states:

- **UPDATING_CONFIG -** In this state, Danny is waiting to receive a new configuration in order to update its trackers. Such configuration is transmitted following this structure: <*trackerX, trackerY, trackerZ*>, and is divided into multiple packets as the Beetle's MTU is 20 bytes. If DAN successfully receives and updates the trackers, it changes to a **READY** state.

[13] https://www.bluetooth.com/specifications/assigned-numbers/

- **READY -** When the communication is in this state, it is assumed that the App is listening for new ratings. If DAN reaches this state and the stack is not empty, it starts sending the ratings one by one, following the structure: {*t:trackerX,r:Y,t:dd/mm/yyyy hh:mm*}, while confirming if each was properly synced. If the application is able to parse the received packet, it responds with an **OK** token, and upon receiving such token, DAN pops the stack and repeats the process. If a rating is sent and a token is not received after 5 seconds, a timeout is triggered which switches the communication to the **NOT_READY** state.
- **NOT_READY (DEFAULT) -** No communication is established.

4.5.2 Background Work

To provide a more robust communication layer, we also implemented background jobs that run when communication is needed, but one or both tools are not in use. Therefore, this allows both DAN and Danny to communicate even when they are in sleep mode (i.e. mobile application is closed or DAN went into sleep mode).

Danny. In order to make background communication possible for our mobile application, we leveraged a Flutter package called background_fetch[14]. This plugin can awaken our App in the background about every fifteen minutes, providing a short period of background running-time. Thus, it allows us to execute a callback function whenever a background-fetch event occurs, which runs the following steps: (1) Initialize Firebase services; (2) Initialize Bluetooth services; (3) Runs the communication steps described in the previous section; (4) If there is no communication to be done in ten seconds, the function times out; and (5) Disposes of the resources that were being used. Furthermore, to be able to do background communication, the device requires Bluetooth (and location on Android) to be enabled. Nevertheless, this does not have a considerable impact on battery consumption as it relies on Bluetooth Low Energy.

DAN. As mentioned before, when DAN does not receive any input for the last twenty seconds, it enters a sleep state in which only an interruption can wake up the device. Nevertheless, Beetle's sleep mode does not disable the Bluetooth module, enabling us to establish a connection with the DAN. Furthermore, since we connected the RX pin (i.e. pin which receives Bluetooth data) to an interrupt pin, we can generate an interruption through Bluetooth communication. Using this to our advantage, we wake up the device by sending a **HI** token, which itself generates an interruption that switches DAN to background mode. When in this state, it is able to run its program—including necessary communication—without turning on the LCD and allowing user input. This background mode times out after five seconds of no communication and places the device back into sleep mode.

[14] https://pub.dev/packages/background_fetch

5

User Study

Contents

5.1 Research Questions 69
5.2 Method 70
5.3 Findings 74
5.4 Limitations 80
5.5 Discussion 80

To properly validate our system, we designed a longitudinal user study that ran through the course of four to six weeks. With this study, we propose to evaluate the overall **acceptability** of our tools and their **effectiveness** regarding changes in self -awareness and -reflection. Finally, we also intend to understand the usage strategies of our participants, including changes in their help-seeking behaviours.

In this section, we expose our proposition and research questions, which should be answered by this study's results. We also describe in detail our study, including a description of our participants, the apparatus, and the procedure. Lastly, after explaining how we collected and analyzed the data, we showcase and discuss our findings.

5.1 Research Questions

With this study, we intend to test whether DAN & Danny can help college students better manage their well-being. Our tools create a link between qualitative and quantitative data by allowing the collection of both analogue and digital data. With such tools, we intend to help students identify and manage issues in their well-being not only by themselves but also with the help of other stakeholders. We can summarize our proposition as follows:

> **Our self-tracking tools, which create a link between qualitative and quantitative data, help students manage their well-being.**

Firstly, we evaluate the overall acceptability of our tools among college students. In order for students to welcome DAN & Danny, they should be able to see the value of using our tools. Therefore, such tools should not only be useful but also be easy to use. Additionally, to help students manage and maintain a positive well-being, our tools offer insights through two different dimensions. Since it is one of the main objectives of self-tracking, we first need to understand if our tool helps students be more aware and reflect on their well-being. We also intend to validate whether our tool eases data-sharing and help-seeking and if that also helps students manage their well-being. Furthermore, our objective is to also gain further insights regarding the challenges that college students face. This means understanding what impacts their well-being and possible strategies to overcome such issues. With these objectives in mind, we derive four research questions that should be answered by the findings extracted from this study. These are:

- **RQ1:** Are our tools easily accepted by students?
- **RQ2:** Do our tools increase students' self -awareness and -reflection regarding their well-being?
- **RQ3:** Do our tools facilitate data-sharing and help-seeking?
- **RQ4:** What are the factors that most impact college students' well-being and their implications?

5.2 Method

In this section, we give a detailed description of our method that allows us to test our proposition and answer the previously established research questions. We describe our participants, the apparatus, the complete procedure, and methods of data collection and analysis.

5.2.1 Participants

Even though our tools are targeted at all college students, we decided to invite participants who might have more difficulties adapting to college. With the help of NAPE from Taguspark campus, we manage to recruit five participants who either have the ENEE statute (i.e. Students with Special Needs) or that are being accompanied by NAPE's services. There were no special requirements regarding demographic factors besides being college students. Nevertheless, the participants needed to be able to handwrite and have access to a smartphone. While our App supports both Android and iOS devices, we were not able to properly test and compile the iOS version. Therefore, two of the initial seven students were not able to participate because they only had iOS smartphones. Furthermore, these two students were the only female interested participants, leaving us with five male students: Participant 1 was 23 years old, was in his 6th year of college, taking his 3rd year of Electronics Engineering (LEE); P2 was 28, in his 4th year of college and 3rd year of LEE; P3 was 18, in his 1st year of college and taking Computer Science and Engineering (LEIC); P4 was 21, in his 3rd year of college and 3rd year of Telecommunications and Informatics Engineering (LETI); and P5 was 19, in his 3rd year of college and 3rd year of LEIC; These students received a voucher as compensation for participating in this study.

5.2.2 Apparatus

The technical requirements of this study include the self-tracking tools described in Chapter 4 and further prerequisites to be able to use such tools. To conduct this study, we built five prototypes of the Digitally Augmented Notebook (DAN), where each one was delivered to a participant together with a USB wireless charger and a USB power adapter. Additionally, participants were also required to install the mobile application Danny that supports smartphones with the Android operating system running at least version 8.0. Furthermore, participants' smartphones must support BLE communication and have internet access. Although our application does not require a persistent internet connection, some operations demand momentary internet access, such as signing up and log in, accessing a new Weekly, adding images to ratings, and generating and sharing PDFs. Besides the self-tracking tools, we maintained a systematic communication with the participants through e-mail, WhatsApp, and Discord[1]. We also shared online surveys through Google Forms to collect information regarding each of the participants.

[1] https://discord.com/

5.2.3 Procedure

To explain our procedure, we split this section into three phases: (1) Preparation and initial meeting; (2) The study's main part were students started self-tracking; and (3) End of study and final interview.

Phase 1. After successfully recruiting five participants, we delivered to each of them a bag with the notebook and charger. We either personally met with the student at Taguspark or left the bag at a pre-established location on campus where students could later pick it up. Since one of the students was not able to go to Taguspark, we delivered the bag to their residence. Finally, when the students confirmed they had the notebook, we scheduled an initial meeting with each of them. Ahead of the meeting, we uploaded the application and sent a link to the participants so they could download and install it. Furthermore, we asked them to create an account on Danny and think about the factors that influence their well-being and which they would like to track throughout this study.

This meeting was conducted through an online audio-conference on Discord and was organized into four segments. Firstly, we gave participants an introduction to the theme of this dissertation, which included a description of the previously stated problem and our approach. Secondly, we briefly presented the tools we developed, including their functionality and purpose. Thirdly, we gave them instructions for what they had to do, which included: (1) Choose 3 to 5 trackers; (2) Rate each of these trackers on at least a daily basis; (3) Write contextual information regarding some of these ratings; (4) Engage with the Weeklies; (5) Gain meaningful insights from the visualizations; and (6) Share your data to get further feedback. Lastly, at the end of the session, we tested the tools to know if participants were able to charge and turn on DAN, create an account and sign in on the App, set up their trackers, and finally, if the App synchronized their trackers and was able to collect the ratings from DAN. After the meeting, we sent each participant a consent form with detailed information concerning the terms and conditions of this study. We also asked the participants to fill a form to collect data such as their age, their experience regarding college, well-being, help-seeking, and self-tracking.

Phase 2. During this phase, participants followed the instructions given to them for a total duration of 4 to 5 weeks. At the beginning of each week, we sent an email to each participant with relevant information and notified them that a new Weekly was available.

- **Week 1:** We made sure participants understood what they had to do throughout the following weeks and checked if everything was properly working.
  - **Question:** Which one of your trackers has a bigger impact on your well-being? Why?
  - **Challenge:** Rate your well-being for 7 days in a row.
  - **Recommendation:** Set up a daily alarm clock to remind you to rate your well-being.

- **Week 2:** The focus of this week was the information visualizations that Danny provides. We explained the charts and gave an example of what kind of insights they could offer. Using such information, we challenged students to improve their ratings following a goal-oriented strategy.
  - **Question:** Are you happy with your average well-being rating? Why? How would you improve it?
  - **Challenge:** Improve your average well-being by 0.5.
  - **Recommendation:** This week, focus on improving the trackers with the lowest ratings.
- **Week 3:** On the third week, we invited participants to share their data (i.e. using the sharing feature on the App) with other stakeholders who can give them further feedback on how to better manage their well-being.
  - **Question:** Do you think there is a benefit to sharing the data you collected? Why? With who?
  - **Challenge:** Generate and share a PDF with 3 individuals that have an interest on your Well-Being.
  - **Recommendation:** Discuss with them what you want to improve, the challenges, and other relevant information you found.
- **Week 4:** This last week, we asked participants to focus, once again, on leveraging the feedback they gained until now and engage in healthier routines in order to improve their ratings.
  - **Question:** What do you think are the factors that negatively impact college students' well-being? Why?
  - **Challenge:** Achieve an average of $>$4.0 on your overall well-being (Home screen).
  - **Recommendation:** Use what you learned in the past weeks and create a healthy routine.

Due to various requests from the participants at this stage, we quickly added the possibility of assessing ratings directly on the App. Students asked for this feature, either because of momentary connectivity issues, because DAN had no battery and they forgot the charger, or they had no access to the DAN at the time. Nevertheless, this feature was controlled by the research team and could be enabled/disabled at any time.

Phase 3. At the end of the study, we scheduled a semi-structured interview with each participant in order to collect our results. This interview included questions regarding the acceptability and effectiveness of our tools and questions concerning their well-being as college students. The full interview guide can be found in Appendix A.

5.2.4 Data Collection & Analysis

In this section, we present our methods of data collection and analysis. To be able to answer our research questions and validate our proposal, we can split our data into three groups: **(1) Acceptability - RQ1; (2) Effectiveness - RQ2 and RQ3; and (3) Well-being in college - RQ4**.

Acceptability

In order to evaluate the solution's acceptability, we leveraged a framework based on the **Technology Acceptance Model (TAM)** [47] that models how users accept and use technology, which includes evaluating **perceived usefulness (PU)** and **perceived ease of use (PEOU)**. We first collected data regarding personal variables that might influence the PU, PEOU, and the intent to use our tools, such as their past experiences with self-tracking and help-seeking. Such data was collected not only through the initial form but also through further questions made in this interview. Finally, while also leveraging usage logs, we analyzed the participant's usage behaviour and patterns between the different participants. These usage logs include: **(1) Trackers configured; (2) Number of ratings; (3) Days in a row with ratings; (4) Number of PDFs generated; and (5) Number of PDFs shared.**

Effectiveness

To evaluate the overall effectiveness of our approach and answer research questions 1 and 2, we asked students a group of questions which included exploring changes in self -awareness and -reflection, and analyzing their help-seeking behaviours. If the participant gave their consent, we also analyzed variations in their ratings.

Well-being in college

Furthermore, to expand on the analysis of the participants' use behaviours, we also included questions regarding their overall college experience. These questions should help us get a better understanding of the challenges that students face throughout college, how it impacts their well-being, and possible solutions.

Data Analysis

Aside from the usage logs, the data collected from this study went through qualitative analysis. With the participant's consent, we audio-recorded and transcribed each session, and following a Grounded Theory [48] methodology, these transcriptions went through an iterative thematic analysis.

Table 5.1: Usage logs

	Trackers	Ratings	Days	Streak	p/Day	PDFs	Shares
P1	Mood, Motivation, Productivity, Sleep, Stress	106	27	8	3.93	2	0
P2	Depression, Exercise, Productivity, Social, Stress	150	36	13	4.17	2	2
P3	Anxiety, Mood, Productivity, Sleep, Stress	143	41	8	3.49	1	1
P4	Exercise, Nutrition, Productivity, Sleep, Stress	190	47	10	4.04	2	1
P5	Exercise, Sleep, Social, Stress, Tiredness	120	33	7	3.64	2	1

5.3 Findings

After analyzing all transcriptions, in this section, we showcase the main findings of this user study.

5.3.1 Acceptability

With the TAM model in mind, we divided this section into four groups: (1) User Behaviour; (2) Perceived Ease of Use; (3) Perceived Usefulness; and (4) Intent to use.

Use Behaviour

All participants chose five trackers and mostly used the recommended ones because, as stated, they already cover the most important dimensions of well-being. Additionally, two of the participants created custom trackers to address more specific issues. Participants' self-tracking was mostly event-based as they usually assessed their well-being before going to sleep. Nonetheless, one participant resorted to a daily reminder, which he did not find invasive, and self-tracked at a specific hour. Furthermore, all participants, at some point, did not rate their well-being because they forgot to do so.

"I only missed a few ratings because I was studying for tests and I forgot to do them." - P2

Participants visited the visualizations periodically or when they felt abrupt changes in their well-being. Students usually did not write much in the notebook since only when these abrupt changes happened, they would write small sentences that justified the discrepancies in their well-being. Some features such as sharing were not as popular and were only used when participants wanted to test them, to unlock achievements, or if someone asked them to.

Perceived Ease of Use

Overall, participants agreed there was a balanced capture burden because while writing involves more time and motivation, the ratings were easy and fast to do (*"when it worked"*). This latter quote is referencing the sporadic connectivity issues between DAN and the application. While these issues rarely occurred, one of the participants had consistent problems connecting the application to the DAN.

"The App itself is very simple, but I had problems with the connection between it and the diary. Either it did not update, or it updated wrongly." - P5

Another complaint regarding DAN was its battery life and the charging burden it poses.

"The diary did not have much lifespan. Sometimes I would forget to charge, and it takes too much time to charge." - P2

Besides these issues, participants stated that the mobile application was easy to use, the visualizations were easy to interpret, and the sharing feature was intuitive. They only pointed out two usability issues: (1) The colours used on some of the charts were hard to distinguish; (2) Confusion among ratings of negative factors. The latter happened because one student was taking into account the amount of stress instead of its impact on his well-being, having him rate with a 5 (green) when he was more stressed and a 1 (red) when he was not stressed.

Perceived Usefulness

Although one participant stated that writing did not help him as it made him remember why he felt so bad, the rest of the participants agreed the link between the ratings and contextual data written on the diary was very useful. Nevertheless, they state that in most cases, the ratings are enough to assess their well-being.

"Something can happen ... that can cause a more drastic change, and in those cases, it might be relevant to know, but besides that..." - P1

"If it is inside the usual values, its just like any other day. I do not think that everything leads me to write." - P5

All participants found the information visualizations useful because they offered meaningful insights. However, students mostly used the Home screen, stating that, most of the times, it was *"enough"* and offered more value than the individual tracker' data. The participants also saw value in sharing their data as it supports their help-seeking and might provide useful feedback.

Lastly, participants also found that the engagement strategies we implemented were effective in promoting reflection and consistent usage of the App's different features.

"I think I did them [achievements] all. So much that it was because of it that I ended up sharing a PDF... Although it does not seem like it, these are things that make you hang on to the App and use it more frequently." - P4

Intent to use

The participants' intent to use was mostly impacted by their perceived ease of use and perceived usefulness. As we stated before, participants often had the intent to try some features, and this was further impacted by the achievements. Additionally, sharing was often not used because of a lack of circumstances that would lead users to do so. Only one participant shared a PDF because a health professional asked him to do so. Some users did not use specific application's features due to a lack of interest, awareness, or time.

> *"I sometimes did not remember that part, I would just do the ratings... I think it is useful. If I had more time, I would have used it more." - P3*

Participants' intent to write on DAN was also influenced by their tendency to write on paper.

> *"To be honest, I never wrote much because I do not like to write." - P4*

DAN & Danny vs Danny

Since we added the possibility of rating directly in the App, we asked participants whether they would prefer the current approach or an App-only solution. While some prefer to use just the application because they do not like to write, others suggested that the App should allow taking notes to improve its portability. Furthermore, two participants propose that students could use a separate diary with the application.

> *"There are two options, there are people who like to write, and so, they could have their own diary to go along ... or a space [in the App] to put, like I did, the reasons for the abrupt change, to write small sentences." - P5*

> *"I would only use the application because it was rare to use the diary, but I thought it was important to use it for writing, not much for the ratings... you could have a separate diary to complement, but I would mostly use the application. Writing on the phone is not as fluid as writing on paper ... but I think if I had the option to add notes [in the App], it would be cool." - P4*

Even though they all understood the value of having a dedicated tool, most of them said they were not impacted by distractions either because they are used to them or because the time they took to rate was not enough to have implications.

5.3.2 Effectiveness

First of all, participants noticed improvements in their self-awareness due to the moments of reflection that our tool provides. Either while participants were assessing their well-being or visualizing their data, they ended up reflecting more and were able to detect certain issues, patterns, and correlations. However, one participant stated that even though he reflected more, he was already fully aware of his well-being.

> *"Yes, because I was able to detect patterns that I was not aware they were related, such as stress and sleep, or productivity and nutrition, or exercise and sleep... I had a vague idea, but I did not know. Because this application mixes everything and can connect them, in a way, it helped me guide myself through these last weeks." - P4*

> *"Yes, because when I looked at my ratings, I remembered the situations which influenced that assessment, and I thought maybe I should not have been so upset with that." - P3*

Nevertheless, participants noticed a lack of tools to support their problem-solving and goal-setting techniques. Some participants tried, both successfully and unsuccessfully, to set certain goals or fix a specific issue that they discovered while using our tools. Only one of them said it successfully solved a productivity issue, and one student said he was already trying his best. While the application helps them monitor their progress, they suggested further functionalities that should be added to Danny to support such practices.

> *"If one does not have the resources or ability to change, tracking becomes pointless. At most, it increases one's frustration." - P2*

> *"I think, with what we have, we can monitor what is happening. I think what is missing is maybe the solution." - P5*

> *"I think it helps, but I think if you could define your own goal, it would be a complement. [Personalized Recommendations?] I think so. If you have your sleep at a 2 or the exercise at 2, it could correlate ... and say: try to do this." - P4*

Every participant agreed that the sharing feature was useful, but as we can see from the usage logs, participants did not share as much as we intended. Even though most of them shared at least one PDF, they stated it was only to try out the feature and unlock an achievement. One participant sent the PDF to his psychologist because they showed interest, but he had not received any feedback at the time. Furthermore, one participant suggested that we should research whether health professionals find the information valuable.

"... because it is the opinion of a professional, things I did not even think about." - P3

The lack of usage was justified by the short period of the study and by the lack of circumstances that would lead them to share their data with someone.

"I ended up not sending because I would not just force a PDF and say: here you go." - P4

One participant also suggested creating a network in the App so they could share their ratings with friends, but another one pointed out the downside of exposing too much information.

"If you start ... watching ratings of other people, you might want to be better and might not be as honest when you rate." - P5

While participants said our tools helped them better manage their well-being, after discussing their ratings and their progress throughout this study, we were not able to detect a conclusive influence of such tools. Students suggested the short period of the study was not enough to improve their well-being, and the increased workload that happens through the semester had a big influence on their ratings.

"If it was for a longer period, probably. Maybe in a month of my life, it does not do much, but maybe in others, it does." - P2

"It is funny, at the time of the tests, it increases. It is probably the productivity that increases ... but the other parameters stayed constant." - P2

"I think that it is because of when I started and the time that followed. I started at the beginning of the semester and ... I started having more work and etcetera." - P5

5.3.3 Well-being in College

Regarding the state of well-being in a college setting, everyone agreed that there is a current issue that impacts many students. Nevertheless, two participants stated that the impact of college on students' well-being varies, as some are not greatly impacted, mostly because they may not worry as much.

"There are two types of students: those who have a positive well-being because they do not care as much about college ... and then, there are the others..." - P1

By analyzing the trackers that the participants chose, we can explore what dimensions of well-being students think are the most important. Five participants chose Stress, both Sleep and Productivity were picked by four of them, and three chose Exercise. Mood and Social were both selected twice and finally, the following trackers were only chosen by one participant: Anxiety, Depression, Motivation, Nutrition, and Tiredness.

A recurrent theme in our conversations with the participants was the trio of Stress, Productivity, and Sleep. There were multiple references to the relation between these dimensions and the loop they can cause since one can influence the other and vice-versa.

> *"I think if I am more tired than usual, my productivity is worse. What I would study in half an hour, I might need double the time to study." - P5*

> *"I noticed it was because I was sleeping badly and I was always stressed. I saw they were connected." - P4*

> *"... everything is intertwined, and that is why I chose those." - P1*

Participants thought the biggest issue that makes college negatively impact their well-being is the abrupt change in pressure caused by excessive workload and the difficulty of that work.

> *"I was not expecting so much to do, things on top of the others." - P3*

> *"... when I joined [college], I was not expecting ... it suddenly started on the first week, and I was still a bit lost." - P3*

> *"That was the biggest shock, the discrepancy between the difficulty and amount of work." - P4*

Participants further explored the problem of excessive workload and its implications. They referenced it was hard to manage their time and that they ended up not having enough to live their lives and do things that actually might improve their well-being.

> *"Pretty complicated how college occupies most of a person's time. People end up not having time to be people." - P2*

We also discussed possible strategies to diminish these issues and implications. One participant admitted he tries to get used to these new adversities, and another suggested that college courses should be spread out over more years. Finally, one participant suggested that students should be better prepared and informed for this transition from high school to college.

> *"I think people should be better prepared for where they are heading... I think people should be more informed about how things are going to be. I think that's important." - P3*

When we addressed help-seeking, most of the participants agreed that students tend to avoid it either because of stigma, lack of trust in third-parties, or because they want to be more independent.

> *"Because that means that we are dependent on something, and all we want is independence." - P4*

Furthermore, even though all the participants were currently being ”helped” by someone, they agreed that most of the time, that only happens if someone approaches them and suggests some sort of help.

”... it has to be someone from the outside, realizing that they need help.” - P1

”I probably do not seek help by myself, only if someone offers it to me.” - P5

5.4 Limitations

The study’s main limitation was its insufficient participant amount, which was also impacted by the lack of an iOS version. A larger participant sample would give us a greater understanding of our tools’ impact in a college setting. Furthermore, the study’s duration also reduced our ability to detect conclusive changes in the participants’ well-being. Finally, regarding technical limitations, since we were not able to test our tools with different smartphones, we were unprepared to support the various participants’ devices.

5.5 Discussion

Taking into account these findings, in this section, we discuss and answer our research questions.

RQ1: Are our tools easily accepted by students? Although we consider that self-tracking as an approach was well accepted among the participants, our findings indicate that our tools present barriers that reduce their acceptability. From such results, we were able to catalogue usability issues that were mainly related to DAN, such as connectivity issues and the burden of charging it. To address these issues, we should focus on fixing the connectivity problems and improving the battery life and charging experience of DAN. Overall, participants agreed that Danny was easy to use and found its features useful. Our engagement strategies were shown to be effective, but some functionalities should be better promoted in order to increase their usage.

Since we enabled a new feature that allows ratings to be done directly on the mobile application, we also explored preferences regarding the current approach versus an App-only solution. Results show that these preferences vary, but most participants suggest that the digital and analogue parts should be detached. This is not only due to the usability issues that DAN presented, but also because, for the participants’ use behaviour, it is not beneficial having both the analogue and digital inputs on the same tool. Finally, these findings suggest that we should focus both on a digital-only approach, which can support taking notes or be coupled with a diary, and on improvements for the current approach.

RQ2: Do our tools increase students' self -awareness and -reflection regarding their well-being? Overall, our results show that our tools were successful in improving students' self-awareness and self-reflection regarding their well-being. Our tools increased the moments of reflection either when they were assessing their well-being or when they were visualizing their data. By doing so, we were able to improve their self-awareness as they were able to detect issues, causes, patterns and correlations. As participants pointed out, there is a lack of support for problem-solving and goal-setting techniques. Therefore, there is also an opportunity for further features that facilitate and promote such practices. Nevertheless, due to the longevity of this study and the usual flow of a semester in college, we were not able to detect obvious improvements in the well-being of our participants. To have more conclusive findings, we suggest a user study with more participants and for an increased period of time.

RQ3: Do our tools facilitate data-sharing and help-seeking? Even though all participants agreed that sharing their data was valuable, this feature was not frequently used because of a lack of circumstances. When the participants shared, they did so to explore the feature, to unlock an achievement, or because someone showed interest in their data. These findings indicate that we should focus on better promoting data-sharing behaviours, but that most of the time, students would not share their data unless they were asked to do so. Although our tools seem to ease the sharing of valuable data, our findings were not conclusive enough to answer this research question.

RQ4: What are the factors that most impact college students' well-being and their implications? From our findings, which include usage logs and discussions we had with the participants, we were able to highlight some of the recurring well-being issues among college students. Although our findings indicate that the impact that college has on students' well-being varies depending on the person, it is a problem that should be addressed. According to our results, these issues are mainly caused because students are not well prepared for the abrupt change that is the transition from high school to college. Our participants considered that college involves more pressure, increased difficulty, and an excessive workload. Because college occupies a large period of their days, students are left with a small amount of time to do other things that might better impact their well-being, such as social and recreational activities. These problems are exacerbated by poor help-seeking behaviours as students usually do not seek help unless it is suggested to them. The well-being dimensions which were referenced as the most impacted were sleep, stress, and productivity. These are closely related, and since they can influence each other, there is a chance that a loop is created and ends up causing harsher implications. Finally, our findings imply that there is a lack of preparation for students who enter college, and there is also a need to analyze the excessive workload and pressure that these students face. Colleges should also focus on providing and promoting effective help.

6

Conclusions and Future Work

Students' mental health and well-being is an international concern [6]. Those who enter college face new challenges that can often generate instabilities in their well-being. Furthermore, college students are amongst the least likely to consult health professionals during an emotional crisis [8]. The variety of problems these students face, which are exacerbated by their help-seeking behaviours, means that they often have to manage their well-being by themselves. Not only is this prejudicial for the students, but also for other stakeholders who are not able to fully understand and monitor their well-being. Latest approaches leverage user-generated data to infer well-being instabilities. However, there is a lack of solutions that support the students' needs and can be used in collaboration with stakeholders. Additionally, these tools focus mostly on quantitative data, lacking context and privacy provided by qualitative data in paper-based solutions.

Following the trend of Personal Informatics, we propose digitally augmented notebooks as a tool for students to self-track their well-being. With that in mind, we designed and developed a flexible system to attend to different needs. Our approach creates a bridge between qualitative and quantitative data and offers feedback through visualizations that can also be shared with stakeholders. We propose a dedicated solution that is easy to configure, start and use, robust, multidisciplinary, and preserves users' privacy. It should help college students better manage their well-being by increasing their self-awareness and self-reflection, easing data-sharing, and therefore, by promoting help-seeking behaviours.

In order to validate our system, we conducted a longitudinal study that allowed us to evaluate the effectiveness and acceptability of our approach. Furthermore, we also contribute with a brief analysis of the current state of well-being among college students. Our findings show that stress, productivity, and sleep are the most impacted dimensions concerning college students' well-being. These issues mostly happen because students are not well prepared for the transition to college and the abrupt changes which come with it. Whether it is because of increased pressure or excessive workload, our study indicated that students have to dedicate a large amount of their day to college and lack the time for other matters beneficial for their well-being. These problems are exacerbated by poor help-seeking behaviours, as students do not usually search for help unless it is suggested to them. Participants agreed that our approach helped them better manage their well-being by increasing moments of reflection, and therefore, their self-awareness. Nevertheless, we elicit acceptability issues that indicate some users might prefer a digital-only approach. Our findings were not conclusive regarding data-sharing, and we were not able to evaluate its value and whether it facilitates and encourages help-seeking. Finally, we also found an opportunity to add more functionalities to our tools to ease and promote problem-solving and goal-setting techniques.

Future work involves research to elicit college students' preferences regarding analogue and digital approaches. To further increase our tools' flexibility and acceptability among college students, we suggest focusing on both a digital-only tool—that can also be supported by a normal diary—and on

improvements for the approach explored in this dissertation. We suggest improvements on the App to allow users to assess ratings and write annotations with a low capture burden. To address users that prefer the use of an analogue tool, we recommend improving DAN's user experience by fixing connectivity and battery issues. While our App was able to increase self-awareness and self-reflection, there is an opportunity to add more functionalities to Danny for better supporting problem-solving and goal-setting techniques. Users should be able to set their goals on the application and be rewarded for reaching such goals. Furthermore, the application could also provide more specific recommendations while taking into consideration the user's trackers and ratings. Since we were not able to prove the value of our tools regarding data-sharing and help-seeking, we suggest a user study with a larger sample of participants and for an increased length of time. Additionally, it would also be beneficial to test this system by integrating it in a college help program, where both students and stakeholders could work together by leveraging said tools. Finally, it would be interesting to gather more opinions from stakeholders such as health professionals.

Bibliography

[1] L. G. Castillo and S. J. Schwartz, “Introduction to the special issue on college student mental health,” *Journal of Clinical Psychology*, vol. 69, no. 4, pp. 291–297, 2013. [Online]. Available: https://onlinelibrary.wiley.com/doi/abs/10.1002/jclp.21972

[2] D. Eisenberg, J. Hunt, and N. Speer, “Help seeking for mental health on college campuses: Review of evidence and next steps for research and practice,” *Harvard Review of Psychiatry*, vol. 20, no. 4, pp. 222–232, 2012, pMID: 22894731. [Online]. Available: https://www.tandfonline.com/doi/abs/10.3109/10673229.2012.712839

[3] J. Hunt and D. Eisenberg, “Mental health problems and help-seeking behavior among college students,” *Journal of Adolescent Health*, vol. 46, no. 1, pp. 3 – 10, 2010. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S1054139X09003401

[4] C. Kelley, B. Lee, and L. Wilcox, “Self-tracking for mental wellness: Understanding expert perspectives and student experiences,” in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, ser. CHI ’17. New York, NY, USA: ACM, 2017, pp. 629–641. [Online]. Available: http://doi.acm.org/10.1145/3025453.3025750

[5] P. Pedrelli, M. Nyer, A. Yeung, C. Zulauf, and T. Wilens, “College students: Mental health problems and treatment considerations,” *Academic Psychiatry*, vol. 39, no. 5, pp. 503–511, Oct 2015. [Online]. Available: https://doi.org/10.1007/s40596-014-0205-9

[6] J. Rooksby, A. Morrison, and D. Murray-Rust, “Student perspectives on digital phenotyping: The acceptability of using smartphone data to assess mental health,” in *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, ser. CHI ’19. New York, NY, USA: ACM, 2019, pp. 425:1–425:14. [Online]. Available: http://doi.acm.org/10.1145/3290605.3300655

[7] D. W. Yoo and M. De Choudhury, “Designing dashboard for campus stakeholders to support college student mental health,” in *Proceedings of the 13th EAI International Conference on Pervasive Computing Technologies for Healthcare*, ser. PervasiveHealth’19. New York, NY, USA: ACM, 2019, pp. 61–70. [Online]. Available: http://doi.acm.org/10.1145/3329189.3329200

[8] L. Biddle, D. Gunnell, D. Sharp, and J. L. Donovan, “Factors influencing help seeking in mentally distressed young adults: a cross-sectional survey.” *British Journal of General Practice*, vol. 54, no. 501, pp. 248–253, 2004. [Online]. Available: https://bjgp.org/content/54/501/248

[9] D. Eisenberg, M. F. Downs, E. Golberstein, and K. Zivin, “Stigma and help seeking for mental health among college students,” *Medical Care Research and Review*, vol. 66, no. 5, pp. 522–541, 2009, pMID: 19454625. [Online]. Available: https://doi.org/10.1177/1077558709335173

[10] R. Wang, F. Chen, Z. Chen, T. Li, G. Harari, S. Tignor, X. Zhou, D. Ben-Zeev, and A. T. Campbell, “Studentlife: Assessing mental health, academic performance and behavioral trends of college students using smartphones,” in *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, ser. UbiComp ’14. New York, NY, USA: ACM, 2014, pp. 3–14. [Online]. Available: http://doi.acm.org/10.1145/2632048.2632054

[11] J. M. Noyes and K. J. Garland, “Computer- vs. paper-based tasks: Are they equivalent?” *Ergonomics*, vol. 51, no. 9, pp. 1352–1375, 2008, pMID: 18802819. [Online]. Available: https://doi.org/10.1080/00140130802170387

[12] N. Bolger, A. Davis, and E. Rafaeli, “Diary methods: Capturing life as it is lived,” *Annual Review of Psychology*, vol. 54, no. 1, pp. 579–616, 2003, pMID: 12499517. [Online]. Available: https://doi.org/10.1146/annurev.psych.54.101601.145030

[13] L. A. Fletcher, D. J. Erickson, T. L. Toomey, and A. C. Wagenaar, “Handheld computers: A feasible alternative to paper forms for field data collection,” *Evaluation Review*, vol. 27, no. 2, pp. 165–178, 2003, pMID: 12703341. [Online]. Available: https://doi.org/10.1177/0193841X02250527

[14] A. Ayobi, T. Sonne, P. Marshall, and A. L. Cox, “Flexible and mindful self-tracking: Design implications from paper bullet journals,” in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, ser. CHI ’18. New York, NY, USA: ACM, 2018, pp. 28:1–28:14. [Online]. Available: http://doi.acm.org/10.1145/3173574.3173602

[15] S. Shiffman, A. A. Stone, and M. R. Hufford, “Ecological momentary assessment,” *Annual Review of Clinical Psychology*, vol. 4, no. 1, pp. 1–32, 2008, pMID: 18509902. [Online]. Available: https://doi.org/10.1146/annurev.clinpsy.3.022806.091415

[16] R. Larson and M. Csikszentmihalyi, “The experience sampling method,” in *Flow and the foundations of positive psychology*. Springer, 2014, pp. 21–34.

[17] T. J. Trull and U. W. Ebner-Priemer, “Using experience sampling methods/ecological momentary assessment (esm/ema) in clinical assessment and clinical research: introduction to the special section.” 2009.

[18] A. Rapp and F. Cena, “Self-monitoring and technology: Challenges and open issues in personal informatics,” in *Universal Access in Human-Computer Interaction. Design for All and Accessibility Practice*, C. Stephanidis and M. Antona, Eds. Cham: Springer International Publishing, 2014, pp. 613–622.

[19] M. Matthews, S. Voida, S. Abdullah, G. Doherty, T. Choudhury, S. Im, and G. Gay, “In situ design for mental illness: Considering the pathology of bipolar disorder in mhealth design,” in *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services*, ser. MobileHCI ’15. New York, NY, USA: ACM, 2015, pp. 86–97. [Online]. Available: http://doi.acm.org/10.1145/2785830.2785866

[20] S. Voida, M. Matthews, S. Abdullah, M. C. Xi, M. Green, W. J. Jang, D. Hu, J. Weinrich, P. Patil, M. Rabbi, T. Rahman, G. Gay, E. Frank, and T. Choudhury, “Moodrhythm: Tracking and supporting daily rhythms,” in *Proceedings of the 2013 ACM Conference on Pervasive and Ubiquitous Computing Adjunct Publication*, ser. UbiComp ’13 Adjunct. New York, NY, USA: ACM, 2013, pp. 67–70. [Online]. Available: http://doi.acm.org/10.1145/2494091.2494111

[21] J. E. Bardram, M. Frost, K. Szántó, M. Faurholt-Jepsen, M. Vinberg, and L. V. Kessing, “Designing mobile health technology for bipolar disorder: A field trial of the monarca system,” in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ser. CHI ’13. New York, NY, USA: ACM, 2013, pp. 2627–2636. [Online]. Available: http://doi.acm.org/10.1145/2470654.2481364

[22] Y.-H. Kim, J. H. Jeon, B. Lee, E. K. Choe, and J. Seo, “Omnitrack: A flexible self-tracking approach leveraging semi-automated tracking,” *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.*, vol. 1, no. 3, pp. 67:1–67:28, Sep. 2017. [Online]. Available: http://doi.acm.org/10.1145/3130930

[23] E. K. Choe, S. Abdullah, M. Rabbi, E. Thomaz, D. A. Epstein, F. Cordeiro, M. Kay, G. D. Abowd, T. Choudhury, J. Fogarty, B. Lee, M. Matthews, and J. A. Kientz, “Semi-automated tracking: A balanced approach for self-monitoring applications,” *IEEE Pervasive Computing*, vol. 16, no. 1, pp. 74–84, Jan 2017.

[24] S.-I. Kim, E. Jo, M. Ryu, I. Cha, Y.-H. Kim, H. Yoo, and H. Hong, “Toward becoming a better self: Understanding self-tracking experiences of adolescents with autism spectrum disorder using custom trackers,” in *Proceedings of the 13th EAI International Conference on Pervasive Computing Technologies for Healthcare*, ser. PervasiveHealth’19. New York, NY, USA: ACM, 2019, pp. 169–178. [Online]. Available: http://doi.acm.org/10.1145/3329189.3329209

[25] G. M. Harari, S. R. Müller, V. Mishra, R. Wang, A. T. Campbell, P. J. Rentfrow, and S. D. Gosling, “An evaluation of students’ interest in and compliance with self-tracking

methods: Recommendations for incentives based on three smartphone sensing studies," *Social Psychological and Personality Science*, vol. 8, no. 5, pp. 479–492, 2017. [Online]. Available: https://doi.org/10.1177/1948550617712033

[26] J. Vega, S. Couth, E. Poliakoff, S. Kotz, M. Sullivan, C. Jay, M. Vigo, and S. Harper, "Back to analogue: Self-reporting for parkinson's disease," in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, ser. CHI '18. New York, NY, USA: ACM, 2018, pp. 74:1–74:13. [Online]. Available: http://doi.acm.org/10.1145/3173574.3173648

[27] O. Dale and K. B. Hagen, "Despite technical problems personal digital assistants outperform pen and paper when collecting patient diary data," *Journal of Clinical Epidemiology*, vol. 60, no. 1, pp. 8 – 17, 2007. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0895435606001934

[28] K. Lee and H. Hong, "Mindnavigator: Exploring the stress and self-interventions for mental wellness," in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, ser. CHI '18. New York, NY, USA: ACM, 2018, pp. 572:1–572:14. [Online]. Available: http://doi.acm.org/10.1145/3173574.3174146

[29] S. D. Hollon and A. T. Beck, "Cognitive and cognitive-behavioral therapies," *Bergin and Garfield's handbook of psychotherapy and behavior change*, pp. 393–442, 2013.

[30] A. Ayobi, "Informing the design of personal informatics technologies for unpredictable chronic conditions," in *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*, ser. CHI EA '18. New York, NY, USA: ACM, 2018, pp. DC02:1–DC02:4. [Online]. Available: http://doi.acm.org/10.1145/3170427.3173025

[31] X. Yan, K. Madier, S. Y. Park, and M. Newman, "Towards low-burden in-situ self-reporting: A design space exploration," in *Companion Publication of the 2019 on Designing Interactive Systems Conference 2019 Companion*, ser. DIS '19 Companion. New York, NY, USA: ACM, 2019, pp. 337–346. [Online]. Available: http://doi.acm.org/10.1145/3301019.3323905

[32] E. K. Choe, B. Lee, M. Kay, W. Pratt, and J. A. Kientz, "Sleeptight: Low-burden, self-monitoring technology for capturing and reflecting on sleep behaviors," in *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, ser. UbiComp '15. New York, NY, USA: ACM, 2015, pp. 121–132. [Online]. Available: http://doi.acm.org/10.1145/2750858.2804266

[33] M. A. Ferrario, W. Simm, A. Gradinar, S. Forshaw, M. T. Smith, T. Lee, I. Smith, and J. Whittle, "Computing and mental health: Intentionality and reflection at the click of a button," in *Proceedings*

of the 11th EAI International Conference on Pervasive Computing Technologies for Healthcare, ser. PervasiveHealth '17. New York, NY, USA: ACM, 2017, pp. 1–10. [Online]. Available: http://doi.acm.org/10.1145/3154862.3154877

[34] J. E. Larsen, K. Eskelund, and T. B. Christiansen, "Active self-tracking of subjective experience with a one-button wearable: A case study in military ptsd," *arXiv preprint arXiv:1703.03437*, 2017.

[35] A. T. Adams, E. L. Murnane, P. Adams, M. Elfenbein, P. F. Chang, S. Sannon, G. Gay, and T. Choudhury, "Keppi: A tangible user interface for self-reporting pain," in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, ser. CHI '18. New York, NY, USA: ACM, 2018, pp. 502:1–502:13. [Online]. Available: http://doi.acm.org/10.1145/3173574.3174076

[36] G. Paruthi, S. Raj, S. Baek, C. Wang, C.-c. Huang, Y.-J. Chang, and M. W. Newman, "Heed: Exploring the design of situated self-reporting devices," *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.*, vol. 2, no. 3, pp. 132:1–132:21, Sep. 2018. [Online]. Available: http://doi.acm.org/10.1145/3264942

[37] G. Paruthi, S. Raj, A. Gupta, C.-C. Huang, Y.-J. Chang, and M. W. Newman, "Heed: Situated and distributed interactive devices for self-reporting," in *Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers*, ser. UbiComp '17. New York, NY, USA: ACM, 2017, pp. 181–184. [Online]. Available: http://doi.acm.org/10.1145/3123024.3123162

[38] T. R. Insel, "Digital Phenotyping: Technology for a New Science of Behavior," *JAMA*, vol. 318, no. 13, pp. 1215–1216, 10 2017. [Online]. Available: https://doi.org/10.1001/jama.2017.11295

[39] J. Torous, M. V. Kiang, J. Lorme, and J.-P. Onnela, "New tools for new research in psychiatry: A scalable and customizable platform to empower data driven smartphone research," *JMIR Mental Health*, vol. 3, no. 2, p. e16, May 2016. [Online]. Available: http://mental.jmir.org/2016/2/e16/

[40] H. Zhang, S. Gashi, H. Kimm, E. Hanci, and O. Matthews, "Moodbook: An application for continuous monitoring of social media usage and mood," in *Proceedings of the 2018 ACM International Joint Conference and 2018 International Symposium on Pervasive and Ubiquitous Computing and Wearable Computers*, ser. UbiComp '18. New York, NY, USA: ACM, 2018, pp. 1150–1155. [Online]. Available: http://doi.acm.org/10.1145/3267305.3274760

[41] K. Saha, L. Chan, K. De Barbaro, G. D. Abowd, and M. De Choudhury, "Inferring mood instability on social media by leveraging ecological momentary assessments," *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.*, vol. 1, no. 3, pp. 95:1–95:27, Sep. 2017. [Online]. Available: http://doi.acm.org/10.1145/3130960

[42] J. A. Lee, C. Efstratiou, and L. Bai, "Osn mood tracking: Exploring the use of online social network activity as an indicator of mood changes," in *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct*, ser. UbiComp '16. New York, NY, USA: ACM, 2016, pp. 1171–1179. [Online]. Available: http://doi.acm.org/10.1145/2968219.2968304

[43] S. Bagroy, P. Kumaraguru, and M. De Choudhury, "A social media based index of mental well-being in college campuses," in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, ser. CHI '17. New York, NY, USA: ACM, 2017, pp. 1634–1646. [Online]. Available: http://doi.acm.org/10.1145/3025453.3025909

[44] J. N. Stinson, "Improving the assessment of pediatric chronic pain: harnessing the potential of electronic diaries," *Pain Research and Management*, vol. 14, no. 1, pp. 59–64, 2009. [Online]. Available: https://doi.org/10.1155/2009/915302

[45] R. McCarney, J. Warner, S. Iliffe, R. Van Haselen, M. Griffin, and P. Fisher, "The hawthorne effect: a randomised, controlled trial," *BMC medical research methodology*, vol. 7, no. 1, p. 30, 2007.

[46] F. Hamidi, K. Poneres, A. Massey, and A. Hurst, "Using a participatory activities toolkit to elicit privacy expectations of adaptive assistive technologies," in *Proceedings of the 17th International Web for All Conference*, ser. W4A '20. New York, NY, USA: Association for Computing Machinery, 2020. [Online]. Available: https://doi.org/10.1145/3371300.3383336

[47] V. Venkatesh and F. D. Davis, "A theoretical extension of the technology acceptance model: Four longitudinal field studies," *Management Science*, vol. 46, no. 2, pp. 186–204, 2000. [Online]. Available: https://doi.org/10.1287/mnsc.46.2.186.11926

[48] J. Corbin and A. Strauss, *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage publications, 2014.

A

Studies' Interview Guides

A.1 Cultural Probe - Interview Guide

A.1.1 Materials & Activities

1. Envelopes
    - What did you like about this?
    - What were the difficulties you faced?
2. Calendar
    - What did you like about this?
    - What were the difficulties you faced?
    - What factors did you consider when evaluating your well-being?
    - Did you back-fill?
    - Do you see value in the data you collected?
    - Did you discover anything new?
    - Would you keep doing this?
3. Map
    - What did you like about this?
    - What were the difficulties you faced?
    - What factors did you consider when evaluating your well-being?
    - Do you see value in the data you collected?
    - Did you discover anything new?
4. Diary
    - Have you ever used a diary/journal?
    - Why do you think people use diaries?
    - Advantages/Disadvantages?
    - What did you like about this?
    - What were the difficulties you faced?
    - Do you see value in the data you collected?
    - Did you discover anything new?
    - Would you keep doing this?

A.1.2 Other Themes

1. Self-Tracking
    - Do you engage in self-tracking practices?
    - What do you track?
    - What tools do you use?
    - Why do you track?
    - Difficulties of self-tracking?
    - Outcome of self-tracking?
2. Sharing
    - Do you think self-tracked data is valuable to be shared?
    - What data and with who?
    - Would you share self-tracked data?
    - With whom would you share?
3. Well-Being
    - Do you consider students to have poor well-being in general?
    - What are the main reasons?
    - What are the implications?
    - What factors do you consider that contribute for your well-being?
4. Help-Seeking
    - Do you usually seek help regarding your well-being?
    - What are the reasons for your help-seeking behaviours?
    - Do you believe young adults such as students tend to avoid seeking help?

A.2 User Study - Interview Guide

A.2.1 Acceptability

1. Relevant Variables
    - Past usage of self-tracking tools
    - Usage of analogue approaches
    - Other approaches to manage well-being
    - Help-seeking behaviours
2. Perceived Ease of Use
    - Talk through each feature and discuss its usability
    - Facilitators and barriers
3. Perceived Usefulness
    - Talk through each feature and discuss its usefulness
    - Benefits and drawbacks
    - Usefulness of qualitative data?
    - Usefulness of quantitative data?
    - Usefulness of the link between both?
4. Intent to Use
    - Talk through each feature and discuss intent to use
    - Why do you use it or not use it?
    - What outcome do you want to achieve by using the feature?
    - DAN & Danny vs Danny vs DAN
5. Actual System Use
    - Talk through each feature and how they used it
    - Usage logs

A.2.2 Effectiveness

- Did you feel more aware of your well-being?
- Were you able to reflect on it and:
  - Identify issues?
  - Identify causes/correlations?
- Discuss effectiveness of some characteristics:
  - Dedicated - Serves as reminder and reduces distractions
  - Active data capture
  - Link between data types
- Were you able to engage in problem-solving and goal-setting techniques in order to improve your well-being?
- Did sharing your data help you in any way?
  - Did you get important feedback?
- Do these tools overall helped you manage your well-being?
  - Go over the weekly averages of their ratings

A.2.3 Well-being in College

1. How did the transition to college affect your well-being?
2. As a college student, what dimensions of your well-being are most impacted and how?
   - Mention the trackers
3. What do you think are the main causes for such?
4. How do you try to manage these issues? Help-Seeking?
5. Do you have any suggestions on how these issues could be avoided?
6. Discuss implications of poor well-being on their lives:
   - Academic Success
   - Substance Use
   - Productivity
   - Social Relationships

B

Cultural Probe - Envelopes

#1

Primeiros Passos

Descreve como correram os teus primeiros dias no IST desde as inscrições

Desafio
Coloca pelo menos um autocolante no mapa e no calendário

Sugestões

- Foste bem recebido?
- Conheceste quantos colegas?
- Qual o sentimento no final do dia?
- Qual foi o assunto mais abordado?
- O que te surpreendeu mais?
- Se soubesses o que sabes hoje, o que terias dito a ti próprio?

#2

Dura Praxis Sed Praxis

Qual a tua opinão sobre praxes?

Desafio
Lista 5 temas de conversa que costumas abordar quando conheces novas pessoas

Sugestões

- Qual era a tua opinião inicial?
- Participaste? Porquê?
- Descreve a tua experiência
- O que te supreendeu mais?
- O que é que mudavas na tua experiência?
- Mudaste a tua opinião?

#3

Interações Sociais

Qual a importância do equilíbrio entre vida social e académica?

Desafio
Escreve uma recomendação para um filme, série, livro, música, atividade ou local

Sugestões

- É importante? Porquê?
- Como é que uma influencia a outra?
- Influencia o teu bem-estar?
- Consegues manter um equilíbrio?
- Se sim, como? Se não, porquê?
- Partilha experiências relevantes

#4

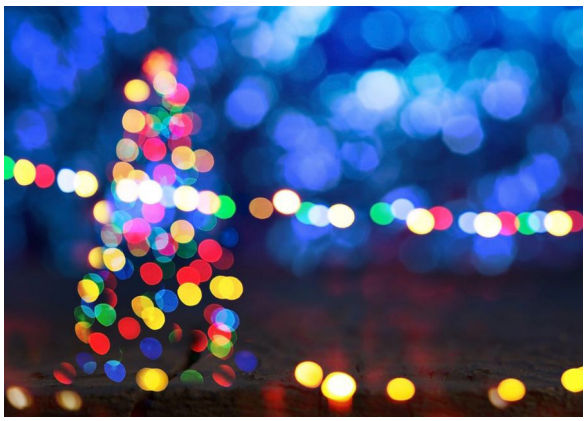
Aulas

Que a tua opinião acerca das aulas no IST?

Desafio
Faz um ranking das tuas cadeiras da tua favorita à menos favorita

Sugestões

- Qual a importância de assistir às aulas?
- Teóricas vs Práticas
- Contribuem para a tua aprendizagem?
- Consideras-te autodidata?
- Como melhorarias as aulas?
- Dá exemplos de razões que te levam a ir ou não ir a certas aulas



#5
Férias

Qual a importância das férias durante o teu percurso académico?

Desafio
Certifica-te que o teu mapa já tem 10 autocolantes e continua a preencher o calendário durante as férias

Sugestões

- São importantes? Porquê?
- Aproveitas as férias?
- Como é que impactam o teu bem-estar?
- Dificuldades em conciliar estudo e trabalho durante as férias
- Descreve as tuas férias ideais. Onde? Quem?

#6
Família

Qual a importância da família para te ajudar durante o teu percurso académico?

Desafio
Pede a um ou mais familiares para classificarem como lhes correu o dia e coloca os autocolantes correspondentes no calendário

Sugestões

- É importante? Porquê?
- Pedes ajuda a familiares? Porquê?
- Evitas alguns assuntos? Elabora
- Como é que te ajudam?
- Ajuda familiar vs Ajuda de amigos

#7

Época de Exames

Qual a importância de manter o bem-estar durante a época de exames?

Desafio
Aponta no calendário os teus testes e exames

Sugestões

- É importante? Porquê?
- Influencia a tua prestação académica?
- Consideras difícil manter o bem-estar?
- Como correu a tua época de exames?
- Como te organizas? Onde estudas?
- O que farias para melhorar?

#8

O Fim

Qual é a tua opinião acerca desta sonda cultural? Qual a importância de monitorizar o bem-estar dos alunos?

Desafio
Tira uma foto à tua sonda cultural

Sugestões

- O que foi mais e menos interessante?
- Como melhoravas?
- Monitorizas o teu bem-estar? Passos? Calorias? Sono? Stress? Humor?
- Se sim, porquê?
- Partilhas ou partilharias essa informação com outros? Amigos? Família? NAPE?

C

Toolkit - Data Type Cards

Emotional Stress qualitative	Emotional Stress quantitative	Emotional Stress rating	Emotional Anxiety rating	Emotional Anxiety qualitative
Emotional Mood qualitative	Emotional Mood quantitative	Emotional Mood rating	Emotional Emotions rating	Emotional Emotions qualitative
Emotional Emotions quantitative	Emotional Addictions quantitative	Emotional Addictions qualitative	Emotional Addictions rating	Environmental Quality of Surroundings qualitative
Environmental Quality of Surroundings rating	Financial Money Earned/Spent quantitative	Financial Spending Behaviours qualitative	Financial Spending Behaviours rating	Financial Satisfaction rating
Financial Satisfaction qualitative	Intellectual Creative Habits quantitative	Intellectual Creative Habits rating	Intellectual Creative Habits qualitative	Occupational Hours of Productivity quantitative
Occupational Productivity qualitative	Occupational Productivity rating	Occupational Grades quantitative	Occupational Satisfaction qualitative	Occupational Satisfaction rating
Occupational Academic Performance rating	Occupational Academic Performance qualitative	Physical Sleep Duration quantitative	Physical Sleep Quality rating	Physical Sleep Description qualitative
Physical Time Spent Exercising quantitative	Physical Exercise Metrics quantitative	Physical Exercise Quality rating	Physical Exercise Description qualitative	Physical Nutrition Metrics quantitative
Physical Appetite rating	Physical Appetite qualitative	Physical Eating Habits rating	Physical Eating Habits qualitative	Physical Symptoms quantitative
Physical Symptoms qualitatives	Physical Symptoms rating	Physical Substance Use quantitative	Physical Substance Use qualitative	Physical Substance Use rating
Physical Hygene rating	Physical Hygene qualitative	Physical Vitals quantitative	Social Quality of Social Life rating	Social Quality of Social Life qualitative
Social Time Spent Socializing quantitative	Spiritual Self-Esteem rating	Spiritual Self-Esteem qualitative		