Exploring the Effects of a Quantified Self Application on Academic Procrastination and Study Habits in University Students

by

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Abstract

Procrastination is a prevalent issue among university students, and it is important to investigate potential interventions. This thesis describes the design and implementation of a self-tracking mobile application that students can use to track their study sessions. The aim of this study was to investigate the impact that the application has on procrastination behaviour, along with an exploration of how students interpret their study data. A pilot study revealed that participants experienced an improvement in their focus, time management skills, and accountability. Following this, results from a six-week randomized controlled trial indicated that only the control group experienced a significant decrease in procrastination scores, however there was no significant difference between the two groups. Additionally, I identified themes that describe how students interpret their data and additional impacts that the application had on study behaviour, which led to a discussion about design implications and areas for future research.
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1 Introduction

1.1 Overview and Motivation

The practice of self-tracking using digital technologies is commonly referred to as *quantified self* [55], and has become an increasingly popular phenomenon over the past several years [57] with the development of smart watches, Wi-Fi scales, and self-tracking applications to help people track mood, food intake, and focus. Individuals can track their caloric intake to help them with maintaining, gaining, or losing weight. Alternatively, they can track their physical activity in order to detect improvements in their performance. Self-tracking has become so widely used that there is a community dedicated solely to it, called the “Quantified Self” [94], in which self-proclaimed “quantified-selfers” share the common interest of gaining knowledge through their personal data. This celebration of personal data does not come without reason; studies have shown that quantified self technologies can be used to effectively change people's behaviour when it comes to physical activity [92] and mood [7]. Although quantified self and general productivity research exists, it is among one of the less commonly researched domains in the literature [26,79]. Furthermore, studies investigating the use of quantified self technologies and productivity in an academic context remain scarce.

The surge of readily available productivity-related quantified self applications presents a promising opportunity to address a commonly faced challenge among university students: procrastination. This is because many
university students already own smartphones; downloading and using an application is relatively simple for attempting to combat this issue when compared to currently available interventions such as cognitive behavioural therapy. Procrastination can be defined as the delay of an intended course of action [72]. Moreover, it is estimated that 80% to 95% of university students procrastinate [72], with around 32% to 46% of students procrastinating at a consistent and problematic level [14,22,71]. Procrastination leads to many negative outcomes, including increased stress, poor grades, and an overall decreased well-being [25,77]. Despite these negative impacts, students still indulge in the behaviour; but why? Procrastination is a problem that is extremely hard to tackle, and most students simply cannot stop procrastinating even if they have a desire to change their behaviour [25]. Interventions for procrastination have been extensively studied, however most interventions, such as therapy or training programs [25], can be costly or time-consuming. These interventions may be an unrealistic solution for a busy university student. In contrast, using a quantified self application as an intervention for procrastination is an inexpensive solution considering that most university students already own a smartphone. Although it may take some time to record and reflect on data, it is less disruptive to a students’ schedule since it is an activity that can be integrated into their everyday routine, whereas larger blocks of time need to be put aside for weekly therapy or training sessions.

Many studies have shown that procrastination is the result of self-regulatory failure [8,28,50,72,86], which is the ability of an individual to
manage their thoughts, affect, behaviour, or attention [52]. Self-monitoring is an important subfunction of self-regulation [9], implying that quantified self technologies may be able to have a positive impact on procrastination, as it is essentially an embellished form of self-monitoring.

Smartphone-based interventions for procrastination remain scarce [56], although they may be particularly advantageous due to their ubiquitous nature, along with the fact that many people already own smartphones [56]. Moreover, there are many quantified self productivity applications available for mobile devices [95–97], which promise to improve focus or even procrastination with the help of a timer (to time a “focus session”) and visualized feedback. However, to my knowledge, these types of applications have not been studied in the context of academic procrastination.

The present study aims to see if quantified self technologies can be a possible intervention for procrastination. I began by designing and implementing a simple quantified self application that can be used for tracking study sessions; I did not use an existing application because most currently available productivity apps include gamified and social persuasive features, and I wanted to be able to have control over the app's elements. During this process, I conducted a usability study to ensure that the application was usable for the following stages of the study. Next, I conducted an exploratory pilot study to gather initial thoughts on the application regarding procrastination and to ensure that the application contained no bugs (i.e., critical errors in the implementation). Following this, I conducted a six-week randomized
controlled trial to examine whether the application had a detectable impact on procrastination habits. Additionally, I gathered qualitative insights about the participants’ experiences using the application. The hypothesis for this study was that the participants in the experimental group would experience a greater decrease in procrastination scores than the participants in the control group. Overall, the study aimed to answer the following questions:

1. Does the application have a positive impact on procrastination habits?
2. What insights do students gain from their study data and how do they use these insights to improve their study habits?
3. What impacts does the developed application have on students’ study behaviour and attitudes?

1.2 Contribution

This work contributed to literature in the following ways: first, many studies analyze overly complex applications containing a lot of persuasive elements, making it difficult to understand which element is having which impact. Therefore, this study contributes to the literature by analyzing a simple quantified self application, focusing solely on self-monitoring and feedback elements. Second, rich qualitative insights about the app’s impact on general academic productivity were gathered, leading to implications for designing quantified self applications that are geared towards promoting productivity with some more generalizable implications for quantified self applications.
Finally, a randomized controlled trial was conducted in order to remove bias, which is not often done in quantified self research [26].

This work was written up in condensed form and is under review for the journal *Behaviour and Information Technology* as M. Murad and K. Collins. A Quantified Self Application as Intervention for Procrastination in University Students (see Appendix A).
2 Related Work

2.1 Persuasive Design

Stanford behaviour scientist B.J. Fogg describes persuasion as “an attempt to shape, reinforce, or change behaviours, feelings, or thoughts about an issue, object, or action”[30]. Due to the many capabilities of computers, they can often be better persuaders than humans [29]. For example, computers can store, access, and manipulate large amounts of data, and they can convey information in many different modes such as graphics, audio, video, or animation [29]. Fogg uses the functional triad framework to describe how computers can interact with humans; they may act as a tool, as a social actor, or as a medium.

In this study, we will focus on computers as a persuasive tool. Fogg lists seven types of persuasive technology tools: reduction, tunneling, tailoring, suggestion, self-monitoring, surveillance, and conditioning [29]. The tool most relevant to this study is self-monitoring. Fogg describes self-monitoring as “taking the tedium out of tracking”; self-monitoring technologies facilitate monitoring to encourage users to change their attitudes or behaviours. This is usually done to achieve a goal or outcome. Self-monitoring technologies help people understand their progress towards a goal by providing them with ongoing data about their current state [29]. Furthermore, humans have a natural drive for self-understanding, meaning that using self-monitoring technologies may be intrinsically motivating [29]. Thus, it makes sense that the
use of self-monitoring technologies, as an element of persuasive design, may be able to aid university students in improving their studying and work habits by intrinsically motivating them.

Current trends in persuasive designs can be separated into three classes [42]:

1. **Gamification**: Gamified applications use elements that one would normally see in games [23]. The commonly used elements include points, leaderboards, and badges [43]. More gamified elements include levels, clear goals, feedback, rewards, progress, and challenges [43]. Apps may include many of these elements to create a fully immersive game-like experience, such as the habit tracker app Habitica [98] which mimics a roleplaying game (see Figure 1 (a)). Alternatively, a more subtle approach can be taken where only a few elements are incorporated, such as in Apple's [99] Fitness application which features awards and challenges for the user (see Figure 1 (b)).

2. **Social Networking**: Applications that feature social networking incorporate social features to motivate users [42]. These applications usually have a community, where users can share their updates and receive support which motivates them to change their behaviour [42]. As an example, the popular fitness-tracking application, Strava [100], has a community where users can share their workouts and receive praise and encouragement from other users.

3. **The Quantified Self**: Quantified self applications incorporate informational feedback to help users become aware of their habits, which can motivate them
to reach their goals [47]. These applications usually have features such as logs, geo-maps, statistical summaries, and visualizations [47]. Essentially, they focus on providing the user with information and facilitate self-tracking in an attempt to motivate users to reach their goals [47]. It is difficult to find applications that strictly employ quantified self elements because they are often paired with gamified and social features.

Figure 1. (a) A screenshot of the popular gamified habit tracking app, Habitica, showcasing some RPG components. (b) The awards that users can receive in Apple’s Fitness application.

Applications frequently include more than one of these classes in their design [42]. Gamification, which is described by Deterding et al. as "the use of game design elements in non-game contexts" [23], is often used alongside
digital self-tracking to further motivate users [34,42,57,58]. However, Zuckerman and Gal-Oz [92] performed a study where they evaluated a quantified version against a gamified version of their walking application StepbyStep, and they found that both versions of the application were equally effective in promoting routine walking. Furthermore, it has been shown that gamification may have counterproductive effects, such as decreasing intrinsic motivation [5,24,44,89] or cheating by recording false information to receive rewards [40]. Due to these counterproductive effects, using gamification may not be effective in increasing productivity, especially in an academic setting where having intrinsic motivation is important for avoiding procrastination [22,50,66].

2.2 The Quantified Self

Self-tracking, which is the process in which individuals monitor, measure, and record data about their body and life, has been practiced for a long time with the use of pen and paper [6,57]. Recent advances in technology, however, have resulted in a resurgence of interest in self-tracking [57] because devices such as Fitbits, heart rate monitors, and Wi-Fi scales facilitate the process of collecting and analyzing data [19]. This interest led to the “Quantified Self” movement, established by Wolf and Kelly, which is a community of individuals who are seeking “self-knowledge through numbers” [94]. The terms ‘quantified-self’, ‘life logging’, ‘personal informatics’, and ‘personal analytics’ can all be used to describe the practice of self-tracking with
the help of digital technologies [55]. Common variables that people track are activity, food, weight, sleep, and mood [19]. Often, self-tracking is used to help improve health; for example, caloric intake can be tracked to help individuals lose, maintain, or gain weight. Although self-tracking is often referred to as ‘quantified-self’, non-quantifiable data can also be tracked, such as daily activities, moods, and relationships [57]. A common model used to describe the process of self-tracking was developed by Li et al. [55]. The model consists of five stages: (1) preparation, which occurs before the user starts collecting personal data and encompasses the users motivations for wanting to self-track, how they decide what information to track, and how they are going to record it (i.e. which tools they will use), (2) collection, which is when the user is observing and recording their information, (3) integration, which is when the information is prepared for the reflection stage (i.e. creating graphs), (4) reflection, which is when the user reflects on their findings, and (5) action, which is when the user decides what changes they are going to make.

Because self-tracking is becoming so popular, many researchers have investigated why people do it. Gimpel et al. [34] found that a large motivator for self-tracking is entertainment: They reported that self-trackers enjoy playing around with their collected data as they consider this fun. They also found this ‘fun’ element to be more enhanced by gamification elements, such as rewards and leaderboards. The researchers observed that users who adhere to their self-tracking practice often realize that it is helping them take responsibility and optimize their lives, as well as helping them be more self-
disciplined, thus further motivating them to continue collecting personal data. It was noted that users who engage in self-tracking without gamification elements felt that their motivation for self-discipline was better met than users who self-track with gamification elements. In a similar study, Lyall and Robards described self-tracking as a ‘tool’, ‘toy’, and ‘tutor’ [58]. As a tool, self-tracking can be used to work towards goals by analyzing personal data. The participants expressed that they self-tracked for a reason, such as to stay active or to get more sleep, and their device acted as a ‘tool’ to help them reach their objectives as the data allowed them to reflect on their past lived experiences. Engaging with gamified rewards and exploration of visual data contribute to the ‘toy’ role of self-tracking, which supports the findings of Gimpel et al. [34]. The social and competitive aspect of self-tracking also contributed to the ‘toy’ role for participants, with many expressing that they enjoyed comparing their data with others. Lastly, self-tracking can act as a ‘tutor’ because the data helps users learn about and reflect on their behaviour, which motivates users to iterate on their behaviour in order to reach their goals.

Another study done by Choe et al. [19] found that users are motivated to self-track because it may help them improve health, improve other aspects of life, and to find new life experiences. Improving health may involve managing a condition or making better health decisions (e.g. tracking caloric intake) whereas improving other aspects of life can involve increasing productivity or increasing mindfulness [19].
Many studies have shown that self-tracking technologies are beneficial for the user [19,69,73]. For example, after analyzing videos on the Quantified Self website, Choe et al. [19] found that users claimed to have improved their health by creating healthy habits such as changing their diet, losing weight, and being more physically active. Users have also managed to avoid negative symptoms by recognizing their triggers, for example, drinking coffee being a trigger for anxiety. Overall, self-tracking helped the users gain awareness of themselves and their environment [19]. However, this study is based on the perceptions of individuals who already self-track, rather than on observations. In another study, Stiglbauer et al. [73] performed a two-week randomized control trial to assess the health and wellbeing outcomes of using an activity tracker. They found that users’ perceived physical health and sense of accomplishment was positively impacted by the tracker.

Researchers have also developed mobile applications to observe the change in behaviour of their participants. For example, Zuckerman and Gal-Oz [92] developed a prototype called StepbyStep that tracked users’ daily walking habits. After a two-week experiment to test the prototype, they found that participants’ daily walking time while using the application was significantly higher than their baseline walking time. Participants’ awareness toward their walking habits increased during the study as well.

Finally, Bakker and Rickard [7] implemented MoodPrism, which is a self-tracking based mental health application. They performed an initial assessment of the participants’ mental health prior to them using the
application. After 30 days of interaction with the application, a final assessment of the participants was performed. Their findings suggested that participants who found their experience with the application more engaging displayed decreased levels of depression and anxiety, as well as a greater increase in mental wellbeing. The aforementioned studies show that self-tracking is a promising method for behavioural change and increasing self-awareness.

### 2.2.1 The Quantified Self and Productivity

Personal productivity can be hard to track because there is no exact definition or measurement of productivity [81], and what is considered to be productive may vary from person to person. Nevertheless, self-tracking to improve personal productivity is commonly practiced [54], and therefore there have been various studies done on the topic. For example, Hiniker et al. [49] developed a self-monitoring application called MyTime, which was designed to help people decrease their smartphone usage. They found that using the application was effective in helping users reach their goals, however these were only short-term results. Whittaker et al. [82] developed an application called meTime, that monitored how much time users spent across different applications. MeTime helped participants decrease usage of social media, email, browsing and total time online. They also found that the application made participants more aware of their ability to focus effectively. However, although time spent on non-productive applications decreased, time spent on productive applications did not increase, which either suggests that the app did not help
improve overall productivity or that the participants were productive outside of the “productive” apps. Finally, Pammer et al. [64] showed that visualizations of the ways in which knowledge workers spent their screen time made them gain self-awareness about their work habits. Most studies have focused on productivity in the workplace, meaning that academic productivity is often overlooked. There are many self-tracking and gamified applications that are tailored towards improving focus such as Forest [95] and Focus Keeper [96], however, to my knowledge, there are little to no studies that test whether or not these types of applications work for reducing procrastination or increasing productivity, specifically within an academic context.

The bulk of the self-quantification studies focus on general workplace productivity and general overall productivity, physical activity, or mental wellbeing and there are only a few studies examining the impact of tracking productivity in an academic context. Wohn and Lee [85] explored how tracking and reflecting on study habits impacts study behaviour and grades. They implemented a simple web-based tool that was compatible with desktop and mobile browsers, consisting of “Start Timer” and “Stop Timer” buttons that students could use to keep track of their study sessions. The tool also featured a scrollable history log of the student’s total logged study time, total weekly study time, and a list of the logged events. For their first study, students participated in the study as a part of their coursework. After the tool was tested, it was revealed that the participants overall did not enjoy using the tool, however it helped them gain more self-awareness about their study habits. For
their second study, the researchers tested four groups: (1) a group that tracked study sessions using the application, (2) a group that tracked with the combination of social reflection (i.e., students shared reflections about their tracking data, class performance, and study habits within a small group every 2 weeks), (3) a group that tracked with a combination of self-reflection (i.e., students wrote a journal entry every two weeks reflecting on their tracking data, performance in class, and study habits), and (4) a group that tracked with a combination of both self-reflection and social reflection. Participants were students in a seminar course, and each section of the seminar course was randomly assigned with one of the four conditions. All the groups performed similarly for the midterm, however the group of participants who had combined tracking with self-reflection received significantly higher grades on their final exam than the group who combined tracking with social reflection. All other groups, including the group that exclusively self-tracked, showed no statistically significant differences between scores. Although a self-tracking application was developed in this study, it was a web-based tool: This created issues when participants wanted to access the tool without an internet connection [85]. Furthermore, the tool did not provide participants with visualized feedback, rather it simply included a log of the sessions. Regarding the second study performed, a control group was not included. Additionally, the researchers did not monitor engagement with the application, making it further difficult to understand if the interventions were contributing to observed changes in grades.
Another study, performed by Tabuenca et al. [74], explored the impacts that self-monitoring and notifications have on self-regulated learning. Their results from testing an application with 36 students showed that self-monitoring study time may have a positive impact on time management skills. They also found that notifications containing the students’ personal time-performance and behaviour were perceived as most useful by the users, and the students preferred to examine their learning analytics through chart visualizations rather than text messages.

2.3 Procrastination

Procrastination is described as the “intentional delay in the beginning or completion of important and timely activities” [65]. It is estimated that around 20% of adults consider themselves to be chronic procrastinators [46]. This habit is even more prevalent among university students; about 32% to 46% of students problematically procrastinate [14,22,71], and 62% have reported that they would like to reduce their procrastination [71]. It has been continuously shown that academic procrastination leads to negative outcomes, such as low grades [77], stress [77], and an overall decreased affective well-being [8].

Due to the prevalence of procrastination despite proven negative outcomes, the causes of procrastination have been widely studied by researchers. Self-esteem [12,14], conscientiousness [14,83], and self-efficacy
are all negatively correlated with procrastination. Moreover, issues related to procrastination seem to be deepening [72].

### 2.3.1 Self-Regulated Learning

Procrastination has been shown to be significantly negatively correlated to self-regulation [8,28,50,72,86]. Self-regulation is the ability of an individual to manage their thoughts, affect, behaviour, or attention in order to attain long-term goals [52]. Baumeister et al. [11] described four components of effective self-regulation: (1) a well-defined goal, (2) monitoring of progress, (3) self-regulatory strength, and (4) motivation to reach the goal.

One study that demonstrated the strong correlation between a lack of self-regulation skills and procrastination was performed by Balkis and Duru [8]. Specifically, they observed that procrastination results from under-regulation, meaning that students who procrastinate have difficulties in setting goals, monitoring their performance, and maintaining motivation [8]. They also reported that poor self-regulation negatively impacted students’ emotional well-being. The researchers suggest that an improvement in self-regulation skills can help students avoid procrastination. Additionally, Grunschel et al. [38] found that providing students with training sessions focused on improving processes of self-regulated learning (such as goal-setting, time management, self-motivation, monitoring, and reflecting), resulted in a significant decrease in the students’ procrastination scores when compared to a control group. Finally, from the results of their study, Wieland et al. [83] suggest that
procrastination interventions should aim to foster students’ abilities to self-regulate. Self-monitoring is a key component of proper self-regulation [11], suggesting that self-tracking using quantified self technologies may aid in an improvement of self-regulation skills and thus reduce procrastination.

Moreover, self-monitoring has often been shown to be a variable in reducing procrastination [65,87,90]. The self-regulation theory suggests that individuals with low self-control also have low willpower and motivation that results in a low time management disposition, which can be resolved by improving self-monitoring skills [90]. Wolters et al. [87] found that students who reported using skills such as goal setting, prioritizing, and monitoring their use of time also reported decreased procrastination. Moreover, self-monitoring can improve motivation as well because it allows individuals to detect subtle progress [91].

### 2.3.2 Common Interventions

It is important to discover viable interventions for procrastination. In their meta-analysis of procrastination intervention studies, van Eerde and Klingsieck [25] found that cognitive behavioural therapy (CBT) is often used to successfully combat procrastination. This type of therapy focuses on identifying and correcting problematic thoughts. In the case of procrastination, CBT is used to explore the individual’s personal experience with procrastination, understand their procrastination patterns, and change irrational thoughts into productive thoughts, which results in a change in
procrastination behaviour [25]. However, CBT can be time-consuming and, in some cases, an expensive solution [60]. Another possible intervention is journaling, as it was found to be an effective way for students to gain self-awareness about their procrastination habits thus motivating them to change their behaviour [48].

Returning to the concept of self-regulation, another common intervention is to enhance the individual’s self-regulation skills by teaching them proper self-reflection, self-monitoring, stimulus control, self-motivation, and emotional-regulation techniques [25]. The individuals may also be taught time-management techniques such as goal-setting, planning, prioritizing, organizing, and monitoring time [25].

2.3.3 Technology-Based Interventions

Although smartphones are now widely used, technology-based interventions for procrastination remain scarce [56]. A technology-based intervention is a broad term to describe any intervention that makes use of technology to help an individual make a behavioural change. This can involve any type of technology ranging from mobile applications to wearable technology. Only a few technology-based methods have been explored for reducing procrastination. Smartphone-based interventions are particularly advantageous because they are ubiquitous, almost always available and smartphones are already owned by most people [56] – in 2018, it was found that 97.9% of Canadians aged 15 to 24 own a smartphone [37].
Wäschle et al. [80] examined the impact of visual feedback on medical students’ procrastination habits. They devised a web-based planning and reflection protocol that the students completed at the end of each week to record their studying behaviours. The students were asked to reflect on their goal achievement and procrastination from the past week, and to set goals for the following week. The self-reported procrastination data was used to create a line chart, which was updated and displayed to the student every week. Findings showed that presenting feedback to the students resulted in a significant decrease in future procrastination behaviour in comparison to the students in the no-feedback condition. These results are promising for my own study, especially since continuous feedback may be even more effective than weekly feedback.

Another study exploring a technology-based intervention was performed by Theobald and Bellhäuser [75], where they had students complete daily electronic survey-based learning diaries during a 30-day period. Students received automated textual feedback based on their diary responses. Findings suggested that electronic feedback positively impacted the students’ procrastination habits, and students in the feedback group received better grades on the final exam compared to students in the control group (no feedback).

Foulonneau et al. [31] developed a smartphone application called TILT (Time Is Life Time) that was aimed to reduce procrastination. The application monitors the amount of time that the user spends on their phone, along with
the number of times that the phone is picked up. Results from their six-week trial suggested that TILT aided users in reducing their smartphone usage by 15%, however there was no follow up with the participants to see if these results persisted. Although this study was aimed at reducing procrastination, only the amount of time spent on the phone was examined rather than actual procrastination levels.

Finally, Lukas and Berking [56] also developed a mobile-based application called MT-PRO, which aims to reduce procrastination by asking users to either avoid dysfunctional stimuli or approach functional stimuli. Results showed that using the application reduced both general and academic procrastination behaviours compared to the control group, and these results were sustained over a one-month period.

From this review of the literature, it is evident that technology can be used to persuade individuals to reduce their procrastination behaviours. However, studies examining the use of quantified self mobile applications as an intervention for procrastination are still lacking.

### 2.4 Gaps in the Literature

There are several gaps in the literature when it comes to quantified self and productivity. First and foremost, there are not many studies that focus on the quantified self in the context of academic productivity. From their review on smartphones in personal informatics, Vaid and Harari [79] pointed out the
lack of productivity research in comparison to other domains, such as physical health.

Epstein et al. [26] recently reviewed 523 publications of personal informatics papers, and found that the bulk of the research focused on health and wellbeing. However, only 27 of the studies focused on productivity although these were categorized as \textit{workplace productivity}, further emphasizing the lack of productivity research in an academic context for quantified self technologies. Furthermore, only nine of the studies that they analyzed conducted a randomized controlled trial to assess a created artifact, showing a need for more controlled studies. This study aims to fill these gaps by analyzing the impact that quantified self technologies have on academic procrastination and study behaviour, which is in the domain of productivity. Along with this, the present study used a randomized controlled trial approach to answer the research question.

In the case where a study is evaluating a developed mobile application, usually it is overly complex, involving many different features and components [53]. This makes it difficult to evaluate what is contributing to behavioural changes. Specifically, quantified self and gamified features are often combined in studies. For example, the MoodPrism [68] app (mentioned prior) includes rewards, which are a gamified feature, along with self-monitoring features. Additionally, Amit et al. [3] developed an application called ProScore which aims to reduce procrastination and improve productivity. However, the application includes a combination of gamified, quantified self, and social
features. This calls for more studies assessing simple applications that focus on one persuasive technique. Therefore, the present study aims to analyze only one element without overcomplicating the system.
3 Design and Implementation

3.1 Overview

The StudyTracker app can be used for tracking work sessions. I designed it to have a focus on self-tracking and feedback, avoiding the addition of any gamification or social elements. StudyTracker uses semi-automated self-tracking, where the user is required to manually start and stop the timer before and after study sessions however the application assists in the remainder of the data capturing and organization (i.e., calculating study session length, keeping track of the number of study sessions, etc.). Feedback is provided in the form of charts and text. The app features a timer, charts, tags, a log of the sessions, and settings. The development process and features are described in the following sections.

3.1.1 Design Recommendations

In order to build a quantified self application for this study, it was important to consider design recommendations from other researchers. Visualization is the main method of communicating information to the user and helps users during the reflection stage [62], and is therefore an essential feature to self-tracking tools. To increase usability, Oh and Lee [62] recommended making user input simple because users do not want to spend too much time or mental effort on recording data. However, Choe et al. [19] suggest that self-tracking tools should maximize the benefits of manual self-tracking, because automated tracking may reduce awareness and self-reflection. They found that
quantified-selfers felt an "intimacy with data" during manual tracking [19]. Therefore, it is important to find a balance between automated and manual data collection in order to increase usability while still preserving user awareness of the data. From their exploration of bullet journals, Abtahi et al. [1] have come up with the recommendation of making digital trackers visually aesthetic. They also said that it is important to allow for some customizability of the application's appearance, such as providing different colour scheme options, so I made sure to include customization options in the developed app.

3.2 Design

While designing this application, for the purposes of this study it was important to put an emphasis on quantified self components, while avoiding the addition of any social networking or gamified features at this time: Many applications incorporate all three classes, so it was necessary to understand the bounds of each. As a reminder see the Persuasive Design section for descriptions of the classes.

It is difficult to distinguish the clear line between gamification, social networking, and quantified self features because applications often use a combination of all three. Furthermore, gamified apps may include elements such as feedback, which happens to be the main component of a quantified self application.

Therefore, I followed this one rule while designing the application: the app will only include informational feedback, meaning that the app will focus
on persuading the user by providing them with information through elements such as logs and visualizations – no other elements that may greatly persuade the user will be added. For this application, I limited the key features to a history log and a charts page, without the addition of persuasive elements that can be considered as gamified or social features such as awards, leaderboards, or points.

**Tracking Mechanism**

There are three types of tracking mechanisms often employed in quantified self applications: (1) *manual tracking*, which is when the user needs to input all the data manually, (2) *semi-automated tracking*, which is characterized by any combination of manual and automated tracking [18], and (3) *automated tracking*, which is when tracking is fully automated and users do not have the burden of inputting data [18].

Oh and Lee [62] recommended making user input as simple as possible, however, it is not yet possible to my knowledge to automate study tracking because it involves both physical and digital activities. If studying were to be restricted to the computer, then automated tracking may have been possible by keeping track of when “productive” applications are opened. However, Choe et al. [18] state that manual forms of tracking increase awareness, accountability, and involvement.

There is a common tracking method used in productivity and focus trackers which employs a timer accompanied by *start* and *stop* buttons, shown
in the apps Focus Keeper [96], Flipd [97], and Forest [95] in Figure 2. The user can manually press these buttons to track their focus sessions. With all things considered, this was the tracking method used for the StudyTracker application, which is considered a form of semi-automated tracking. Therefore, the app provided the user with time-based information about how often and how long they have studied.

![Figure 2. Timing mechanisms for some popular focus-tracking apps. From left to right: Focus Keeper, Flipd, and Forest.](image)

**Data Visualizations**

To my knowledge, there are no studies that provide extensive guidelines for data visualizations in quantified self productivity applications. Therefore, the data visualizations included in this application were inspired by current productivity applications on the market. Some of these data visualizations are...
summed up in Table 1. I also made sure to provide a wide range of data visualizations, as reflection is often a barrier in self-tracking because not all graphs are understood by everyone [55].

<table>
<thead>
<tr>
<th>App</th>
<th>Overview of Charts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Focus Keeper [96]</strong></td>
<td>- Overview of user’s total sessions, total focus hours, etc. (textual feedback)&lt;br&gt;- The amount of time spent studying per hour/per week is displayed in a bar chart (also called time distribution)&lt;br&gt;- Task data is displayed as a horizontal bar chart showing the total amount of time spent on each task</td>
</tr>
<tr>
<td><strong>Forest [95]</strong></td>
<td>- Focus trends are displayed as a horizontal bar chart, which compares the user’s daily/weekly/monthly focus to previous dates/weeks/months&lt;br&gt;- Time distribution is displayed as a bar chart, showing how much time the user spent studying per hour/day/week.&lt;br&gt;- Most focused period of the day/week is displayed as a line chart, showing what time of the day/what day of the week the user is the most focused&lt;br&gt;- Tag distribution is displayed as a pie chart showing the user how their time is split up according to their tags</td>
</tr>
<tr>
<td><strong>Flipd [97]</strong></td>
<td>- The app shows insights in the form of textual feedback, displaying information about typical study times, study trends, and the most used tag of the week&lt;br&gt;- Time distribution is displayed as a bar chart&lt;br&gt;- Tag distribution is displayed as a pie chart</td>
</tr>
</tbody>
</table>
**Visual Aesthetics**

It was necessary to make the application visually appealing, as Abtahi et al. [1] and Oh and Lee [62] found that users place value on aesthetics in quantified self applications. It was further noted that users find colour schemes important as they like to customize applications to match their personal style [1]. Finally, Abtahi et al. [1] found that users like trackers that are neat and organized. Therefore, I came up with the following directions for the visual design of the StudyTracker application:

1. There should be customizable elements so users can personalize the application.
2. The application should be neat, organized, and visually appealing.

To design a visually appealing application, I had to take the following principles into consideration: *balance, symmetry, regularity, predictability, sequentaility, economy, unity, proportion, simplicity,* and *groupings* [33]. These principles are what contribute to an aesthetically appealing user interface and are described in Table 2 [33]. The aesthetics of the application were generalized rather than being tailored directly for university students because the focus of this study was not on the impact of aesthetics.

For the colour scheme, I chose one colour as the accent with the default being purple. The user was able to customize the accent colour, with options including blue, green, orange, pink, and red. A simple font, Open Sans [101], was used across the entire application.
Table 2. Design Principles for aesthetically pleasing user interfaces [33]

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance</td>
<td>Create screen balance by providing an equal weight of screen elements, left and right, top and bottom.</td>
</tr>
<tr>
<td>Symmetry</td>
<td>Create symmetry by replicating elements left and right of the screen centerline.</td>
</tr>
<tr>
<td>Regularity</td>
<td>Create regularity by establishing standard and consistently spaced horizontal and vertical alignment points. Use similar element sizes, shapes, colours, and spaces.</td>
</tr>
<tr>
<td>Predictability</td>
<td>Create predictability by being consistent and following conventional orders or arrangements.</td>
</tr>
<tr>
<td>Sequentiality</td>
<td>Provide sequentiality by arranging elements to guide the eye through the screen in an obvious, logical, rhythmic, and efficient manner.</td>
</tr>
<tr>
<td>Economy</td>
<td>Provide economy by using as few styles, display techniques, and colours as possible.</td>
</tr>
<tr>
<td>Unity</td>
<td>Create unity by using similar sizes, shapes, or colours for related information and by leaving less space between elements of a screen than the space left as the margins.</td>
</tr>
<tr>
<td>Proportion</td>
<td>Create windows and groupings of data or text with aesthetically pleasing proportions.</td>
</tr>
<tr>
<td>Simplicity</td>
<td>Optimize the number of elements on a screen, within limits of clarity. Minimize the alignment points, especially horizontal or columnar.</td>
</tr>
<tr>
<td>Groupings</td>
<td>Provide functional groupings of associated elements.</td>
</tr>
</tbody>
</table>
**Prototype**

I initially drew rough paper prototypes of a potential design for the application and created a list of features that I wanted the application to have, inspired by currently available applications: (1) stopwatch to track sessions, (2) tags to categorize sessions, (3) log of previous study sessions, where sessions can be edited or deleted, (4) a variety of feedback charts, and (5) some customization settings.

Following this, I created wireframes using Figma [102] which I used as references to create a high-fidelity prototype of the app, as shown in Figure 3.

![Figure 3. Initial wireframes (top) and some frames from the resulting high-fidelity prototype (bottom).](image-url)
Figma is a web-based design and prototyping tool commonly used to create user interfaces and wireframes.

3.3 Development and Deployment

I developed StudyTracker\(^1\) using Swift [4]. Swift is Apple’s programming language for iOS applications. I tested and debugged the application on an iPhone 13 Pro. I used this hardware because it was what I had on hand, making it more convenient to develop the application for iPhone rather than Android. This was not an issue, however, because many people own iOS devices.

Since this application had to be developed in a short amount of time, I sacrificed maintainability and optimization of the code because there was insufficient time to plan the back-end structure on top of learning Swift and implementing a fully functioning application. Regardless, code maintainability and optimization were not prioritized because the application was solely being built for this study, after which it was archived.

To implement some of the charts, I used a public library called Charts [35]\(^2\). The final application was compatible with iOS and iPadOS 15.0 and above.

The StudyTracker application was available to download through Apple’s TestFlight [51] application. TestFlight allows developers to invite users to beta test their applications. I sent participants a public link to download the

\(^1\) Full code can be found at: https://github.com/mayaserena/Study-Tracker

\(^2\) Although Apple recently released their own charts framework [103], it is only compatible with iOS 16.0 and above. Considering that, at the time of the study, iOS 16.0 was recently released, I opted not to use this framework in case potential participants had not yet decided to update their mobile devices.
application, since this allowed their app usage information to remain completely anonymous. I did this purposely as to not make participants feel as though they were being watched, since this may have changed their behaviour while interacting with the application. Participants were informed that their usage information was completely anonymous.

3.4 The Application

Stopwatch

Since the stopwatch is the main feature and it had to be easily accessible to the users, I made it the landing page when the user first opens the app. The user can click “Start Timer” to begin a session. Once “Start Timer” is pressed, it is replaced with a “Stop Timer” button, which the user can press to end the session. Sessions were restricted to being at least five minutes long to discourage users from creating an excess number of sessions which would cause erratic feedback and app behaviour. Furthermore, many experts in procrastination recommend breaking large goals down into smaller subgoals in order to combat the problem [39,70]. Although the research to support this phenomenon is still lacking, many individuals stand by the “5-minute rule” to help with procrastination [70], which states that if you simply aim to do a task for five minutes, you may end up finishing it (i.e., working on it for longer than five minutes). Telling yourself that you will only work on something for five minutes is supposed to make the beginning of a task feel less daunting. Additionally, other quantified self productivity applications tend to restrict
sessions to being at least five to ten minutes long, therefore this application mimicked that feature.

If the user attempts to stop the timer before the five-minute mark, they are presented with a warning, informing them that their data will not be recorded, as shown in Figure 4. From this popup, they can choose to continue the timer or stop the session without recording. If the user stops the timer after the five-minute mark, they are presented with a popup saying “Study Session Complete” with details about the length of their session, shown in Figure 4.

![Image of stopwatch page]

*Figure 4. The Stopwatch page along with the "Session Too Short" and "Study Session Complete" popups.*

The user can click “Choose a tag” which opens a popup where they can select the tag for their session (see Figure 5). In the popup, they can jump to the “Edit Tags” page as well to easily edit or add tags. The user can choose the tag before they begin the session, during the session, or they can edit or add a tag after they record the session. The user can also change the tag during the
session. Once the timer is stopped, the currently selected tag will be the one recorded with the session (Figure 5).

![Image](image.png)

*Figure 5. The process of selecting a tag for a study session.*

The user is free to leave the app as they please and the timer will continue to run in the background. If the user quits the application, the timer has been implemented to keep track of the start time and calculate changes in time accordingly as the user restarts the application.

The timer automatically stops and records the session after eight hours have passed, sending the user a notification informing them of such. Notifications are also sent in intervals chosen by the user to remind them that the timer is still running.
**Tags Page**

The tags page is where users can go to manage their tags. In the tags page, users can click the “+ Add a new tag” button to add a new tag, or they can tap their existing tags to edit them, shown in Figure 6. When adding a tag, users are prompted to type in a name for their tag. They have the option to select a colour, however if they do not, the tag colour will default to grey. When editing a tag, the user can change the name or colour associated with the tag. The edit tag and add tag forms are implemented so that the save button is inactive until users enter at least one character. Users are also warned to choose another tag name if they attempt to create duplicate tags.

![Figure 6. The “Add Tag” and “Edit Tag” popups from the Tags page.](image)

An edited tag will be updated for already recorded entries. Deleting a tag does not delete its associated entries, rather all entries with that tag will receive a grey “Untagged” tag. Users are also warned after clicking “delete tag” with a popup asking, “are you sure you want to delete this tag?”, outlining what will
happen prior to permanently deleting the tag. From this popup, they can choose “delete forever” to proceed with deletion or “nevermind” to go back. This was done to ensure that users do not delete tags by accident, since it is an action that cannot be undone.

History

In the History tab, the user’s study sessions are displayed in descending order, with a header separating each date. As shown in Figure 7, tapping the pencil displays a popup where the user can edit the start time, end time, and associated tag of their entry by tapping each field. In the case that there is a previous entry from the same day, the user is unable to set the start time prior or equal to the end time of the previous entry. In the case that there is a following entry from the same day, the user cannot set the end time to a time after or equal the start time of the following entry. The app also does not allow the user to set the start time to a time after the end time, and vice versa. In short, there is logic implemented that ensures that the user selects times that make sense. Tapping the tag field will display a popup identical to the one on the timer page, where the user can select a new tag. Pressing the “x” in the top left corner will close the popup and cancel the edit.

Users can also delete an entry; in which case they will receive a warning after tapping the “Delete” button prior to permanent deletion, similar to deleting a tag (Figure 7).
Figure 7. The process of editing a recorded session.
**Settings**

Described below are the features in the settings page:

1. **Accent colour:** the user can change the accent colour of the app. The new accent colour will be applied to various elements of the app, including the background on the stopwatch page, button colours, and some text elements (see Figure 8).

2. **Colour mode:** the user can toggle between light mode, dark mode, or system default (see Figure 8).

*Figure 8. Preview of the app in dark mode and some customization features.*
3. **Timer running reminder**\(^3\): the user can choose to get a notification after the timer has been running for a specified time. The user will get the reminder in intervals (i.e., if they choose 1 hour, they will receive a reminder every hour).

4. **Stopwatch page customization**\(^4\): the user can enter their name to receive a personalized greeting when they open the app. The app simply stores the inputted name on the user’s device, meaning that this information is not accessible by the developer. Therefore, the user inputting their name into the app maintains their anonymity. They are also provided with several options to change the emoji on the stopwatch page (see Figure 8).

**Charts**

When entering the Charts page, users are presented with the Daily overview for the current day.

Users can switch between a Daily, Weekly, and Monthly view. Providing the user with multiple chart view options was a common theme while analyzing other apps, and was therefore mimicked in the StudyTracker App.

Users can use the back-and-fourth arrows to change the day, week, or month and they can click on the calendar button in the top right corner, which opens a calendar that the user can use to jump to further away dates (see Figure 9). Below is an explanation of each chart provided to the user:

---

\(^3\) The reminder feature was added after the Pilot study.  
\(^4\) These customization features were added after the Pilot study.
1. **Overview:** On each view, the user is initially greeted with an overview which provides textual feedback, as shown in Figure 10 (a). The Daily Overview shows users their total study time for the day, number of sessions for the day, and most used tag for the day. The Weekly and Monthly overviews show the same information except it is for the total week or total month.

2. **Total Study Time Trends:** Total Study Time Trends are available for the current day, current week, and current month. This chart combines both text and a horizontal bar chart to visualize to users how their study habits are comparing to previous days, weeks, and months, as shown in Figure 10 (b).

*Figure 9. Ways in which users can explore their data in the Charts page.*
3. **Tag Overview:** Tag Overview provides a visual to the user in the form of a horizontal bar chart with labeled times, as shown in Figure 10 (c). This type of graph was in several examined productivity apps. The Daily view provides the user with the total time they have spent on each tag per day. The Weekly view provides the user with the total time they spent on each tag per week. Finally, the Monthly view shows how much time the user spent on each tag per month. The bars are displayed in order of most amount of time to least amount of time.

4. **Time Distribution:** This chart shows the user how much time they have spent studying in a bar chart format. The Daily Time Distribution chart, shown in Figure 10 (d), has the hour of the day as the x-axis and therefore shows the user how much time they have spent studying per hour. The Weekly Time Distribution chart has the day of the week as the x-axis and shows the user how much time they have spent studying per day of the week. The Monthly Time Distribution chart has the day of the month as the x-axis and therefore shows the user how much time they spent studying per day of the month. The user can also drag their finger over the bar graph to see the exact time associated with each bar (see Figure 10 (d)).

5. **Average Focus:** The Weekly view Average Focus calculates the sum of the minutes spent studying during each hour for the week and divides each of the resulting sums by seven (i.e., the length of a week). The user receives different textual feedback based on the time of day that they are most typically focused. The Monthly view Average Focus calculates the sum of the minutes spent studying during each weekday for the month and divides the resulting sums by
the number of times that weekday occurs in the month, usually four or five. The user receives different textual feedback based on the day of the week that they are most typically focused. Both charts, along with their textual feedback options, are shown in Figure 10 (f).

6. **Tag Distribution**: The tag distribution provides the user with an overview of how their time is distributed among their tags, along with textual feedback providing the total amount of time and percent (see Figure 10 (e)). The time distribution is available in the Daily, Weekly, and Monthly views, which shows the tag distribution for either the day, week, or month.

![Image](image_url)

*Figure 10. The various chart types in the application.*
4 Usability Study

The goal of this initial usability study was to evaluate the usability of the application design prior to moving onto the pilot and main stages of the study. I wanted to identify usability problems for improvement of the application design and ensure that the application was ready for use during the next stages of the study. Ethics Clearance for this study was provided by Carleton University Research Ethics Board B (CUREB-B) under Clearance #118650.

4.1 Participants

I recruited participants for the usability study by posting a call for participants in the “Carleton Research Participants” Facebook group as well as by posting on my personal Instagram page (see Appendix B.1). Participants had to be at least 18 years of age, speak English fluently, and have access to a device on which they can participate in the Zoom call and interact with the high-fidelity Figma prototype.

I recruited 8 participants aged from 21 to 30 years old (7 self-identified females, 1 self-identified male) (M=25, SD=2.93). Participant personal technical expertise ratings ranged from 2.5 to 5 out of 5 (M=4.16, SD=.89).

4.2 Materials

To assess the usability of the application, I chose to use the System Usability Scale (SUS) [16]. The SUS is a widely used questionnaire and is an effective tool for measuring the usability of a system. The SUS consists of 10
questions that are rated on a 5-point Likert scale (where 1 = Strongly Disagree, 5 = Strongly Agree) as shown below:

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

Participants were also asked one extra question on the survey, which was “do you have any other comments about the application design (i.e. things you liked, things you did not like, any recommendations, etc.)?”

4.3 Procedure

After a participant contacted me expressing interest in the study, I sent them a consent form to sign (see Appendix C.1) after which we scheduled a meeting for the session. I conducted the usability studies over a Zoom call. First, I debriefed the participant on the process of the session and what I will be
asking them to do. After I received their consent, I began recording the session. Prior to the test, I asked participants for their age, gender, occupation, and to rate their technical expertise on a scale of 1 to 5 (1 = not comfortable with technology at all, 5 = fully confident with technology). I sent participants a link to the Figma prototype and then asked them to share their screen. Once they informed me that they were ready to begin, I gave them scenarios and asked them to think aloud as they stepped through their process of completing the tasks (see Appendix D).

Following the completion of all scenarios, I sent participants the link to a survey and asked them to fill it out after the Zoom call ended. The survey contained the SUS and a question asking if they think the app design can be improved in any way (described in Materials, above). I used the feedback from this part of the study to iterate on the application design before the commencement of the Pilot study.

4.4 Data Analysis

The usability of the application was assessed using the SUS. During the interviews, I kept track of whether the participants were able to complete each task without my help or not. I took note of any verbal suggestions they made in a Microsoft Word [104] document. The participants were also able to input more comments in the post-study survey, which were added to the document as well. Since there was not much data to analyze, all feedback was taken into consideration and implemented if it was a feasible and good suggestion.
Suggestions that involved additional persuasive elements (i.e., gamified or social features) were not considered.

4.5 Results

The resulting average SUS score from the usability study was 83.75. According to Bangor, Kortum, and Miller [10], a passable SUS score is at least 70 whereas better products tend to score in the high 70s to upper 80s. Based on these guidelines, the resulting average SUS score from this usability study was acceptable. Responses to the SUS are summarized in Figure 11. All participants disagreed with the statements that they would need to learn a lot of things before they could get going with the system. All participants agreed with the statements that they felt very confident using the system and that most people would learn to use this system very quickly. Finally, seven out of eight of the participants disagreed that there was too much inconsistency in the system.

During the usability study, I observed that there was 100% task-completion rate for all participants. All participants were able to complete all tasks in a reasonable amount of time without me intervening.

The most common usability problem that I took note of was that participants had a hard time understanding some of the graphs. Two participants mentioned that some of the graphs appeared to represent goal-tracking. Moreover, four out of the eight participants mentioned difficulties understanding the graphs at first glance. In the comments section of the survey,
two participants mentioned that they found the application user-friendly and five participants re-iterated that they liked the application.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{sus_responses.png}
\caption{SUS Responses. Questions accompanied by an asterisk (*) used negative phrasing.}
\end{figure}

### 4.5.1 App Iterations

After analyzing results, I altered some graphs on the Charts page. The Study Trends chart caused confusion among some participants, so I took inspiration from common “Trends” charts (Apple’s [99] Health App charts and Forest’s [95] Trend charts) and simplified the chart while adding more details, shown in Figure 12 (a). Additionally, I changed the design of the Tag Overview chart, making it look less like a meter by removing the lighter background colour (see Figure 12 (b)). I did this because some participants inferred that the graph was implying progress towards a goal.
Figure 12. Changes made to the charts after the usability study. (a) The study time trends charts before (left) and after (right) the usability study. (b) The tag overview chart before (left) and after (right) the usability study.
5  **Pilot Study**

Following the usability test, I conducted a Pilot Study with 7 participants to make sure that the application was working as expected (i.e., there were no bugs) and to get initial feedback. I asked each participant to use the app during academic-related tasks for a period of 10 days. I then conducted semi-structured interviews with the participants to learn more about their experience. Ethics Clearance for this study was provided by CUREB-B under Clearance #118650.

5.1  **Participants**

I recruited participants by posting a call for participants on the “Carleton Research Participants” Facebook page as well as by posting on my personal Instagram page (see Appendix B.2). Participants were required to be at least 18 years of age, a current student at Carleton University, fluent in English, own an iPhone or iPad, and currently struggling with academic procrastination.

A total of 7 participants were recruited for this study, with 5 participants identifying as female, 1 as male, and 1 as other. Participant ages ranged from 18 to 51 (M=27.43, SD=11.21). Five out of seven participants had experience using self-tracking technologies such as fitness trackers. None of the participants mentioned having experience using self-tracking apps for studying.
5.2 Procedure

After participants expressed interest in the study, I sent them a consent form to sign (see Appendix C.2) and the pre-study survey to fill out (see Appendix E.1). Once I confirmed eligibility, I gave them instructions on how to download the application onto their device. I also instructed participants to use the application during academic-related tasks. I provided the app to the participants through an anonymous link, which they used to download the app through the Apple TestFlight app.

Participants confirmed with me once they downloaded the application, then their 10 days of testing began. Once the 10 days was up, I conducted semi-structured interviews with each participant to learn more about their experience (see Appendix E.2). The duration of the interviews ranged from 10 minutes to 25 minutes, depending on how much the participant had to say.

5.3 Data Analysis

I first transcribed the data collected from the semi-structured interviews using NVivo’s transcription service. Following this, I analyzed the transcriptions using an inductive approach following guidelines established by Thomas [76]. The primary objective of the analysis was to learn more about the participants’ general experience using the app and to collect application feedback. First, I read through all the transcripts to familiarize myself with the data. Following this initial phase, I printed out the transcripts and applied open coding, which resulted in 36 codes. I transferred the coded data into a Microsoft
Excel [106] spreadsheet, making it easier to manage. At this stage, I grouped similar codes together and codes containing low amounts of data (i.e., an excerpt from only one participant) that could not be grouped were discarded. From these final codes, I identified themes within the codes. I iterated on the themes to ensure that they were representative of the data. The final themes established a general overview of the participants’ experience with the application. It is important to note that the data was only coded by one researcher and may therefore have biases.

5.4 Results

From the analysis, I formed four themes that encapsulated the experiences of the participants:

1. Improvement in Study Behaviour
2. Invoked Positive Feelings
3. Satisfaction With the App
4. Design Suggestions

The details of these themes are summarized in the following sections.

5.4.1 Improvement in Study Behaviour

Overall, participants generally noticed positive changes in their study habits and procrastination behaviour. Below are changes that participants noticed in their behaviours and mindsets that led them to feel like there was a reduction in their procrastination:
Four participants mentioned that the application helped them better focus when they would have otherwise gotten distracted. P5 said that their focus had increased because it felt like they were being managed: “I think it improved my focus. [...] It felt like there was an entity that was managing me.” Additionally, P7 said that the application acted as a reminder that they should put down their phone whenever they picked it up: “well, it kind of helped me focus more because every time I reach over to start using my phone, I’d see it open and I’d be like, oh yeah, I’m supposed to be working.”

Another result of using the application was that it helped P1 “create a space” to focus on school. This phenomenon is further explained by a quote said by P1:

“[When I used the app], it’s like I had my school brain, and so I found myself able to create spaces in my day where I normally wouldn't have thought, ‘Oh, look, I have two hours’ or ‘I got to work an hour early. OK, I’m just going to go in and do a little bit of work.’ Yeah, so I found it useful [in] that way.”

All participants said that the app helped them with time management, which was a result from analyzing the graphs: “I like how I have like the weekly and the monthly option just for time management because my time management sucks” (P4). P1 said that the tag feature combined with the charts helped them think more critically about where they were spending their time:
“So, I could see like, the amount of time I’m putting towards different aspects of what I’m working on. So, I really enjoyed that labelling capability because then I would go to the chart area and I would look to see like, oh, I spent most of my time doing data analysis. Is that what I should be doing right now? Or should I maybe be focusing more on just revising what I already have?”

Most participants said that the charts helped them better plan and manage their time in some way. From analyzing the data in the charts, they were able to see what topics they spend the most time on and during which times of day they were most productive. With this information, many participants were able to optimize their study sessions. For example, P4 said that the app helped them with organization:

“Calculation for me is it comes from lack of organization, so just having something that will manage my time just makes it easier to know when and how long I should be studying.”

The application also helped participants feel more accountable for their schoolwork. Some participants described that keeping a record of their study sessions enforced the fact that they should study. This stemmed from wanting their data to be accurate; if the timer was running, the participants wanted to be studying. For example, P6 described that they would normally be social at
the library however the application made them feel more accountable for their schoolwork, encouraging them to study:

“[…] but when there's a timer, I'm just like, OK, I'm going to use this as an analytic to measure myself. I should be trying to actually work rather than just be in the library with friends and have Starbucks and then just chill. Because I'm like, OK, I'm studying whatever, but when I'm actually recording myself studying, then maybe I should be more accountable to it.”

P1 described that having the timer running made it feel like somebody is watching: “there’s that aspect of somebody is watching, so I better do what I’m supposed to do.”

Another reason mentioned by P3 was that starting the timer acted as a “pledge” to begin studying: “you already mentioned that you were studying, so you need to study, kinda thing.”

5.4.2 Invoked Positive Feelings

This theme describes the positive feelings that the application invoked within participants. As a result of using the application, participants felt enjoyment and a sense of accomplishment.

The app made two of the participants feel like they were playing some sort of game, resulting in a feeling of enjoyment and fun. Seeing their feedback made them want to compete against themselves and get higher “scores”. P2
explained, “this is actually a good app because it makes me productive because I want to beat the timer. I want a large number on the timer.” Additionally, P6 said that they enjoy “collecting” time:

“I always find these apps are quite fun because it’s [like] a little bit of a game in a way because instead of collecting points, you’re collecting time. Yea, I don’t know. I think that that’s one thing that helps me a bit.”

Another two participants felt a sense of accomplishment from using the application. P5 said that visualizing their progress made them want to “pat themselves on the back”, as it allowed them to feel proud and satisfied with the amount of effort they were putting into their schoolwork. The application also helped P7 solidify their progress, which led to a feeling of accomplishment as well, as they explain in the following quote:

“[The app] helped me stay more focused while I was working and also, I felt a bit more productive because I felt like I was accomplishing a goal, setting the timer and like stopping it and everything.”

### 5.4.3 Satisfaction With the App

Six participants enjoyed the aesthetics of the application. Three participants liked that the application had an organized and light feel to it, as P7 said, “I think [the user interface] was good, it was clean.” Another two participants enjoyed the familiarity of the aesthetics: “the [user interface] is
actually pretty good, it’s familiar with what we are using in the day to day life” (P2).

Three of the participants made mention of the app being user friendly. P1 explained, “I found it very intuitive to get around.” Furthermore, four participants said that they found the app helpful in improving their procrastination and study habits: “I think it was a good experience. I think this app has the potential to be very helpful, especially for people like me” (P5).

5.4.4 Design Suggestions

Participants had several suggestions that they thought would improve the app. This theme is split up into three subthemes: Difficulties with Tracking, Difficulties With Data Interpretation, and Additional Features or Changes to the App. Detailed below are the subthemes describing problems that participants encountered along with their suggestions.

Difficulties With Tracking

This subtheme encompasses the barriers that participants encountered while tracking their study sessions. Participants faced many difficulties with tracking due to forgetfulness. They namely faced problems with remembering to start the timer or stop the timer.

Four participants said that they would often forget to stop the timer after starting it: “some other times I would remember to start it, but forget to stop it until there was one where it was like 17 hours” (P1). One participant said that they would become too focused with their task, which made them forget. Other
participants said that they are simply forgetful people. Several of these participants suggested that a notification would help solve this problem, as P7 said, “if a session goes on for more than like two hours, it could be a pop up like, ‘are you still working?’ or something.” P3 said that a live timer widget on the phone’s lock screen could also act as a reminder that the timer is running.

Four participants said that they would forget to start the timer, as P4 described: “it’s hard to remember to actually go and start timing it and just to remember to keep track.”

However, when asked if daily notifications would help solve this issue, P7, P2, and P5 said that they think a notification reminder would be annoying:

“But I feel like if notifications were like every day like, “Are you going to work on something?” that would kind of be a little annoying.” (P7)

P5 went into even more detail, explaining that they are unsure if the solution to this problem lies within the app:

“So, I think the problem right now with the app is to find a way to make people remember to use it more regularly. [...] But at the same time, you know, [the user has to build a habit] to remember to use the app every time they sit down to do a task, and I don’t know it is a problem with the app. I don’t know if the solution lies within the app.”
Another solution that two participants recommended was allowing the user to make manual entries, so they could add forgotten sessions later: “being able to do a manual entry would be [a] feature that I suggest” (P1).

**Difficulties With Data Interpretation**

This subtheme encompasses the barriers that participants encountered while analyzing the charts and interpreting their data. Three participants said that they felt there needed to be more variety in the charts section so that they could better interpret the data. P1 explained that the chart section should contain both text and visuals combined to create more context. P3 suggested that there could be data displayed within a calendar view. Lastly, P6 explained that there could be an option to change the type of graphs because everybody understands data differently:

“The only other thing that I’d say would be kind of interesting to do is if the analytics could be like in different types of graphs. Like I know some people, they prefer like line graphs or things like that, and also some other apps similar to [this one] also have the option that you can change it from bar graph to pie chart to like different things.”

Another problem pointed out by two of the participants was the unit of time used in the charts. At the time of the study, some of the charts used minutes as the unit of time. However, as indicated by these participants, that
can make it hard to quickly interpret the data because time is usually displayed in an hours and minutes format:

“I don’t want to calculate the time using the minutes. So, like in [the y axis of the chart], there is 200 minutes, 400 minutes, 600 minutes, and 800 minutes.” (P3)

**Additional Features or Changes to the App**

Participants had many suggestions for additional features that they would like to see in a study tracking application. This theme encapsulates those suggestions, which did not necessarily fit into the two previous subsections. Three participants said they would like to see predefined tags or tag suggestions: "*predefined labels, like some labels you could choose from that might be relevant to student experience would be kind of cool*" (P1). P3 said that sometimes they just do not know what type of work they are doing, so predefined tags would reduce burden on the user: “*because, sometimes, for some type of work, we don't actually know what type of work it is.*”

Additional features that were suggested included: (1) restricting users from leaving the app so they do not get distracted by other apps, (2) adding a goal-setting feature, (3) gamifying the application by allowing the user to unlock additional features, (4) the addition of a countdown or pomodoro timer, and (5) allowing the user to tag a session with multiple tags.

An issue that two participants faced was during the tag creation process; the application forced users to select a colour for the tag when they created it.
However, P3 said that sometimes choosing a colour for the tag is not important. P7 said they initially did not realize that they had to select a colour, which resulted in frustration:

“I didn’t know that I had to pick a colour for it. So, [I was] kind of struggling like, ‘Yeah, I want this tag.’ So, I had to then figure it out myself. [...] I didn’t realize I had to choose a colour. So, someone who’s like less experienced with technology might struggle with it and be like, ‘why isn’t it working?’”

5.5 Discussion

It was significant that the most common problem was forgetfulness, whether that meant forgetting to stop or start the timer. However, most participants said that a notification would be an annoying, and therefore ineffective, solution to this problem. Notifications may also be ineffective if they are sent at the wrong time. A less annoying solution involving notifications may include an artificial intelligence component that can learn the user’s study behaviour and notify them at convenient times to begin the timer when they study. However, this may take a lot of data to implement and is therefore an inefficient solution. As one participant mentioned, perhaps the solution for this issue lies outside of the application, because it is essentially a habit that must be formed.

All participants mentioned that the application helped them with their time management, suggesting that self-tracking productivity applications can
help improve self-regulated learning. This means that there is potential for quantified self technologies to act as an intervention for procrastination. All participants expressed that they enjoyed the application in some way and felt like it had a positive impact on their academic procrastination habits. In addition to time management, participants reported that they experienced an improvement in focus, productivity, and accountability, showing that the application may have an overall positive impact on study behaviour.

When it comes to data visualizations, participants value a variety in the charts whether that be due to preference or accessibility reasons. Therefore, self-tracking applications should provide multiple ways for users to view their data since different users will process information differently. The same information can be provided in textual format, bar chart format, and line chart format. More research is needed to understand how to tailor data visualizations, however for the time being, it is best for designers to provide a variety of options with a customizable dashboard. Therefore, users can display graphs that they find useful and hide graphs that they do not use. Due to time constraints, the charts in the application used for this study remained unchanged, however future applications should feature more chart format options.

5.5.1 App Iterations

During the interviews, I took note of every suggestion that participants made to improve the application. To my advantage, participants did not notice
any critical bugs while using the application. The time I had to make changes to the app was limited so I was unable to add some features, such as a manual entry for study sessions. Detailed below are the changes that I made to the application:

I added a notification feature where the user can choose to be notified if the timer runs over a certain amount of time. I also edited the code to make the timer automatically stop and record the session after eight hours. This was the most important feature to add because most participants mentioned that they would start the timer then forget to stop it. Furthermore, due to the way the application was implemented, bugs would appear if a session over 48 hours was recorded although this was not mentioned by any of the participants. Therefore, automatically stopping the timer after eight hours prevented these bugs from appearing and was therefore a critical update.

I updated the tag creation so that users were no longer forced to choose a colour for their tag. The tag colour defaulted to grey if the user chose no colour.

Additionally, I added customization features that were recommended by one of the participants, which allowed the user to input their name for the app greeting and change the emoji on the timer page (it was originally a clock emoji) so the application can be more tailored to their liking.
Due to confusion surrounding the meaning of some charts, I added a button to each chart that the user can press to display more information about the feedback, shown in Figure 13. The popup also informed the user that they can view exact times by dragging their finger over the chart, since some users were unaware that this feature existed. The unit of time on all charts and feedback was updated to be displayed in hours and minutes, however the y-axis on bar charts remained in minute format as there was not enough room on the screen to format it into hours and minutes.

![Time Distribution](image)

*Figure 13. The button added to each chart.*

Two small user interface changes were made: (1) I updated the Stopwatch button on the tab bar to be more prominent (see Figure 14) and (2) I made the “Start Timer” button on the Stopwatch page stand more by increasing its size. Both changes were recommended by participants.
Daily notification reminders were not added because I wanted to solely examine quantified self technologies’ impact on procrastination, and notifications have been shown to have additional impact on students’ procrastination behaviours [21]. Additionally, participants expressed that reminders can be annoying, which influenced my decision to avoid implementing daily reminders.

Figure 14. The tab bar before (top) and after (bottom) the pilot study. The stopwatch button was made to be larger and a different colour from the rest of the buttons.
6 Main Study

6.1 Experimental Design

For the main study of the application, I used a between-subject design. I randomly assigned participants to either the control group or the experimental group. The control group responded to weekly procrastination surveys and the experimental group responded to weekly procrastination surveys in combination with using the self-tracking application. The control group and experimental group responded to the same weekly procrastination surveys, described in the next subsection of this chapter.

This study was a six-week longitudinal study to explore the impact that long-term use of a quantified self application has on academic procrastination. Ethics Clearance for this study was provided by CUREB-B under Clearance #118650.

The independent variable in this study was whether the participant was in the control group – not using the application - or in the experimental group – using the application. The dependent variable was academic procrastination levels reported by the participant. This study aimed to test the following hypothesis:

H1: Participants in the experimental group will experience a greater decrease in self-reported academic procrastination levels.
6.2 Materials

**Pre- and Post-Study Surveys**

To measure overall procrastination levels pre-study and post-study, I used the Academic Procrastination Scale (APS) [59]. I chose this scale because it focuses on academic procrastination, unlike the more popular Tuckman Procrastination Scale [78] which assesses general procrastination. Another option was the Procrastination Assessment Scale–Students [71], however this scale is fairly outdated and focuses on specific types of academic tasks (writing a term paper, studying for exams, keeping up with weekly reading assignments, and academic administrative tasks) which may not apply to all students’ coursework.

The APS contains 25 items that are rated on a Likert-type scale from 1 (Disagree) to 5 (Agree). The ratings can then be summed up to calculate an overall score. The scale contains statements such as "I put off projects until the last minute" and "I know I should work on schoolwork, but I just don’t do it" (see Appendix F.1). McCloskey [59] found that the APS scale has a high internal consistency (α = .94).

The APS (see Appendix F.1) was given to each participant (both control and experimental groups) in the pre-study survey and in the post-study survey to measure their baseline (pre-study) and final (post-study) procrastination levels. A detailed look at the pre- and post-study surveys can be seen in Appendix F.3 and Appendix F.5.
**Weekly Surveys**

To monitor weekly changes to procrastination habits, participants responded to a weekly survey containing the Academic Procrastination Scale – Short Form (APS-SF) [88]. This was done to see if there were subtle changes in procrastination scores across the weeks. I chose the short form of the scale for the weekly survey to reduce burden on the participants. Since the scale is very short, this ensured that participants had enough time to fill out the survey every week. The APS-SF contains five items from the APS which are rated on a Likert-type scale from 1 (Disagree) to 5 (Agree) (see Appendix F.2). The ratings can then be summed up to calculate an overall score. Yockey [88] found that the APS-SF has an internal consistency estimate of .87.

The APS-SF was given in a survey to each participant every week (both control and experimental groups) to measure their weekly changes in procrastination habits. A detailed look at the weekly surveys can be seen in Appendix F.4. The weekly surveys did not provide any visual feedback to the participants.

**6.3 Participants**

I recruited participants by posting a call for participants on the “Carleton Research Participants” Facebook page. The office administrator also sent an e-mail to all undergraduates in the School of Information Technology at Carleton informing them of the study. Finally, I put up posters in several places around campus (see Appendix B.3). Participants were required to be at least 18 years
of age, fluent in English, currently an undergraduate student at Carleton University, currently struggling with academic procrastination, and own an iPhone or an iPad.

I recruited a total of 18 participants for the study. Nine participants were assigned to each condition (control and experimental).

The control group included 5 self-identified females and 4 self-identified males, with ages ranging from 18 to 26 (M=20.89, SD=2.42). Six participants had tried various methods to reduce their procrastination habits, such as study trackers, reducing phone usage, creating schedules, studying with friends, and calendars. Five participants were currently using tools to help them reduce procrastination, including studying with friends, calendars, dividing work into smaller parts, and planner apps. No participants in the control group mentioned that they were currently using study trackers to help reduce procrastination.

The experimental group included 7 self-identified females, 1 self-identified male, and 1 participant chose not to specify gender, with ages ranging from 18 to 24 (M=20.67, SD=1.94). Eight participants had tried various methods to reduce their procrastination, such as the Pomodoro method, speaking with academic advisors, deleting apps off their phones to limit distractions, and to-do lists. Five participants were currently using various tools to help reduce their procrastination, including calendars, to-do lists, studying with friends, breaking assignments into smaller bits, and rewarding themselves after studying. Six participants had experience using self-tracking
technologies such as fitness trackers, mood trackers, and period trackers. None of the participants had experience using study trackers. One participant withdrew from the study after completing four of the weekly surveys. Their data was not used in the statistical tests as it was incomplete; however, their survey responses were used for most of the descriptive statistics and qualitative analysis.

6.4 Procedure

After a participant expressed interest in the study, I randomly assigned them to either the control group or the experimental group and sent them the corresponding consent form.

Control Group

Participants in the control group filled out the consent form (see Appendix C.4) followed by a pre-study survey (see Appendix F.1, F.3) containing demographic questions to confirm eligibility and the APS. I also asked participants what tools they have tried to use to reduce their procrastination, and if they were currently using any of those tools. Every seven days, I sent them a survey containing the APS-SF (see Appendix F.2, F.4). After six weeks, I sent the participants a post-study survey containing the final weekly survey, a question about their overall experience in the study, and the APS (see Appendix F.1, F.5). In total, the participants completed six weekly surveys.
**Experimental Group**

Participants in the experimental group filled out the consent form (see Appendix C.3) followed by a pre-study survey (see Appendix F.1, F.3) containing demographic questions, questions about their experience with self-tracking technologies, and the APS. I also asked participants what tools they have tried to reduce their procrastination, and if they were currently using any of those tools. After I confirmed eligibility, I provided the participants with instructions on how to download the application onto their device. I instructed participants to use the application during academic-related tasks for the following six weeks. Every seven days, I sent them a survey containing the APS-SF and questions about their experience using the app (see Appendix F.2, F.4). After six weeks, I sent the participants a post-study survey containing the final weekly survey, questions about their overall experience in the study, questions about the self-tracking app and feedback, and the APS (see Appendix F.1, F.5). In total, the participants completed six weekly surveys.

### 6.5 Data Analysis

#### 6.5.1 Qualitative Approaches

Similar to the pilot study, I analyzed all of the survey data from the experimental group using an inductive approach following guidelines established by Thomas [76]. The primary objective of the analysis was to better understand the changes of behaviour that participants experienced as well as what they gained from their study data. I assembled all written responses from
the weekly surveys and final surveys of the experimental group and printed them out. I proceeded to colour-code excerpts with highlighters using an open coding approach. After I coded all the data, I transferred the data into a Microsoft Excel sheet accompanied by its given code, making it easier to manage. At this stage, I re-iterated on the data and ensured that I still agreed with the codes. Similar codes were grouped together. Stand-alone codes containing low amounts of data (i.e., an excerpt from only one participant) were discarded. It was at this point that I re-analyzed codes containing large amounts of data and separated them into multiple codes to find clearer patterns. I added the final codes onto sticky notes in a FigJam file to simplify the grouping process. I grouped together similar codes, which resulted in several themes. I iterated on the themes to ensure that they were representative of the data. The final themes established a general overview of how participants’ behaviour was impacted by the application and how they benefitted from the data. Once again, it is important to note that the data was only coded by one researcher and may therefore have biases, although the codes and themes were iterated on at several different points in time.

6.5.2 Quantitative Approaches

The main goal of the quantitative data analysis was to discover if the application had a positive impact on the dependent variable, procrastination scores of the participants. This was accomplished through statistical data analysis methods, as described in the following sections. Nonparametric tests
were used to analyze the data because of the low number of participants. I analyzed the remainder of the quantitative results gathered from the surveys using descriptive statistics. Due to the low number of participants, the quantitative results cannot be definitive but were analyzed regardless to explore if there were differences between the two groups.

### 6.6 Quantitative Results

**Within-Group APS Scores**

I conducted a Wilcoxon signed-rank test to determine the decrease in APS scores within the groups. First, each participant’s baseline APS responses and final APS responses were summed up to determine their baseline and final procrastination scores. Results from the Wilcoxon signed-rank test suggested that the control group experienced a significant decrease from their baseline scores \((M=64.56, \ SD=8.31)\) to final scores \((M=41.89, \ SD=20.2)\), \(z=2.31, \ p=.01\). Results suggested that the experimental group did not experience a significant decrease from their baseline scores \((M=56.38, \ SD=9.52)\) to final scores \((M=42.63, \ SD=18.63)\), \(z=1.68, \ p=.055\).

**Within-Group APS-SF Scores**

A Friedman test was performed to determine whether mean APS-SF scores differed across the weeks. First, each participant’s weekly APS-SF responses were summed up to receive their weekly APS-SF score. The Friedman test determined that the mean APS-SF scores within the control group differed significantly across the weeks \((X^2(5)=17.95, \ p=.003)\).
analysis showed that scores became significantly different during week six, 
p=.031. The Conover’s post hoc comparison is shown in Table 3.

Table 3. Conover’s post hoc comparison of the control group’s weekly APS-SF scores.

<table>
<thead>
<tr>
<th></th>
<th>T-Stat</th>
<th>df</th>
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<th>W_j</th>
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<td></td>
<td></td>
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<tr>
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<td>38</td>
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<td>1.000</td>
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<tr>
<td>Week 3</td>
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<td>0.973</td>
<td>0.649</td>
</tr>
<tr>
<td>Week 6</td>
<td>2.278</td>
<td>40</td>
<td>38</td>
<td>20</td>
<td>0.028</td>
<td>0.422</td>
<td>0.338</td>
</tr>
<tr>
<td><strong>Week 3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 4</td>
<td>1.519</td>
<td>40</td>
<td>37</td>
<td>25</td>
<td>0.137</td>
<td>1.000</td>
<td>0.957</td>
</tr>
<tr>
<td>Week 5</td>
<td>1.772</td>
<td>40</td>
<td>37</td>
<td>23</td>
<td>0.084</td>
<td>1.000</td>
<td>0.756</td>
</tr>
<tr>
<td>Week 6</td>
<td>2.151</td>
<td>40</td>
<td>37</td>
<td>20</td>
<td>0.038</td>
<td>0.563</td>
<td>0.413</td>
</tr>
<tr>
<td><strong>Week 4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 5</td>
<td>0.253</td>
<td>40</td>
<td>25</td>
<td>23</td>
<td>0.801</td>
<td>1.000</td>
<td>1.000</td>
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<tr>
<td>Week 6</td>
<td>0.633</td>
<td>40</td>
<td>25</td>
<td>20</td>
<td>0.530</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td><strong>Week 5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Week 6</td>
<td>0.380</td>
<td>40</td>
<td>23</td>
<td>20</td>
<td>0.706</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

A Friedman test was performed to determine whether APS-SF scores differed across the weeks. The Friedman test determined that the mean APS-SF scores within the experimental group did not differ significantly across the weeks ($\chi^2(5)$=8.61, p=.126). Average weekly scores for the control and experimental groups are illustrated in Figure 15.
Between-Group Changes

I conducted a Mann-Whitney U test to determine the significance of the difference in baseline and final APS scores between the two groups. The results indicated that there was no significant difference between the groups, $U=46.5$, $p=.336$, although the control group ($M=22.67$, $SD=21.89$) experienced a greater decrease in scores than the experimental group ($M=13.75$, $SD=19.67$).

![Figure 15. The average weekly APS-SF scores for the control and experimental groups.](image_url)
**Frequency of Use and Procrastination Scores**

The weekly survey asked users how often they were tracking their study sessions (0% of the time they performed academic tasks, 25% of the time, 50% of the time, 75% of the time, or 100% of the time). I computed a Spearman's rank correlation to evaluate the relationship between average application use throughout the weeks and the change in APS score. As shown in Figure 16, there was a slightly positive correlation between the two variables, although the relationship was not statistically significant, \( r(6)=.587, \ p=.126 \).

![Figure 16. The correlation between average use and decrease in APS score for the experimental group.](image)
Perceived Survey and App Effectiveness

The surveys asked participants in the control and experimental groups whether they found the weekly procrastination survey effective in improving their procrastination habits. I asked this question in order to understand whether the weekly surveys were influencing participants’ behaviours as an additional variable in the study. It is interesting to note that six participants from the control group found the weekly surveys effective, while this was only agreed upon by four of the participants in the experimental group, shown in Figure 17.

When it comes to perceived application effectiveness, not many participants thought highly of the application. Only two participants found the application to be either extremely or very effective, three participants found the application to be moderately effective, and four participants found the

Figure 17. Whether the weekly surveys were perceived as effective or not by each participant in the control and experimental groups (yes – effective, no – not effective).
application to be either slightly effective or not effective at all, shown in Figure 18.

Digging deeper, participants who did not find the application effective were more likely to also not find the weekly survey effective. The participants who found the app to be “extremely effective” and “very effective” both found the weekly surveys to be effective as well. Two of the participants who found the app to be “moderately effective” found the weekly surveys to be effective.

The remaining five participants who found the application to be “moderately effective”, “slightly effective”, and “not effective at all” did not find the weekly surveys to be effective. This perception of effectiveness may give insight into why there is a similarity in procrastination scores between the experimental and control groups.

![Figure 18. Experimental group’s responses for perceived effectiveness of the application for reducing procrastination.](image)
Favourite Charts

Participants were also asked to rank the charts from 1 (likes this chart the most/finds this chart the most helpful) to 5. As shown in Table 4, there is no clear pattern for chart preferences, however participants seemingly agreed that they enjoyed the daily overview chart, with two participants ranking it as their favourite chart and two other participants ranking it as their second favourite chart.

Table 4. This table displays the number of participants who gave each rank (1, 2, 3, 4, or 5) to each chart, where 1 is the best rank a chart can receive.

<table>
<thead>
<tr>
<th>Chart</th>
<th>Rank 1</th>
<th>Rank 2</th>
<th>Rank 3</th>
<th>Rank 4</th>
<th>Rank 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily Overview</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Daily Total Study Time Trends</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Daily Tag Overview</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Daily Time Distribution</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Daily Tag Distribution</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Weekly Overview</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Weekly Total Study Time Trends</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Weekly Tag Overview</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Weekly Time Distribution</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Weekly Average Focus</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
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<td>Weekly Tag Distribution</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Monthly Overview</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Monthly Total Study Time Trends</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Monthly Tag Overview</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Monthly Time Distribution</td>
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<tr>
<td>Monthly Average Focus</td>
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<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Monthly Tag Distribution</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>


**Likelihood of Continuing to Study Track**

Although there was debate on the effectiveness of the application for procrastination, five of the participants in the experimental group were “likely” or “extremely likely” to continue tracking their studying, implying that although the app may have not been fully effective in reducing procrastination, participants still found other benefits to using the application thus wanting to continue tracking. Results are summed up in Figure 19.

![Figure 19: Experimental group's responses for likelihood of continuing to track their study time.](image)

**Frequency of Use**

Finally, participants were asked weekly how often they were using the application (100% of the time they do schoolwork, 75% of the time, 50% of the time, 25% of the time, 0% of the time). As displayed in Figure 20, average use
declines over the weeks, as participants who were not experiencing benefits lost interest in the app\textsuperscript{5}.

![Average Use of App Throughout 6 Weeks](image)

*Figure 20. The average use of the app throughout the 6 weeks (experimental group).*

### 6.7 Experimental Group Reflections

Detailed below are the insights that I gathered from the thematic analysis on the survey results from the experimental group. Themes, subthemes, and codes are summed up in Table 5:

\textsuperscript{5} The data from the participant who withdrew from the study is not included due to incompleteness.
<table>
<thead>
<tr>
<th>Theme</th>
<th>Subtheme</th>
<th>Code and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Perception</td>
<td>General increased self-awareness</td>
<td>participant makes a general comment about their self-awareness increasing</td>
</tr>
<tr>
<td></td>
<td>Seeing and feeling progress</td>
<td>the participant says that the app is helping them better “see”/”feel” progress</td>
</tr>
<tr>
<td></td>
<td>Studies less than they thought</td>
<td>the app helped the participant realize that they study a lot less than they thought</td>
</tr>
<tr>
<td>Remaining Focused on Studies</td>
<td>Getting less distracted</td>
<td>the app helped the participant get less distracted</td>
</tr>
<tr>
<td></td>
<td>“Study” mindset</td>
<td>the app helped the participant get into a mindset to study</td>
</tr>
<tr>
<td></td>
<td>Studying for longer periods of time</td>
<td>the app helped the participant study for longer than they usually can</td>
</tr>
<tr>
<td>Improved Time Management</td>
<td>Peak Productivity</td>
<td>Seeing when they study the most: the participant used the charts to see when they studied most</td>
</tr>
<tr>
<td></td>
<td>Task Duration</td>
<td>Seeing how much time tasks take: the participant used the charts to see how much time tasks take</td>
</tr>
<tr>
<td></td>
<td>Topic Balance</td>
<td>Balancing time spent on each topic/time allocation: the participant used the charts to balance the time they spent on topics/better allocate their time</td>
</tr>
<tr>
<td>Data is Not Enough</td>
<td>Not helping</td>
<td>the participant says that the app is not helping them</td>
</tr>
<tr>
<td></td>
<td>Does not motivate</td>
<td>the participant says that the app is not motivating them</td>
</tr>
<tr>
<td></td>
<td>Charts don’t “give” anything</td>
<td>the participant says that they do not know what to make of the feedback</td>
</tr>
<tr>
<td>Application Design</td>
<td>Forgetting to Use the Application</td>
<td></td>
</tr>
<tr>
<td>--------------------</td>
<td>----------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Forget to use application</strong>: the participant says that they forgot to use the application</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Data accuracy or inaccuracy</strong>: the participant mentions the accuracy or inaccuracy of their data</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Reminder notifications needed</strong>: the participant says that the app needs reminder notifications</td>
<td></td>
</tr>
<tr>
<td>Feature Suggestions</td>
<td><strong>App is boring</strong>: the participant mentions that the app is boring or lacking features</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Exiting the app</strong>: the participant recommends a feature that stops them from leaving the app when it is running</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Charts need to be improved</strong>: the participant says that the charts need some type of improvement</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Misc. feature suggestion</strong>: the participant makes a feature suggestion that does not fit into the other codes</td>
<td></td>
</tr>
</tbody>
</table>

### 6.7.1 Time Perception

Participants initially had difficulties perceiving the passage of time; tracking time helped participants gain a sense of time, which resulted in motivation and a sense of accomplishment. This theme encompasses the impact that visualizing time had on participants.

The feedback from the app made some participants realize that they study for less time than they thought, which resulted in various reactions. P15 said, “*seeing how much time I spent on tasks versus how much time I should be spending has been eye-opening.*” For some participants, this information encouraged them to study more. For example, P7 wanted to stop studying,
however, the timer helped them realize that they had been studying for a short amount of time, which motivated them to continue studying:

“When I feel like time has passed and I wanna stop studying I check the timer and see it’s only been 20 minutes, so I told myself to keep going.”

However, for P3, the realization that they study less than they thought was not enough to push them to study more:

“Seeing the time spent didn’t seem to mean much to me. It did show me that I don’t spend a whole lot of time studying, but it also didn’t make me feel like I should do more.”

Gaining a sense of time also helped participants become more aware of the progress they were making in school. For example, P20 said, “[the app] helped visualize how much work I was doing even though it may have felt like I was not making progress.” Therefore, measuring progress helped participants recognize that they are accomplishing something, even when they felt like they were not making progress. Specifically, they felt a sense of progress when they saw the numbers going up as they were better able to visualize their work. For P7, this gave them a sense of achievement and motivated them to keep working:

“I think I have a really hard time visualizing and feeling time pass so having a number going up makes me feel like I am moving in a forward direction, so I know that something is being done to complete a task. I
found this app to be more useful for study time retention as I was able to see ‘oh that’s what 30 mins feel like, I can actually get a lot done in 30 minutes. Why not keep going?’ was my thinking.”

### 6.7.2 Remaining Focused on Studies

This theme describes how the application helped participants remain focused on their studies and the reasonings behind this observed behaviour change. For example, the application, specifically the Stopwatch component, served as a constant reminder for P4 to not get distracted whenever they picked up their phone:

“When I turn my phone off and study for 20 minutes or so, I get distracted and go back on my phone but I see the studying timer there, so it reminds me to stay off my phone and continue studying, which I do.”

In addition to the timer acting as a reminder for P4 to study, they also knew that the app was tracking them, and they did not want there to be any "false data", which discouraged them from getting distracted:

“It would be tracking the amount of time I’m being distracted as well, which would be false tracking, so it immediately put me back on track.”
P20 felt similar effects, explaining that getting distracted meant they had to either deduct time from their data or stop the timer, which they wanted to avoid doing:

“The more I spent tracking my productive tasks, the more it forced me to focus on the task. As if I started something else or got distracted, I had to stop the timer or subconsciously deduct time counted. This made me more focused, and one tracked instead of getting distracted with other things.”

Additionally, participants said that using the app helped them study for longer periods of time than usual, as explained by P7:

“Maybe [the app did] not completely reduce procrastination, but more so improve my study retention time. I am able to study for longer and more concentrated periods of time.”

For some participants, the application helped them get into a “study mindset”, allowing them to focus on their work. P15 referred to tracking as their “study ritual”: “gets me in the mindset to work, sort of [like a] ritual.” This suggests that the application helped participants get “in the zone” for studying. P7 said that the application acted as a “signal” to their brain that they were going to start studying.
6.7.3 Improved Time Management

This theme describes how the application helped participants plan their time more effectively by analyzing the chart data. Specifically, the application helped them see which subjects they were studying the least and encouraged them to study those subjects more. By tracking their time and tasks, participants were better able to estimate how long tasks took, which helped them plan their time more accurately. Furthermore, the app helped them see when they were most focused and productive, and they were able to use this information to be more strategic in choosing which times of the day to study. This was all accomplished by analyzing and reflecting on their data.

These three processes were summed up into three subsections: topic balance, peak productivity times, and task duration.

**Topic Balance**

Many participants mentioned that the feedback helped them better understand which subjects they were spending time on, and which subjects they were pushing aside. This information allowed them to allocate their time more evenly across their various courses. Understanding how their time was being spent mainly helped them with prioritizing: "I found it helpful because it shows the percent of time that I spent doing different things, it makes me prioritize more important things" (P11).

For example, P7 would switch their task when they saw that they had been spending too much time on it, which helped them balance the time they spent on assignments and avoid "cramming":
“It also helped me with spreading out the amount of time I am spending on studying a specific subject since I could see quantifiably, “oh it's been an hour, lets switch to this task because I don’t want to be using all my time on this thing. This helps with procrastination because I can rely on myself more to spread out the time I am spending on assignments and ensuring that I’m not always cramming last minute.”

Furthermore, the feedback encouraged P4 to get started on subjects that they would have otherwise pushed aside:

“The daily overview helped me see how long I studied in the day and how many exact sessions I needed and what courses along with the tag overview so it would be in an easier way to see which courses got the most focus in that day and it would encourage me to study for another course tomorrow (one that got less attention from the previous study session).”

Participants said that tags were the most useful feature when it came to allocating their time because they were able to compare the time they spent on each subject. In fact, six participants said that the tag feature was their favorite. P3 said, “the tags help me see which subjects I spent the most time on in a week. It helps balance how much time I spend per assignment.”
**Peak Productivity Times**

Other participants used the feedback to understand when they are most productive, and they would use this information to manage their time accordingly. This mainly helped them with planning, which applies to task duration as well: “to be able to analyze how one studies throughout a week is a helpful tool to plan one’s days” (P1).

For example, P7 was able to be more strategic about planning their day by analyzing when they are most productive:

“I was able to be more strategic in choosing which times I am most productive and ready to study and plan the time of day I feel more tired like 2 pm I tend to be slower and sometimes nap so I leave smaller tasks or less energy draining tasks until then.”

P5 also said that seeing when they are most productive helps them with future planning: “I like that it allows me to see when I am most productive or when I tend to do work. I could apply that when devising future plans.”

**Task Duration**

Additionally, participants used the feedback from the charts to learn how much time it took them to complete tasks such as assignments, so they were able to plan their study sessions around this information. For example, P5 said, “it is nice to see how much time I spend on tasks to help me plan more accurately in the future.” Similarly, P15 expressed, “it also helped me see how
much time I was spending on tasks, and I could more effectively plan and get my tasks done because I knew how much time the task required.” P7 said that learning how long tasks should take allowed them to “pick up the pace” if they were slacking: “I can now monitor how long tasks really take me and check if I am going slower than usual to pick up the pace.”

6.7.4 Data is Not Enough

Although the app was helpful to some participants, other participants did not agree. This theme describes instances when participants expressed that seeing their data was ineffective in reducing their procrastination habits, which was noted by three participants. The main concern was that tracking study data was merely not enough to reduce procrastination or generally improve study habits.

For example, P3 expressed that they did not see much benefit in tracking their study time:

“I realize that after I stop the timer, the time spent doesn’t really mean much to me. I can see how much time I spent studying weekly, monthly and daily, but I personally didn’t find much benefit in knowing this.”

P5 felt like the data helped them gain self-awareness, however this was an inadequate method in helping them alter their habits, “I see it more as a self tracker to utilize as data for self-realization, but the self-improvement part takes a different approach.” P15 expressed the same, “the app itself was a tool but the
“hardest part of getting myself to do tasks is something it couldn’t really help with.”

Although these participants were consistently tracking their study time, they felt no benefits regarding their procrastination habits.

6.7.5 Application Design

This theme is comprised of two subthemes: *forgetting to use the application* and *features suggestions*. This theme encompasses the comments that participants made about the usability and functionality of the application. The main obstacle that participants faced with study tracking was remembering to time their study sessions, which resulted in them suggesting some possible solutions. Participants also felt like the application did not have enough features. These subthemes are detailed below.

*Forgetten to Use the Application*

Although some participants were easily able to integrate the application into their study routines, other participants had trouble remembering to start the timer. P1 and P7 recommended that there be strategically timed notification reminders based on the users’ peak study times to help them remember to track their study sessions:

“Potentially a prompt to suggest studying if there was a trend to study at that time. Example: if someone always studies on Tuesday evening, a prompt around 5-6pm suggesting a study session would be helpful.” (P1)
Similarly, P14 and P5 recommended general notifications to remind them that the application exists:

“Having a reminder notification for the user to use the application [would be helpful]. It will help to remind them that the application exists.” (P14)

Forgetting to start the timer led participants to recommend a manual data entry feature. Although there was a feature to edit entries, this feature did not allow enough freedom for participants, as described by P5:

“I wish it had a way to add ‘study times’ after it has passed. Sometimes I forget to turn on the timer while studying but I remember once I finished. I may be able to adjust study times within the same day, but if I wanted to add a study time from yesterday, I cannot do so.”

Participants put a lot of value on the accuracy of their data, since they could not properly analyze the feedback if it was inaccurate. P4 ensured that they used the application as often as they could to keep their data accurate: “I made sure to use it as much as possible to get more accurate results for when I want to compare my studying times again”. Some participants got frustrated because they would forget to start the timer while studying, however they would remember once they have finished. When P5 ran into these issues, they would work around it by running the timer afterwards to make up for the time that they forgot to track:
“Because I sometimes forget to use the app while I am studying, I try to make up (display as accurately as I can) the time I missed by letting the stopwatch run during ‘normal activities’ the approximately same amount of time I was studying for.”

This can be cumbersome for participants, so a manual data entry was often suggested as an effective solution.

**Feature Suggestions**

Three participants got bored of the application and felt like the interface was not engaging enough. Specifically, P14 said that the application had “minimal functions” while P3 said that it was “pretty bare bones”. The lack of features led P14 to stop using the application altogether: “towards week four I lost interest in the app, because there are very minimal features that I could use.” P7 expressed that they would have liked to see more gamified and social features.

Due to the “bare bones” nature of the application, participants had an abundance of suggestions for additional features. Two participants suggested that there be a feature that restricts the user from exiting the app: “the app didn’t really help me because I could still be using other applications on my phone and totally forgetting about the app” (P14). Another two participants had suggestions for the Charts page; P15 recommended that there be more visuals, “I wish the tag display was more visual like a bar chart instead of a pie chart,” and
P7 said that the feedback can be more engaging, “[the] UI for displaying data could be better and more easily digestible and engaging.”

P20 faced obstacles with using the application because they found it inconvenient to take out their phone whenever they study. As a solution, they suggested that there be a web application.

Finally, P15 recommended three more features that can benefit the application: (1) the option to add a note to the study session entry, (2) a to-do list that the user can use to cross off completed tasks, and (3) the ability to add multiple tags to a session.

### 6.8 Control Group Reflections

At the end of the study, the final survey asked participants in the control group if they felt as though the weekly surveys had a positive impact on their procrastination habits (this was given as a yes/no question), and it also asked them to explain why or why not they felt a change in behaviour (this was given as an open-ended question where participants can type in their answer) (see Appendix F.5). I asked this in order to better understand if the surveys were directly impacting the control group and to gain insight on their experiences.

Since there was not much data from their written responses, these results have been split up into two sections: reasons for perceived effectiveness and reasons for perceived ineffectiveness. Some of the data is also presented in a chart due to the nature of the analysis. I used a mixture of qualitative and quantitative approaches to analyze these results, considering that patterns,
along with their frequencies, were evident in the data due to how little data there was.

As a reminder, six of the participants from the control group perceived the surveys as effective, and three participants perceived them as ineffective.

I deemed it of importance to understand the control group’s experiences since their responses may help with gaining a more profound comprehension of the similarities and differences in the procrastination scores between the experimental and control groups.

**Reasons for Perceived Effectiveness**

From the six participants who found the surveys effective, seven different insights and reasons for behavioural change arose from responding to the weekly surveys. These are listed below (see frequencies in Figure 21):

1. Weekly surveys acted as a reminder to get started on schoolwork.
2. Becoming more aware of study habits, thus making necessary changes to curb procrastination.
3. Noticing improvement increased feelings of accomplishment, impacting work in a positive way.
4. The desire to “improve their score” on the surveys each week (i.e., kind of like a game).
5. Weekly surveys helped with creating a routine.
6. Improved accountability.
Responding to the surveys acted as a time to reflect on study habits.

Reasons for Perceived Ineffectiveness

Below is a summary of the responses from the three participants who found the weekly surveys ineffective:

1. One participant said that there were no repercussions from answering poorly on the survey, hence not motivating them to make a change.

2. One participant felt no impact from the survey, however their habits improved due to an increased workload as the semester progressed.

3. One participant did not give a clear reason or explanation for their perceived ineffectiveness.

Figure 21. Frequencies of insights and reasons for behavioural change because of responding to the weekly surveys (control group). The y-axis describes the number of participants who mentioned each reason.
6.9 Discussion

In this study, I developed a quantified self application that allows students to track their study sessions. I aimed to see if this application can help students reduce academic procrastination by comparing the change in procrastination levels between an experimental group and a control group. I also collected insights on how students interact with and interpret their data.

Results showed that there was only a significant decrease in procrastination scores within the control group. There was no significant difference in scores between the two groups: this result does not support the hypothesis, which stated that the experimental group will experience a greater decrease in self-reported procrastination scores than the control group. Furthermore, although the difference was found to be statistically insignificant, the control group experienced a larger decrease in APS scores than the experimental group. There could be several reasons for this result:

First, many participants in the experimental group found that the app was not engaging enough, and it was hard to form the habit of beginning the timer whenever they began studying. Higher engagement with the app may have resulted in an overall higher decrease in procrastination scores within the experimental group. The app is unable to help the participants if they do not use it to their full advantage, however there was no dependable way to ensure that participants were engaging with the app whenever they sat down to do schoolwork. Second, the natural progression of the semester may have had an impact on all procrastination scores. Since this study was performed over the
course of a semester, some participants expressed that they had noticed a positive change in their procrastination habits because they could no longer “afford” to procrastinate as midterms and exams approached. Perhaps a longer study, occurring over the course of an entire schoolyear, would yield different results.

It is also interesting to note that participants in the control group felt similar effects to participants in the experimental group, solely from responding to the weekly surveys. These effects may have been felt to a smaller degree; however, results still showed a larger drop in procrastination scores within the control group. This suggests that the accountability of filling in weekly surveys, even small ones, is enough to have a strong impact on procrastination behaviour. It is also peculiar that the majority of participants in the control group perceived the weekly surveys as effective, whereas the majority of participants in the experimental group did not find the weekly surveys effective. This brings up the question of whether the app distracted from the positive benefits that the weekly surveys alone may have had.

There is also research outlining the role that personality types have on perceived persuasiveness [2,61,63]. For example, Orji et al. [63] found that conscientious people tend to be motivated by self-monitoring. It is a possibility that, given the small test size, the control group contained more conscientious individuals than the experimental group, because many of them benefitted from the weekly surveys and perceived the surveys as a form of self-
monitoring. However, personality was not a variable that was measured in this study so there is no way of knowing.

There is also the possibility that consistently tracking study sessions is too much of a burden for students, especially students who are prone to procrastinate. Consequently, for procrastination, perhaps a different approach should be taken. For example, an application that prompts students to respond to surveys about their habits and produces visual and textual feedback based on their responses. This may also present an opportunity to create a system that can be more actively involved in the intervention, rather than the student only relying on their own insights and reflections. For example, depending on the survey score, the system can provide advice to the student on which changes they should make to improve their behaviour. Alternatively, the system can give positive feedback to the student if they are scoring high on the surveys. However, this method may not provide the benefit of improving time management, because, as the results of this study suggest, participants in the experimental group analyzed specific time-related data to gather insights about the actions they must take to experience improvements.

Regardless, this study did not provide sufficient evidence as to whether or not the quantified self application had an impact on procrastination.

Due to insignificance of the results, the results from this study cannot be supported by the results from the study performed by Waschle et al. [80], where they found that students who received weekly visual feedback
experienced a stronger reduction in procrastination compared to students in a controlled condition.

In contrast, from their study, Wohn and Lee [84] concluded that self-tracking alone is not enough to have a significant impact on students’ study habits and grades due to students’ lack of motivation for improving themselves academically. However, their web-based tool did not feature any visualized feedback. Another study done by Fabriz et al. [27] explored how standardized learning journals may foster students’ self-regulation. The aim of keeping a journal was to improve the students’ self-monitoring skills, comparable to the aim of the application in this study. They found that keeping a structured learning diary without any further interventions on self-regulated learning (i.e., a weekly course on self-regulated learning) did not result in an improvement in students’ self-regulated learning skills. In fact, students who only kept a learning diary showed a decrease in motivation. Their results showed that self-monitoring by itself is not enough to make an improvement on self-regulated learning skills. This study highlights that it is imperative to continue investigating the sole act of self-monitoring as an intervention for procrastination. However, as shown in Waschle et al.’s study [80], it is possible that the addition of visual feedback can have a large impact on procrastination, meaning that quantified self could still be a plausible intervention.

In addition to procrastination, I also explored how the application impacts study behaviour. I found that the application mainly had a positive impact on time management skills, although I did not assess this variable
quantitatively. This finding is supported by the study done by Tabuenca et al. [74], where they also found that self-tracking study time may have a positive impact on time management skills.

Time management has been defined in several different ways. A general definition suggested by Claessens et al. [20] is, “behaviours that aim at achieving an effective use of time while performing certain goal-directed activities.” The specific behaviours they described are: (1) time assessment behaviours, which include self-awareness of one’s use of time, (2) planning behaviours, which include setting goals, planning tasks, prioritizing, making to-do lists, and grouping tasks, and (3) monitoring behaviours, which includes observing one's use of time. It is notable that most participants in the experimental group displayed these types of behaviours. The application made monitoring easy, hence being a tool to help them become more self-aware. This resulted in an improvement in planning, particularly planning tasks and prioritizing.

Overall, from the present study, no conclusions can be made about the effectiveness of the developed application for reducing academic procrastination due to the insignificant results. However, is it evident that the application caused participants in the experimental group to perceive that they gained new skills such as time management, which was a benefit that the control group did not experience. Although the results were insignificant, it is important to acknowledge that students must have a strong willingness to change their procrastination habits for an intervention such as the one presented in this study to make a positive impact. Otherwise, the student will
not commit to habitually timing their study sessions, nor will they invest time into reflecting on their study data. Additionally, students need to be made aware of the benefits of self-tracking otherwise they will lack motivation to use apps such as the one presented in this study [27], as many students seemed to disregard the application when they did not notice an immediate impact.
7 General Discussion and Design Implications

Through the design of the app and qualitative results of both studies, I have come up with insights on how students interpret their data and several design recommendations for productivity-focused semi-automated tracking applications. Some implications can also be extended to other self-tracking applications, which is specified in each of the following sections:

7.1 Reminding Users to Track

Notification reminders are essential however should be controllable by the user. This is important for not only productivity-related quantified self applications, but also for any semi-automated tracking applications where the user needs to remember to track. Since the self-tracking feature in this app was semi-automated, participants often forgot to begin the timer when they started studying, especially if they have never used a quantified self application before or if they were lacking motivation. Regardless, some of the participants were able to create a habit of beginning the timer whenever they studied.

Current studies have reported mixed results on the effectiveness of reminders in self-tracking applications. Some studies have shown that reminders are very effective in increasing engagement [13,15] while other studies have found that reminders are only effective in the short term, after which they become annoying [32]. Another study found that novice self-tracking users find reminders bothersome and unhelpful in encouraging them to use the app [67]. Additionally, optimizing reminders for applications aiming
to improve study habits among university students may be more complicated. Students tend to have more sporadic schedules and may not study at the same time every day, making it difficult to know exactly when they should receive notifications to track their study sessions. In contrast, other tracked activities and habits tend to have a schedule, such as brushing teeth (e.g., every morning at 8am and every evening at 9pm) or food intake (e.g., 3 times a day for breakfast, lunch, and dinner).

In the Pilot Study, several participants said that they find reminders annoying. Out of the seven participants in the main study who forgot to use the application, only two participants recommended general reminders. A better solution recommended by one of the participants was strategically timed notifications; the application would learn the user’s peak study times and send notifications accordingly. However, this may be difficult to implement so a more efficient implementation would be customizable notifications; users should be able to control when and how often they receive notification reminders.

Overall, reminding users to track with the help of customizable notifications is important for any quantified self application that involves the user in the data inputting process.

7.2 Ensuring That Data is Accurate

When self-tracking is semi-automated, it is essential to provide users with tools that allow them to edit and add data. This recommendation is
generalizable to any quantified self application (i.e., not restricted to productivity-related applications). Semi-automated tracking leaves a lot of room for human error, and users dislike when their data is inaccurate. Participants place a lot of value on the accuracy of their data, which was also found in a study done by Oh and Lee [62]. This can also be a problem with automated tracking, as sometimes technology can make errors that the user will have to correct. Data must be accurate for users to be able to reflect upon it and gain valuable insights, which is why I suggest that self-tracking apps, whether they use semi-automated or automated tracking mechanisms, support data editing and manual entry.

7.3 Optimizing Data Visualizations

When analyzing charts, participants gathered specific insights that helped them better manage their time. These data visualization recommendations are exclusive to productivity-related quantified self apps because the visualizations helped users learn specific insights that they were able to use to enhance their productivity. I discovered three themes that classify the ways in which participants interpreted their data: (1) Topic Balance, (2) Peak Productivity Times, and (3) Task Duration.

Participants often used the charts to determine which topics were taking up most of their time, which helped them better allocate their time across different subjects. If a participant found that they spent a lot of time on one topic, they would conclude that they were spending too much effort on that
topic and would then direct their focus to a different topic. Along with this, they were made aware of the amount of time that they were spending on tasks. Participants would use this information to plan future study sessions because they had a better estimate of how much time they needed to allocate for each of their tasks.

Tags were the feature most helpful to the participants because it helped them determine where their time was going and how much time they were spending on tasks. With a tagging function, students can easily determine which subjects they are spending adequate time on, and which subjects need more of their attention. They can also recognize the amount of time being dedicated to each task. Recommended visualizations to help users understand how their time is being spent are bar charts or pie charts showing how much time has been spent on each topic. Therefore, tags are an essential feature in any productivity-related quantified self application.

Participants also focused on which hours of the day that they logged the longest sessions. From this information, they established that those are the times that they work best, and they would plan to work during those hours. Therefore, charts should help students easily determine which time of the day they study most. For example, a chart that displays average logged focus time per hour of day. The chart should be accompanied by textual feedback informing the user what their peak productivity time is, so they can easily interpret the data.
When it comes to charts generally, there was a lack of pattern in the feedback that participants preferred. This suggests that a wide variety of charts should be provided, since there is no “one size fits all” solution. Furthermore, some participants requested that there be the same information displayed, however in a different type of chart (i.e. bar charts vs. line charts). Ideally, self-tracking apps should include a customizable dashboard in which users can display their preferred charts, allowing them to hide feedback that they do not make use of. More research is still needed to understand how to tailor data visualizations, which is why I currently recommend providing a variety of charts that can be customized, displayed, and hidden by the user.

### 7.4 Gamification and Social Features

The results of this study showed that self quantification may not be enough to persuade users to change their procrastination habits. Although some participants were satisfied with the features offered by the developed app, many participants suggested a variety of different gamified and social elements, such as shareable stats, unlockable features, and goal-setting with rewards. It is understandable that participants requested gamified features, as gamification elements have been shown to increase user engagement [93]. However, some studies have shown that gamification elements can have a negative impact on intrinsic motivation [17,45], meaning that these elements have the potential to counteract the goal of productivity-focused applications. In a real-world context, designers should consider the disadvantages (e.g.,
decreased intrinsic motivation) and advantages (e.g., increased engagement) of certain features in combination with the target users and intended behavioural goals of the application in order to make a decision about appropriate features, and this suggestion is generalizable to any persuasive application. For the purposes of this study, we did not want to influence motivation or engagement with gamified elements, as we wanted to see the impact of self quantification directly.

Another factor to consider is personality: Personality was not analyzed in this study, however there is evidence that different personality types benefit from different persuasion techniques [2,41,63]. These studies often use the Big-Five model [36] to differentiate personalities, which separates personalities into five different traits: extraversion, agreeableness, openness, conscientiousness, and neuroticism. Therefore, designers should provide a reasonable set of persuasive elements in applications, whether these are persuasive applications for productivity, mood, or physical activity, which would make the app effective for a more diverse set of users. Furthermore, individuals may score high on multiple traits making them receptive to many persuasive tactics.
8 Limitations and Future Research

Self-quantification is an area of growing interest, and the popularity of habit tracking applications, along with data gathering smart devices offer new opportunities for attempted interventions in poor habits. However, the elements that constitute effective design of such applications remains underexplored. Here, I examined the effects of a basic application on procrastination habits. An obvious future direction would be to include gamified elements into the design and compare results: particularly helpful might be a study that compares the impact of different gamified elements.

I experienced some limitations that may have influenced the results of this study. One major limitation of this study was the number of participants. Due to the small sample size, the results of this study are less reliable and some results were insignificant. Future studies should include a larger number of participants to receive more generalizable results.

Furthermore, the present study only looked at one variable: procrastination. Future studies would benefit from looking into how quantified self applications quantitatively impact additional variables such as general productivity, motivation, time management, achievement, and focus. Although the present study found that procrastination levels were not impacted by the application, it may have had a significant impact on other variables that were not examined in this study.

Another limitation was that the results were self-reported. It is difficult to know exactly how procrastination was impacted, since self-reported
measures may be biased. Engagement data was self-reported as well. Although I asked participants how often they were tracking their study sessions, I did not collect any data on how often they were interacting with and reflecting upon the feedback. Future studies may benefit from investigating the impacts of engagement on effectiveness more in-depth.

During this study, it was difficult to encourage participants to use the application regularly without some form of daily notification reminder. Future studies can investigate how notifications and gamification elements may impact engagement and effectiveness in the long-term when it comes to semi-automated self-tracking. Current studies suggest that notifications work in the short-term to increase engagement however may become annoying to users [32]. More studies are needed to examine an effective way to help users form the habit of self-tracking consistently.
9 Conclusion

To conclude, the results of this study make it difficult to know whether the application had a positive impact on procrastination due to the insignificant results caused by a low participant number. However, participants felt that the application helped them improve their time management skills, focus, accountability, and overall awareness, therefore quantified self is a potential solution for improving study habits that is worth investigating further. I came to these conclusions by developing a study tracking app and conducting a six-week randomized controlled trial. Only the control group showed a significant decrease in overall procrastination scores, although there was no significant difference in baseline and final procrastination scores between the control and experimental groups. However, the experimental group claimed to have gained valuable time management skills, which was an effect that the control group did not report from their experience. Regardless, this improvement in skills was insufficient in significantly impacting procrastination. It is also important to note that the control group perceived the weekly surveys as more helpful than the experimental group. As a result, the control group showed a significant decrease in weekly procrastination scores by the sixth week of the study, which was not observed in the experimental group. This implies that social accountability may be enough of a motivator for students to make a change in their procrastination habits; perhaps productivity-based quantified self apps that are geared towards students would benefit from a social feature in which
users have a “buddy” that surveys them weekly on their study habits and increase engagement. This would also create an opportunity for self-reflection.

It was further found that users place a lot of value on the accuracy of their data, indicating that quantified self apps that employ semi-automated tracking techniques should provide users with ways to edit or manually add data. When it comes to data visualizations, applications should provide the user with a variety of chart options and ways to customize the feedback, as it was observed that participants made use of many different charts. Furthermore, many participants would forget to track their sessions, implying that we need to find effective ways to help users form the habit of consistently self-tracking with the help of technology. Overall, quantified self applications have the potential to help users improve productivity and focus, however, additional persuasive features are needed to motivate students or to keep them engaged in such an application.
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Appendices

Appendix A. Manuscript For Journal

A Quantified Self Application as Intervention for Academic Procrastination in University Students

With procrastination being a prevalent issue among university students, it is important to investigate potential interventions. In this paper, we describe 2 studies in which we developed a quantified self application that students can use to track their study sessions. The app also provides feedback to the student in the form of text and charts. We aimed to investigate the impact that our application has on procrastination habits, and we explored how students interpret their study data. In Study 1, 7 participants used the application for 10 days, after which time we conducted semi-structured interviews. Students reported that they felt an improvement in their focus, time management skills, and accountability. In Study 2, we conducted a 6-week randomized controlled trial to investigate the impact that the app had on procrastination habits. Results indicated that both the control group (N=9) and the experimental group (N=8) experienced a significant decrease in procrastination scores, however there was no significant difference between the two groups. Additionally, we identified three themes that classify how students interpret their study data – topic balance, peak study times, and task duration – and discuss the design implications of our findings.

Introduction

The practice of self-tracking using digital technologies is commonly referred to as quantified self (QS) [31]. Studies have shown that QS technologies can be used to effectively change people’s behaviour when it comes to physical activity [59] and mood [3]. Since procrastination is such a prevalent issue amongst university students [8,14,41] and smartphone-based treatments remain scarce [32], the present study aims to see if QS technologies can be a possible intervention, especially since productivity-focused self-tracking applications are widely available for mobile devices. In this paper, we investigate whether QS technologies can be an effective tool for reducing procrastination in university students. Specifically, we developed an application that students can use to track their study sessions. We initially conducted an exploratory study to understand students’ general thoughts on the app (Study 1, below). Following this, we conducted a 6-week randomized controlled trial to examine whether the application has a positive impact on procrastination habits (Study 2, below). We expected that participants in the experimental group would experience a greater decrease in procrastination than participants in the control group.

Background

Self-Tracking and the Quantified Self

Self-tracking, which is the process in which individuals monitor, measure, and record data about
their body and life, has been practiced for a long time with the use of pen and paper [2,33]. Recent advances in technology, however, have resulted in a resurgence of interest in self-tracking [33] because devices such as Fitbits, heart rate monitors, and Wi-Fi scales facilitate the process of collecting and analyzing data [12]. This interest led to the “Quantified Self” movement, established by Gary Wolf and Kevin Kelly, which is a community of individuals who are seeking “self-knowledge through numbers” [61]. The terms ‘quantified-self’, ‘life logging’, ‘personal informatics’, and ‘personal analytics’ can all be used to describe the practice of self-tracking with the help of digital technologies [31]. Common variables that people track are activity, food, weight, sleep, and mood [12]. Often, self-tracking is used to help improve health; for example, caloric intake can be tracked to help individuals lose, maintain, or gain weight. Although self-tracking is often referred to as ‘quantified-self’, non-quantifiable data can also be tracked, such as daily activities, moods, and relationships [33].

Because self-tracking is becoming so popular, many researchers have investigated why people do it. Gimpel et al. [20] found that a large motivator for self-tracking is entertainment: They reported that self-trackers enjoy playing around with their collected data as they consider this fun. They also found this ‘fun’ element to be more enhanced by gamification elements, such as rewards and leaderboards. The researchers observed that users who adhere to their self-tracking practice often realize that it is helping them take responsibility and optimize their lives, as well as helping them be more self-disciplined, thus further motivating them to continue collecting personal data. It was noted that users who engage in self-tracking without gamification elements felt that their motivation for self-discipline was better met than users who self-track with gamification elements.

Another study done by Choe et al. [12] found that users are motivated to self-track because it may help them improve health, improve other aspects of life, and to find new life experiences.

Many studies have shown that self-tracking technologies are beneficial for the user [12,40,43]. Some researchers have developed applications to observe the change in behaviour of their participants. For example, Zuckerman and Gal-Oz [59] developed a prototype called StepbyStep that tracked users’ daily walking habits. After a two-week experiment to test the prototype, they found that participants’ daily walking time while using the application was significantly higher than their baseline walking time. Participants’ awareness toward their walking habits increased during the study as well.

**Self-Tracking and Productivity**

Personal productivity can be hard to track because there is no exact definition or measurement of productivity [49], and what is considered to be productive may vary from person to person. Nevertheless, self-tracking to improve personal productivity is commonly practiced [30], and therefore there have been various studies done on the topic. For example, Hiniker et al. [27] developed a self-monitoring application called MyTime, which was designed to help people decrease their smartphone usage. They found that using the application was effective in helping users reach their goals, however these were only short-term results. Whittaker et al. [50] developed an application called meTime, that monitored how much time users spent across different applications. MeTime helped participants decrease usage of social media, email, browsing and total time online. They also found that the application made participants more aware of their ability to focus effectively. However, although time spent on non-productive applications decreased, time spent on productive applications did not increase, suggesting that the app did not help improve overall productivity. Finally, Pammer et al. [37] showed that visualizations of the ways in which knowledge workers spent their screen time made them gain self-awareness about their work habits. Most studies have focused on productivity in the workplace, meaning that academic productivity is often overlooked. There are many self-tracking and gamified applications that are tailored
towards improving focus such as Forest [62] and Focus Keeper [63], however, to our knowledge, there are little to no studies that test whether or not these types of applications work for reducing academic procrastination or increasing academic productivity.

There are few studies that involve self-tracking technologies and academic productivity or procrastination. Wohn and Lee [53] explored how tracking and reflecting on study habits impacts study behaviour and grades. They implemented a simple web-based tool that was compatible with desktop and mobile browsers, with which students can use to keep track of their study sessions. After the tool was tested by university students, it was revealed that the participants overall did not enjoy using the tool, however it helped them gain more self-awareness about their study habits. The group of participants who had combined tracking with active self-reflection received significantly higher grades on their final exam, however the impact on procrastination was not assessed.

Another study, performed by Tabuenca et al. (2015), explored the impacts that self-monitoring and notifications have on self-regulated learning. Their results showed that self-monitoring study time may have a positive impact on time management skills. They also found that notifications containing the students’ personal time-performance and behaviour were perceived as most useful by the users, and the students preferred to examine their learning analytics through chart visualizations rather than text messages.

**Procrastination**

Procrastination is described as the “intentional delay in the beginning or completion of important and timely activities” [38]. It is estimated that around 20% of adults consider themselves to be chronic procrastinators [26]. This habit is even more prevalent among university students; about 32% to 46% of students problematically procrastinate [8,15,41], and 62% have reported that they would like to reduce their procrastination [41]. It has been continuously shown that academic procrastination leads to negative outcomes, such as low grades [47], stress [47], and an overall decreased affective well-being [4].

**Self-Regulated Learning**

Procrastination has been shown to be significantly negatively correlated to self-regulation [4,17,28,42,54]. Self-regulation is the ability of an individual to manage their thoughts, affect, behaviour, or attention in order to attain long-term goals [29]. Baumeister et al. [6] described four components of effective self-regulation: (1) a well-defined goal, (2), monitoring of progress, (3) self-regulatory strength, and (4) motivation to reach the goal.

One study that demonstrated the strong correlation between a lack of self-regulation skills and procrastination was performed by Balkis and Duru [4]. Specifically, they observed that procrastination results from under-regulation, meaning that students who procrastinate have difficulties in setting goals, monitoring their performance, and maintaining motivation [4]. They also reported that poor self-regulation negatively impacted students’ emotional well-being. The researchers suggest that an improvement in self-regulation skills can help students avoid procrastination. Additionally, Grunschel et al. [23] found that providing students with training sessions focused on improving processes of self-regulated learning, such as goal-setting, time management, self-motivation, monitoring, and reflecting, resulted in a significant decrease in the students’ procrastination scores when compared to a control group. Finally, from the results of their study, Wieland et al. [51] suggest that procrastination interventions should aim to foster students’ abilities to self-regulate. Self-monitoring is a key component of proper self-regulation.
[6], suggesting that self-tracking using quantified self technologies may aid in an improvement of self-regulation skills and thus reduce procrastination.

Moreover, self-monitoring has often been shown to be a variable in reducing procrastination [38,55,57]. The self-regulation theory suggests that individuals with low self-control also have low willpower and motivation that results in a low time management disposition, which can be resolved by improving self-monitoring skills [57]. Wolters et al. [55] found that students who reported using skills such as goal setting, prioritizing, and monitoring their use of time also reported decreased procrastination. Moreover, self-monitoring can improve motivation as well because it allows individuals to detect subtle progress [58].

**Technology-Based Interventions for Procrastination**

Although smartphones are now widely used, technology-based interventions for procrastination remain scarce [32]. Only a few technology-based methods have been explored for reducing procrastination. Smartphone-based interventions are particularly advantageous because they are ubiquitous, almost always available and smartphones are already owned by most people [32].

Wäschle et al. [48] examined the impact of visual feedback on medical students’ procrastination habits. They devised a web-based planning and reflection protocol that the students completed at the end of each week to record their studying behaviours. The students were asked to reflect on their goal achievement and procrastination from the past week, and to set goals for the following week. The self-reported procrastination data was used to create a line chart, which was updated and displayed to the student every week. Findings showed that presenting feedback to the students resulted in a significant decrease in future procrastination behaviour in comparison to the students in the no-feedback condition.

Another study exploring a technology-based intervention was performed by Theobald and Bellhäuser [45], where they had students complete daily electronic survey-based learning diaries during a 30-day period. Students received automated textual feedback based on their diary responses. Findings suggested that electronic feedback positively impacted the students’ procrastination habits, and students in the feedback group received better grades on the final exam compared to students in the control group (no feedback).

Foulonneau et al. [18] developed a smartphone application called TILT (Time Is Life Time) that was aimed to reduce procrastination. The application monitors the amount of time that the user spends on their phone, along with the number of times that the phone is picked up. Results from their 6-week trial suggested that TILT aided users in reducing their smartphone usage by 15%, however there was no follow up with the participants to see if these results persisted. Although this study was aimed at reducing procrastination, only the amount of time spent on the phone was examined rather than actual procrastination levels.

Finally, Lukas and Berking [32] also developed a mobile-based application called MT-PRO, which aims to reduce procrastination by asking users to either avoid dysfunctional stimuli or approach functional stimuli. Results showed that using the application reduced both general and academic procrastination behaviours compared to the control group, and these results were sustained over a one-month period.

From this review of the literature, it is evident that technology can be used to persuade individuals to reduce their procrastination behaviours. However, studies examining the use of quantified self mobile applications as an intervention for procrastination are still lacking.
The StudyTracker Application

Our StudyTracker application can be used for tracking work sessions. We designed it to have a focus on self-tracking and feedback, avoiding the addition of any gamification or social elements at this time. StudyTracker uses semi-automated self-tracking, where the user is required to manually start and stop the timer before and after study sessions. Feedback is provided in the form of charts and text.

StudyTracker was developed to run on any iOS smartphone (i.e., iPhone). It features a timer, charts, tags, a log of sessions (also called History), and settings. Similar to other productivity apps, the Timer is on the home page (see Figure 1(a)) making it easily accessible to the user. There is a “Start Timer” button that the user can press to start timing their session. Upon clicking the button, it toggles to the “Stop Timer” button which the user can press to end and record the session. The timer runs in the background even if the user leaves or fully closes the app.

Tags were added to allow the user to organize their sessions by topic. The data from tags can also be used to provide more feedback to the user, such as which topic they are focused on the most. The user can select a tag when they start a new session or edit the tag of a session afterwards.

The History section provides the user with a log of their previous sessions (see Figure 1(b)). Users can select recorded sessions and edit the start time, end time, and tag associated with that session.

Settings provided users with the option to change the colour scheme and toggle between light or dark modes.

The Charts section included feedback for the users (see Figure 1(c) and Figure 1(d)). Charts were inspired by popular apps, such as Forest [62] and Focus Keeper [63]. The charts included a Daily View, Weekly View, and Monthly View so the user can toggle between which data they would like to see, as described below:

- **Daily View:** Shows the data for the current day.
- **Weekly View:** Shows the data for the current week.
- **Monthly View:** Shows the data for the current month.

All views include back and forward buttons that the user can press to navigate between different days, weeks, and months.

We conducted a usability study on a high-fidelity prototype of the application with eight participants to ensure that the application design was usable. Ethics Clearance for the usability study was provided by Carleton University Research Ethics Board B under Clearance #118650. Participants were asked to think aloud as they performed several tasks on the prototype. After the test, participants filled out the System Usability Scale (SUS) [10], and were also asked if they had any other comments about the design of the application.

We observed a 100% task completion rate for all participants. The average SUS score was 83.75 (according to Bangor, Kortum, and Miller [5], a passable SUS score is at least 70 whereas better products tend to score in the high 70s to upper 80s). Based on these guidelines, the resulting average SUS score from this usability study was acceptable, meaning that the application was deemed to have high usability and we could proceed to the next phase of the study. [Figure 1]

**Study 1**

The purpose of Study 1 was to ensure that the application was working as expected and to gather students’ initial thoughts on the application. Ethics Clearance for this study was provided by
Carleton University Research Ethics Board B under Clearance #118650. For this study, we aimed to explore the following research questions: (1) What are student’s thoughts on the developed self-tracking application? (2) How does the app impact students’ study behaviour? and (3) How can the app be improved?

Methods

Participants

We recruited participants on Facebook and Instagram. Participants were required to be at least 18 years of age, a current student at Carleton University, fluent in English, own an iPhone or iPad, and consider themselves to be struggling with academic procrastination. We recruited 7 participants, 5 of which identified as female, 1 identified as male, and 1 selected other. Ages ranged from 18 to 51 (M=27.43, SD=11.21). Additionally, 4 of the participants were undergraduate students while the remaining 4 were master’s students. 5 of the participants had experience using self-tracking technologies such as fitness trackers and mood trackers. None of the participants had prior experience using self-tracking apps for studying.

Procedure

We instructed participants to use the application during academic-related tasks for the following 10 days. After 10 days, we conducted semi-structured interviews to learn more about participants’ experience. The interview included questions about the application’s functionality, features, user interface, and about the participants’ general experience using the application. Participants were also asked if they felt like their procrastination habits improved from using the application. Participants were compensated with a $25 Amazon e-gift card for their participation in the study.

Results

To answer our research questions, we performed a thematic analysis on the interview transcripts using an inductive approach following guidelines established by Thomas [46]. The codes were then grouped into main themes with subthemes, which were iterated on at several different points in time. The final themes are described below; participant names were omitted and replaced with their participant code.

Improvement in Study Behaviour

Overall, participants generally noticed positive changes in their study habits and procrastination behaviour. Below are changes that participants noticed in their behaviours and mindsets that led them to feel like there was a reduction in their procrastination:

Increased Focus and Productivity. Participants mentioned that the application helped them better focus when they would have otherwise gotten distracted. P5 said that their focus had increased because it felt like they were being managed. Additionally, P7 said that the application acted as a reminder that they should put down their phone whenever they picked it up, “well, it kind of
helped me focus more because every time I reach over to start using my phone, I’d see it open and I’d be like, oh yeah, I’m supposed to be working.” The application also helped P7 solidify their progress, as they explain in the following quote:

“[The app] helped me stay more focused while I was working and also, I felt a bit more productive because I felt like I was accomplishing a goal, setting the timer and like stopping it and everything.”

**Time Management.** Most participants said that the app helped them with time management, which was a result from analyzing the graphs: “I like how I have like the weekly and the monthly option just for time management because my time management sucks” (P4). P1 said that the tag feature combined with the charts helped them think more critically about where they were spending their time:

“So, I could see like, the amount of time I'm putting towards different aspects of what I'm working on. So, I really enjoyed that labelling capability because then I would go to the chart area and I would look to see like, oh, I spent most of my time doing data analysis. Is that what I should be doing right now? Or should I maybe be focusing more on just revising what I already have?”

Participants said that the charts helped them better plan and manage their time in some way. From analyzing the data in the charts, they were able to see what topics they spend the most time on and during which times of day they were most productive. With this information, many participants were able to optimize their study sessions. For example, P4 said that the app helped them with organization:

“Calculation for me is it comes from lack of organization, so just having something that will manage my time just makes it easier to know when and how long I should be studying.”

**Accountability.** The application helped participants feel more accountable for their schoolwork. Some participants described that keeping a “record” of their study sessions enforced the fact that they should study. This stemmed from wanting their data to be accurate; if the timer was running, the participants wanted to be studying. For example, P6 described that they would normally be social at the library however the application made them feel more accountable for their schoolwork, encouraging them to study:

“… but when there's a timer, I'm just like, OK, I'm going to use this as an analytic to measure myself. I should be trying to actually work rather than just be in the library with friends and have Starbucks and then just chill. Because I'm like, OK, I'm studying whatever, but when I'm actually recording myself studying, then maybe I should be more accountable to it.”

P1 described that having the timer running made it feel like somebody is watching: “There’s that aspect of somebody is watching, so I better do what I'm supposed to do.” Another reason mentioned by P3 was that starting the timer acted as a “pledge” to begin studying: “You already mentioned that you were studying, so you need to study, kinda thing.”
Invoked Positive Feelings

Overall, the application invoked positive feelings within participants. For example, the app made two of the participants feel like they were playing some sort of game. Seeing their feedback made them want to compete against themselves and get higher “scores”. P2 explained, “this is actually a good app because it makes me productive because I want to beat the timer. I want a large number on the timer.”

Another two participants felt a sense of accomplishment from using the application. P5 said that visualizing their progress made them want to “pat themselves on the back”, as it allowed them to feel proud and satisfied with the amount of effort they were putting into their schoolwork. The application also helped P7 solidify their progress, which led to a feeling of accomplishment as well, as they explain in the following quote:

“[The app] helped me stay more focused while I was working and also, I felt a bit more productive because I felt like I was accomplishing a goal, setting the timer and like stopping it and everything.”

Design Suggestions

Participants had several suggestions that they thought would improve the app. Detailed below are problems that participants encountered along with their suggestions.

Difficulties With Tracking. Many participants encountered difficulties with tracking, which mostly had to do with either forgetting to start or stop the timer: “some other times I would remember to start it, but forget to stop it until there was one where it was like 17 hours” (P1). One participant said that they would become too focused with their task, which made them forget. Other participants said that they are simply forgetful people. Several of these participants suggested that a notification would help solve this problem, as P7 said, “if a session goes on for more than like two hours, it could be a pop up like, ‘are you still working?’ or something.” P3 said that a live timer widget on the phone’s lock screen could also act as a reminder that the timer is running. Another problem that participants faced was forgetting to start the timer, as P4 described: “it’s hard to remember to actually go and start timing it and just to remember to keep track.” However, when asked if daily notifications would help solve this issue, P7, P2, and P5 said that they think a notification reminder would be annoying.

Difficulties With Data Interpretation. Three participants said that they felt there needed to be more variety in the charts section to aid them in interpreting their data. P1 explained that the chart section should contain both text and visuals combined to create more context. P3 suggested that there could be data displayed within a calendar view. Lastly, P6 explained that there could be an option to change the type of graphs because everybody understands data differently:

“The only other thing that I’d say would be kind of interesting to do is if the analytics could be like in different types of graphs like I know some people, they prefer like line graphs or things like that, and also some other apps similar to also have the option that you can change it from bar graph to pie chart to like different things.”
Discussion

The results of this study showed that there is potential for QS technologies to act as an intervention for procrastination. All participants expressed that they enjoyed the application in some way and felt like it had a positive impact on their academic procrastination habits. Participants reported that they experienced an improvement in time management skills, focus, productivity, and accountability, showing that the application may have a long-term positive impact on procrastination.

Several feature suggestions were taken from this study and implemented within the application. Firstly, we added a notification feature that reminds the users when the timer is running so they do not forget to turn it off. Additionally, we set the timer to automatically stop and record the session after 8 hours.

Daily notification reminders were not added because we wanted to solely examine QS technologies’ impact on procrastination, and notifications have been shown to have additional impact on students’ procrastination behaviours [13]. Additionally, participants expressed that reminders can be annoying, which influenced our decision to avoid implementing daily reminders.

Study 2

For the second study, we conducted a 6-week randomized controlled trial to explore how self-tracking schoolwork and receiving feedback impacts procrastination habits. We hypothesized that students in the experimental group will experience a greater decrease in procrastination than students in the control group. There was also an exploratory component to this study, which aimed to investigate how students interact with and interpret their data, as well as the impact that the app has on students’ study behaviours. Ethics Clearance for this study was provided by Carleton University Research Ethics Board B under Clearance #118650.

Methods

To measure overall procrastination levels pre-study and post-study, we used the Academic Procrastination Scale (APS) [34]. The APS contains 25 items that are rated on a Likert-type scale from 1 (Disagree) to 5 (Agree). The scale contains statements such as “I put off projects until the last minute” and “I know I should work on schoolwork, but I just don’t do it”. McCloskey and Scielzo (2015) found that the APS scale has a high internal consistency (α = .94).

To monitor weekly changes to procrastination habits, students responded to a weekly survey containing the Academic Procrastination Scale – Short Form (APS-SF) [56]. The short form of the scale was chosen for the weekly survey to ensure that students have enough time to fill it out on top of their schoolwork. The APS-SF contains 5 items from the APS which are rated on a Likert-type scale from 1 (Disagree) to 5 (Agree). Yockey (2016) found that the APS-SF has an internal consistency estimate of .87.

Participants

We recruited participants by sending a call for participants to all undergraduate students in the School of Information Technology at Carleton University. Participants were required to be at least 18 years of age, fluent in English, own an iPhone or iPad, and consider themselves to be struggling with academic procrastination. In total, we recruited 18 participants. The control group included 5
self-identified females and 4 self-identified males. Ages ranged from 18 to 26 (M=20.89, SD=2.42). No participants in the control group were using a study-tracking application at the time of the study.

The experimental group included 7 self-identified females, 1 self-identified male, and 1 selected other. Ages ranged from 18 to 24 (M=20.67, SD=1.94). None of the participants had experience using study trackers. One participant withdrew from the study after completing three of the weekly surveys. Their data was not used in the statistical analysis; however, their survey responses were used in the qualitative analysis.

Procedure

After a participant expressed interest in the study, we randomly assigned them to either the control group or the experimental group using block randomization with block sizes of 2 and 4.

Control Group. Participants in the control group (n = 9) filled out the consent form followed by a pre-study survey containing demographic questions and the APS. We also asked participants what tools they have tried to use to reduce their procrastination, and if they are currently using any of those tools. Every 7 days, we sent them a survey containing the APS-SF. After 6 weeks, we sent the participants a post-study survey containing the final weekly survey, a question about their overall experience in the study, and the APS. In total, the participants completed 6 weekly surveys.

Experimental Group. Participants in the experimental group (n = 8) filled out the consent form followed by a pre-study survey containing demographic questions, questions about their experience with self-tracking technologies, and the APS. We also asked participants what tools they have tried to reduce their procrastination, and if they are currently using any of those tools. We instructed participants to use the application during academic-related tasks for the following 6 weeks. Every 7 days, we sent them a survey containing the APS-SF and questions about their experience using the app. After 6 weeks, we sent the participants a post-study survey containing the final weekly survey, questions about their overall experience in the study, questions about the self-tracking app and feedback, and the APS. In total, the participants completed 6 weekly surveys.

Results

Although the sample size was too small for definitive results to be gleaned from statistical analysis, we conducted several tests on the data to explore differences between our groups.

Within-Group APS Scores

We conducted a paired samples t-test to determine the decrease in APS scores within the groups. Initially, we performed Shapiro-Wilk tests which did not show evidence of non-normality (control: W=.94, p=.59; experimental: W=.83, p=.063). Based on these results, it was appropriate to use a parametric test. Results from the t-test showed that the control group experienced a significant decrease from their baseline scores (M=64.56, SD=8.31) to final scores (M=41.89, SD=20.2), t(8)=3.11, p=.007. The experimental group also experienced a significant decrease from their baseline scores (M=56.38, SD=9.52) to final scores (M=42.63, SD=18.63), t(7)=1.98, p=.044.
**Within-Group APS-SF Scores**

We performed a Shapiro-Wilk test for each weekly measurement for the control group, which showed that the distribution of a measurement deviated from normality (week 5: W=.81, p=.024). Therefore, a Friedman test was performed to determine whether APS-SF scores differed across the weeks. The Friedman test determined that the mean APS-SF scores within the control group differed significantly across the weeks (χ²(5)=17.95, p=.003). A post hoc analysis showed that scores became significantly different during week four (p=0.011). The Conover’s post hoc comparison is shown in Table 1. [Table 1]

Again, we performed a Shapiro-Wilk test for each weekly measurement for the experimental group, which showed that the distribution of some measurements deviated from normality (week 5: W=.79, p=.023; week 6: W=.82, p=.042). Therefore, a Friedman test was performed to determine whether APS-SF scores differed across the weeks. The Friedman test determined that the mean APS-SF scores within the experimental group did not differ significantly across the weeks (χ²(5)=8.61, p=.126). Average weekly scores for the control and experimental groups are illustrated in Figure 2. [Figure 2]

**Between-Group Changes**

We conducted an independent samples t-test to determine the significance of the difference in baseline and final APS scores between the two groups. Again, we performed Shapiro-Wilk tests which did not show evidence of non-normality (control: W=.94, p=.59; experimental: W=.83, p=.063). Based on these results, it was appropriate to use a parametric test. The results indicated that there was no significant difference between the groups, t(15)=-.88, p=.393, although the control group (M=22.67, SD=21.89) experienced a greater decrease in scores than the experimental group (M=13.75, SD=19.67).

**Frequency of Use and Procrastination Scores**

The weekly survey asked users how often they were tracking their study sessions (0% of the time they performed academic tasks, 25% of the time, 50% of the time, 75% of the time, or 100% of the time). Initially, we performed a Shapiro-Wilk test which did not show evidence of non-normality (W=.84, p=.07). Then, we computed a Pearson correlation coefficient to evaluate the relationship between average application use throughout the weeks and the change in APS score. As shown in Figure 3, there was a positive correlation between the two variables, although the relationship was not statistically significant, r(6)=.398, p=.329, due to the small sample size. [Figure 3]

**Survey Responses and Reflections**

We used thematic analysis to examine all survey responses from the experimental group. First, survey responses were carefully analyzed and coded using an inductive approach following guidelines established by Thomas [46]. Then, the codes were grouped into themes, which were iterated on at several different points in time. Detailed below are the insights that we gathered from the analysis.

**Time Perception.** Using the application helped participants gain an increased perception of time.
The feedback from the app made some participants realize that they study for less time than they thought, which resulted in various reactions. P15 said, “seeing how much time I spent on tasks versus how much time I should be spending has been eye-opening.” For some participants, this information encouraged them to study more. For example, P7 wanted to stop studying, however, the timer helped them realize that they had been studying for a short amount of time, which motivated them to continue studying:

“When I feel like time has passed and I wanna stop studying I check the timer and see it’s only been 20 minutes, so I told myself to keep going.”

However, for P3, the realization that they study less than they thought was not enough to push them to study more:

“Seeing the time spent didn’t seem to mean much to me. It did show me that I don’t spend a whole lot of time studying, but it also didn’t make me feel like I should do more.”

Gaining a sense of time also helped participants become more aware of the progress they were making in school. For example, P20 said, “[the app] helped visualize how much work I was doing even though it may have felt like I was not making progress.” Therefore, measuring progress helped participants recognize that they are accomplishing something. For P7, this gave them a sense of achievement and motivated them to keep working:

“I think I have a really hard time visualizing and feeling time pass so having a number going up makes me feel like I am moving in a forward direction, so I know that something is being done to complete a task. I found this app to be more useful for study time retention as I was able to see ‘oh that’s what 30 mins feel like, I can actually get a lot done in 30 minutes. Why not keep going?’ was my thinking.”

**Remaining Focused on Studies.** Overall, the application was reported to have helped participants increase their focus. For example, the application served as a reminder for P4 to not get distracted whenever they picked up their phone:

“When I turn my phone off and study for 20 minutes or so, I get distracted and go back on my phone but I see the studying timer there, so it reminds me to stay off my phone and continue studying, which I do.”

In addition to the timer acting as a reminder for P4 to study, they also knew that the app was “tracking” them and they did not want there to be any “false” data, which discouraged them from getting distracted:

“It would be tracking the amount of time I'm being distracted as well, which would be false tracking, so it immediately put me back on track.”

P20 felt similar effects, explaining that getting distracted meant they had to either deduct time from their data or stop the timer, which they wanted to avoid doing:

“The more I spent tracking my productive tasks, the more it forced me to focus on the task. As if I started something else or got distracted, I had to stop the timer or
subconsciously deduct time counted. This made me more focused, and one tracked instead of getting distracted with other things.”

Additionally, participants said that using the app helped them study for longer periods of time than usual, as explained by P7:

“Maybe [the app did] not completely reduce procrastination, but more so improve my study retention time. I am able to study for longer and more concentrated periods of time.”

For some participants, the application helped them get into a “study mindset”, allowing them to focus on their work. P15 referred to tracking as their “study ritual”: “Gets me in the mindset to work, sort of [like a] ritual.” This suggests that the application helped participants get “in the zone” for studying. P7 said that the application acted as a “signal” to their brain that they were going to start studying.

**Improved Time Management**

The following subsections describe how participants made use of the feedback to improve their time management skills, which was achieved through balancing time spent on subjects, learning how much time tasks take, and understanding when productivity was highest.

**Topic Balance.** Many participants mentioned that the feedback helped them better understand which subjects they were spending time on, and which subjects they were pushing aside. This information allowed them to allocate their time more evenly across their various courses. For example, P7 would switch their task when they saw that they had been spending too much time on it, which helped them balance the time they spent on assignments and avoid “cramming”:

“It also helped me with spreading out the amount of time I am spending on studying a specific subject since I could see quantifiably, “oh it’s been an hour, lets switch to this task because I don’t want to be using all my time on this thing. This helps with procrastination because I can rely on myself more to spread out the time I am spending on assignments and ensuring that I’m not always cramming last minute.”

Furthermore, the feedback encouraged P4 to get started on subjects that they would have otherwise pushed aside:

“The daily overview helped me see how long I studied in the day and how many exact sessions I needed and what courses along with the tag overview so it would be in an easier way to see which courses got the most focus in that day and it would encourage me to study for another course tomorrow (one that got less attention from the previous study session).”

Participants said that tags were the most useful feature when it came to allocating their time because they were able to compare the time they spent on each subject. In fact, six participants said that the tag feature was their favorite. P3 said, “the tags help me see which subjects I spent the most time on in a week. It helps balance how much time I spend per assignment.”
**Peak Productivity Times.** Other participants used the feedback to understand when they are most productive, and they would use this information to manage their time accordingly. For example, P7 was able to be more strategic about planning their day by analyzing when they are most productive:

“I was able to be more strategic in choosing which times I am most productive and ready to study and plan the time of day I feel more tired like 2 pm I tend to be slower and sometimes nap so I leave smaller tasks or less energy draining tasks until then.”

P5 also said that seeing when they are most productive helps them with future planning: “I like that it allows me to see when I am most productive or when I tend to do work. I could apply that when devising future plans.”

**Task Duration.** Additionally, participants used the feedback from the charts to learn how much time it took them to complete tasks such as assignments, so they were able to plan their study sessions around this information. For example, P5 said, “it is nice to see how much time I spend on tasks to help me plan more accurately in the future.” Similarly, P15 expressed, “it also helped me see how much time I was spending on tasks, and I could more effectively plan and get my tasks done because I knew how much time the task required.”

**Data is Not Enough**

Although the app was helpful to some participants, other participants did not agree. The main concern was that tracking study data was merely not enough to reduce procrastination or generally improve study habits. For example, P3 expressed that they did not see much benefit in tracking their study time:

“I realize that after I stop the timer, the time spent doesn't really mean much to me. I can see how much time I spent studying weekly, monthly and daily, but I personally didn't find much benefit in knowing this.”

P5 felt like the data helped them gain self-awareness, however this was an inadequate method in helping them alter their habits, “I see it more as a self tracker to utilize as data for self-realization, but the self-improvement part takes a different approach.” P15 expressed the same, “the app itself was a tool but the hardest part of getting myself to do tasks is something it couldn’t really help with.” Although these participants were consistently tracking their study time, they felt no benefits regarding their procrastination habits.

**Application Design**

Described below are comments made by participants regarding the application design.

**Forgetting to Use the Application.** Although some participants were easily able to integrate the application into their study routines, other participants had trouble remembering to start the timer. P1 and P7 recommended that there be strategically timed notification reminders based on the users’ peak study times to help them remember to track their study sessions:
“Potentially a prompt to suggest studying if there was a trend to study at that time. Example: if someone always studies on Tuesday evening, a prompt around 5-6pm suggesting a study session would be helpful.” (P1)

Similarly, P14 and P5 recommended general notifications to remind them that the application exists:

“Having a reminder notification for the user to use the application [would be helpful]. It will help to remind them that the application exists.” (P14)

Forgetting to start the timer led participants to recommend a manual data entry feature. Although there was a feature to edit entries, this feature did not allow enough freedom for participants, as described by P5:

“I wish it had a way to add ‘study times’ after it has passed. Sometimes I forget to turn on the timer while studying but I remember once I finished. I may be able to adjust study times within the same day, but if I wanted to add a study time from yesterday, I cannot do so.”

Participants put a lot of value on the accuracy of their data, since they could not properly analyze the feedback if it was inaccurate. P4 ensured that they used the application as often as they could to keep their data accurate: “I made sure to use it as much as possible to get more accurate results for when I want to compare my studying times again”. Some participants got frustrated because they would forget to start the timer while studying, however they would remember once they have finished. When P5 ran into these issues, they would work around it by running the timer afterwards to “make up” for the time that they forgot to track:

“Because I sometimes forget to use the app while I am studying, I try to make up (display as accurately as I can) the time I missed by letting the stopwatch run during ‘normal activities’ the approximately same amount of time I was studying for.”

This can be cumbersome for participants, so a manual data entry was often suggested as an effective solution.

The App Was Too Boring. Three participants got bored of the application and felt like the interface was not engaging enough. Specifically, P14 said that the application had “minimal functions” while P3 said that it was “pretty bare bones”. The lack of features led P14 to stop using the application altogether: “towards week four I lost interest in the app, because there are very minimal features that I could use.” P7 expressed that they would have liked to see more gamified and social features.

Discussion

In this study, we developed a quantified self application that allows students to track their study sessions. We aimed to see if this application can help students reduce academic procrastination by comparing the change in procrastination levels between an experimental group and a control group. We also collected insights on how students interact with and interpret their data.
Results showed that, within both groups, there was a significant decrease in procrastination scores. However, between the two groups, there was no significant difference in scores: This result does not support our hypothesis, which stated that the experimental group will experience a greater decrease in self-reported procrastination scores than the control group. Furthermore, although the difference was found to be statistically insignificant, the control group experienced a larger decrease in APS scores than the experimental group. There could be several reasons for this result:

First, many participants in the experimental group found that the app was not engaging enough, and some found it was hard to form the habit of beginning the timer whenever they began studying. Higher engagement with the app may have resulted in an overall higher decrease in procrastination scores within the experimental group. Such engagement could be encouraged for instance with gamification elements, competition with their peers, and so on. The app is unable to help the participants if they do not use it to their full advantage, however there was no dependable way to ensure that participants were engaging with the app whenever they sat down to do schoolwork.

Second, the natural progression of the semester may have had an impact on all procrastination scores. Since this study was performed over the course of a semester, some participants expressed that they had noticed a positive change in their procrastination habits because they could no longer “afford” to procrastinate as midterms and exams approached.

There is also the possibility that consistently tracking study sessions is too much of a burden for students, especially students who are prone to procrastinate. Consequently, for procrastination, perhaps a different approach should be taken. For example, an application that prompts students to respond to surveys about their habits and produces visual and textual feedback based on their responses. However, this method may not provide the benefit of improving time management, because, as the results of this study suggest, participants in the experimental group analyzed specific time-related data to gather insights about the actions they must take to experience improvements.

Regardless, the QS application was simply not enough to impact procrastination significantly, resulting in similar experiences between the control and experimental groups. Although the control group’s procrastination habits may have been impacted by the weekly procrastination survey, the experimental group was also responding to this same weekly survey, and as such a weekly check-in on habits may be enough to make a difference to student procrastination. Overall, the effects of using the application in addition to the survey should have been evident if the application was truly effective.

The results from this study are not supported by the results from the study performed by Waschle et al. [48], where they found that students who received weekly visual feedback experienced a stronger reduction in procrastination compared to students in a controlled condition.

However, from their study, Wohin and Lee [52] concluded that self-tracking alone is not enough to have a significant impact on students’ study habits and grades due students’ lack of motivation for improving themselves academically. Although they did not examine procrastination specifically, their conclusions are similar to the findings in this study. Another study done by Fabriz et al. [16] explored how standardized learning journals may foster students’ self-regulation. The aim of keeping a journal was to improve the students’ self-monitoring skills, comparable to the aim of the application in this study. They found that keeping a structured learning diary without any further interventions on self-regulated learning (i.e., a weekly course on self-regulated learning) did not result in an improvement in students’ self-regulated learning skills, in fact, students who only kept a learning diary showed a decrease in motivation. Although the strategy was different (learning diary vs. tracking study time), the results of the current study are in line with their results, showing that self-monitoring by itself is not enough to make an improvement on self-regulated learning skills thus not being able to positively impact procrastination behaviour.
In addition to procrastination, we also explored how the application impacts study behaviour. We found that the application mainly had a positive impact on time management skills, although we did not assess this variable quantitatively. This finding is supported by the study done by Tabuenca et al. (2015), where they also found that self-tracking study time may have a positive impact on time management skills.

Overall, from the present study, it can be concluded that using our QS application was not enough of an intervention to reduce academic procrastination. However, the application helped students gain new skills such as time management, which was a benefit that the control group did not experience. Regardless, this was not enough to result in a significant decrease in procrastination scores when compared to the control group. Students must have a strong willingness to change their procrastination habits for an intervention such as the one presented in this study to make a positive impact. Otherwise, the student will not commit to habitually timing their study sessions, nor will they invest time into reflecting on their study data. Additionally, students need to be made aware of the benefits of self-tracking otherwise they will lack motivation to use apps such as the one presented in this study [16], as many students seemed to disregard the application when they did not notice an immediate impact.

### General Discussion and Design Implications

Through the design of the app and qualitative results of both studies, we have come up with insights on how students interpret their data and several design recommendations for productivity-focused semi-automated tracking applications, as described in the following sections.

#### Reminding Users to Track

Notification reminders are essential; however, should be controllable by the user. Since the self-tracking feature in this app was semi-automated, participants often forgot to begin the timer when they started studying, especially if they have never used a QS application before or if they were lacking motivation. Regardless, some of the participants were able to create a habit of beginning the timer whenever they studied.

Current studies have reported mixed results on the effectiveness of reminders in self-tracking applications. Some studies have shown that reminders are very effective in increasing engagement [7,9] while other studies have found that reminders are only effective in the short term, after which they become annoying [19]. Another study found that novice self-tracking users find reminders bothersome and unhelpful in encouraging them to use the app [39]. In Study 1, several participants said that they find reminders annoying. Out of the 7 participants in Study 2 who forgot to use the application, only two participants recommended general reminders. A better solution recommended by one of the participants was strategically timed notifications; the application would learn the user’s peak study times and send notifications accordingly. However, this may be difficult to implement, so a more efficient implementation would be customizable notifications; users should be able to control when and how often they receive notification reminders.

#### Ensuring That Data is Accurate

When self-tracking is semi-automated, it is essential to provide users with tools that allow them to edit and add data. Semi-automated tracking leaves a lot of room for human error, and users dislike
when their data is inaccurate. Participants placed a lot of value on the accuracy of their data, which was also found in a study done by Oh and Lee (2015). Data must be accurate for users to be able to reflect upon it and gain valuable insights, which is why we suggest that self-tracking apps support data editing and manual entry.

**Optimizing Data Visualizations**

When analyzing charts, participants gathered specific insights that helped them better manage their time. We discovered three themes that classify the ways in which participants interpreted their data: (1) Topic Balance, (2) Peak Productivity Times, and (3) Task Duration.

Participants often used the charts to determine which topics were taking up most of their time, which helped them better allocate their time across different subjects. If a participant found that they spent a lot of time on one topic, they would conclude that they were spending too much effort on that topic and would then direct their focus to a different topic. Along with this, they were made aware of the amount of time that they were spending on tasks. Participants would use this information to plan future study sessions because they had a better estimate of how much time they needed to allocate for each of their tasks.

Tags were the feature most helpful to the participants because it helped them determine where their time was going and how much time they were spending on tasks. With a tagging function, students can easily determine which subjects they are spending adequate time on, and which subjects need more of their attention. They can also recognize the amount of time being dedicated to each task. Recommended visualizations to help users understand how their time is being spent are bar charts or pie charts showing how much time has been spent on each topic. Therefore, tags are an essential feature in any productivity-related QS application.

Participants also focused on which hours of the day that they logged the longest sessions. From this information, they established that those are the times that they work best, and they would plan to work during those hours. Therefore, charts should help students easily determine which time of the day they study most. For example, a chart that displays average logged focus time per hour of day. The chart should be accompanied by textual feedback informing the user what their peak productivity time is, so they can easily interpret the data.

When it comes to charts generally, there was a lack of pattern in the feedback that participants preferred. This suggests that a wide variety of charts should be provided, since there is no “one size fits all” solution. Furthermore, some participants requested that there be the same information displayed, however in a different type of chart (i.e., bar charts vs. line charts). Ideally, self-tracking apps should include a customizable dashboard in which users can display their preferred charts, allowing them to hide feedback that they do not make use of.

**Gamification and Social Features**

The results of this study showed that QS is not enough to persuade users to change their procrastination habits. Although some participants were satisfied with the features offered by the developed app, many participants suggested a variety of different gamified and social elements, such as shareable stats, unlockable features, and goal-setting with rewards. It is understandable that participants requested gamified features, as gamification elements have been shown to increase user engagement [60]. However, some studies have shown that gamification elements can have a negative impact on intrinsic motivation [11,25], meaning that these elements have the potential to counteract the goal of productivity-focused applications. In a real-world context, designers should consider the disadvantages (e.g., decreased intrinsic motivation) and advantages
(e.g., increased engagement) of certain features in combination with the target users and intended behavioural goals of the application in order to make a decision about appropriate features. For the purposes of this study, we did not want to influence motivation or engagement with gamified elements, as we wanted to see the impact of self quantification directly.

Another factor to consider is personality: Personality was not analyzed in this study, however there is evidence that different personality types benefit from different persuasion techniques [1,24,36]. These studies often use the Big-Five model [21] to differentiate personalities, which separates personalities into five different traits: extraversion, agreeableness, openness, conscientiousness, and neuroticism. Therefore, designers should provide a reasonable set of persuasive elements in applications, which would make the app effective for a more diverse set of users. Furthermore, individuals may score high on multiple traits making them receptive to many persuasive tactics.

Conclusions

Self-quantification is an area of growing interest, and the popularity of habit tracking applications, along with data gathering smart devices offer new opportunities for attempted interventions in poor habits. However, the elements that constitute effective design of such applications remains underexplored. Here, we examined the effects of a basic application on procrastination habits. An obvious future direction would be to include gamified elements into the design and compare results: Particularly helpful might be a study that compares the impact of different gamified elements.

We experienced some limitations that may have influenced the results of this study. One major limitation of this study was the number of participants. Due to the small sample size, the results of this study are less reliable, and some results were insignificant due to the smaller sample size. Future studies should include a larger number of participants to receive more generalizable results.

Furthermore, the present study only looked at one variable: procrastination. Future studies would benefit from looking into how QS applications quantitatively impact additional variables such as general productivity, motivation, time management, achievement, and focus. Although the present study found that procrastination levels were not impacted by the application, it may have had a significant impact on other variables that were not examined in this study.

Another limitation was that the results were self-reported. It is difficult to know exactly how procrastination was impacted, since self-reported measures may be biased. Engagement data was self-reported as well. Although we asked participants how often they were tracking their study sessions, we did not collect any data on how often they were interacting with and reflecting upon the feedback. Future studies may benefit from investigating the impacts of engagement on effectiveness more in-depth.

During this study, it was difficult to encourage participants to use the application regularly without some form of daily notification reminder. Future studies can investigate how notifications and gamification elements may impact engagement and effectiveness in the long-term when it comes to semi-automated self-tracking. Current studies suggest that notifications work in the short-term to increase engagement however may become annoying to users [19]. More studies are needed to examine an effective way to encourage users to self-track consistently.
References (for journal manuscript)


[34] Justin Mccloskey and Shannon Scielzo. 2015. Finally! The Development and Validation of the Academic Procrastination Scale. DOI:https://doi.org/10.13140/RG.2.2.23164.64640

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Appendix B. Recruitment Material

B.1. Usability Study Recruitment Poster

PARTICIPATE IN A
USABILITY STUDY FOR A SELF-TRACKING APPLICATION

This study is being done to test the usability of an application design. Participation in this study includes a short pre-study interview and post-study survey. You will be performing a couple of tasks on a prototype of an application as the researcher watches. During the session, you will have to share your screen and audio/video will be recorded. The session is expected to last 25-30 minutes and is fully remote.

To participate, you must:
✓ Be at least 18 years old
✓ Speak English
✓ Have access to a device on which you can remotely share your screen

Participants will be compensated with a
$10 AMAZON E-GIFT CARD!

If you're interested, please contact
Maya Murad
mayamurad@cmail.carleton.ca

This study has been cleared by the Carleton University Research Ethics Board B Clearance #118650
PARTICIPATE IN A PILOT STUDY ON
SELF-TRACKING TECHNOLOGIES
AND ACADEMIC PROCRASTINATION

This pilot study is being done to receive feedback on a self-tracking app for studying. Participation in this study includes a pre-study questionnaire and a post-study semi-structured interview. You will test the application for 10 days by using it regularly, which is expected to take less than 5 minutes of your time daily. The semi-structured interview is expected to last between 20-25 minutes. The interview will be audio(required) and video(optional) recorded. This study is fully remote. The study will take place when the new semester begins (around January 9th).

To participate, you must:
✓ Be at least 18 years old
✓ Speak English
✓ Own either an iPhone (iOS 15.0+) or an iPad (iPadOS 15.0+)
✓ Currently a student at Carleton University
✓ Consider yourself to be struggling with academic procrastination

If you're interested, please contact:
Maya Murad
mayamurad@cmail.carleton.ca

Participants will be compensated with a $25 AMAZON E-GIFT CARD!

This study has been cleared by the Carleton University Research Ethics Board B Clearance #118650
B.3. Main Study Recruitment Poster

PARTICIPATE IN A STUDY ON

SELF-TRACKING TECHNOLOGIES
AND ACADEMIC PROCRASTINATION

This study is on self-tracking technologies and their impact on academic procrastination. Participation in this study includes responding to pre- and post-study questionnaires, as well as filling out weekly questionnaires for a time span of 6 weeks. You may be asked to download an app onto your phone and use it regularly. The study is not expected to take up more than 15-20 minutes of your time per week. The study is fully remote. This study will begin at the beginning of February 2023.

Participants will be compensated with a $50 AMAZON E-GIFT CARD!

To participate, you must:

✓ Be at least 18 years old
✓ Speak English
✓ Own either an iPhone (iOS 15.0+) or an iPad (iPadOS 15.0+) (*in case you are chosen to download the app)
✓ Currently an undergraduate student at Carleton University
✓ Consider yourself to be struggling with academic procrastination

If you're interested, please contact:

Maya Murad
mayamurad@cmail.carleton.ca

This study has been cleared by the Carleton University Research Ethics Board B Clearance #118650
Appendix C. Consent Forms

C.1. Usability Study Consent Form

General Informed Consent

Study Title
The Use of Quantified Self Technologies to Reduce Academic Procrastination – Usability Study

Name and Contact Information of Researchers:
Maya Murad, Carleton University, Human-Computer Interaction
Email: mayamurad@cmail.carleton.ca

Supervisor and Contact Information:
Dr. KC Collins, Carleton University, School of Information Technology
Email: KCCollins@cunet.carleton.ca

Carleton University Project Clearance
Clearance #: 118650
Study Clearance Date: November 22, 2022
Consent form version date: November 17, 2022

Project Sponsor and Funder (if any)
N/A

Invitation
You are invited to take part in a research project because you are at least 18 years of age, English-speaking, and have access to a device on which you can remotely share your screen. The information in this form is intended to help you understand what we are asking of you so that you can decide whether you agree to participate in this study. Your participation in this study is voluntary, and a decision not to participate will not be used against you in any way. As you read this form, and decide whether to participate, please ask all the questions you might have, take whatever time you need, and consult with others as you wish.

What is the purpose of the study?
Procrastination is prevalent among the general population, and it is even more common among university students; many students consider their procrastination habits to be problematic. There are several interventions for procrastination, however current solutions can be costly and time-consuming, therefore making them inaccessible to students. The purpose of this study is to examine ways in which technology can be used to help students increase awareness about their study habits. Specifically, we would like to see if the use of self-tracking technologies can help students decrease academic procrastination. You will be participating in the first stage of this study, which will help us determine the usability of the application that will be used during the main study.

What will I be asked to do?
If you agree to take part in the study, we will ask you to:

- Participate in a usability test over Zoom where you will be asked to perform a couple of tasks on an app prototype as the researcher watches your shared screen. You will be asked to “think out loud” as you perform the tasks,
meaning that you will speak out loud about your thought process. Before the usability test, you will also be asked to answer some demographic questions.

- Share your screen during the usability test.
- Participate in a short survey on Qualtrics following the usability test. The survey will ask questions about the usability of the application and allow you to give your feedback.
- Audio and screen recording will be mandatory. Video recording will be optional, and you may turn off your camera if you wish to opt-out. All audio and video data will be stored on password protected devices only accessible by the lead researcher.
- Anonymized data collected from the study may be used in future reports or publications, which may include a summary of the findings. No identifiable information will be included.

Risks and Inconveniences

We do not anticipate any risks to participating in this study.

Possible Benefits

Your participation in this study may allow researchers to better understand how technology can be used as an intervention for procrastination, and it will contribute to the growing knowledge of quantified-self technologies as well. This study may also help you gain awareness of your procrastination habits, which can help you reduce procrastinating behaviour.

Compensation/Incentives

You will be compensated with a $10 Amazon e-gift card for your participation in the study. If you are found to not meet the inclusion criteria, you will not be compensated and will be notified of this. Compensation will be sent upon completion of the post-usability test survey. It will be delivered to the email that you used to express interest in the study, which will be confirmed with you at the end of the usability study. If you decide to withdraw from the study at any time, you will still be provided with compensation.

No waiver of your rights

By signing this form, you are not waiving any rights or releasing the researchers from any liability.

Withdrawing from the study

If you withdraw your consent during the usability test or completion of the survey, all information collected from you before your withdrawal will be deleted and not used in the study.

Once you have completed the post-test survey, you will no longer be able to request that your data be removed from the study because the data will be used immediately to iterate on the design of the application.

Confidentiality

We will remove all identifying information from the study data as soon as possible, which will be after the data has been collected.

We will treat your personal information as confidential, although absolute privacy cannot be guaranteed. No information that discloses your identity will be released or published without your specific consent. Research records may be accessed by the Carleton University Research Ethics Board in order to ensure continuing ethics compliance.

All data will be kept confidential, unless release is required by law (e.g. child abuse, harm to self or others).

The results of this study may be published or presented at an academic conference or meeting, but the data will be presented so that it will not be possible to identify any participants unless you give your express consent.
We will remove all identifying information from the study data as soon as possible, which will be after the data has been collected.

You will be assigned a code so that your identity will not be directly associated with the data you have provided (e.g., P1, P2, P3…). All data, including coded information, will be kept in a password-protected file on a secure computer. A list with your identifying information and your assigned code will be saved in a password-protected USB key in a secure location in the researcher’s personal office that only they have access to.

“In-session” data, such as the audio and video from the usability test, will be recorded using Zoom’s built-in recording software and stored locally on the researcher’s computer. Consent forms and any other typed data will be backed up securely on Carleton’s Citrix ShareFile. All data on the Carleton server is secured in Carleton’s data centers.

We will password protect any research data that we store or transfer.

Data Retention
Your de-identified data will be retained for a period of 2 years and then securely destroyed.

New information during the study
In the event that any changes could affect your decision to continue participating in this study, you will be promptly informed.

Ethics review
This project was reviewed and cleared by the Carleton University Research Ethics Board B. If you have any ethical concerns with the study, please contact Carleton University Research Ethics Board (by phone at 613-520-2600 ext. 4085 (CUREB B) or by email at ethics@carleton.ca).

Statement of consent – print and sign name
I voluntarily agree to participate in this study. ___Yes ___No
I agree to be audio recorded ___Yes ___No
I agree to have my screen recorded ___Yes ___No
I agree to be video recorded (optional) ___Yes ___No
I agree to be contacted for follow up research ___Yes ___No

______________________________
Signature of participant (or parent/guardian) Date

Research team member who interacted with the participant
I have explained the study to the participant and answered any and all of their questions. The participant appeared to understand and agree. I provided a copy of the consent form to the participant for their reference.

______________________________
Signature of researcher Date
C.2. Pilot Study Consent Form

Study Title
The Use of Quantified Self Technologies to Reduce Academic Procrastination

Name and Contact Information of Researchers:
Maya Murad, Carleton University, Human-Computer Interaction
Email: mayamurad@carleton.ca

Supervisor and Contact Information:
Dr. KC Collins, Carleton University, School of Information Technology
Email: KCCollins@cunet.carleton.ca

Carleton University Project Clearance
Clearance #: 118650
Study Clearance Date: November 22, 2022
Consent form version date: November 17, 2022

Project Sponsor and Funder (if any)
N/A

Invitation
You are invited to take part in a research project because you are at least 18 years of age, English-speaking, own either an iPhone (iOS 15.0+) or an iPad (iPadOS 15.0+), currently a student at Carleton University, and consider yourself to be struggling with procrastination. The information in this form is intended to help you understand what we are asking of you so that you can decide whether you agree to participate in this study. Your participation in this study is voluntary, and a decision not to participate will not be used against you in any way. As you read this form, and decide whether to participate, please ask all the questions you might have, take whatever time you need, and consult with others as you wish.

What is the purpose of the study?
Procrastination is prevalent among the general population, and it is even more common among university students; many students consider their procrastination habits to be problematic. There are several interventions for procrastination, however current solutions can be costly and time-consuming, therefore making them inaccessible to students. The purpose of this study is to examine ways in which technology can be used to help students increase awareness about their study habits. Specifically, we would like to see if the use of self-tracking technologies can help students decrease academic procrastination. You will be participating in the pilot study, which will help us test the functionality of the app and receive initial feedback prior to the main study.

What will I be asked to do?
If you agree to take part in the study, we will ask you to:

- Participate in a short pre-study survey. The pre-study survey will contain demographic questions to confirm your eligibility.
• Participate in a post-study semi-structured interview over Zoom. The interview will consist of questions about your experience using the app and is expected to last 20-25 minutes.
• Download a self-tracking study application onto your phone, which you will be asked to use regularly over the course of 10 days.
• Report application crashes if there are any, and this information will be used solely to improve the application.
• To download the study app, you will have to download Apple’s mobile application testing app called TestFlight. You will be invited to download the beta app through a public link; therefore the researcher will not be able to see your name or e-mail. The researcher will, however, have access to other data such as the number of times the app has been installed by you, the number of times you have used the beta app, and the number of crashes but they will not be able to see which participant that this data is linked to. Your TestFlight data will be permanently deleted at the end of the study and you will lose access to the application.
• Audio recording of the interview is required. The audio recordings will be stored on a password-protected computer only accessible by the lead researcher. The files will be deleted once audio transcription is completed. Audio will be transcribed using Nvivo’s transcription service.
• Video recording of the interview is optional. You will be asked to turn off your webcam if you wish to opt-out of being video-recorded. The files will be deleted once audio transcription is completed.
• Anonymized data collected from the study may be used in future reports or publications, which may include a summary of the findings and quotes from the interviews. No identifiable information will be included.

Risks and Inconveniences
We do not anticipate any risks to participating in this study.

Possible Benefits
Your participation in this study may allow researchers to better understand how technology can be used as an intervention for procrastination, and it will contribute to the growing knowledge of quantified-self technologies as well. This study may also help you gain awareness of your procrastination habits, which can help you reduce procrastinating behaviour.

Compensation/Incentives
You will be compensated with a $25 Amazon e-gift card for your participation in the study. If you are found to not meet the inclusion criteria following the pre-study interview, you will not be compensated and will be notified of this. Compensation will be sent following the conclusion of the post-study interview. It will be delivered to the email that you used to express interest in the study, which will be confirmed with you at the end of the post-study interview. If you decide to withdraw from the study at any time, you will still be provided with compensation.

No waiver of your rights
By signing this form, you are not waiving any rights or releasing the researchers from any liability.

Withdrawing from the study
If you withdraw your consent during the usability test or completion of the survey, all information collected from you before your withdrawal will be deleted and not used in the study.

After the post-study interview, you may request that your data be removed from the study and deleted by notice given to the Principal Investigator (named above) within 1 week after your completion because the data will be used to iterate on the design of the application.
Confidentiality

We will remove all identifying information from the study data as soon as possible, which will be after the data has been collected.

We will treat your personal information as confidential, although absolute privacy cannot be guaranteed. No information that discloses your identity will be released or published without your specific consent. Research records may be accessed by the Carleton University Research Ethics Board in order to ensure continuing ethics compliance.

All data will be kept confidential, unless release is required by law (e.g., child abuse, harm to self or others).

The results of this study may be published or presented at an academic conference or meeting, but the data will be presented so that it will not be possible to identify any participants unless you give your express consent.

We will remove all identifying information from the study data as soon as possible, which will be after the data has been collected.

You will be assigned a code so that your identity will not be directly associated with the data you have provided (e.g., P1, P2, P3…). All data, including coded information, will be kept in a password-protected file on a secure computer. A list with your identifying information and your assigned code will be saved in a password-protected USB key in a secure location in the researcher’s personal office that only they have access to.

“In-session” data, such as the audio and video from the interview, will be recorded using Zoom’s built-in recording software and stored locally on the researcher’s computer. Data from the interviews will be transcribed using NVivo’s transcribing service, then the original audio and video files will be deleted once transcription is complete. Transcribed data, consent forms, and any other typed data will be backed up securely on Carleton’s Citrix ShareFile. All data on the Carleton server is secured in Carleton’s data centers.

All media files and transcripts uploaded to or produced by NVivo Transcription are encrypted while in storage and in transit. Data is securely stored in data centers located in Canada. Media files are automatically deleted by the software 90 days after they have been transcribed, however they will be deleted by the researcher directly after transcription is complete.

Apple may collect some data through the TestFlight application to improve the TestFlight app. To view and manage your data with Apple, including your data that is sent to Apple through TestFlight, you may visit https://privacy.apple.com/. To learn more about the TestFlight app, you may visit https://testflight.apple.com/. Your TestFlight data will be permanently deleted by the researcher at the end of the study.

We will password protect any research data that we store or transfer.

Data Retention

Your de-identified data will be retained for a period of 2 years and then securely destroyed.

New information during the study

In the event that any changes could affect your decision to continue participating in this study, you will be promptly informed.

Ethics review

This project was reviewed and cleared by the Carleton University Research Ethics Board B. If you have any ethical concerns with the study, please contact Carleton University Research Ethics Board (by phone at 613-520-2600 ext. 4085 (CUREB B) or by email at ethics@carleton.ca).
**Statement of consent – print and sign name**

I voluntarily agree to participate in this study. ___Yes ___No

I agree to be audio recorded ___Yes ___No

I agree to be video recorded (optional) ___Yes ___No

I agree to be contacted for follow up research ___Yes ___No

Signature of participant (or parent/guardian) ___________________________

Date ___________________________


**Research team member who interacted with the participant**

I have explained the study to the participant and answered any and all of their questions. The participant appeared to understand and agree. I provided a copy of the consent form to the participant for their reference.

Signature of researcher ___________________________

Date ___________________________
C.3. Main Study Experimental Group Consent Form

General Informed Consent for Participants

Study Title
The Use of Quantified Self Technologies to Reduce Academic Procrastination

Name and Contact Information of Researchers:
Maya Murad, Carleton University, Human-Computer Interaction
Email: mayamurad@cmail.carleton.ca

Supervisor and Contact Information:
Dr. KC Collins, Carleton University, School of Information Technology
Email: KCCollins@cunet.carleton.ca

Carleton University Project Clearance
Clearance #: 118650
Study Clearance Date: November 22, 2022
Consent form version date: November 17, 2022

Project Sponsor and Funder (If any)
N/A

Invitation
You are invited to take part in a research project because you are at least 18 years of age, English-speaking, own either an iPhone (with iOS 15.0+) or an iPad (with iPadOS 15.0+), currently a student at Carleton University, and consider yourself to be struggling with procrastination. The information in this form is intended to help you understand what we are asking of you so that you can decide whether you agree to participate in this study. Your participation in this study is voluntary, and a decision not to participate will not be used against you in any way. As you read this form, and decide whether to participate, please ask all the questions you might have, take whatever time you need, and consult with others as you wish.

What is the purpose of the study?
Procrastination is prevalent among the general population, and it is even more common among university students; many students consider their procrastination habits to be problematic. There are several interventions for procrastination, however current solutions can be costly and time-consuming, therefore making them inaccessible to students. The purpose of this study is to examine ways in which technology can be used to help students increase awareness about their study habits. Specifically, we would like to see if the use of self-tracking technologies can help students decrease academic procrastination.

What will I be asked to do?
If you agree to take part in the study, we will ask you to:

- Participate in pre- and post-study surveys. The pre-study survey will contain demographic questions to confirm your eligibility, questions about your current procrastination habits, and will ask you about your experience with self-tracking technologies and is expected to take around 10-15 minutes to fill out. The post-study survey will contain questions about your experience using the app and procrastination habits and should take around 30-40 minutes to fill out.
Download a self-tracking study application onto your phone, which you will be asked to use regularly over the course of 6 weeks. The app will not collect or record any information about you.

To download the study app, you will have to download Apple’s mobile application testing app called TestFlight. You will be invited to download the beta app through a public link; therefore the researcher will not be able to see your name or e-mail. The researcher will, however, have access to other data such as the number of times the app has been installed by you, the number of times you have used the beta app, and the number of crashes but they will not be able to see which participant this data is linked to. Your TestFlight data will be permanently deleted at the end of the study.

Fill out weekly surveys during the 6-week study (totals 5 surveys – the post-study survey will be filled out at the end of the 6th week). These surveys will contain questions about your procrastination habits over the past week and questions about your experience using the app. The surveys are expected to take 10 minutes to fill out.

Anonymized data collected from the study may be used in future reports or publications, which may include a summary of the findings and quotes from the surveys. No identifiable information will be included.

Risks and Inconveniences
We do not anticipate any risks to participating in this study.

Possible Benefits
Your participation in this study may allow researchers to better understand how technology can be used as an intervention for procrastination, and it will contribute to the growing knowledge of quantified-self technologies as well. This study may also help you gain awareness of your procrastination habits, which can help you reduce procrastinating behaviour.

Compensation/Incentives
You will be compensated with a $50 Amazon e-gift card for your participation in the study. If you are found to not meet the inclusion criteria following the pre-study survey, you will not be compensated and will be notified of this. Compensation will be sent following the conclusion of the post-study survey. It will be delivered to the email that you used to express interest in the study. If you decide to withdraw from the study at any time, you will still be provided with compensation.

No waiver of your rights
By signing this form, you are not waiving any rights or releasing the researchers from any liability.

Withdrawing from the study
If you withdraw your consent during the course of the study, all information collected from you before your withdrawal will still be used, unless you request that it be removed from the study data. If you would like to withdraw from the study without withdrawing your data, you will be invited to partake in an optional post-study survey to complete the withdrawal process.

After the study, you may request that your data be removed from the study and deleted by notice given to the Principal Investigator (named above) within 2 weeks after your completion.

Confidentiality
We will remove all identifying information from the study data as soon as possible, which will be after the data has been collected.

We will treat your personal information as confidential, although absolute privacy cannot be guaranteed. No information that discloses your identity will be released or published without your specific consent. Research records may be accessed by the Carleton University Research Ethics Board in order to ensure continuing ethics compliance.
All data will be kept confidential, unless release is required by law (e.g. child abuse, harm to self or others).

The results of this study may be published or presented at an academic conference or meeting, but the data will be presented so that it will not be possible to identify any participants unless you give your express consent.

We will remove all identifying information from the study data as soon as possible, which will be after the data has been collected.

You will be assigned a code so that your identity will not be directly associated with the data you have provided (e.g., P1, P2, P3...). All data, including coded information, will be kept in a password-protected file on a secure computer. A list with your identifying information and your assigned code will be saved in a password-protected USB key in a secure location in the researcher’s personal office that only they have access to.

Apple may collect some data through the TestFlight application to improve the TestFlight app. To view and manage your data with Apple, including your data that is sent to Apple through TestFlight, you may visit https://privacy.apple.com/. To learn more about the TestFlight app, you may visit https://testflight.apple.com/. Your TestFlight data will be permanently deleted by the researcher at the end of the study.

We will password protect any research data that we store or transfer.

Data Retention
Your de-identified data will be retained for a period of 2 years and then securely destroyed.

New information during the study
In the event that any changes could affect your decision to continue participating in this study, you will be promptly informed.

Ethics review
This project was reviewed and cleared by the Carleton University Research Ethics Board B. If you have any ethical concerns with the study, please contact Carleton University Research Ethics Board (by phone at 613-520-2600 ext. 4085 (CUREB B) or by email at ethics@carleton.ca).

Statement of consent – print and sign name
I voluntarily agree to participate in this study. __Yes __No
I agree to be contacted for follow up research __Yes __No

______________________________________ __________
Signature of participant (or parent/guardian) Date

Research team member who interacted with the participant
I have explained the study to the participant and answered any and all of their questions. The participant appeared to understand and agree. I provided a copy of the consent form to the participant for their reference.

______________________________________ __________
Signature of researcher Date
C.4. Main Study Control Group Consent Form

General Informed Consent for Participants

Study Title
The Use of Quantified Self Technologies to Reduce Academic Procrastination

Name and Contact Information of Researchers:
Maya Murad, Carleton University, Human-Computer Interaction
Email: mayamurad@email.carleton.ca

Supervisor and Contact Information:
Dr. KC Collins, Carleton University, School of Information Technology
Email: KCCollins@eunet.carleton.ca

Carleton University Project Clearance
Clearance #: 118650
Study Clearance Date: November 22, 2022
Consent form version date: November 17, 2022

Project Sponsor and Funder (if any)
N/A

Invitation
You are invited to take part in a research project because you are at least 18 years of age, English-speaking, own either an iPhone (with iOS 15.0+) or an iPad (with iPadOS 15.0+), currently a student at Carleton University, and consider yourself to be struggling with procrastination. The information in this form is intended to help you understand what we are asking of you so that you can decide whether you agree to participate in this study. Your participation in this study is voluntary, and a decision not to participate will not be used against you in any way. As you read this form, and decide whether to participate, please ask all the questions you might have, take whatever time you need, and consult with others as you wish.

What is the purpose of the study?
Procrastination is prevalent among the general population, and it is even more common among university students; many students consider their procrastination habits to be problematic. There are several interventions for procrastination, however current solutions can be costly and time-consuming, therefore making them inaccessible to students. The purpose of this study is to examine ways in which technology can be used to help students increase awareness about their study habits. Specifically, we would like to see if the use of self-tracking technologies can help students decrease academic procrastination.

What will I be asked to do?
If you agree to take part in the study, we will ask you to:

- Participate in pre- and post-study surveys. The pre-study survey will contain demographic questions to confirm your eligibility and questions about your current procrastination habits. The post-study survey will contain
questions about your procrastination habits and experience during the study. The surveys are expected to take about 10-20 minutes to complete.

- Fill out weekly surveys during the 6-week study (totals 5 surveys – the post-study survey will be filled out at the end of the 6th week). These surveys will contain questions about your procrastination habits over the past week and should take 5 minutes to fill out.
- Anonymized data collected from the study may be used in future reports or publications, which may include a summary of the findings and quotes from the surveys. No identifiable information will be included.

Risks and Inconveniences
We do not anticipate any risks to participating in this study.

Possible Benefits
Your participation in this study may allow researchers to better understand how technology can be used as an intervention for procrastination, and it will contribute to the growing knowledge of quantified-self technologies as well. This study may also help you gain awareness of your procrastination habits, which can help you reduce procrastinating behaviour.

Compensation/Incentives
You will be compensated with a $50 Amazon e-gift card for your participation in the study. If you are found to not meet the inclusion criteria following the pre-study survey, you will not be compensated and will be notified of this. Compensation will be sent following the conclusion of the post-study survey. It will be delivered to the email that you used to express interest in the study, which will be confirmed with you at the end of the post-study survey. If you decide to withdraw from the study at any time, you will still be provided with compensation.

No waiver of your rights
By signing this form, you are not waiving any rights or releasing the researchers from any liability.

Withdrawing from the study
If you withdraw your consent during the course of the study, all information collected from you before your withdrawal will still be used, unless you request that it be removed from the study data. If you would like to withdraw from the study without withdrawing your data, you will be invited to participate in an optional post-study survey to complete the withdrawal process.

After the study, you may request that your data be removed from the study and deleted by notice given to the Principal Investigator (named above) within 2 weeks after your completion.

Confidentiality
We will remove all identifying information from the study data as soon as possible, which will be after the data has been collected.

We will treat your personal information as confidential, although absolute privacy cannot be guaranteed. No information that discloses your identity will be released or published without your specific consent. Research records may be accessed by the Carleton University Research Ethics Board in order to ensure continuing ethics compliance.

All data will be kept confidential, unless release is required by law (e.g. child abuse, harm to self or others). The results of this study may be published or presented at an academic conference or meeting, but the data will be presented so that it will not be possible to identify any participants unless you give your express consent.
We will remove all identifying information from the study data as soon as possible, which will be after the data has been collected.

You will be assigned a code so that your identity will not be directly associated with the data you have provided (e.g., P1, P2, P3…). All data, including coded information, will be kept in a password-protected file on a secure computer. A list with your identifying information and your assigned code will be saved in a password-protected USB key in a secure location in the researcher’s personal office that only they have access to.

We will password protect any research data that we store or transfer.

**Data Retention**

Your de-identified data will be retained for a period of 2 years and then securely destroyed.

**New information during the study**

In the event that any changes could affect your decision to continue participating in this study, you will be promptly informed.

**Ethics review**

This project was reviewed and cleared by the Carleton University Research Ethics Board B. If you have any ethical concerns with the study, please contact Carleton University Research Ethics Board (by phone at 613-520-2600 ext. 4085 (CUREB B) or by email at ethics@carleton.ca).

**Statement of consent – print and sign name**

<table>
<thead>
<tr>
<th>I voluntarily agree to participate in this study.</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>I agree to be contacted for follow up research</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

Signature of participant (or parent/guardian) Date

**Research team member who interacted with the participant**

I have explained the study to the participant and answered any and all of their questions. The participant appeared to understand and agree. I provided a copy of the consent form to the participant for their reference.

Signature of researcher Date
Appendix D. Usability Study Interview Script

Debriefing

Today we’re performing this session to figure out if this application is easy to use or not. The application is supposed to be a study timer, with which you can time your academic-related tasks and keep track of the amount of time that you spend doing schoolwork. The app also provides feedback in the form of graphs and charts. This session will consist of 3 parts.

1. First, I will ask you some general questions about yourself which should only take 2-3 minutes.
2. Then, I will give you a link to a prototype of the application. You will need to share your screen for this part of the session. I will ask you to perform some actions on the prototype. Since it is a prototype, not everything will fully work, so I will fill in the blanks if something is not working as it should.
3. After the prototype activity, I will give you a link to a survey containing questions about how easy you found the application to use and your thoughts on the design, which you can fill out once the meeting is over. It should only take 5-10 minutes to fill out.

Since we are trying to figure out how easy the application is to use, I won’t be able to answer any questions you may have. Just remember, we are testing the application, not you. Nothing is wrong or right in this session.

As we are going through the tasks, I would also like you to “think out loud”, meaning that I would like you to express your thought process as you perform each step.

I would like to record audio and video of this session; do I get your consent to begin recording? If you would not like the video to be recorded, you may turn off your camera now (if it is not already off).

[Wait for participant consent then begin recording]

Great! Now we will begin with some general questions:

Pre-test Demographic Questions

1. How old are you?
   [Participant response]

2. What gender do you identify as (you may prefer not to say)?
   [Participant response]

3. What is your occupation (you may be as specific or general as you wish)?
   [Participant response]

4. How would you rate your technical abilities on a scale of 1-5? 1 being that you are not comfortable with technology at all, and 5 being that you are fully confident with using technology.
   [Participant response]

Now I would like you to share your screen [guide the participant through sharing screen if they do not know how]. I will provide you with a link to the Prototype in the Zoom chat. Now, using the prototype, I would like you to perform some tasks. Don’t forget to think out loud, and once again, there are no wrong or right answers. Do you have any questions before we begin? [Participant response, answer questions if any] Alright, let’s begin...
Usability Test Scenarios

Now, I’m going to guide you through some scenarios:

1. You want to begin studying so you would like to begin the timer. You want to tag the study session. How would you do this? (Task: Begin a tagged study session) [Wait for participant to perform task]

2. You want to add a new tag into your existing tags. (Task: Add a new tag) [Wait for participant to perform task]

3. You want to check out some stats from the past week about your study habits. Does the information on this page make sense to you? (Task: Look at your Weekly charts overview) [Wait for participant to perform task]

4. Now you would like to check out your stats from yesterday. [Wait for participant to perform task]

5. Now you want to edit one of your tags. [Wait for participant to perform task]

6. You want to edit your most recent study session because you forgot to stop it at the right time. How would you go about doing this? (Tasks: Go to your study session history, edit a study session) [Wait for participant to perform task]

Great! We are all done the tasks. Thank you for your participation in this study. Now I will provide you with a link to a survey, which I recommend filling out right after this session ends. [Send participant the link to the survey in the Zoom chat]

Do you have any questions or comments before we end the session? [Participant Response]

Thank you again for your participation.
Appendix E. Pilot Study Materials

E.1. Pre-Study Questionnaire

1. Please enter your participant code provided to you by the researcher: 

2. How old are you? 

3. What gender do you identify as? 
   - Male 
   - Female 
   - Non-binary 
   - Other (option to specify): 
   - Prefer not to say 

4. Are you currently a student at Carleton University? 
   - Yes, I am an undergraduate student 
   - Yes, I am a Master’s student 
   - Yes, I am a PhD student 
   - Yes, other (please explain): 
   - No 

5. Do you consider yourself to be struggling with academic procrastination? 
   - Yes 
   - No 

6. Do you own either an iPhone with iOS 15.0+ or an iPad with iPadOS 15.0+? 
   - Yes 
   - No 

7. What is your experience with self-tracking technologies (for example, fitness trackers, mood trackers, etc.)? 

8. Are you currently using any self-tracking technologies? If so, what? 

E.2. Post-Study Semi-Structured Interview Questions

1. How often did you end up using the application? (If you did not use it often – Why did you not end up using it often?)
2. Did you enjoy using the application? Why or why not?
3. Was the application working as expected? (Were there any bugs?)
4. Are there any features that you would want to be added to the application?
5. What do you think about the visual design of the application?
6. Which visualizations (i.e., charts, graphs) in the “Charts” section did you find the most useful?
7. Are there any other types of feedback/charts that you would find useful to have?
8. Is there anything else that you would change about the application?
9. Have you noticed a change in your procrastination habits over the past 10 days? Why do you think there was a change?
10. Do you think that this application would help you stop procrastinating if you continued using it? Why or why not?
Appendix F. Main Study Materials

F.1. Academic Procrastination Scale

How much do you, yourself agree with the following statements? (Scored on a 1 to 5 Likert-type scale, with 1=Disagree and 5=Agree)

1. I usually allocate time to review and proofread my work.
2. I put off projects until the last minute.
3. I have found myself waiting until the day before to start a big project.
4. I know I should work on school work, but I just don’t do it.
5. When working on schoolwork, I usually get distracted by other things.
6. I waste a lot of time on unimportant things.
7. I get distracted by other, more fun, things when I am supposed to work on schoolwork.
8. I concentrate on school work instead of other distractions.
9. I can’t focus on school work or projects for more than an hour until I get distracted.
10. My attention span for schoolwork is very short.
11. Tests are meant to be studied for just the night before.
12. I feel prepared well in advance for most tests.
13. “Cramming” and last minute studying is the best way that I study for big tests.
14. I allocate time so I don’t have to “cram” at the end of the semester.
15. I only study the night before exams.
16. If an assignment is due at midnight, I will work on it until 11:59.
17. When given an assignment, I usually put it away and forget about it until it is almost due.
18. Friends usually distract me from schoolwork.
19. I find myself talking to friends or family instead of working on school work.
20. On the weekends, I make plans to do homework and projects, but I get distracted and hang out with friends.
21. I tend to put off things for the next day.
22. I don’t spend much time studying school material until the end of the semester.
23. I frequently find myself putting important deadlines off.
24. If I don’t understand something, I’ll usually wait until the night before a test to figure it out.
25. I read the textbook and look over notes before coming to class and listening to a lecture or teacher.

F.2. Academic Procrastination Scale – Short Form

How much do you, yourself agree to the following statements? (Scored on a 1 to 5 Likert-type scale, with 1=Disagree and 5=Agree)

1. I put off projects until the last minute.
2. I know I should work on schoolwork, but I just don’t do it.
3. I get distracted by other, more fun, things when I am supposed to work on schoolwork.
4. When given an assignment, I usually put it away and forget about it until it is almost due.
5. I frequently find myself putting important deadlines off.
F.3. Pre-Study Questionnaire

1. Please enter your participant code provided to you by the researcher: 

2. How old are you? 

3. What gender do you identify as? 
   - Male 
   - Female 
   - Non-binary 
   - Other (option to specify): 
   - Prefer not to say 

4. Are you currently an undergraduate student at Carleton University? 
   - Yes, I am an undergraduate student 
   - No, I am not an undergraduate student 

5. Do you consider yourself to be struggling with academic procrastination? 
   - Yes 
   - No 

6. Do you own either an iPhone with iOS 15.0+ or an iPad with iPadOS 15.0+? [Question for Experimental Group Only] 
   - Yes 
   - No 

7. Have you ever tried anything to help you reduce your procrastination? If YES, what have you tried? 

8. Are you currently using any tools/techniques to help you reduce procrastination? If YES, what tools/techniques are you using? 

9. What is your experience with self-tracking technologies (for example, fitness trackers/watches, mood trackers, etc.)? [Question for Experimental Group Only] 

10. Are you currently using any self-tracking technologies? If so, what? [Question for Experimental Group Only] 

11. [Academic Procrastination Scale (Shown Above)]
F.4. Weekly Survey

1. Please enter your participant code provided to you by the researcher:

2. Thinking back at the past week... [Academic Procrastination Scale – Short Form (Shown Above)]

3. Approximately how often have you been using the app during academic-related tasks? [Question for Experimental Group Only]
   - Never (approx. 0% of the time)
   - Sometimes (approx. 25% of the time)
   - About half the time (approx. 50% of the time)
   - Most of the time (approx. 75% of the time)
   - Always (approx. 100% of the time)

4. Explain why you have been using the application never/sometimes/about half the time/most of the time/always. [Question was customized according to their previous response] [Question for Experimental Group Only]

5. Do you enjoy using the app? Why/why not? [Question for Experimental Group Only]

6. Do you feel like the self-tracking application has helped you reduce procrastination this week? Why/why not? [Question for Experimental Group Only]

7. Do you have any other comments about your experience using the app? [Question for Experimental Group Only]
F.5. Post-Study Questionnaire

Section 1: Final Weekly Survey

[Participants were given the Weekly Survey (Shown Above) to respond to]

Section 2: Overall Reflection (For Control Group)

1. Do you think responding to the weekly procrastination questionnaire had a positive impact on your procrastination habits over the past 6 weeks?
   - Yes
   - No

2. Why do/Why don’t you think responding to the weekly procrastination questionnaire had a positive impact on your procrastination habits? [Question was customized according to previous response]

Section 2: Overall Reflection (For Experimental Group)

1. Reflect on and describe your overall experience with the self-tracking application for the past 6 weeks.
   - Extremely effective
   - Very effective
   - Moderately effective
   - Slightly effective
   - Not effective at all

2. Why do you think the app was effective/moderately effective/slightly effective/not effective in changing your procrastination habits? [Question was customized according to previous response]

3. Do you think responding to the weekly procrastination questionnaire had a positive impact on your procrastination habits over the past 6 weeks? *NOTE: This question is strictly about the weekly procrastination habits survey, not about the app
   - Yes
   - No

4. Why do/Why don’t you think responding to the weekly procrastination questionnaire had a positive impact on your procrastination habits? [Question was customized according to previous response]
5. Which charts did you find the most helpful/effective? Select up to five charts.  
[All chart names were provided as radio buttons for the participant to select from]

6. Please rank your selected choices (1 being most helpful/favourite).  
[Selected charts from previous question were provided for the participant to rank]

7. Explain why you found each of these charts helpful.

8. Are there any charts or data visualizations that you felt were missing from the application? Briefly explain why you feel like these would be helpful.

9. Are there any features of the application that you particularly liked? Briefly explain why you liked these features.

10. Are there any features you would add to the app to make it more effective? Briefly explain why you think these features would make the app more effective.

11. How likely are you to use an app to track your studying in the future?  
   - Extremely Likely  
   - Likely  
   - Unsure/Neutral  
   - Unlikely  
   - Extremely unlikely

12. Do you have any other comments about your overall experience using the self-tracking app or about the app itself?

Section 3: Academic Procrastination Scale

After the past 6 weeks.... [Academic Procrastination Scale (Shown Above)]