Z^3-Wellness: Evaluating and Improving a Sleep Wellness Application for College-Age Students

A Major Qualifying Project

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Abstract

The Z^3-Wellness application provides a platform for college students to monitor their sleep and wellness patterns. The application has been developed by a sequence of WPI Major Qualifying Project (MQP) teams, who have improved and expanded its functionality over the years. Our team continued this through a focused user study, which highlighted a need to fix specific functionality and improve navigation. This resulted in development of a new user interface, a refined backend, stronger error handling, and reformatting of the frontend to allow for easier use and further development of the app.

Acknowledgements

Our team would like to thank the individuals and groups that assisted us in the completion of our project. Firstly, this project would not have been possible without our advisor, Professor Carolina Ruiz, who was always available to aid us with any issues we encountered. Ruth McKeogh, Director of WPI's Human Subjects Research and Academic Programs, was also a crucial aid for our team throughout the entire user study process, and we would not have been able to conduct our study without her. We would also like to acknowledge Dr. Ermal Toto and the rest of the WPI Academic & Research Computing (ARC) Unix team for their help with accessing the application and other additional tools that were needed. Finally, we thank the individuals who took the time to participate in our user study.

Table of Contents

List of Figures

1. Introduction

Sleep health plays a crucial role in overall health and well-being, and the repercussions of not getting enough sleep can be troublesome, especially for college students. Sleep deprivation in students can lead to poor performance in academics and increased risk of mood disturbances (Hershner and Chervin, 2014). For college students, who already face high levels of stress and demanding schedules, adequate sleep is vital for mental well-being, learning, and physical health. The National Sleep Foundation qualifies 7-9 hours per day as an adequate amount of sleep for people ages 18-25 (National Sleep Foundation, 2020).

There are numerous methods for tracking sleeping habits, such as a handwritten dream diary or a digital sleep health application. Recently, more people have been opting into digital solutions for their sleep wellness needs (Karasneh et al., 2022). Today, there are hundreds of sleep apps available for download or purchase, each with their own unique sets of functionality to help improve the user's sleep. Some of these functionalities include sleep and mood trackers, personalized trend charts, guided meditations, and white noise recordings. All of these apps often have the same goal of promoting healthy sleep habits and raising awareness for sleep conditions (Ananth, 2021).

Groups of students from Worcester Polytechnic Institute (WPI) have taken on the task of developing a web-based sleep management application called Z^3-Wellness, which aims to accomplish these exact goals, particularly for college students. The development and improvement of this app have been the focus of several Major Qualifying Projects, or MQPs (Nguyen, 2018; Armstrong et al., 2020; Kim & Mejia, 2023). Z^3-Wellness, formerly *SleepHealth*, has evolved drastically since Holly Nguyen first added personality trait and chronotype tests to its list of functionalities in 2018. Since then, other groups of students have implemented daily routine management, meditation resources, and trackers for sleep, mood, and exercise.

The large size of our group allowed us to continue development on the app through the exploration of users' attitudes toward these existing features. To gather feedback, we conducted a user study and implemented new features based on the results. With the information gained from the study, we focused on improving the application and gearing it toward our target demographic while preserving much of the previous group's foundations.

2. Background

In this section, we explore the significance of sleep health and its impact on the well-being of college students. We also investigate existing technology aimed at enhancing one's sleep quality, including the previous version of our Z^3-Wellness application, and delve into methodologies that could be employed prior to implementing new features.

2.1 Sleep Health

Sleep health has been defined as the "multidimensional pattern of sleep-wakefulness, adapted to individual, social, and environmental demands, promoting physical and mental well-being" (Buysse, 2014). Sleep is a vital resource for the human brain to properly function as it plays a crucial role in cognitive functioning, physiological processes, mood regulation, physical development, and overall quality of life. While sleep can have similar benefits for many individuals, the recommended hours of sleep vary for all age groups. According to the National Sleep Foundation, adults who are 18-25 years old are recommended to get 7-9 hours of sleep daily (National Sleep Foundation, 2020). Similarly, the Centers for Disease Control and Prevention (CDC), American Academy of Sleep Medicine (AASM), and Sleep Research Society (SRS) suggest 7 hours or more on a regular basis (CDC, 2022; Watson et al., 2015). Despite this suggestion, a 2022 Gallup poll revealed that 1 in 3 American adults reported their sleep as "fair" or "poor", indicating that many people fail to get high-quality sleep (Gallup Inc, 2022.). This lack of adequate rest can lead to harmful short and long-term effects including fatigue, mood swings, and neurocognitive slowing (Klumpers et al., 2015).

2.2 Sleep Health in College Students

Negative effects due to a lack of sleep are especially prominent in college students. Studies show that as many as 70% of college age students get less than 8 hours of sleep a night (Hershner and Chervin, 2014). Due to the overwhelming number of ongoing responsibilities in a college student's life, many find it difficult to fit the recommended hours of sleep into their schedule. Over time, this has become a significant issue for most students as it begins to affect their everyday functions. A study found that students who sleep fewer hours along with poorer quality of rest tend to perform worse than students who have a more consistent and overall better quality of sleep (Okano et al., 2019). Many students have also developed sleep disorders due to irregular sleep habits, stemming from their lack of rest and other prevalent factors (Schlarb et al., 2017).

2.3 Factors Which Affect Sleep

Sleep health is affected by numerous internal and external factors. To gain a better understanding of how sleep can impact one's mental and physical well-being, it is necessary to examine these factors closely, and identify in what ways they impact sleep. This section specifically focuses on the following factors: caffeine, mood, hydration, and exercise.

2.3.1 Caffeine

There is substantial evidence of caffeine enhancing performance, which is often why people consume it in beverages, food, and medications (Gardiner et al., 2023). The stimulant activates the central nervous system and results in a decrease in feelings of fatigue and sleepiness during the day. However, the overuse of caffeine can be detrimental to regulating and maintaining a consistent resting schedule and can lead to disrupted sleep throughout the night. Caffeine consumption has been found to influence the production of melatonin, a hormone that helps regulate our circadian rhythms (O'Callaghan et al., 2018). With the disruption in melatonin production, it is more difficult for individuals to fall asleep after consuming caffeine. Total sleep time is significantly reduced when larger doses of caffeine are consumed closer to bedtime (Gardiner et al., 2023). Because of its impact on sleep health, it is crucial to monitor daily caffeine intake as it can significantly decrease the amount and quality of sleep over a long period of time.

2.3.2 Mood/Stress

Sleep is closely related to mood, as one can affect the other. It can be seen in the concept of sleep reactivity, which is the trait-like degree to which stress exposure disrupts sleep, resulting in difficulty falling and staying asleep (Kalmbach et al., 2018). The higher the sleep reactivity of an individual, the more disturbed and deteriorated sleep quality they experience. It was also found that these individuals experience decreased REM sleep, which indicates a person dreaming in deep sleep and could be a potential psychological indicator of insomnia. People who have higher sleep reactivity also experience depression and anxiety, as excessive sleep reactivity directly increases the risk of depression and is further amplified by sleep disturbances. Tracking moods on a regular basis may help individuals become aware of their emotions in order to take steps to regulate them. Identifying potential triggers for a worsening mood could be beneficial in improving one's well-being.

2.3.3 Hydration

Hydration plays a pivotal role in sleep health, influencing an individual's ability to achieve restful and uninterrupted sleep. Adequate hydration is essential for maintaining various bodily functions, including those that regulate sleep patterns. Dehydration, which occurs when the body loses more fluids than it takes in, can have adverse effects on sleep quality. When the body is dehydrated, it may trigger sensations of thirst that can wake individuals from their slumber, interrupting their sleep cycle.

Moreover, studies have suggested that dehydration can affect the body's ability to regulate its internal temperature, making it more challenging to achieve and maintain a comfortable sleep environment (Wang and Biró, 2021). As the body struggles to cool down, individuals may experience restless and fitful sleep, leading to reduced overall sleep duration and quality. Hydration levels can also impact the production of important sleep-related hormones, such as vasopressin, which helps regulate the body's water balance. When the body is adequately hydrated, it can support the secretion of vasopressin, contributing to a more stable sleep pattern (Wang and Biró, 2021). Therefore, maintaining proper hydration by drinking enough water during waking hours is crucial for promoting optimal sleep hygiene and ensuring a restorative night's sleep.

2.3.4 Exercise

Physical activity and exercise are significant factors that can impact an individual's sleep patterns. Thus, understanding the relationship between exercise and sleep is crucial for achieving better sleep quality and overall well-being. Engaging in physical activity helps to reduce the time it takes to fall asleep, increase total sleep time, and enhance sleep efficiency (Dolezal et al., 2017). These positive effects are often attributed to the body's increased production of sleep-promoting hormones, such as serotonin and endorphins, which are released during physical exertion.

However, the timing and intensity of exercise can have adverse effects on sleep. Vigorous exercise too close to bedtime may have a stimulating effect. Therefore, it is generally recommended to finish intense workouts at least a few hours before bedtime to allow the body to return to a more relaxed state. Conversely, adopting a consistent exercise routine that incorporates moderate-intensity physical activity during the day can lead to improved sleep patterns over time. Regular exercise helps regulate the body's internal clock, or circadian rhythm, promoting a more predictable sleep-wake cycle (Dolezal et al., 2017). This, in turn, can contribute to better sleep quality and overall sleep health.

2.4 Sleep Wellness and Enhancing Applications

To familiarize ourselves with the current standard of available sleep health apps, we decided to test a variety of available options on the market. This allowed us to more thoroughly evaluate the current state of the Z^3-Wellness application and led to an educated discussion as to where the current app is lacking, and what improvements we could implement. The apps we chose to test were: Calm, ShutEye, Sleep++, Sleep on Android, SnoreLab, and Pillow. Aside from logging the users' wake and bed times, there were many interesting features across the set of apps that enhanced the user experience.

In any app that collects sleep health data, it is intuitive that the app also displays the collected information back to the user. The most common way that the apps presented sleep-related data was in a day-to-day format showing data about individual nights of sleep in sequence. Some focused on the specific details about a single night of sleep such as different sleep stages, snoring, and general sleep health, while others compared general data directly between different nights. Additionally, the Sleep++ app had a unique way of presenting data by grouping all collected data by days of the week to show overall sleep trends on given days. Figure 1 shows an example dashboard from ShutEye that effectively displays sleep data in an aesthetically pleasing and interpretable manner. Visualizations such as these are crucial for users to interpret sleep patterns. With more flexibility in such visualizations, users can gain more valuable insights and thus improve their sleep health.

Figure 1. *ShutEye statistics dashboard*

Another common feature across several of the apps we tested involved prompting users to answer a series of questions upon opening the app. This approach is convenient for users who want to quickly enter important information, and is also convenient for the initial setup process.

For example, The Sleep++ app gives users a survey about what kind of sleeper they are and the ShutEye app uses startup questions for new users to answer about their current sleep habits, and displays the various features the app has to offer. Presenting information to users in this way can reduce the amount of time users have to spend navigating through the app to complete important tasks, and is a great way to familiarize new users with the app.

Many of the apps we tested offered various forms of sleep-related media to complement the tracking aspect of the app. Some examples of this included white noise recordings, relaxing audiobooks, guided meditations, and explanations of common sleep-related disorders. Presenting these resources gives people more to explore on the app and strengthens the user experience. The media can also be used as an educational tool to teach users about sleep health and encourage better sleep habits. Providing additional content outside of sleep tracking functionality is a standard of modern sleep apps and can greatly benefit users.

2.5 Previous State of the Z^3-Wellness Application

The Z^3-Wellness web-based application encompassed a multitude of features and implementations. Users were required to log in using their Google, WPI email, or Facebook credentials to obtain access to the application. Upon gaining access, the application's main page, shown in Figure 2.1, offered six primary features, which students can navigate and utilize at their discretion. These features extended beyond sleep wellness, including a diverse array of tools such as personality assessments, yoga and meditation videos, and various health metric trackers. Figures 2.2 and 2.3 show the previous application’s page for mindfulness and the personality tracker page, respectively.

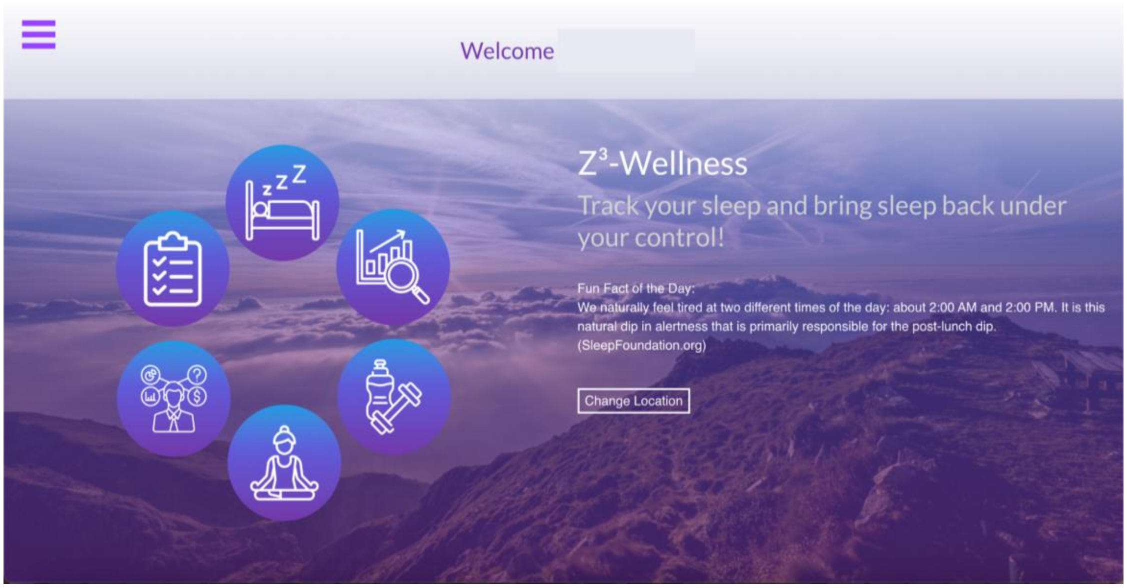

Figure 2.1 *Previous application Welcome page*

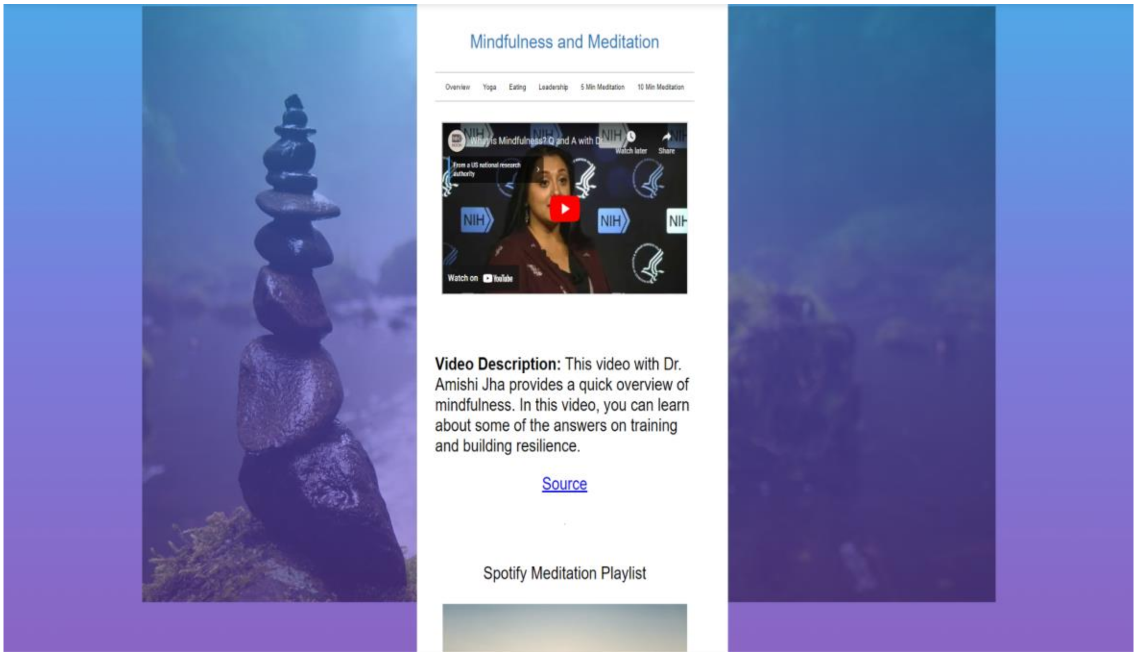

Figure 2.2 *Previous application Mindfulness and Meditation page*

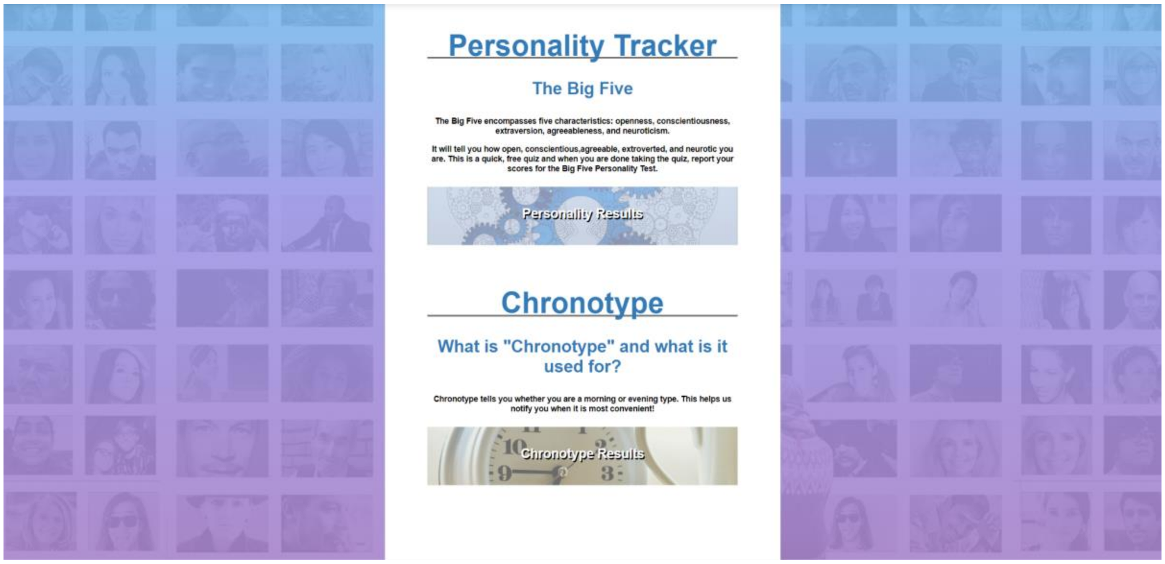

Figure 2.3 *Previous application Personality Tracker page*

Despite the variety of features the application offered, there were a multitude of issues that had not yet been addressed. Some of these issues included inconsistent functionality across browsers, incorrect statistical displays, and unfinished data logging mechanisms. Furthermore, a considerable number of the packages and dependencies the app relied on were outdated or unfit for current industry standards.

2.6 Suggestions from Previous Group

The previous MQP group provided valuable recommendations aimed at enhancing the application's quality and augmenting user retention (Kim and Mejia, 2023). Their suggestions included the integration of Apple Watch, similar to the integration of Fitbit already implemented in the app. In addition to this, the majority of their recommendations focused on optimization strategies. These encompassed exploring the capabilities of D3.js for more flexible and dynamic data visualization. On the backend, they advised capitalizing on the adaptability of PostgreSQL, potentially enabling future teams to establish a versatile database structure that supports task customization through the recording of task data in JSON format. Lastly, they recommended a thorough investigation into the application's compatibility issues with different browsers as their experience revealed errors when running the application in Firefox (Kim and Mejia, 2023). This divergence was attributed to disparities in outdated React components in React.js, given that React applications compile differently for individual browsers.

2.7 User Studies

In the context of evaluating an artifact and its functionality, user studies are one form of information gathering in which individuals are asked to interact with the artifact and provide their opinions on its functionality (Wilson-Davis, 1977). The main goal of a user study in this context is typically to gain insights from an external perspective about why certain features are effective and/or how other features can be improved (Kosara et al., 2003).

When organizing a user study, it is important to consider how data will be collected from participants. One option is to create a survey as studies have found that electronic surveys in particular are capable of collecting large amounts of information, which can be representative of a larger population in a timely manner (Jones et al., 2013). Gathering data through an electronic survey can increase the number of possible participants a user study can feasibly have, and provides researchers with ample representative data to analyze. This method is also largely preferred by users and researchers alike when the artifact in testing is also electronic.

2.7.1 Sample Size

When deciding the sample size of a survey, one must aim for diversity and representation while also considering feasibility. A representative sample size is not necessarily large in numbers, but rather in perspectives. In one study done throughout the entire state of California, researchers were unable to interview every resident due to the massive state population, so instead a representative sample was created by selecting individuals from different geographic areas and neighborhoods across the state (Case, 2002, p. 195). This method allowed researchers to collect unbiased and fully representative data while successfully trimming the interview pool to a feasible number.

Some research involves gaining information multiple times from the same source over the course of the study. One study was tasked with obtaining information that would be representative of an entire college campus on the topic of researching in an academic setting. The researchers recruited only 31 individuals at Stanford University but still managed to collect 2,050 data points to analyze (Case, 2002, p. 205). This was achieved through gaining insights from the informant several times per day.

2.7.2 Ethics of User Studies

Conducting a user study with first-hand interactions necessitates research on the ethics of working with users. Surveys require individuals to answer many, sometimes personal, questions, and these individuals must be willing to do so, as voluntariness is essential to the respect for all participating persons (Bailey, 2018). An ideal study would have more volunteers than necessary to account for individuals who decide to opt-out before the research is completed.

Preserving user confidentiality is another important ethical consideration. In our case, Z^3-Wellness is a sleep health app, and people have a fundamental right to privacy, especially concerning their health information. Researchers who collect said data have a duty to protect their subjects without question or judgment.

3. Collecting User Feedback: Methodology

The first step toward our goal of improving the Z^3-Wellness application was to collect user feedback. This was accomplished through two main data collection methods: researcher experience and a user study. Researcher experience refers to experience that the team gathered through the initial use and testing of the application, gained mainly in the weeks leading up to the beginning of our project. The user study was conducted with the goal of obtaining large-scale user feedback from the target audience. The data collected from both methods were to be used in improving and updating the application, tailoring it to users' needs.

3.1 Researcher Experience

Prior to beginning this project, our team was encouraged to integrate the Z^3-Wellness application into our daily routines. Over the course of two months, we utilized the application individually and kept notes on our experiences, which we shared upon the start of the project. Due to the diversity of our group members, these notes provided several insights into how the application was received from different perspectives. These insights primarily discussed the application's unorganized User Interface (UI) structure, as it was difficult for us to navigate and continue to use consistently.

Along with our own observations, there were several suggestions left by the previous MQP group on how to further enhance the application. This team had spent several months working with the application at the time of providing recommendations, making their insights highly valuable. These suggestions consisted of changes to the application's external integrations and execution.

3.2 User Study

To decide what application features to include or improve upon, we needed to learn about our intended users' desires. A user study is the preferred research method in cases where a product will be used by a specific population because it focuses on the system's ability to respond to the users' needs and provide feedback in an efficient manner (Wilson-Davis, 1977). Since the target population was college-age students, hosting a campus-wide study was crucial in catering our application toward users' needs.

3.2.1 Recruitment

Our study was made available and advertised to the entirety of the WPI student body, with the understanding that only a fraction of the population would express interest in participating. The initial goal was to recruit around 75-100 students to become active participants over the course of the two-week long study, starting November 28th, 2023 and ending December 12th, 2023. A flier that linked to a Qualtrics survey was distributed one week prior to the beginning of the study through personal interactions, student organizations, and online platforms. This initial pre-screening survey (Appendix B), was used to gauge interest in the study, determine if those who answered were able and willing to partake, and gather relevant information users may have on using sleep health applications.

3.2.2 User Procedure

Once the study officially began, students who were eligible to partake in the study were sent an email that contained video instructions on how to create an account on the application and begin their experience with Z^3-Wellness. Participants were asked to utilize the app's components and features regularly for two weeks, fill out a mid-study survey sent after one week had passed, and complete a post-study survey sent on the last day of the two-week study. These surveys provided users with a space for constructive feedback and criticism (Appendices C and D). Users were sent emails every three days that reminded them to use the application and complete the surveys. To further encourage participation, users who were deemed 'active' were entered in four raffles, each one with one of the following prizes: a $100, a $50, and two $25 gift cards to a location or store of the winner's choosing. Raffle eligibility (i.e., 'active' user status) was determined by the completion of all three surveys and regular use of the application, which was defined as ten to fourteen days of application use and data logging.

3.2.3 Data Collected

The team collected a wide range of data from the user study through both the surveys and application use, with each providing unique information about the users' experiences while using Z^3-Wellness. Survey questions gave us insight into the student backgrounds and demographics, including academic study, class year, and club activities. This informed us on how a participant's background might affect their responses and existing biases in the study due to the collected sample. Through structured multiple-choice and open-ended questions, participants were able to provide feedback on the application's user interface, ease of use, accessibility, bugs, and content available for everyday use. This approach enabled them to freely express their opinions and strengthened the robustness of our feedback analysis.

Further data was obtained through the application's authentication dashboard, Firebase. This provided our team with important analytics such as the number of new accounts and the engagement on each web page. The Firebase also contains information on what time people most commonly accessed the app, the most popular data tracking features, deeper insight into app functionality, and data for future machine learning applications.

4. Collecting User Feedback: Results

Through researcher experience and the user study, our team was able to collect valuable insights into potential areas for improving the Z^3-Wellness application. In this section, we discuss the initial issues that were noticed during testing, suggested changes to existing features, and newly proposed features.

4.1 Researcher Experience

Utilizing the Z^3-Wellness application prior to the user study provided our team with several insights. Our focus rested on any issues or suggestions that multiple group members discovered separately. An initial problem was that signing up for the application through Facebook was not possible when researchers began using the application. Due to the complex nature of the problem, the Facebook sign-in option was removed before the user study.

Another common occurrence was researchers forgetting to input data on a regular basis. Unanimously, our team decided that notifications would promote more regular usage of the application. Several researchers proposed the development of a Chrome extension to facilitate the delivery of notification reminders along with improving ease of access for Chrome users. This prompted us to create a draft of an extension, shown in Figure 3 below, which was shown to the user study participants.

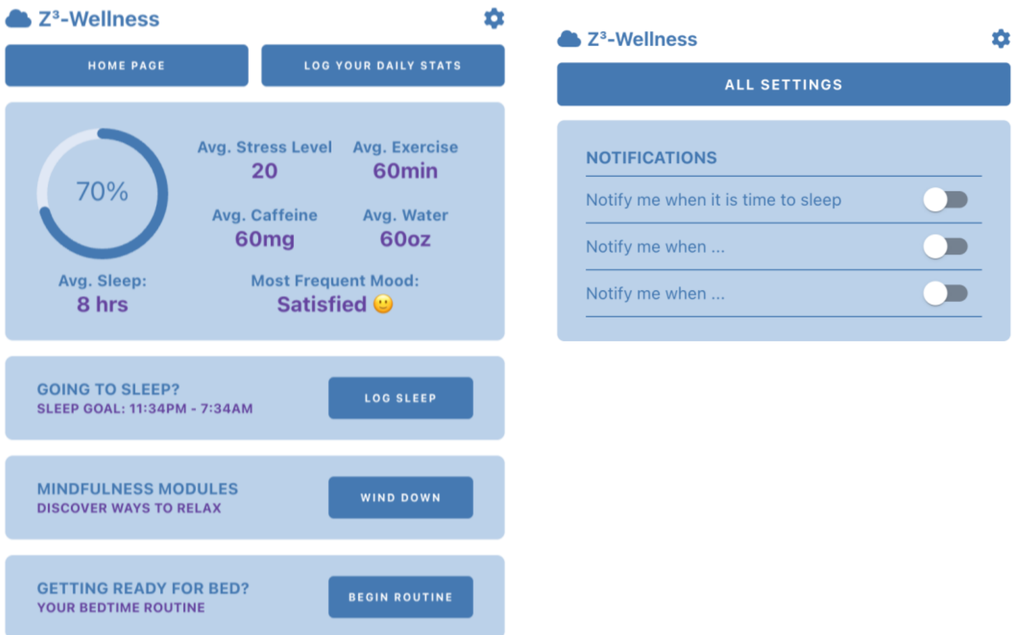

Figure 3. *Proposed Chrome Extension*

One suggestion from the previous group was to look into integrating the application with Apple watches, in a similar fashion to the existing integration with Fitbit trackers. They also mentioned that potential improvements could be made to the application's visuals, which was considered when moving forward with this project (Kim and Mejia, 2023). A mock-up design for a new dashboard, shown in Figure 4 below, was created and displayed to the user study participants with the extension.

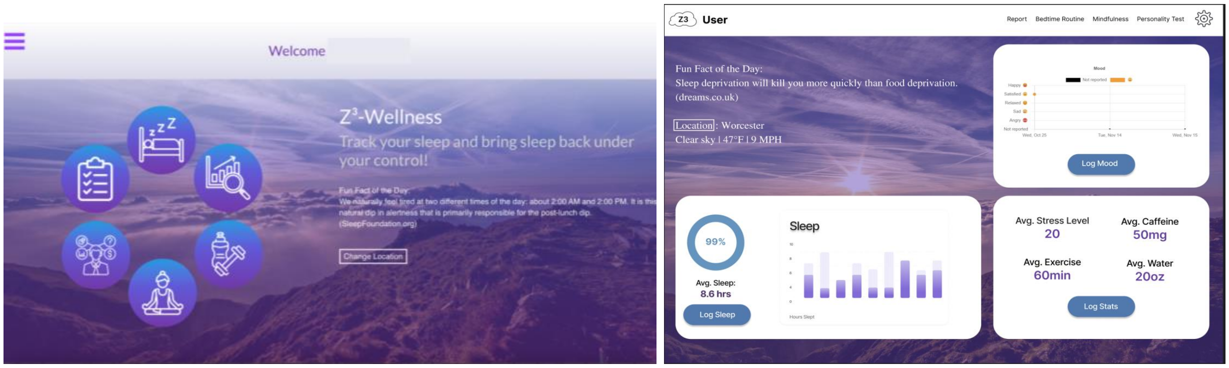

Figure 4. *Old dashboard (left) and proposed dashboard (right)*

4.2 User Study

Our initial goal of 75 to 100 participants was met through our pre-screening survey, with a total of 75 respondents who signed up before the official study start date. Within the designated two-week study timeframe, there was a large drop off in participation, with our final count of 32 active participants. Once the study was completed, the results from all three surveys were compiled and analyzed to gather insight into the users' experiences while using the Z^3-Wellness application. We utilized the suggestions and feedback from these participants to establish our main set of goals for the remainder of our project, leaving aspects that were out of the scope of our project timeline as priority recommendations within the Future Work section.

4.2.1 Survey Demographics

The user study results consisted of 75 student responses in the pre-screening survey, 36 in the mid-study survey, and 33 in the post-study survey. In the pre-screening survey, students provided information on their major, minor, year of graduation, and club affiliation. The response distributions of these questions across all three surveys are shown below in Figure 5.

The most common majors among students were computer science, mechanical engineering, civil engineering, and biomedical engineering with the majority of students not having a minor. Most students who responded to the surveys were from the graduation classes of 2024 and 2025 and were affiliated with club sports, Greek life, or professional development clubs. While these distributions showcased the predominant majors and minors at WPI, the results of this study may not fully represent the entire student population due to the small sample sizes of our results. There were also very few respondents from the remaining undergraduate classes or at the graduate level and there was a noticeable difference between the participants across the categories of student club associations. These findings may encounter limitations regarding their generalizability, as many areas of the student population are underrepresented in our sample.

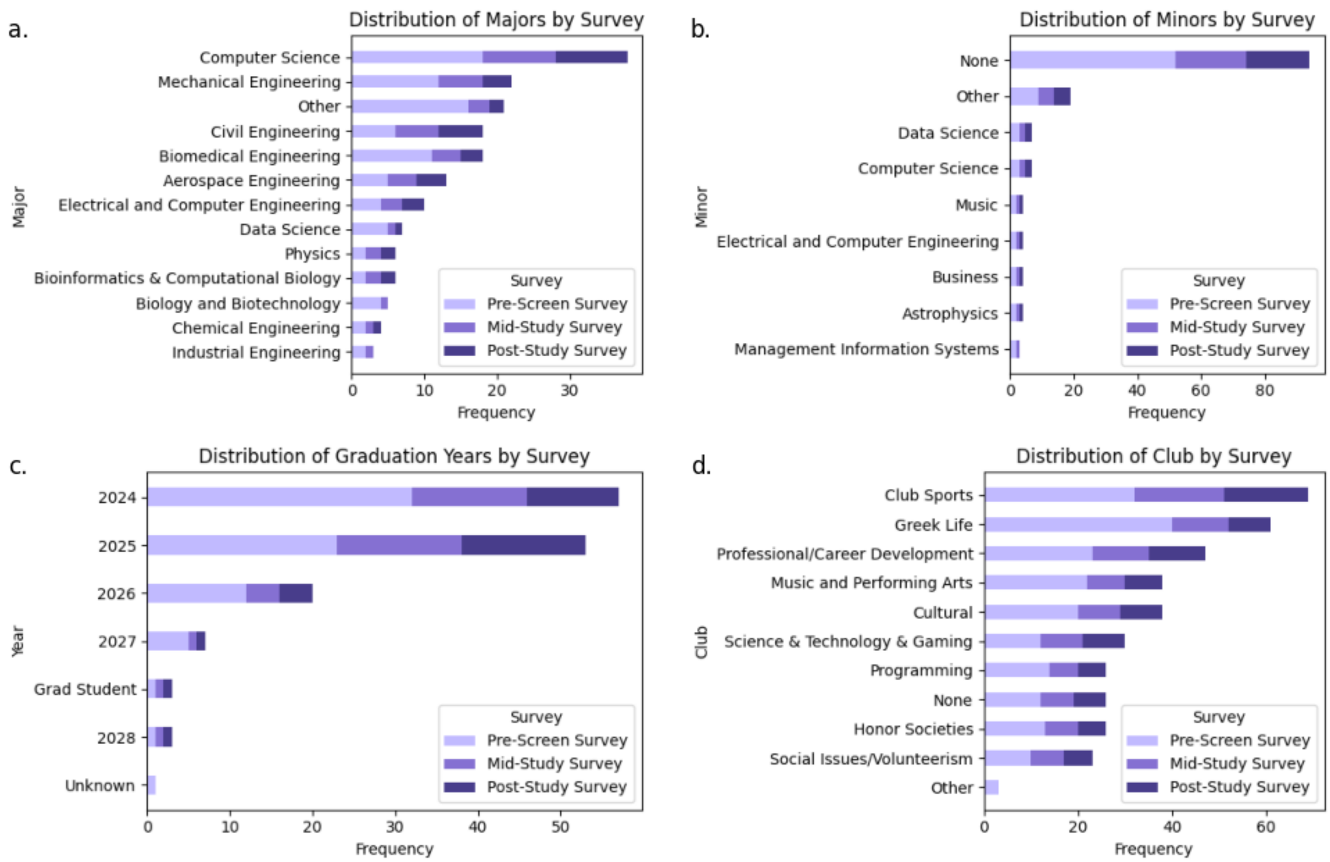

Figure 5. *Demographics Panel*

Note. Figure displays distributions of student majors, minors, graduation years, and club affiliation for pre-screening ($n=75$), mid-study ($n=36$), and post-study ($n=33$) surveys. Responses were allowed to mention multiple categories, resulting in total responses exceeding the sample size.

4.2.2 Pre-Screening Survey

We analyzed the pre-screening survey responses to establish a baseline understanding of students' use of sleep health applications before beginning the study. The pre-screening survey asked potential users if they had used Gmail or Fitbit, as these were integrated into the past version of the Z^3-Wellness application. While all users indicated that they had previously used Gmail, the distribution of Fitbit users shown in Figure 6 shows that only 6 out of 75 students owned a Fitbit while the rest either have not owned one or did not respond. This indicated that the Fitbit integration may go unused by participants due to the low number of participants who owned a Fitbit. Also, with very few Fitbit users, we might collect limited feedback on the integration's effectiveness.

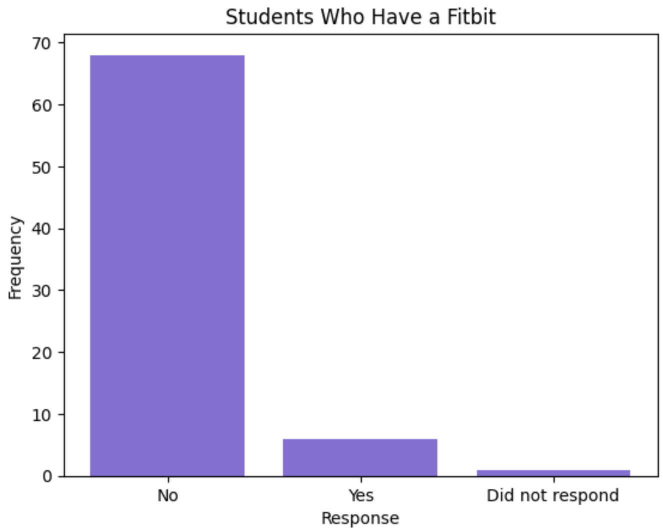

Figure 6. *Student responses for whether they have owned a Fitbit watch, (n=75).*

Additional questions from the pre-screening survey asked whether students have used a sleep health application in the past and an explanation of their experience of using or not using an application. If students have used one, they responded with the applications they have tried and explanations of what they liked and disliked. Among 28 students who had experience using a sleep health application, the most common responses stated that they enjoyed sleep health applications that included the following components: In-Depth Sleep Analysis, Easy Sleep Logging, and Engaging User Interaction as shown in Figure 7 below. Popular responses within these categories discussed enjoying the breakdown of their daily sleep cycle, the ease of the application's sleep-tracking and logging functions, and the gamified or personalized component of the application. The remaining four contextual categories contained responses that noted the precise data collection through health trackers; various sound recordings such as alarms, music, and white noise; and visual aspects within the app.

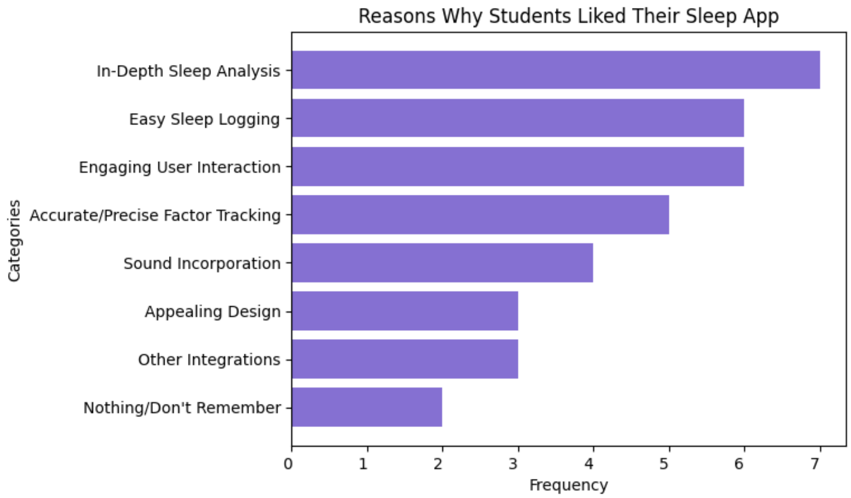

Figure 7. *Encoded categories of what students enjoyed about a sleep app, (n=28).*

Note. Responses were allowed to mention multiple categories, resulting in total responses exceeding the sample size.

Students also stated their dislike of sleep health applications for reasons in the following categories: Little/Inaccurate Tracking and Analysis, Payment Requirement, and Poor UI Design, which is shown in Figure 8 below. These categories frequently mentioned using sleep apps that had little variety in tracked information and short-term sleep analysis, limited access to application features without paying, and confusing app navigation. Other responses included but were not limited to requiring too much time to use consistently and not functioning properly.

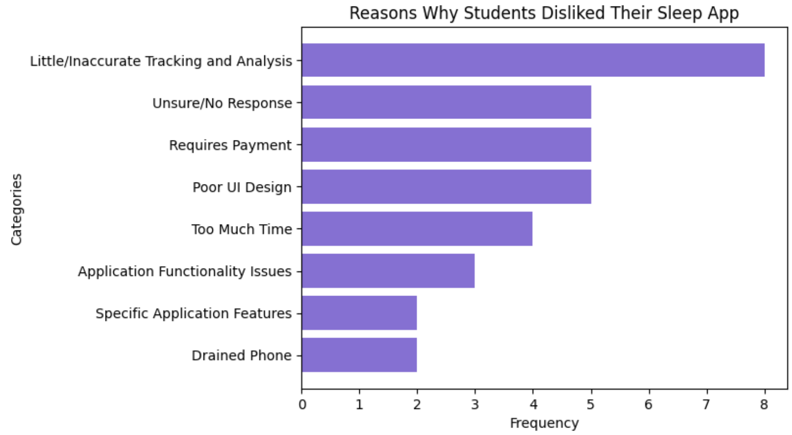

Figure 8. *Encoded categories of what students disliked about a sleep app, (n=28).*

Note. Responses were allowed to mention multiple categories, resulting in total responses exceeding the sample size.

Among 47 students who did not have prior experience with a sleep wellness application, responses indicated their main reasons stemmed from lacking the need or interest for an app, never considering using an app to track their sleep health, and not having sleep-related issues as shown in Figure 9 below. The remaining categories discussed being too much effort and not believing that it would help. This suggests that these individuals may find our application unhelpful regardless of its quality.

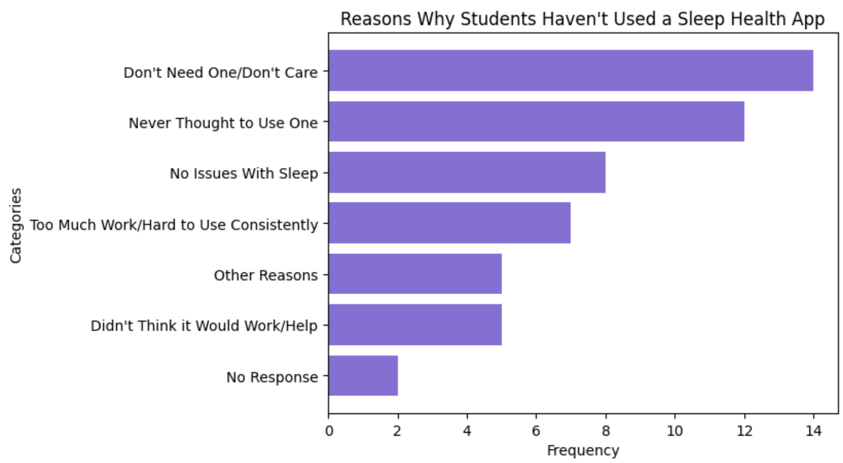

Figure 9. *Encoded categories of why students have not used a sleep app, (n=47).*

Note. Responses were allowed to mention multiple categories, resulting in total responses exceeding the sample size.

4.2.3 Mid & Post-Study Surveys

Along with the pre-screening results, we analyzed the mid-study and post-study survey results to identify potential areas of improvement within the Z^3-Wellness web application based on user feedback. The mid-study survey contained 36 responses while the post-study survey contained 33 responses. Questions from both surveys prompted users to provide feedback on their experience using the application.

From the post-study survey, we gathered information on the browsers and devices participants used to run the application, as shown in Figure 10 below. Throughout the study, we received messages from users who noticed bugs in the application functionality. These questions were included to help us identify the potential platforms where the application fails to properly function. Most users reported using their mobile devices to partake in the study and listed Safari and Google Chrome as their primary browsers.

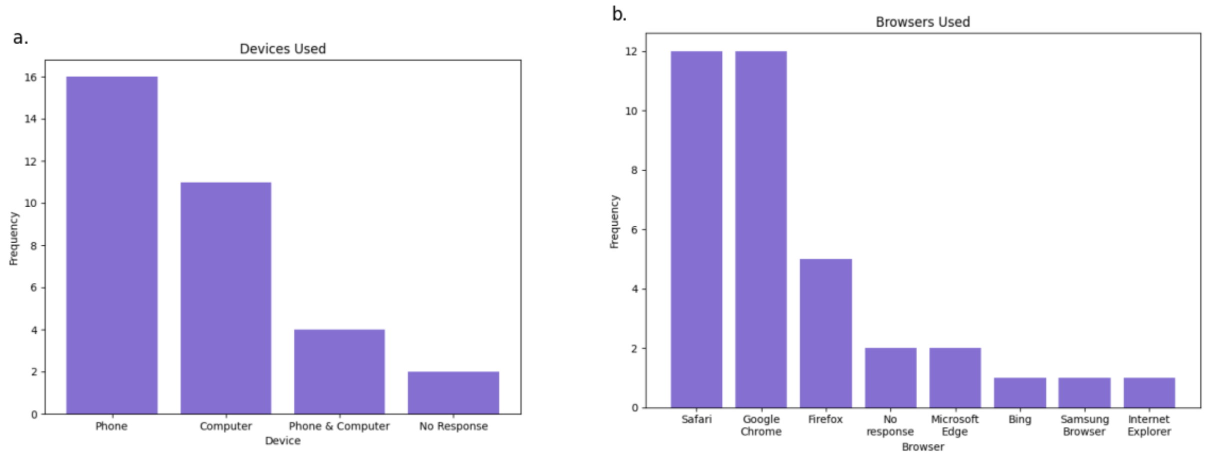

Figure 10. *Devices and Browser Panel*

Note. (a) Devices used to run the application, (*n=33*). (b) Browsers used to run the application, (*n=33*). Note that responses were allowed to mention multiple categories, resulting in the total number of responses exceeding the sample size in (b).

In the mid-study survey, participants were asked to rate different application components on a scale from 1 to 5, where 1 indicates 'Strongly Dislike' and 5 indicates 'Strongly Like': *functionality*, referring to the application's overall execution; *appearance*, relating to the visual design; and *content*, encompassing the available resources and tasks, which is shown in Figure 11a. Users were also provided the chance to explain their ratings summarized in Figure 11b, which presents the counts of positive and negative responses across the three main components broken down into several categories. Across all three categories, their median ratings were '3', meaning that users did not strongly like nor dislike each component. These ratings were accompanied by varying perceptions of the application's functionality, appearance, and content. The "Navigation & Execution" and "Content Usage" categories received the most positive and negative feedback across all six categories, which may suggest these areas are of high importance to users and require further attention to improve.

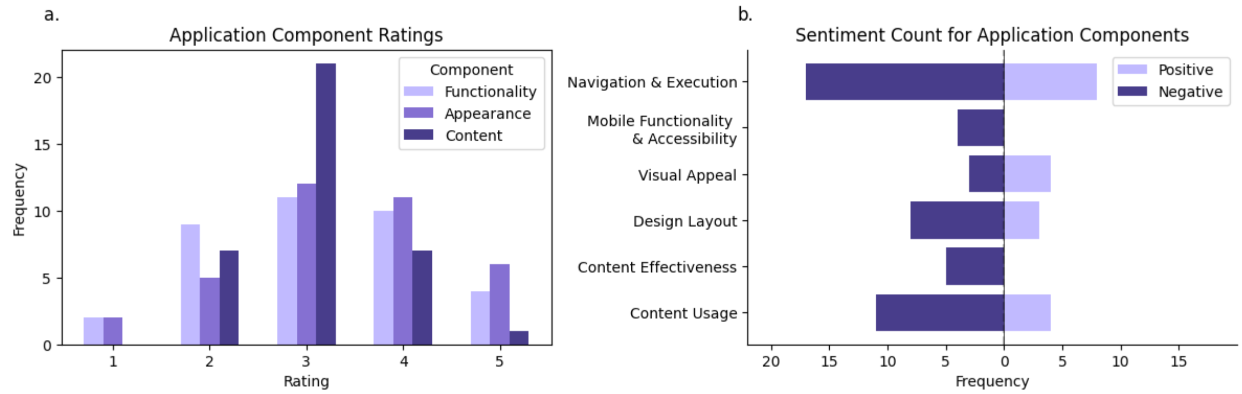

Figure 11. *Application Components Panel*

Note. (a) Mid-study ratings of the Z^3-Wellness application components, (n=*36*). Rating of 1 indicates 'Strongly Dislike' while a rating of 5 indicates 'Strongly Like'. (b) Counts of positive and negative responses across aspects within each component, (n=*36*). Note that responses were allowed to mention multiple categories, resulting in the total number of responses exceeding the sample size in (b).

Users were asked to rank a list of application features from most to least used, with Rank 1 representing their most used feature and Rank 13 representing their least used feature. Figure 12 displays a heatmap of the count distribution of features across ranks, listed in the order from the survey, where each cell represents the number of users who placed a feature in that rank. As indicated by the heat map, the sleep-logging function, personal report, water tracker, caffeine tracker, and exercise tracker were more prominently used, as users ranked them in positions 1-5. Users stated they primarily used the application for these functions since they had larger importance to their sleep health and tracking. Features such as the stress and mood trackers tended to have mid-level rankings, with users mentioning being unable to use them to their full extent. Feedback expressed frustration with the limited mood options and inability to use the Google Calendar integration to rate their stress levels for scheduled events as many students opt to use Outlook instead. The least used features were the Fitbit integration, Spotify, and meditation, as the majority of users assigned them to Ranks 9-13; feedback from users emphasized a lack of importance and helpfulness to their sleep health as these features did not apply to their everyday routine. Additional features such as the bedtime routine, personality test, and home screen were widely dispersed on the rank scale, reflecting mixed sentiments regarding their usefulness. This feature usage analysis was utilized in determining possible areas of improvement to further enhance the application's effectiveness and execution.

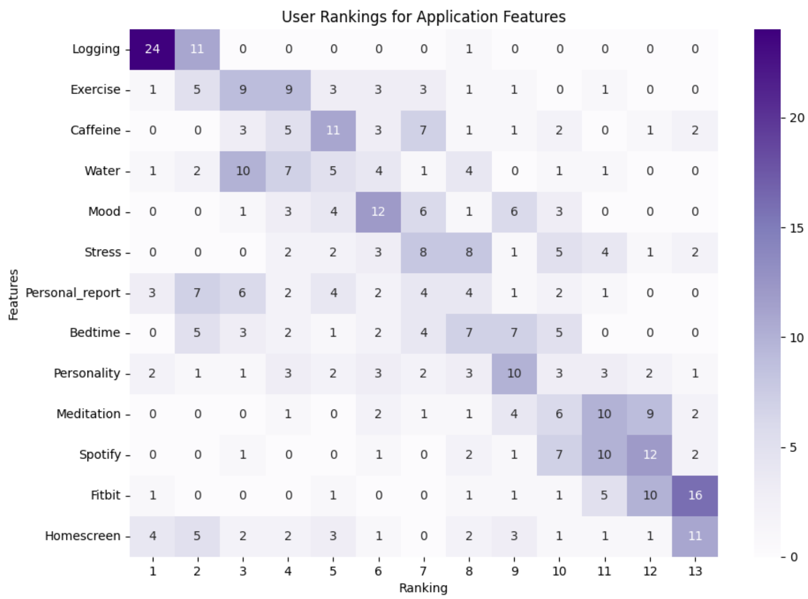

Figure 12. *Count distribution for rankings of Z^3-Wellness features, (n=36)*

Note. Each cell represents the number of times a feature was ranked in the corresponding rank, where Rank 1 indicates 'Most Used' and Rank 13 indicates 'Least Used'. Features are listed in the order in which they appeared in the survey.

In both surveys, users were asked to rate their overall experience using the app and explain what they enjoyed about the application. These results are summarized in Figure 13 below. The median rating across the mid-study and post-study survey, on a scale of 1 to 5 ranging from strongly dislike to strongly like, were both 3 with users slightly favoring 3 more after prolonged use of the application. Users appeared to enjoy using the application for its variety of health trackers, personal data reports, and user-friendly navigation more as the study progressed, but felt as if the application had already served its purpose toward the end. This was reflected in the consistency in responses from the mid-study to post-study surveys, where ratings tended to stay the same and reasons for enjoying the app overlapped. This feedback corresponded with the initial responses from the pre-screening survey, where students expressed enjoying sleep health applications that provided interactive components for user engagement, visual analysis of their sleep data, and user-friendly sleep-logging tools. Based on the user feedback, Z^3-Wellness appears to perform well for its target demographic for its basic function of helping users track their sleep and other sleep-related health attributes.

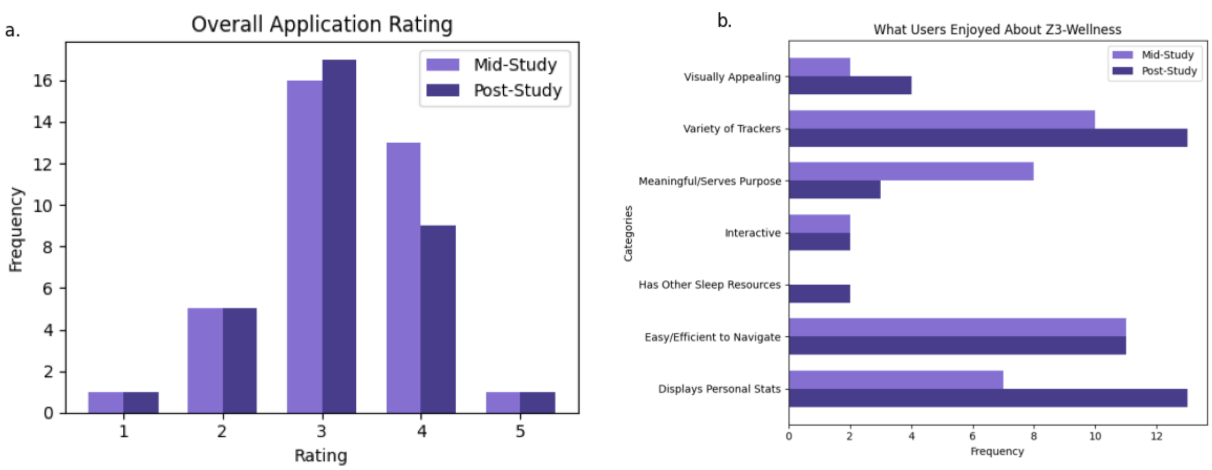

Figure 13. *Overall Enjoyment Panel*

Note. (a) Users' general ratings of the application from the Mid-Study (*n=36*) and Post-Study survey (*n= 33*). (b) Users' comments on what they enjoyed about the application from both studies. Responses were allowed to mention multiple categories, resulting in the total number of responses exceeding the sample size in (b).

4.2.4 Analytics

Despite the positive feedback from both surveys, there was a decrease in the logged information collected by the application within the two-week study. Survey results showed that there was a slight decrease in participants during the two weeks, as fewer users filled out the post-study survey compared to the mid-study survey. While there was no noticeable difference in self-reported usage when asked in the two surveys, the Firebase Analytics Dashboard displayed a drop in user data and engagement, which is summarized in Figure 14. From the Firebase website analytics, there was almost a 50% decrease in logged entries from week 1 to week 2 across all trackers.

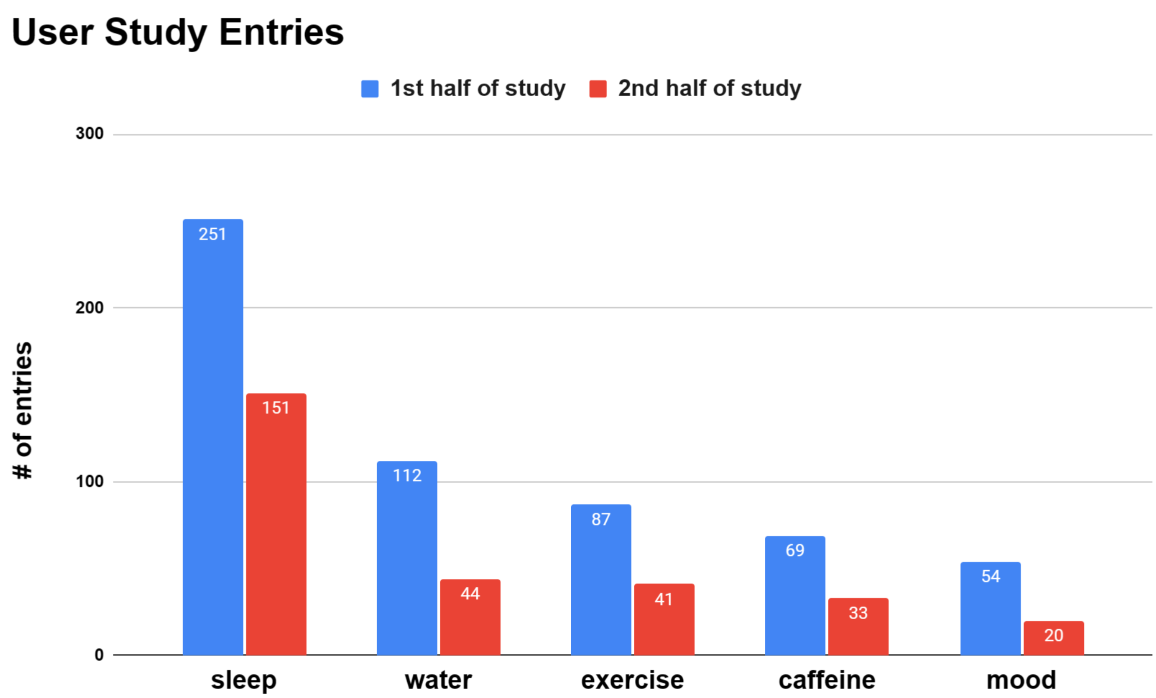

Figure 14. *User entries by feature, split into first half of study and second half of study*

To investigate this drop in user activity, we analyzed what students disliked in the application and their suggested improvements that could be implemented for future use. In the mid-study and post-study surveys, participants were asked what they would like to see improved in the application. As shown in Figure 15 below, respondents frequently noted the inability to edit data that was incorrectly entered, the limited options for tracking data, and confusing application flow and navigation across both surveys. Users also stated that they were confused when using the app's homepage icons, experienced difficulty with the mobile web version, and disliked how slow the application performed various tasks. Compared to the initial responses from the pre-screening survey, several of those categories coincide with reasons for why users disliked the Z^3-Wellness application, such as the inaccuracy of the tracked data and difficulty in navigating the application's functions.

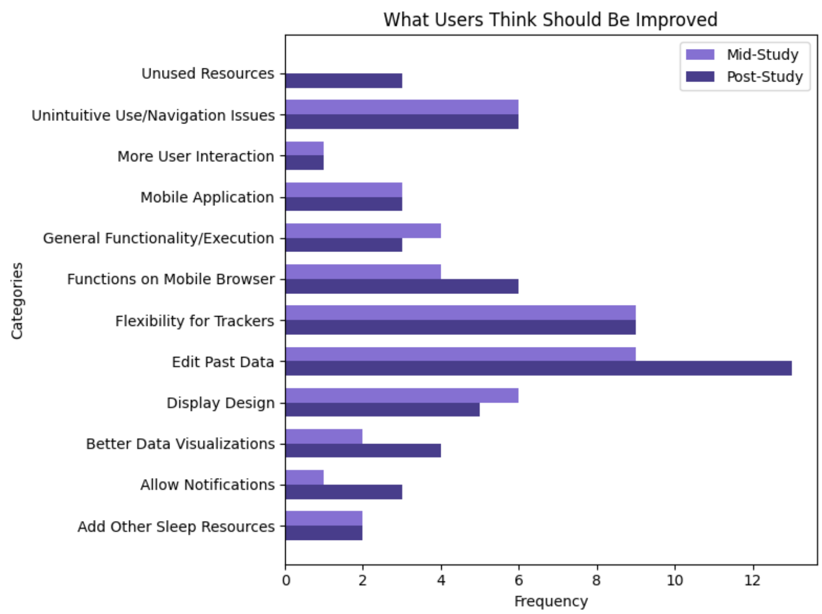

Figure 15. *Users' responses on what they would like to see improved*

Note. Responses were allowed to mention multiple categories, resulting in the total number of responses exceeding the sample size.

These results were further analyzed from the post-study survey where users could list new features they would like implemented in Z^3-Wellness, and these responses are categorized in Figure 16 below. This allowed users to suggest additional aspects of a successful sleep health application that were not currently implemented into Z^3-Wellness. While some users did not have any suggestions, other users frequently suggested altering the current features, such as including a larger selection of moods and better use of the stress tracker integration with a calendar. Additional suggestions included incorporating new features to the application, such as notifications to remind a user and a section for notes, and other external integrations, such as Apple Watch health tracking.

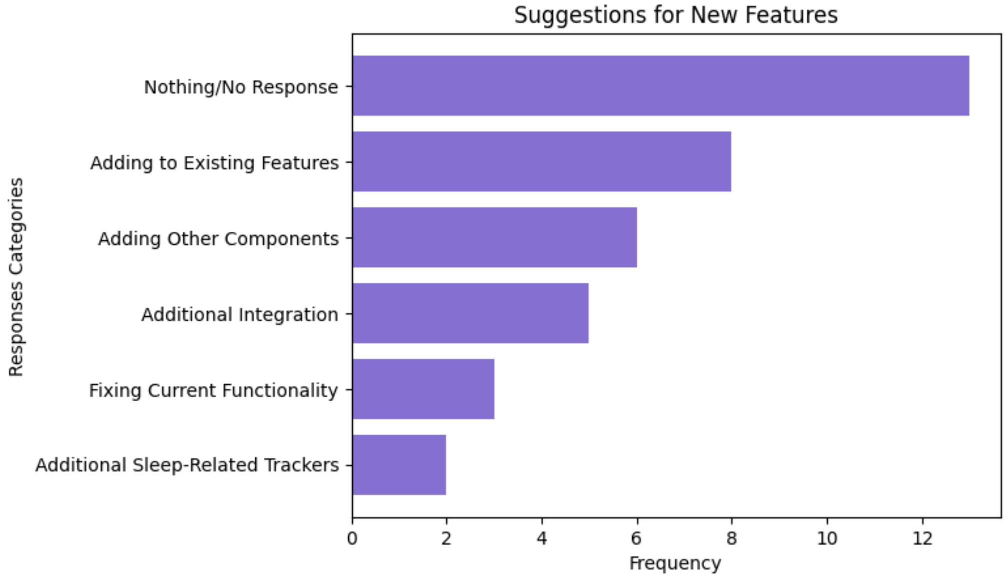

Figure 16. *Response categories for potential new features, (n=33).*

Note. Responses were allowed to mention multiple categories, resulting in the total number of responses exceeding the sample size.

The post-study survey also asked users for their opinions on the new features, which are the dashboard design and Chrome extension, that we began to develop after our initial observations. Students were asked to select one of three responses from the given choices on how the proposed dashboard homepage design should be implemented, shown in Figure 17, along with providing optional feedback on the new homepage. The majority of responses indicated they would like to see the current homepage design replaced with the newly proposed dashboard shown in Figure 18 as it aligns with their suggestions for improvements in previous questions, making it easier to navigate the app and consolidate their data in a single place. Users also frequently commented that the dashboard could be clearer in design and allow customization on the homepage if users do not utilize some of the trackers.

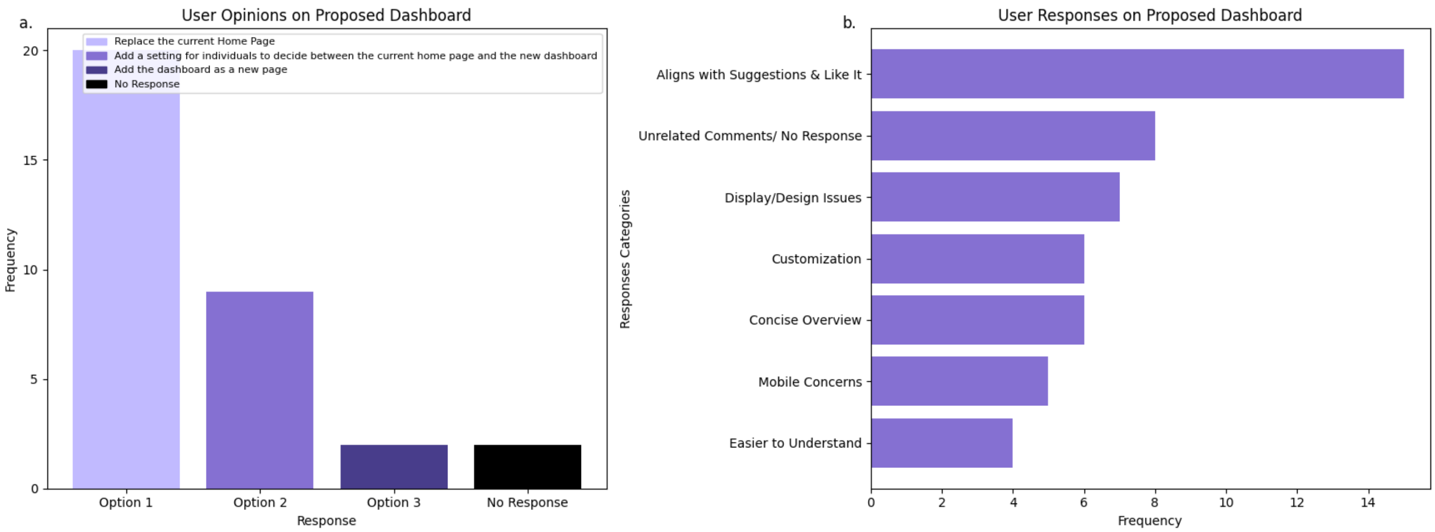

Figure 17. *Proposed Dashboard Panel*

Note. (a) Distribution of user choices on the newly designed dashboard, (*n=33*). (b) Response categories for users' opinions on the new dashboard design, (*n=33*). Responses were allowed to mention multiple categories, resulting in total responses exceeding the sample size in (b).

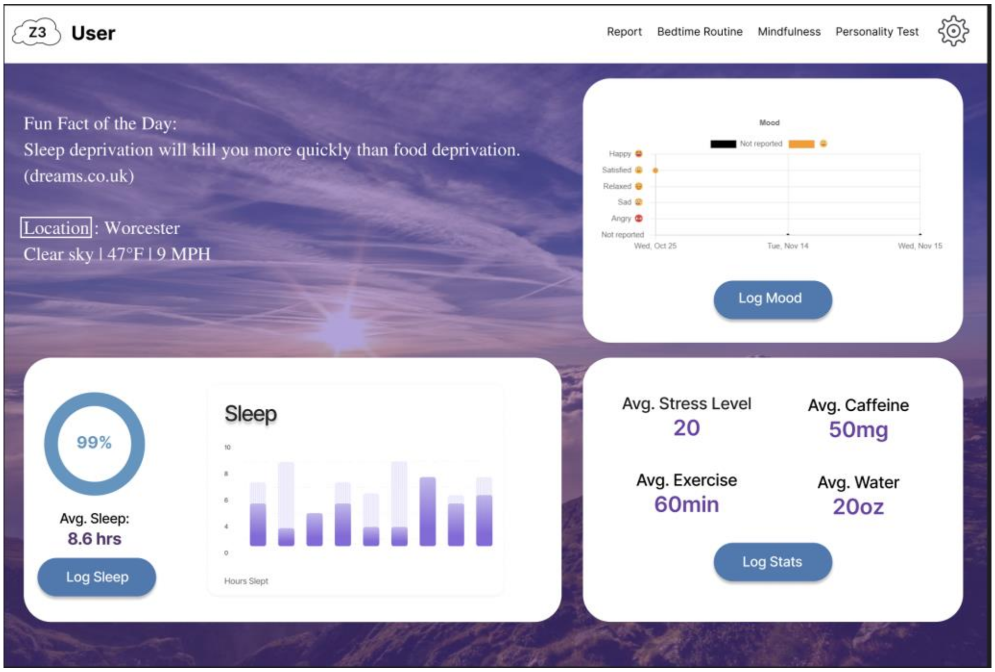

Figure 18. *Proposed New User Interface (shown also in Fig. 4)*

Figure 19 below summarizes users' comments on the proposed Chrome extension (shown in Fig. 3). While some indicated that they would use it, there were concerns about the addition of the new extension. The second common response category consisted of users who preferred if the extensions replaced the mobile web version or if it operated as a standalone mobile app. The third common response stated that users did not utilize Chrome or its extensions. These results may suggest that this proposed feature will not be useful or applicable to users' application experiences.

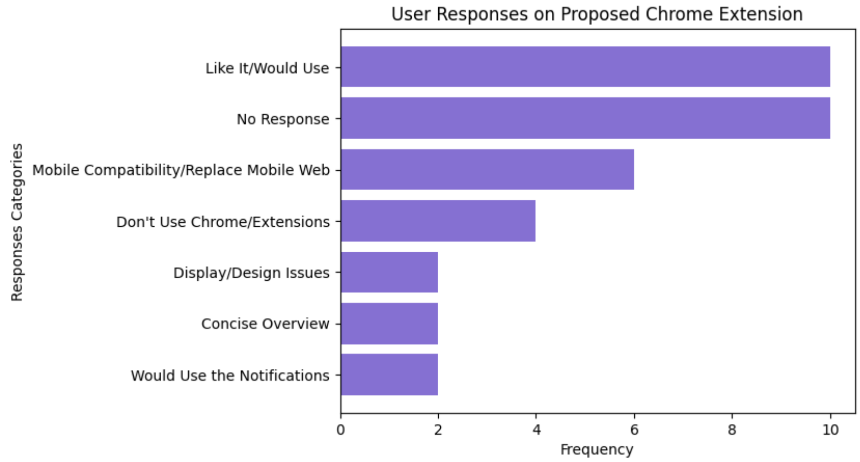

Figure 19. *Response categories for users' opinions on the Chrome extension, (n=33).*
Note. Responses were allowed to mention multiple categories, resulting in total responses exceeding the sample size.

The remaining survey questions asked if using the Z^3-Wellness application had helped improve their sleep health and if they would consider using the application past the study timeframe. Nine users stated that they would like to continue using the app and their reasons were due to the app's data visualizations, health trackers, and simplicity. However, 24 users indicated that they would not continue or that the app must undergo improvements before they consider using the application again. Common reasons for these responses were the unintuitive use of the application functions, forgetting to regularly log their data, and lack of an accessible mobile version.

5. Application Redesign: Methodology

When the group began development on the code at the beginning of our project, we found many issues within the application that prohibited us from proceeding with the user study we had planned for. As a result of this, we had to leave many of our initial expectations behind and move toward fixing critical issues in the code. Some of the expectations left behind were pieces such as an artificial intelligence algorithm, which would have allowed users to get an in-depth analysis of the users' sleep and well-being habits, as well as increased functionality through new trackers and application integrations.

A timetable was laid out through group discussion and priority was added to numerous tasks that were believed to be necessary for a successful user study (Appendix A). These included things such as bug fixes with the water and sleep tracking pages, as well as making pieces of the old user interface functional again as the library dependencies had gone out of support. While the user study was in session, the focus was shifted back to implementing more functionality and improving what was left to the group. These tasks were split into one of three major categories: Backend, frontend, or database.

Plans for expansion on the backend had quickly adjusted to become a full overhaul, as the original codebase was just two files and had little organization, leading to difficulty with further implementation. With current industry standards in mind, this task was tackled during the second and third terms of the three-term project and was a huge priority for the group. Frontend development was mainly rooted in feedback from our user study and thus started later. Through this study, the team gathered a plethora of information to enhance the application's user interface and functionality. Larger efforts revolved around a full user interface redesign as requested by study participants, but other endeavors included allowing for both Outlook and Google calendars to be used with the stress and fixing user input issues. However, all database revisions were made due to internal decisions as participants in the user study were not made aware of database functionality and design. Rationale for these changes circled around both a desire to speed up the application's performance and simplify the backend and data relationships, especially as very little future database work was recommended by the previous team.

5.1 Backend Overhaul

The initial state of the backend code inherited from the previous MQP group consisted of only two files: server.js and database.js. The two files were large and contained everything needed for the application to run with little organization or documentation to aid future groups in further development. With no ability to navigate or organize the backend in its existing state, members of the group with industry experience decided it was in the project's best interest to do a redesign. Many design practices were considered but the final decision arrived upon was CRUD, which stands for Create, Read, Update, Delete. This practice, a current industry standard, uses models, use cases, controllers, routers, and repos to allow for easily transferable data, testing, ease of expansion, and clear-cut organization. Another rationale for this change was the ease of connection between the front and backend of our codebase, something that the original backend did not have. Through the use of CRUD and API calls the group made expanding on the application incredibly simple for our development as well as for future groups.

The new file system was expanded upon in compliance with the CRUD methodology and now allows for simple navigation and expansion. Frontend code was also found scattered throughout the backend codebase which made the storage and navigation difficult, so it was removed as none of it was necessary for the backend to function.

Past these fixes, the group worked to expand on the backend by adding new material as well. The engines that supported database communications and whitelisting to the application server were both updated and now function. Queries were also added to expand on the functionality of the application as a whole, as well as safeguards to previously existing queries. Some examples include the addition of historical queries which allow for a user to see all of the data which they have logged, user models with test queries to ensure proper data transfer, and views based on the most frequently used queries which make the application faster.

5.2 Frontend Development

The initial state of the frontend was burdened with outdated libraries and dependencies which upheld a tangled mess of previous groups' code contributions. Various coding styles, unorganized or duplicate imports, and poor documentation were some of the main issues that weakened the app’s integrity. Many of the issues we identified were fixed over the full duration of the project, but other things such as dependencies causing errors and broken functionality were handled before distributing the application to users for our study.

Dependencies were one of the first things tackled as they were messy, outdated, or unnecessary (Appendix E). A subset of them that had even caused our application to lose functionality, mostly stemming from user interface issues such as an inability to click buttons, buttons that were unable to properly log data, or inaccurate graphics. Fixing these took a large effort but was crucial to complete before the study to ensure fewer issues for users and a bigger focus on the content rather than functionality.

After cleaning the dependencies, code coherency was the largest issue that the team had to face and it shifted to one of the main focuses of our project. It was abundantly clear that there was no common coding practice throughout the files, resulting in poor readability across the code base. This was one of the main priorities throughout the three terms in which the project took place and happened through multiple methods. The first method was tackling the different code files as sub teams moved through the areas of code which affected the functionality issues they were aiming to resolve. Through rewriting bits of code as typescript instead of javascript, reformatting working files, and adding clean and consistent documentation to functions, getters, setters, and user interface widgets, we were able to make the code uniform as we went. This allowed the team to consistently expand upon what we had with ease as many processes became repeated rather than innovated. One nice advantage to this is that it also allows for future groups to understand and develop what we pass on rather than spend the significant amount of time we did redoing work and deciphering existing systems.

Throughout the early stages of the project, the team began to explore the possibility of altering the user interface after poor functionality and usability became clear. Plans to revamp the interface were made within the first term and a framework was created for our group and users participating in the user study to analyze. Through the study we were able to confirm that the initial UI was indeed detrimental to the application and caused users difficulty, leading them to use some features less than we had hoped for.

Enhancing productivity and the user experience was a key objective from the beginning of our project. To address this, our team developed a Chrome extension designed to prompt users for quick log entries and streamline access to key application features. This development occurred alongside our user study, with the extension being showcased in the post-study survey for feedback. The preliminary design featured a stats averages modal, direct links to popular features, and customizable notification settings. However, feedback indicated that the Chromeexclusive extension's limitations, notably its Chrome exclusivity and lack of mobile device compatibility, rendered it an inefficient solution.

Many participants complained of three main issues: little support for mobile devices, difficulty navigating to different pages, and the previously mentioned bugs that affected user input, navigation, and visuals. Resizing pages for mobile devices was something the group had known was an issue and planned to fix immediately. Simple changes to how the interface widgets shifted when on a mobile device as well as dynamic text sizing allowed the team to solve this issue after the user study concluded. The team drafted a wide range of layouts while tackling the navigation issue but ultimately decided on the use of a navigation bar and customizable graphs on the homepage. This allowed for the fewest number of pages and minimized clicks needed to get to specific information, all while keeping it clear which page a user was currently viewing. Finally, many of the bugs which affected functionality were slowly phased out of the codebase through a mix of development, rewriting of files, and overhaul of the interface. Both backend and database changes also allowed for simplifying much of the initial application logic which had controlled a lot of data input and querying.

One of the most commonly mentioned features which users wished they could have used more was the stress tracker. At the start of the project the tracker, which ranks events in your calendar in terms of stress levels, was only able to be linked to a user’s Google Calendar, an application that very few WPI students keep up-to-date. Outlook is by far the most popular email application used on campus by students, faculty, and staff, and thus the Outlook’s native calendar feature is prevalent across all who use a scheduling app. This, paired with the initial work and future recommendations of previous groups to integrate Outlook with our app, motivated the group to allow for dual functionality with the stress tracking. After the user study’s conclusion, this feature was a main focus of the team and proof of functionality was finished by the end of the project. Only one small issue remained with the Outlook integration: It was unable to be linked to a WPI account without whitelisting our application on WPI servers. This is something that we recommend future groups look into so that users can link their WPI specific emails to this app.

5.3 Database Improvements

Compared to the front and backend of the application, the initial state of the database was solid and only needed some slight revision and development to become polished. A few smaller issues such as redundant table attributes were discovered later on in development and some other changes were made to the database management system to bolster efficiency as well as lighten the burden placed on the front and backend. None of the changes that were needed or made affected users during the user study, and were able to occur at the group's need or discretion.

In terms of redundant columns there were only a couple on various tables. The users table had what we believed to be the biggest issue in that there were two user identification columns, one given by the application and the other given by our authentication service, Google Firebase. After reviewing the user identification keys within Google Firebase and seeing that they are unique across all users and cannot be duplicates, we opted to remove the Z^3-Wellness application generated id field as it was not necessary and took extra storage on the host server. In doing this the group also needed to alter all existing data entry tables as they used the application id to connect a user to sleep, water, exercise, mood, and stress entries. After this was completed the only remaining redundant attributes within the database were a few tables with a combination of a date field and then individual day, time, and month columns, which were just removed as the date field contained all of these in a consistent format that could be handled easily by the rest of the code.

To increase efficiency of the application, changes were made within the database management system (DBMS) too. These changes were small and are not visible to users aside from faster loading times and data entering. A tool within the DBMS which the application runs on, PostgreSQL, called a view allows for the most commonly run data queries to be stored in the system and be enacted with heightened speeds. Many were added for fetching a user's data as well as for statistical analysis used in development. Other tools called triggers were added which are provoked when a new data entry request is made. A few triggers were added which automatically fetch the date and time in a specified format and add it to the entry so that we did not need the backend to do so, and some data security features were added as well to ensure proper formatting.

6. Application Redesign: Results

After much research and implementation, our team produced an updated version of the Z^3-Wellness application. Our modifications can be divided into the following categories: dashboard design, navigation bar, mobile view, and calendar integration.

6.1 Dashboard Design

One of the biggest takeaways from the user study was that many users thought the UI needed improvement. Most of the criticism was related to the homepage, report page, and navigation of the app. Users wanted to see improved visuals while increasing the general ease of access to data logging. The new dashboard page was designed to incorporate all these suggestions by combining the old homepage and the report page, shown in Figure 20. The navigation to other pages from the dashboard was implemented in the form of a navbar on the top of the page that was also implemented throughout the app.

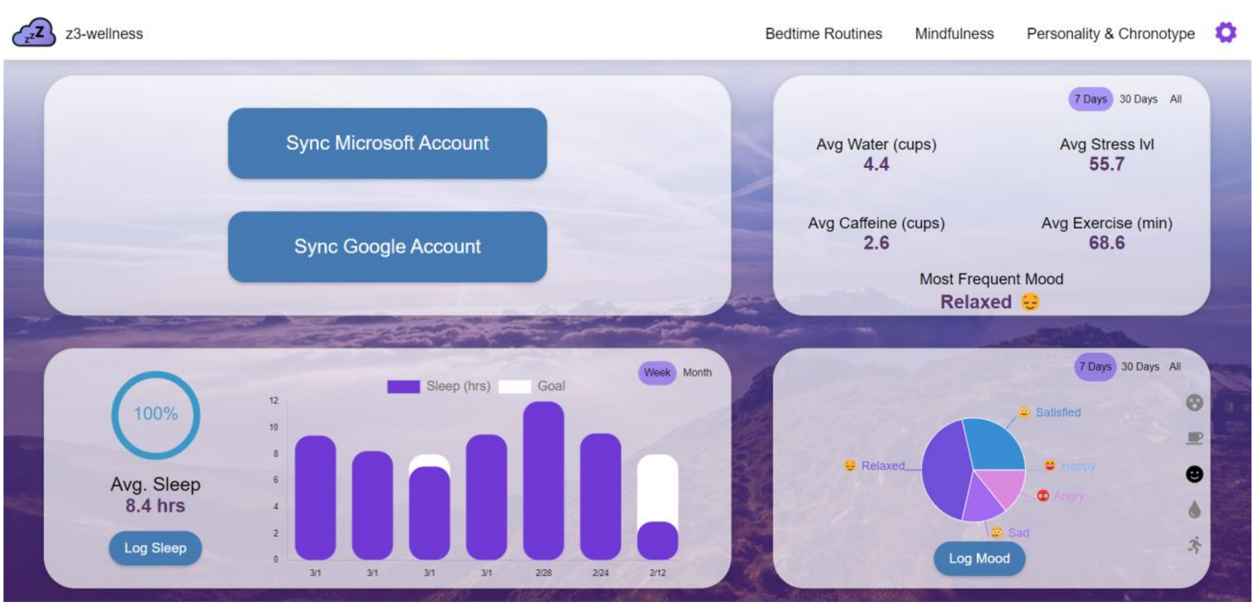

Figure 20. *New Dashboard Design*

The rest of the dashboard consisted of four cards; The top-right card displayed the averages for all the users' self-reported features: water, exercise, stress, caffeine, and mood. The bottom-right card contained the corresponding graphs for these app features. Only one of the graphs is displayed at a time, allowing users to switch between the graphs using the column of icons on the right-hand side of the card. Each graph, apart from stress, also has a matching button that could be clicked to log that feature. When clicked, the button would open a popup with an interface for logging the corresponding feature, illustrated in Figure 21.

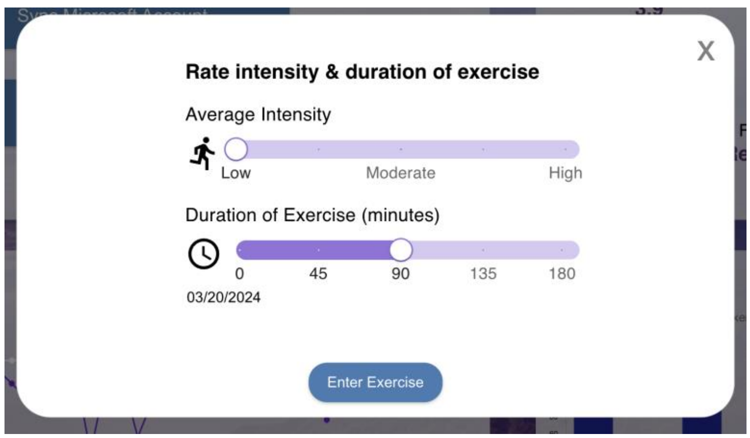

Figure 21. *Popup for Logging Exercise*

Both cards on the right side also include a selector on the top right of the card that allows users to toggle between the last 7 days, the last 30 days, and all entries. The card of averages also provides an option to include all logged entries. The averages card calculates the averages for each feature over the selected number of entries, and the graphs only display data over the selected number of entries.

The card on the bottom left contains all of the user's sleep information. On the right side of the card, two graphs can be toggled between to show a bar graph that displays the last 7 days of sleep entries or a line graph that displays the last 30 days, graphed out in Figure 22. Both graphs showed the user's sleep goal so users can see a visual representation of how well they are meeting their goal.

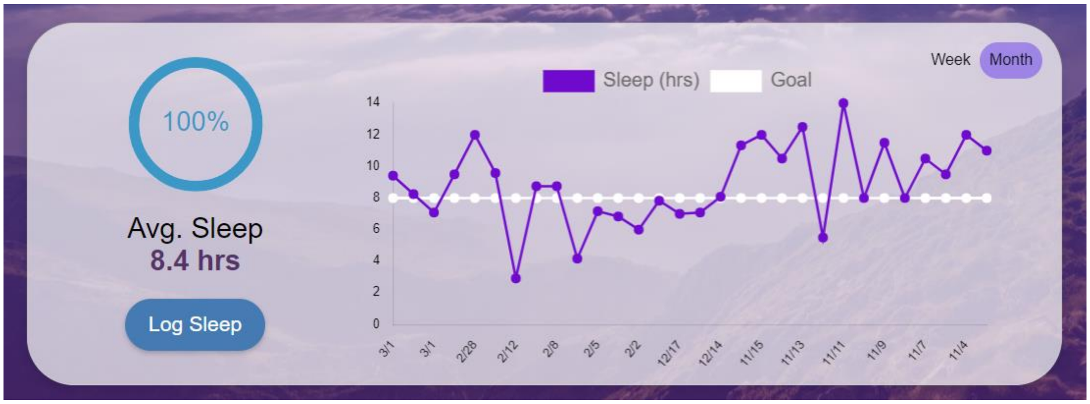

Figure 22. *Monthly Sleep View*

The left side of the sleep card displays a circular progress bar to show how well the user is meeting their sleep goal. The average sleep duration and a button for logging sleep are also present on the left side of the card. Similar to the other logging buttons, the log sleep button displays a pop-up to log sleep, as seen in Figure 23. Finally, the top-left card contains a calendar that could be integrated with Outlook or Google Calendar to log stress.

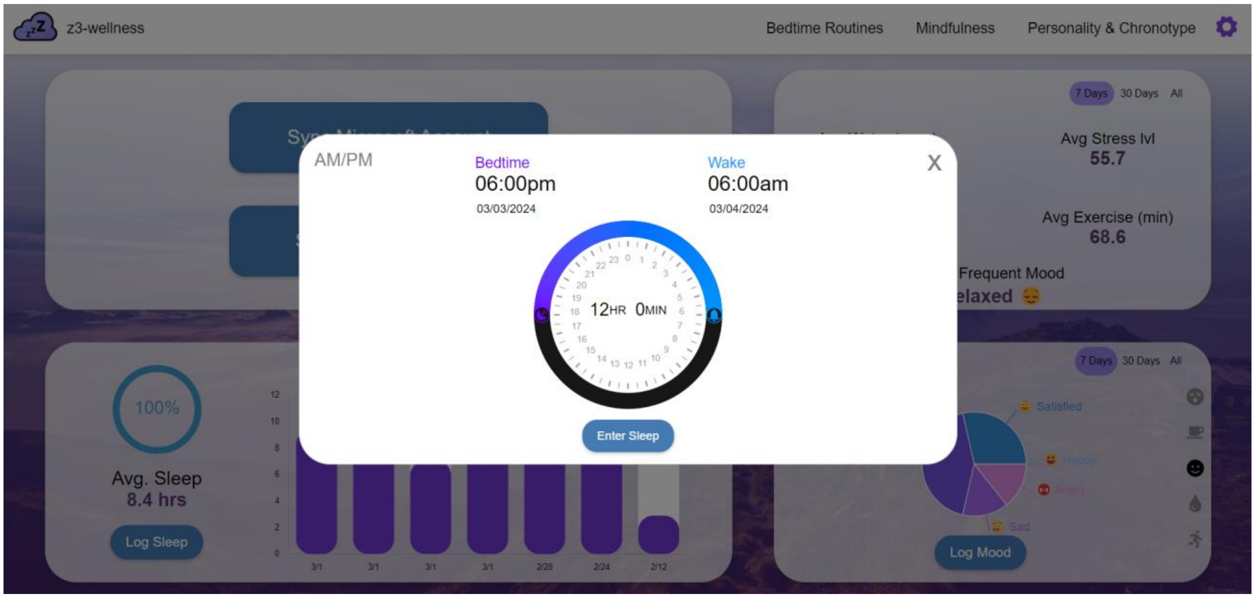

Figure 23. *Log Sleep Pop-up*

6.2 Navigation Bar

To make the app more cohesive, we implemented a navigation bar that appears at the top of every page, displayed in Figure 24.

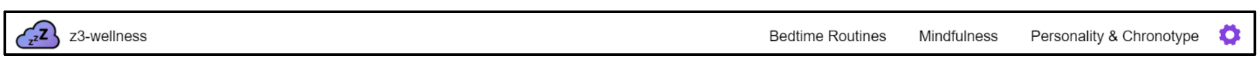

Figure 24. *Navigation Bar*

This nav-bar shows the user's profile name as well as links to the other pages on the app. The far left of the nav-bar displays the updated Z^3-Wellness logo that we made for the app, which will bring the user back to the dashboard if clicked on. The far right of the nav-bar is a gear icon that will display the new settings sidebar, as displayed in Figure 25.

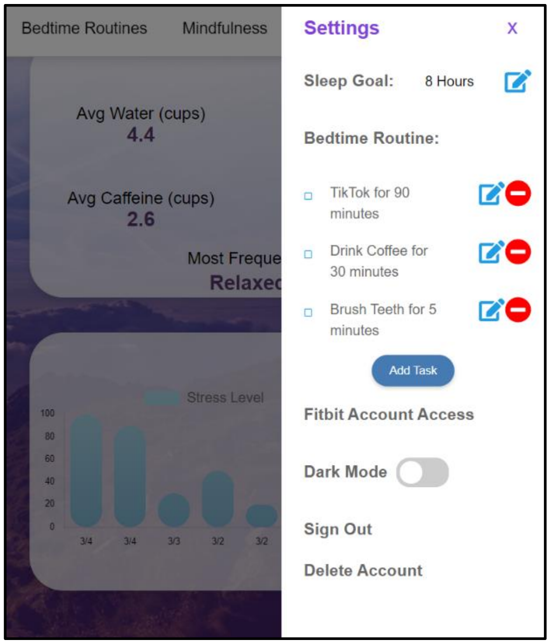

Figure 25. *Settings Sidebar*

This sidebar has all the functionality of the old settings page implemented by the previous MQP groups, however, it is now more concise and accessible throughout the entire application. There is also a new "Dark Mode" switch, which will allow the user to set the app to dark mode so that it is less harsh on the eyes either at night or in the morning as shown in Figure 26.

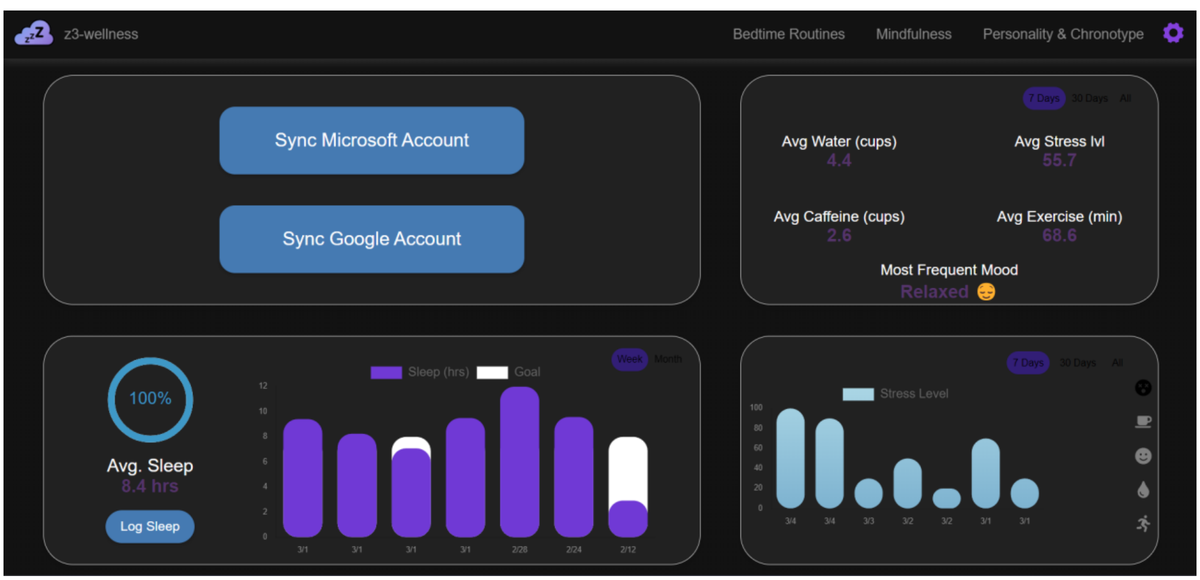

Figure 26. *Dark Mode Dashboard*

6.3 Mobile View

Many participants in the user study complained about the experience of using the app on mobile devices, so we addressed this concern when designing new pages. Using media queries based on screen size, we adapted the styling of the pages for a new mobile view. In the dashboard, we stacked all the graphs on top of one another so that the user can scroll to their desired feature. The nav-bar also changes shifting all the page links into a burger menu. On the mindfulness page, the meditation options are all put into a dropdown menu so that the links do not sprawl across the entire screen, exemplified in Figure 27.

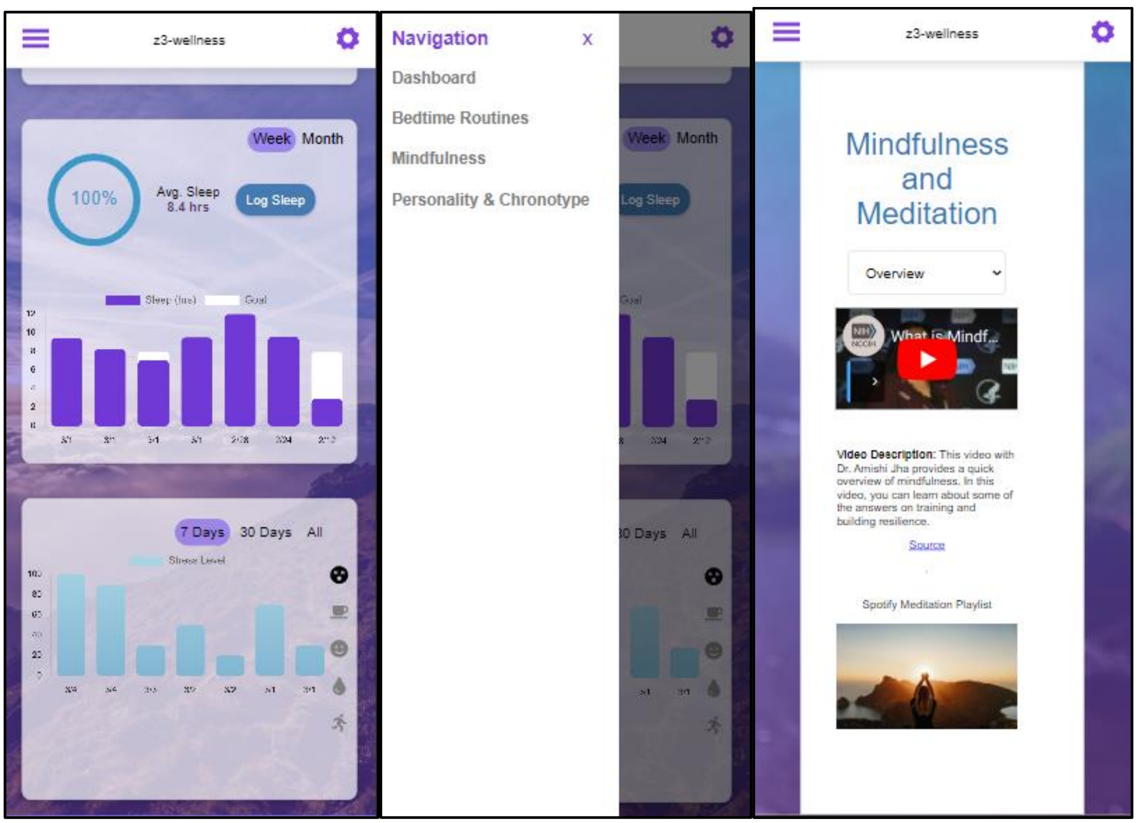

Figure 27. *Mobile views for Dashboard (left), Navigation Menu (center), and Mindfulness (right)*

6.4 Calendar Integration

Upon successful login, users have the option to integrate their calendar by connecting either their Microsoft (Outlook) or Google account, noted in Figure 28.

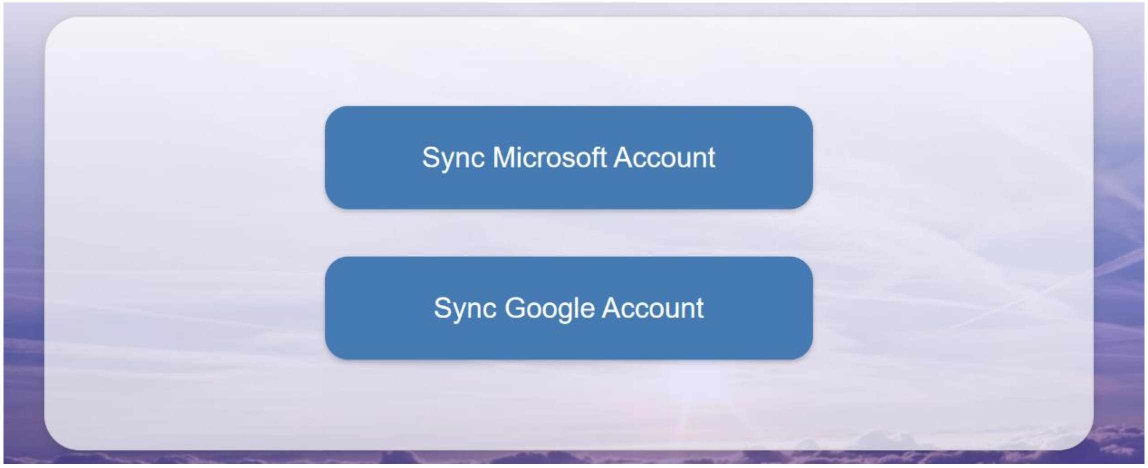

Figure 28. *New user sign-in page*

When the user selects 'Sync Microsoft Account,' a pop-up will appear prompting them to select their preferred Microsoft account for synchronization. Upon selecting their account, the user's Outlook calendar schedule will be displayed within a modal window for review and integration, listed out in Figure 29.

Clicking the 'Sync Google Account' button prompts a pop-up window where the user can select their preferred Google account. After selecting their Google account, users will be requested to grant permission for the application to access their calendar information. After successfully connecting their calendar, the user's daily events from Google Calendar will be showcased within the modal window.

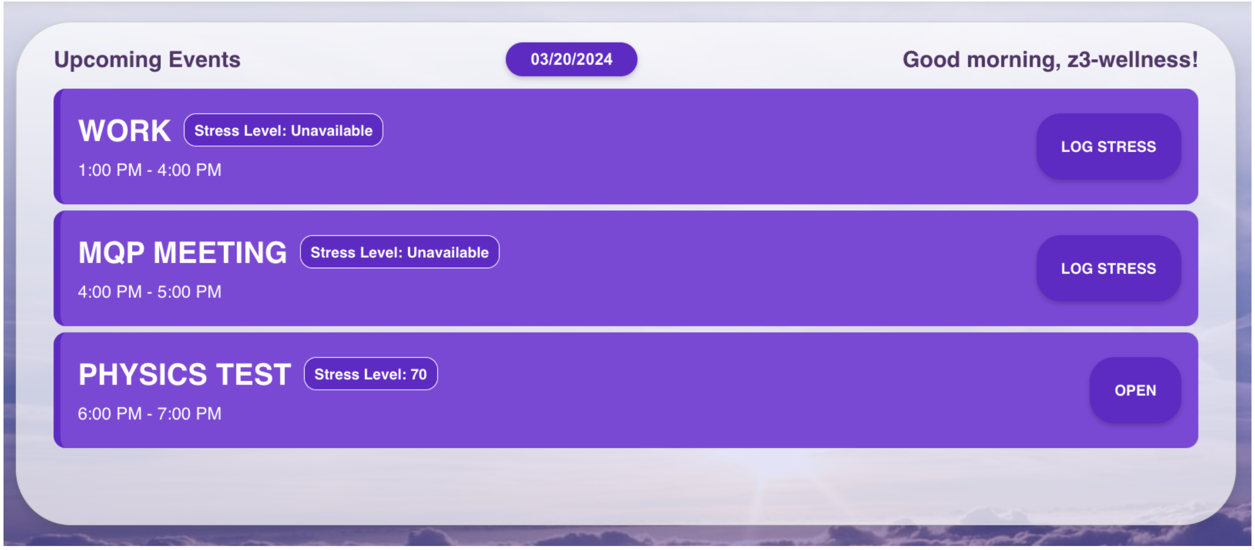

Figure 29. *Updated calendar when signing in with Microsoft or Google*

Following synchronization with either an Outlook or Google calendar, users can select any event to zoom in. This detailed view shown in Figure 30 allows them to log their stress levels associated with that particular event.

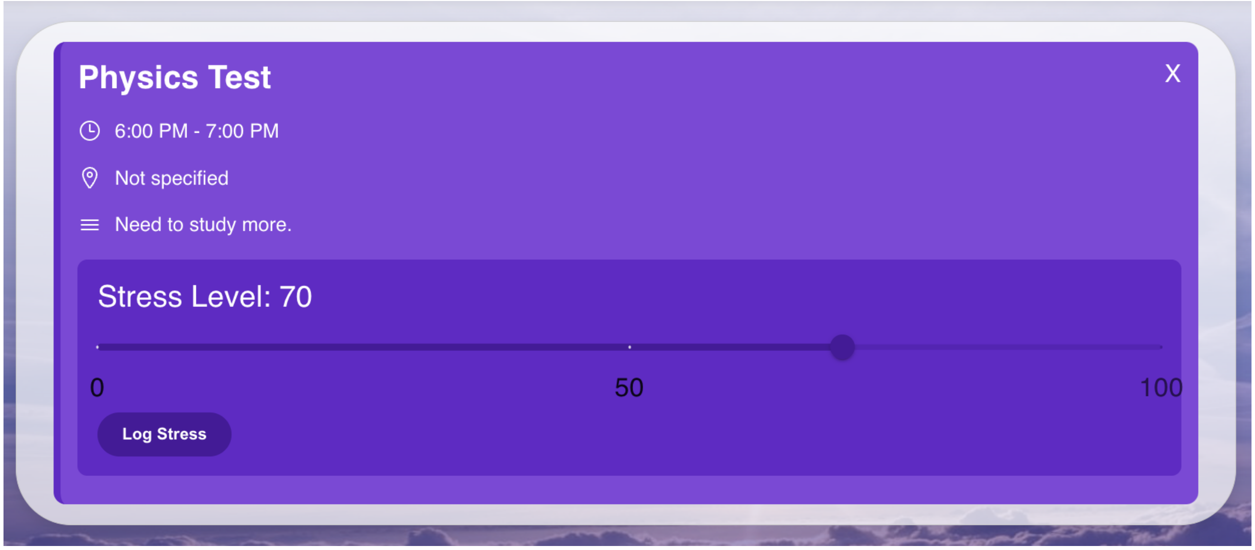

Figure 30. *Detailed view of an event where stress level can be logged*

After logging stress, a notification stating "Creating Stress Entry" appears. Should users wish to modify their stress level for the calendar event, they can click "Update Stress Level" to make changes, they can do so with the fixture in Figure 31. Upon updating, a message "Updated Stress Entry" confirms the adjustment.

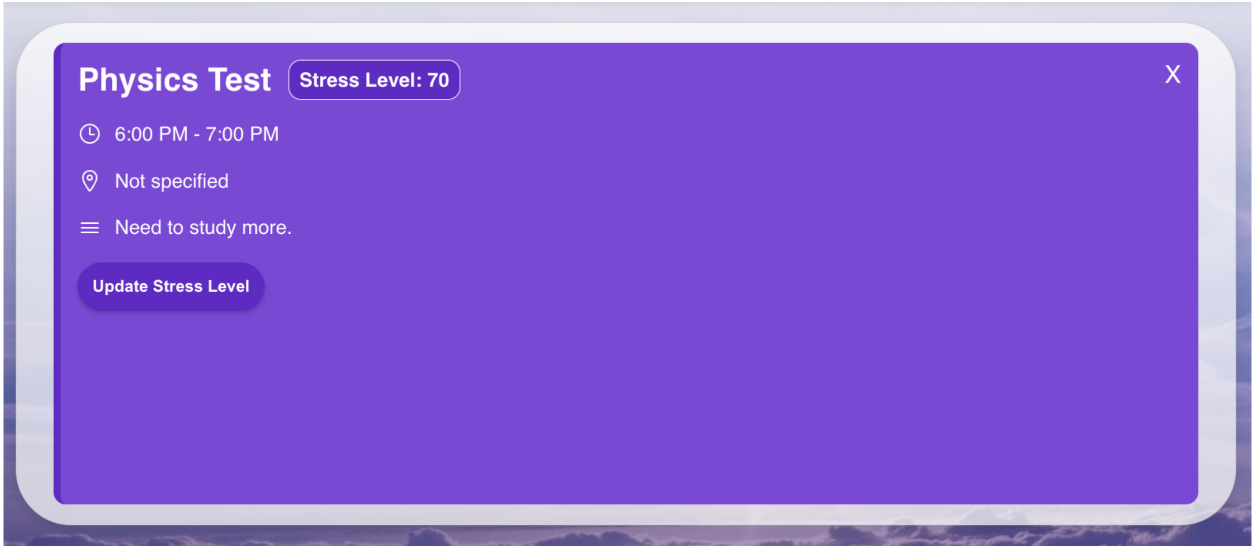

Figure 31. *An event with an associated stress level, providing the option to update the level*

7. Conclusions and Future Work

This MQP project extended upon the works of previous MQP groups who have contributed to the Z^3-Wellness application. To evaluate its functionality and effectiveness, we conducted a user study to receive feedback on the previous state of the application to identify areas of improvement. After analyzing user feedback from surveys and application use, we decided to design a new homepage that incorporates the user-suggested improvements. Our group also redesigned the structural layout of the code for future work on the application as it previously lacked organization.

7.1 Considerations

Over the course of this project, several incidents prevented our team from achieving as much as we had aimed for. Our first issue was in regards to gaining access to the application. In order to begin work on the user study and enhancement of the Z^3-Wellness application, we required access to the associated GitLab, Firebase, Linux Server, and several API keys. Some of these required team members to get permissions from various sources, and some were accessible through a pre-existing account. Several of these accounts, however, were created using prior students' personal emails, which made them inaccessible to our team. We were able to eventually gain access to everything that was necessary and renew any expired certificates or keys, but this process took up a considerable amount of our time before the user study.

Initially, our team had planned to conduct the user study from November 8th to December 8th, 2023, providing us with 30 days worth of data. Due to some issues during the initial planning stage, our study was rescheduled to run from November 28th to December 12th, 2023, which is 14 days. This change significantly lowered the amount of data that could have been collected, therefore leading our conclusions to be less informed overall.

7.2 Future Work

Despite the work that our group accomplished, there is more to be improved within this application. Immediate work for future groups should include allowing users to be able to edit their logged data. Users frequently mentioned incorrect sleep inputs and needing to edit their past logs. While we created a visual display before a user inputs their logged sleep times, we were not able to allow users to modify their previous entries. This should be a high priority as it caused frustration for users who wished to accurately log their wake and sleep times. Another area for immediate improvement should be allowing more input options across all trackers. The water and caffeine trackers were not considered user-friendly as they required a manual calculation using values not commonly associated with standard measurements for water and caffeine. The values consisted of 6, 12, and 18 oz., which users noted as being uncommon in water bottles and caffeine drinks. For the mood tracker, there was a limited set of available inputs: happy, satisfied, relaxed, sad, and angry, which users found restrictive when accurately logging their mood. Additional research should go into designing these preset options to enhance the user experience.

Future work can include implementing machine learning for data-driven user recommendations. Based on user feedback, users indicated that they did not find the application useful as they did not know how to utilize their data to improve their sleep health. Implementing machine learning can provide users more insight into how to make changes in their daily lives to achieve their goals.

Another major area to be worked on is establishing mobile accessibility. Several users pinpointed errors in the mobile version of Z^3-Wellness and stated that its inaccessibility discouraged consistent use since it is not a mobile application. Our group ensured that the new proposed homepage was compatible and functioning on mobile view, but future groups could consider working to make sure all aspects of the mobile version properly runs or create an entirely new mobile application.

Other recommendations for future work are better integration of Spotify, meditation resources, and Outlook calendar. Many users listed Spotify and meditation pages as some of their least used features as they were not aware of their existence or felt they were disconnected from the rest of the application. As this application evolves, these integrations should be redesigned to be accessible to users and beneficial to a user's sleep health journey. Also, with the new integration with Outlook calendars, this feature could be extended to connect to WPI-specific email accounts. As most WPI students are provided an Outlook account, having the application connect to academic WPI accounts would be more convenient to users if they do not typically utilize Google calendar. In doing so, the team will need to see if WPI IT Services is willing to whitelist the application, otherwise this will not be possible.

Further work can be done on the revamped homepage such as incorporating personal goals for trackers besides sleep, improving the tracking UI widgets, and adding a notification feature. Adding more personal benchmarks for the caffeine, water, and exercise tracker can help a user achieve their goals and make the application more engaging. By improving the UI widgets, users will be able to better visualize their personal data and customize their dashboard to their preferences. User experience could be enhanced with a notification system to prevent users from forgetting to log their data, which was a common occurrence stated in our user study's survey results.

Also, providing the user with the option to set their dashboard as their homepage and re-implementing the previous group's homepage could prove beneficial. This would give the user even more power to customize their profile, while also giving the previous group's homepage another chance to shine.

Lastly, this application should be shifted to GitLab03.wpi.edu as the current repository is old and lacking support. ARCUnix recommended that the code repositories be switched to gitlab03 due to the changes made between them. This would then require the team to clone the new repositories on the server.

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Sleep++: https://apps.apple.com/us/app/sleep/id1038440371

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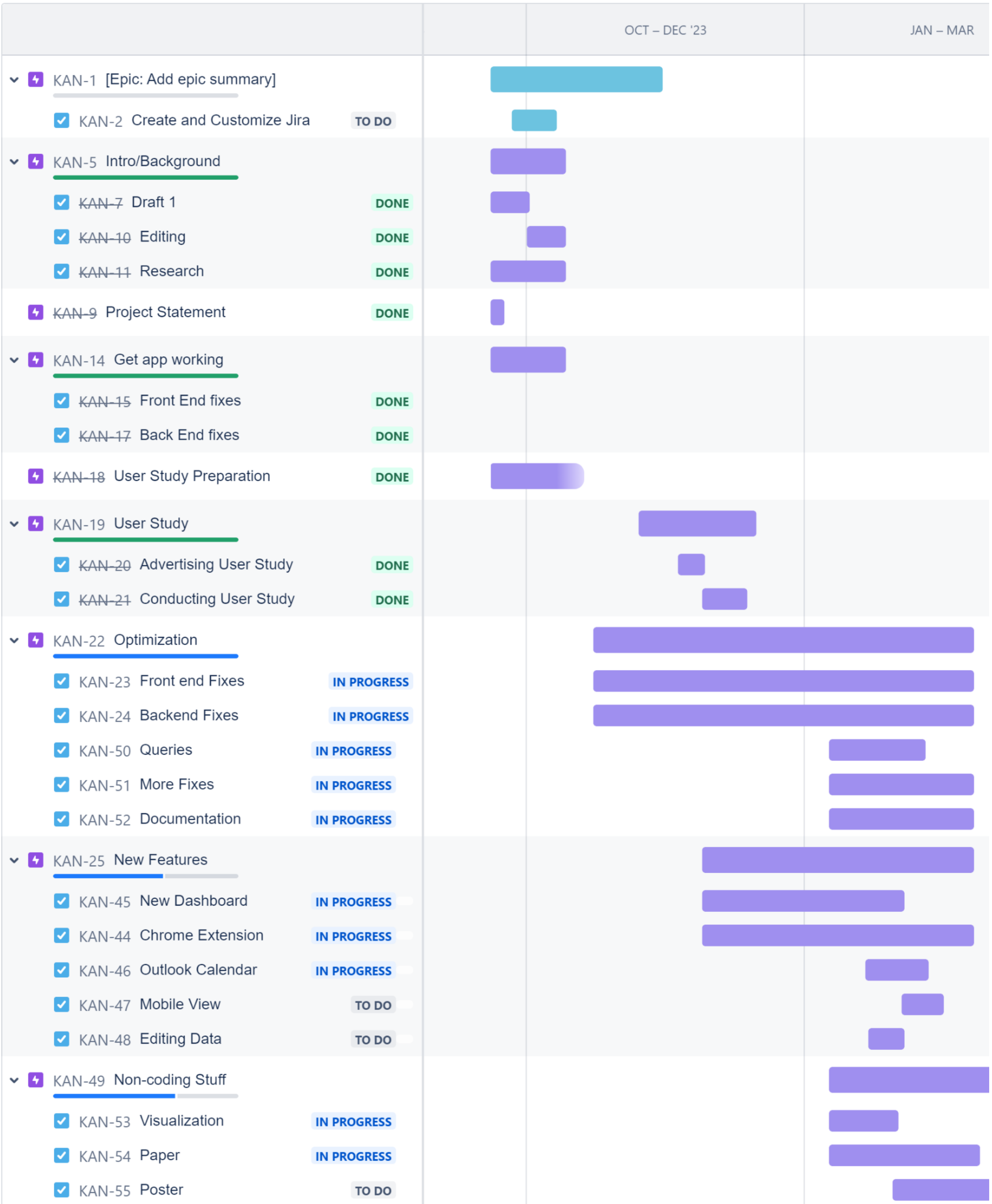
Appendix A: Project Timeline

Project timeline from the Jira board from August 2023 - March 2024



Appendix B: Pre-screening Survey Questions

** _____ indicates individuals' manually inputted answers*

General Information

Name: _____

WPI Email: _____

Class Year: _____

Major: _____

Minor: _____

How did you hear about this study?

a. Flyer b. Student organization c. Word of mouth d. Other: _____

What organizations are you a part of on campus? _____

Past Experience

Have you used a sleep health application before?

a. Yes b. No

If yes, which application(s) have you used in the past? _____

What did you like about the application(s)? _____

What did you dislike about the application(s)? _____

How was your overall experience with the application(s)? _____

(Strongly disliked it) 1 2 3 4 5 (Strongly liked it)

If not, could you explain why you have not tried a sleep health application in the past? _____

Study Information

Are you 18 years or older?

a. Yes b. No

Do you have a device (smartphone, laptop, desktop computer) with access to wifi?

a. Yes b. No

Do you have a Google account?

a. Yes b. No

Do you have a FitBit account?

a. Yes b. No

Are you available and willing to partake in this study starting from November 28, 2023 and ending on December 12, 2023? (Keep in mind that you may withdraw from the research at any time, but only participants who participate in the study for the entire duration will be entered in the raffle.)

a. Yes b. No

Appendix C: Mid-Study Survey Questions

**, _____ indicates individuals' manually inputted answers*

General Information

Name: _____

WPI Email: _____

Other email if you did not use a WPI address to create an account: _____

Personal Use

On average, how many days have you used the Z3-Wellness app?

1 2 3 4 5 6 7

Please rate the aspects of the Z3-Wellness application described below:

Application functionality (navigation, speed, page loading, etc)

(Strongly dislike) 1 2 3 4 5 (Strongly like)

Application appearance (design, colors, text size, font, etc)

(Strongly dislike) 1 2 3 4 5 (Strongly like)

Application content (trackers, meditation guides, playlists, suggestions, etc)

(Strongly dislike) 1 2 3 4 5 (Strongly like)

If you would like to provide your reasoning for your ratings, please explain below: _____

For the following features, please rank them in order of most used or useful to least used or least useful:

- Logging sleep and wake up times
- Exercise tracker
- Caffeine tracker
- Water tracker
- Mood tracker
- Stress tracker
- Personal Report
- Bedtime Routine
- Personality Test
- Meditation Videos
- Spotify Playlists
- Fitbit Extension
- Home-screen feature bubbles

If you did not use any of the above listed features, please list them and explain why if possible:

_____

Overall Experience

How would you rate your experience using the Z3-Wellness app so far?

Do not like it 1 2 3 4 5 Love it

What have you enjoyed about the application? _____

What would you like to see improved or changed? _____

Appendix D: Post-Study Survey Questions

** _____ indicates individuals' manually inputted answers*

Name: _____

WPI Email: _____

Class: _____

Major: _____

Minor: _____

Personal Use

On average, how many days have you used the Z3-Wellness app? (# of days per week)

1 2 3 4 5 6 7

Overall Experience

How would you rate your experience using the Z3-Wellness app so far?

(Strongly dislike) 1 2 3 4 5 (Strongly like)

What did you enjoy about the application? ___

What do you think could be improved with the application? ___

Do you believe that the Z3-Wellness application aided or improved your sleep health? Why or why not? _____

Future Use

Would you continue to use the Z3-Wellness application past this study? Why or why not? _____

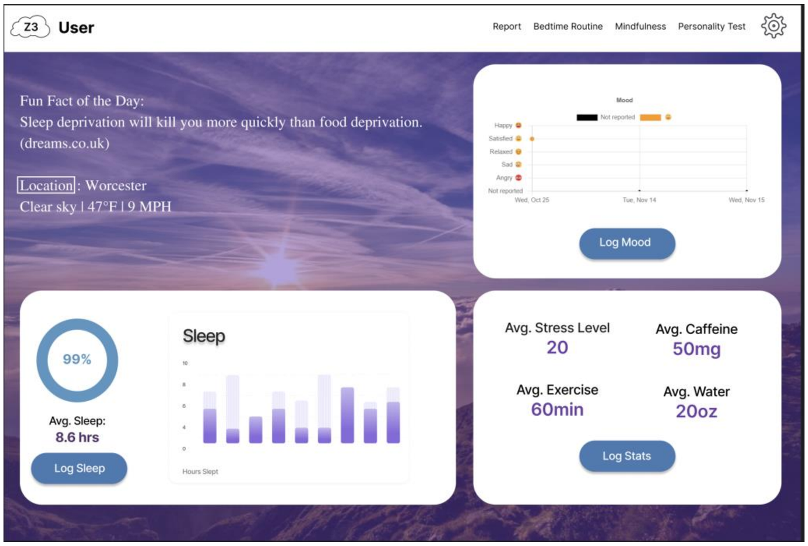
If not, would you find another sleep wellness application to use in the future?

a. Yes b. No c. Maybe

Are there any features not currently on the Z3-Wellness application that you would have liked to use? Any you believe we need to make the app more complete? _____

Proposed New Features

Here is a proposed design for a new Dashboard on the Z3 Wellness Application:

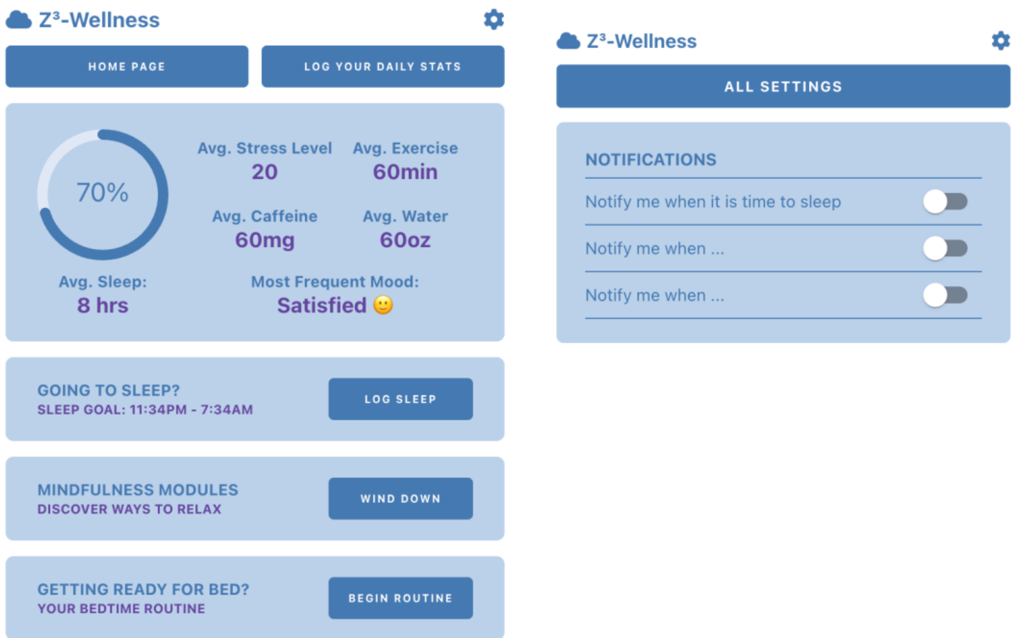


If this dashboard were to be implemented into the application, should we:

a. Replace the current Homepage
b. Add the dashboard as a new page
c. Add a setting for individuals to decide between the current homepage and the new dashboard

Please leave any comments on this new design: _____

Here is a proposed design of a chrome extension for Z3 Wellness Application:



Would you utilize a chrome extension for the application? _____

Please leave any comments on the chrome extension: _____

Appendix E: Updated Dependencies

Outdated Dependencies and Packages that our group updated.

Package	Current	Wanted	Latest
@material-ui/system	MISSING	4.12.2	4.12.2
@microsoft/microsoft-graph-client	3.0.4	3.0.7	3.0.7
axios	1.3.3	1.5.1	1.5.1
body-parser	1.20.1	1.20.2	1.20.2
chart.js	3.9.1	3.9.1	4.4.0
chartjs-plugin-annotation	2.1.0	2.2.1	3.0.1
create-react-app	3.4.1	3.4.1	5.0.1
express-handlebars	3.1.0	3.1.0	7.1.2
firebase	7.24.0	7.24.0	10.4.0
firebase-admin	8.13.0	8.13.0	11.11.0
firebaseui	4.8.1	4.8.1	6.1.0
helmet	3.23.3	3.23.3	7.0.0
jquery	3.6.1	3.7.1	3.7.1
react	16.14.0	16.14.0	18.2.0
react-bootstrap	1.6.6	1.6.7	2.9.0
react-burger-menu	2.9.2	2.9.2	3.0.9
react-chartjs-2	4.3.1	4.3.1	5.2.0
react-dom	16.14.0	16.14.0	18.2.0
react-google-calendar-api	1.5.2	1.5.2	2.3.0
react-helmet	5.2.1	5.2.1	6.1.0
react-native	0.69.7	0.69.12	0.72.5
react-native-elements	1.2.7	1.2.7	3.4.3
react-router-dom	5.3.4	5.3.4	6.16.0
react-scripts	3.4.4	3.4.4	5.0.1
react-time-picker	3.9.0	3.9.0	6.5.1
semantic-ui-react	0.88.2	0.88.2	2.1.4
sweetalert2	9.17.2	9.17.4	11.7.31