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

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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

1. Introduction

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. The academic workload, peer pressure, social and extracurricular activities, and pressure of graduating are all factors that can induce instabilities to the students' well-being [10, 11, 19, 21]. The diverse college population means that students vary in their ability to cope with these challenges, and some face more barriers than others. Furthermore, it is also relevant 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"* [28]. Thus, it is of great importance to create solutions to monitor and maintain students' overall well-being.

Students' mental health and well-being is already an international concern [21], and it has been widely recognized that there exists a college mental health crisis [10, 11, 19, 21]. Anxiety, depression, eating disorders and suicidal tendencies are some of the most common disturbances present among students [19]. Although mental health problems are the primary issue, the diverse student population means that some might face additional and unexpected obstacles. These factors may have significant implications towards academic success, productivity, substance use, and social relationships [10].

Additionally, college students are also among those least likely to consult health professionals during an emotional crisis [3]. Hunt et al. [10] 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 [7].

The 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 [11, 27, 28]. 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.

1.1. 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' self-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 [17], 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 [4, 9]. 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 flexibility of notebooks, our tool will be structure-free and even allow practices of bullet journaling [1]. 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 other peers. Furthermore, this feature should facilitate the student's help-seeking behaviours to get more support and feedback.

1.2. Contributions

With this dissertation, we intend to provide a self-tracking system with the necessary features that 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 App 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.

2. 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 that cause differences in accuracy or completeness. Experience sampling method (ESM) and Ecological momentary assessment (EMA) are two common research tools used to overcome these issues. ESM consists in asking individuals to provide systematic self-reports at random moments [23]. EMA involves repeated sampling of individuals' behaviours and experiences in real-time, and in their natural environments [13]. Despite some differences, the two concepts are often interchangeable.

3. Related Work

Throughout our research, we explored different works the leverage various types of user-generated data that can offer meaningful insights about the state of students' well-being. We researched approaches regarding: (1) Personal Informatics that refers to the school of thought that uses technology to collect data on different aspects of the daily lives of people [20]; (2) Digital Phenotyping, which uses data collected from smartphone sensors; and (3) Leveraging Social Media. Most of our focus went towards self-tracking as previous research showcased its potential in college settings [11].

3.1. Passive vs Active

The works explored either use active sensing, passive sensing, 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 [6]. Manual tracking, even though it requires more motivation and has a higher capture burden, it also raises the users' awareness [6], which is one objective of self-tracking approaches. Semi-automated tracking [5] balances the advantages and drawbacks of both types of data-sensing. Furthermore, we also explored different solutions that successfully improved the burden of manual tracking [6, 8, 18].

3.2. 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 [17], they can offer more contextual data such as time-stamps and location [4], and can increase compliance through signalling [24]. 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 [18]. Mobile apps for self-tracking remind people that they are being monitored and therefore change how they interact with those solutions [16]. Devices that are dedicated for self-tracking have the advantage of reminding the user to self-track and requiring less preparation time [18]. Ayobi et al. [1] leverages bullet journaling because *"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"* [1]. Vega et al. [25] 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 users write faster on paper [17] which might be relevant for qualitative data input. Paper diaries are also easy to start and use, cheap, portable and robust [4].

3.3. Data collected
Quantitative data is the most common and easily tracked data as it can be tracked passively. However, since this data may require context provided by descriptive data, a combination of quantitative and qualitative data might 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 [14], and this data might not represent their well-being [28]. The raw sensor data leveraged in the digital phenotyping approaches complements [26, 29] and correlates [27] with other types of data. Nonetheless, users do not find this data relevant [21] and further data treatment is needed to be presentable to individuals so they can act upon it [27]. Flexibility to support different data is an important requirement [1, 12] and there is a clear need for it in a solution dedicated for students in a college setting.

3.4. 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 [2, 21, 28] 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.

3.5. Sharing & Privacy
Sharing the data with therapists, health professionals, family and peers can also improve the feedback and motivation. Some authors [1, 11, 15] reference social sharing as a way to support and connect with others in similar situations. However, sharing personal data raises concerns related with privacy and ethics. Social media and raw sensor data used in some of the works are examples of delicate data that users prefer not to share [21, 22, 27, 28]. Students would share their information [11] but solutions should offer full control to the user, so he/she chooses what to share and knows how the data is being used.

4. User Research
To further explore the potential of self-tracking among college students and to catalogue design guidelines that take into account their perspectives, we conducted two studies.

4.1. Study 1: Cultural Probes
We first designed a cultural probe to leverage self-tracking in a college setting and elicit opinions from students. These probes included a map and calendar to self-track well-being by placing coloured stickers, a diary to complement the assessments, and envelopes with questions and challenges.

Overall, participants seemed to enjoy the activities as it helped them reflect on different subjects and increased their awareness regarding their well-being. It helped us elicit and confirm some design guidelines, such as the value of a dedicated tool and active self-tracking. 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 a concern.

4.2. Study 2: Participatory Activities Toolkit
Though we found self-tracking to be well-accepted among college students, collecting and sharing user-generated data raises privacy concerns. To ease conversations regarding user expectations, we propose a participatory toolkit with activities

that expose students' views concerning the most valued types of data, their perceived usefulness and intention to share their data, and their preferences regarding the sharing process.

Our findings indicate that although participants agreed on which well-being' dimensions should be tracked, their preferences regarding types of data are very diverse. There was no favourite between quantitative and qualitative measures and combining data types was appreciated, as most of the times, they offer distinct value. The results show that students perceive data-sharing as a useful tool but they feel threatened when their data might be used for different purposes. Furthermore, their willingness to share is related to the data types 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. Findings also indicate a preference for having more control over how their data is shared. In general, students expect tools to support different data types and offer a customizable sharing experience.

5. System Overview

Taking into account the related work and user research, we gathered the 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**. To further increase student's self-awareness, our tool relies on **active assessments (EMAs)**. Considering the advantages and drawbacks of analogue and digital approaches, we propose to **digitally augment a notebook** to allow both types of input. With this, we expect users to be able to input descriptive data coupled with ratings and, therefore, building a bridge between qualitative and quantitative data.

We also propose a companion App linked with the self-tracking tool in the interest of increasing awareness and promoting reflection. Furthermore, this application focuses on providing **visualizations** that are easily perceived and understood, giving **meaningful insights** back to the student. Besides the feedback provided by the visualizations, students should also be allowed to **share their data** with others to gain further support. To preserve users' privacy we intend to offer control over what data is shared and how the data is shared.

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-

Figure 1: Digitally Augmented Notebook

seeking behaviours.

5.1. Architecture

Regarding our system architecture, it is divided into two components: Digitally Augmented Notebook (DAN) and the Student's Companion App (Danny). DAN is based on a regular notebook and includes an Arduino-based augmentation that allows users to rate well-being related measures. Each assessment is stored in DAN and then synced through BLE with the student's mobile App if the phone is nearby. Danny is the companion App that includes functionalities to configure the tracked measures, visualize the data collected, and share their information with stakeholders. The application was developed using Flutter and Firebase services.

5.2. DAN: Digitally Augmented Notebook

DAN's main characteristic is the fact that it allows both digital and analogue data collection, leveraging the advantages of both approaches and offering a **balanced capture burden**. The ratings can be easily captured and analyzed but might provide insufficient insights. 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. Our digital augmentation includes the addition of a small LCD, a button to interact with it, and five buttons where each represents a different rating. This allows users to select a specific aspect of their well-being and rate it accordingly. We preserve the notebooks form factor, allowing the user to easily carry it and not requiring any external ports. Furthermore, this means that DAN is a tool dedicated solely for self-tracking. We hope that this helps the user to focus and stay away from further distractions while they reflect and input their data. Finally, we chose to focus on active data collection because, while it might impact the capture burden, it promotes more self-awareness and self-reflection. Since a notebook is already a
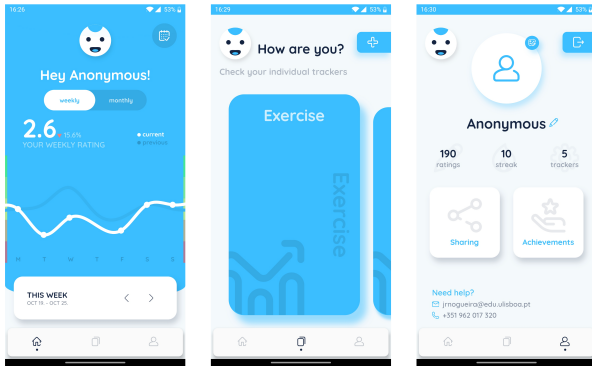
4

Figure 2: Danny's main screens

flexible tool when it comes to analogue data capture, 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.

5.3. 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. 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. By consuming the data which the user collects, our application is capable of generating various visualizations that provide meaningful insights, promoting 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. On this App, users are also allowed to 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. Finally, to preserve user engagement, we leverage unlockable achievements and weekly questions, challenges, and recommendations.

6. User Study

In order to properly validate our system, we designed a longitudinal user study that ran through the course of four to six weeks.

6.1. Research Questions

With this study, we intend to test whether DAN & Danny can help college students better manage their well-being. Firstly, we evaluate the overall acceptability of our tools among college students.

In order for students to welcome DAN & Danny, these tools should not only be useful but also be easy to use. 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 helps students manage their well-being. Furthermore, our objective is to also gain insights regarding the challenges that college students face and their implications. With these objectives in mind, we derive the following research questions: **(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?

6.2. Method

In this section, we give a detailed description of our method that allows us to test our proposition and answer the established research questions.

6.2.1 Participants

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. Participant 1 was 23 years old and was in his third year in college; P2 was 28 years old and on its 3rd year; P3 - 18 years - 1st year; P4 - 21 years - 3rd year; P5 - 19 years - 2nd year.

6.2.2 Apparatus

The technical requirements of this study include the self-tracking tools described in the previous section and prerequisites to be able to use such tools. In order to conduct this study, we built five DANs, where each was delivered to a participant together with a wireless charger. Additionally, participants were required to install Danny that supports smartphones running at least Android 8.0.

6.2.3 Procedure

When the students confirmed they had the notebook and application installed, we scheduled an initial meeting with each of them. Firstly, we gave participants an introduction to the theme of this dissertation and presented the tools we developed. After that, we gave them instructions for what they had to do, which included: (1) Choose 3 to 5 trackers; (2) Rate each tracker on a daily basis; (3) Write contextual information regarding these ratings; (4) Engage with Weeklies; (5) Gain insights

from the visualizations, and (6) Share your data to get further feedback. After that, participants followed these instructions for 4 to 5 weeks. Due to various requests at this stage, we added the possibility of assessing ratings directly in the App. At the end of the study, we scheduled an interview with each participant to collect our results.

6.2.4 Data Collection & Analysis

To be able to answer our research questions, we can split our data into three groups: **(1) Acceptability - RQ1; (2) Effectiveness - RQ2 and RQ3; and (3) Well-being in college - RQ4**.

In order to evaluate the solution's **acceptability**, we leveraged a framework based on the **Technology Acceptance Model (TAM)** that models how users accept and use technology, which includes evaluating **perceived usefulness (PU)** and **perceived ease of use (PEOU)**. We first collected data that might influence the PU, PEOU, and the intent to use our tools, such as their past experiences with self-tracking and help-seeking. Finally, while also leveraging usage logs, we analyzed the participant's usage behaviour. To evaluate the **effectiveness** of our approach, we asked students a group of questions which included exploring changes in self-awareness and -reflection, and analyzing their help-seeking behaviors. Furthermore, we included questions that should help us get a better understanding of the challenges that they face throughout college and how it impacts their **well-being**.

Finally, with the participant's consent, we audio-recorded and transcribed each session, and proceeded with an iterative thematic analysis.

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

6.3.1 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 5 trackers and mostly used the recommended ones because, as stated, they already cover the most important dimensions of well-being. Participants' self-tracking was mostly event-based as they usually assessed their well-being before going to sleep. Furthermore, all participants, at some point, did not rate their well-being because they forgot to do so. Participants visited the visualizations periodically or when they felt abrupt changes in their well-being. Students usually did not write much in DAN as they

would only do it to justify these abrupt 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 App. Another complaint regarding DAN was its battery life and the charging burden it poses.

> "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

Besides these issues, participants stated the App was easy to use, the visualizations were easy to interpret, and the sharing feature was intuitive.

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

All participants found the information visualizations useful because they offered meaningful insights. 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 different features of the application.

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. Some users did not use specific application's features due to a lack of interest, awareness, or time. Participants' intent to write on DAN was also influenced by their tendency to write on paper.

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. Furthermore, two participants propose that students could use a separate diary with the application.

"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 the reasons for the abrupt change" - P5

6.3.2 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.

"I was able to detect patterns that I was not aware they were related... Because this application mixes everything and can connect them, in a way, it helped me guide myself through these weeks." - P4

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 issues that they discovered while using our tools. While the App 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

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. 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.

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

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.

6.3.3 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. 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. 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.

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

They referenced it was hard to manage their time and that they ended up not having enough to do things that might improve their well-being. 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 should be spread out over more years. Finally, one participant suggested that students should be better prepared and informed for the transition 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." - 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. 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.

6.4. Limitations

The study's main limitation was its insufficient participant amount, as a larger sample would give us a greater understanding of our tools' impact. The study's duration also reduced our ability to detect conclusive changes in the participants' well-being.

6.5. Discussion

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

RQ1 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. To address these issues, we should focus on fixing the connectivity problems and improving the battery life and charging experience of DAN. Nevertheless, 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. Furthermore, due to adding the possibility of rating in the App, we 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 behavior, 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 and on improvements for the current approach.

RQ2 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.

RQ3 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 From our findings, we were able to highlight some of the recurring well-being issues among college students. 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. 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 a need to analyze the excessive workload and pressure that they face.

7. Conclusions & Future Work

The variety of problems college 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. 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 -reflection, easing data-sharing, and thus, by promoting help-seeking.

To validate our system, we conducted a longitudinal study with five 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. 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 increase our tools' acceptability among college students, we suggest focusing on both a digital-only tool and on improvements for the approach explored in this dissertation. There is also an opportunity to add more functionalities to Danny for better supporting problem-solving and goal-setting techniques. 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 be beneficial to test this system by integrating it in a college help program, where both students and stakeholders could work together.

References

[1] 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*, CHI '18, pages 28:1–28:14, New York, NY, USA, 2018. ACM.

[2] 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*, CHI '17, pages 1634–1646, New York, NY, USA, 2017. ACM.

[3] 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*, 54(501):248–253, 2004.

[4] N. Bolger, A. Davis, and E. Rafaeli. Diary methods: Capturing life as it is lived. *Annual Review of Psychology*, 54(1):579–616, 2003. PMID: 12499517.

[5] 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*, 16(1):74–84, Jan 2017.

[6] 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*, UbiComp '15, pages 121–132, New York, NY, USA, 2015. ACM.

[7] 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*, 66(5):522–541, 2009. PMID: 19454625.

[8] 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*, PervasiveHealth '17, pages 1–10, New York, NY, USA, 2017. ACM.

[9] 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*, 27(2):165–178, 2003. PMID: 12703341.

[10] J. Hunt and D. Eisenberg. Mental health problems and help-seeking behavior among college students. *Journal of Adolescent Health*, 46(1):3 – 10, 2010.

[11] 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*, CHI '17, pages 629–641, New York, NY, USA, 2017. ACM.

[12] 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.*, 1(3):67:1–67:28, Sept. 2017.

[13] R. Larson and M. Csikszentmihalyi. The experience sampling method. In *Flow and the foundations of positive psychology*, pages 21–34. Springer, 2014.

[14] 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*, UbiComp '16, pages 1171–1179, New York, NY, USA, 2016. ACM.

[15] 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*, CHI '18, pages 572:1–572:14, New York, NY, USA, 2018. ACM.

[16] 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*, 7(1):30, 2007.

[17] J. M. Noyes and K. J. Garland. Computer- vs. paper-based tasks: Are they equivalent? *Ergonomics*, 51(9):1352–1375, 2008. PMID: 18802819.

[18] 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.*, 2(3):132:1– 132:21, Sept. 2018.

[19] P. Pedrelli, M. Nyer, A. Yeung, C. Zulauf, and T. Wilens. College students: Mental health problems and treatment considerations. *Academic Psychiatry*, 39(5):503–511, Oct 2015.

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

[21] 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*, CHI '19, pages 425:1– 425:14, New York, NY, USA, 2019. ACM.

[22] 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.*, 1(3):95:1–95:27, Sept. 2017.

[23] S. Shiffman, A. A. Stone, and M. R. Hufford. Ecological momentary assessment. *Annual Review of Clinical Psychology*, 4(1):1– 32, 2008. PMID: 18509902.

[24] J. N. Stinson. Improving the assessment of pediatric chronic pain: harnessing the potential of electronic diaries. *Pain Research and Management*, 14(1):59–64, 2009.

[25] 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*, CHI '18, pages 74:1–74:13, New York, NY, USA, 2018. ACM.

[26] 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*, UbiComp '13 Adjunct, pages 67– 70, New York, NY, USA, 2013. ACM.

[27] 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*, UbiComp '14, pages 3–14, New York, NY, USA, 2014. ACM.

[28] 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*, PervasiveHealth'19, pages 61–70, New York, NY, USA, 2019. ACM.

[29] 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*, UbiComp '18, pages 1150–1155, New York, NY, USA, 2018. ACM.