The Thought Journal App: Designed to confront thoughts that influence sleep

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Abstract

Problems initiating or maintaining sleep are prevalent and impact the quality of life negatively. Negative thinking patterns may perpetuate insomnia by inducing a state of arousal and consequently disrupting sleep. 'Thought challenging' is a common strategy to adopt a positive and peaceful mindset, but requires high awareness to internalize rational reasoning. Regular self-report and feedback may support the acquisition of fundamental reflection skills. We developed a thought journal in a mobile app to facilitate thought challenging. With the app, the users can reflect on daily situations and get visualized summaries as feedback. We carried out one week trial to explore perceived benefit, motivation, user engagement, and its integration with a sleep support tool. The results showed that using the app improved self-reflection skills and visualized summaries are perceived as motivating to log thoughts.

• **Human-centered computing**; • **Human computer interaction (HCI)**; • **HCI design and evaluation methods**; • **Field studies**;

Keywords: thought journal, self report, feedback, Visualization, sleep management, user-centered design

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1 Introduction

Almost one-third of life is occupied by sleep. Unfortunately, 35% to 40% of people worldwide suffer from sleep disorders [21]. A common one is insomnia which is defined as having problems with initiating and maintaining a good quality of sleep [6]. Consequently, there is a substantial negative impact on life quality. Commonly reported problems after a sleepless night are tiredness, lack of concentration, and irritability [21].

Insomnia is reinforced by lifestyle habits (i.e., irregular sleep times, excessive caffeine consumption) and cognitive factors (i.e., intrusive thoughts) [16]. The way individuals perceive the world relate to their beliefs and values [4], which then influence thoughts, and the regulation of bodily cycles [2]. Positive thoughts would promote harmony, while negative ones would arouse and disrupt sleep.

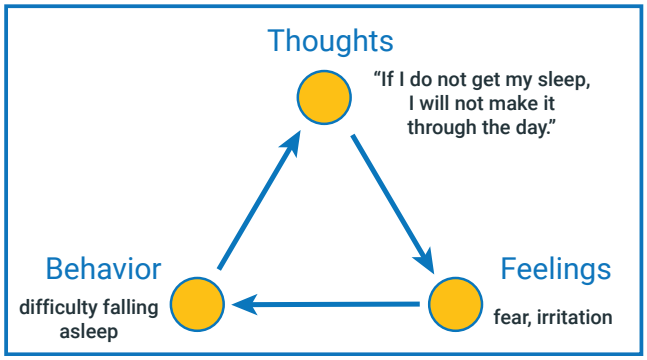

Figure 1. The cognitive triad and an example explaining the vicious flow of thoughts for sleep.

An aroused state of mind would produce dysfunctional thoughts that may disrupt the process of falling asleep [16]. Therefore, intense negative emotions and worrisome thoughts are dysfunctional and play a significant role in the reinforcement of insomnia, which is a self-triggering state called "the vicious cycle of sleep." Figure 1 shows an illustration of the vicious cycle and an example of how dysfunctional thoughts disrupt sleep.

Thought challenging is a common therapeutic process to cope with dysfunctional thoughts [16]. Through practice and awareness, patients break the habit of negative reasoning (i.e., "I will never be able to fall asleep tonight") and internalize healthier and rational thinking (i.e., "I will probably get tired soon and fall asleep") [4].

In the clinic, thought challenging is trained with the therapist in several steps [4]. First, patients describe the situation and reflect on their feelings. Then they are encouraged to identify the distortions in their thoughts (i.e., catastrophizing, black and white thinking) [4]. Finally, patients are encouraged to formulate their thoughts more realistically and positively.

Behavioral treatment is a long-lasting clinical solution for insomnia [16]. However, only 13% of insomnia patients can get access to specialist [22]. It is essential to invest in alternative delivery methods, and digitalization is promising. Thought challenging is an abstract concept, hard to grasp if provided by a digital medium. For instance, the online CBT platforms [9, 20] explain the rationale behind thought challenging, yet it lacks interactivity and personalized feedback [9]. Additional effort is needed to facilitate the adoption of thought challenging into practice.

A thought journal app would serve as a mediator role for individuals to be ready to confront their thoughts. To be more specific, self-report and feedback would help users to recognize the distortions in their thoughts and improve on inner reflection skills. We want to emphasize that such a tool is not intended as a substitute for thought challenging yet a preparatory step to tune into emotional states.

2 Self-Report and Feedback

Unprocessed daily stressors seem to be a factor for an aroused state of mind [11]. Being able to report situations and feelings promotes a re-thinking of the events, processes the daily hassles, and evaluate them with an objective point of view [23]. In other words, writing down the most profound thoughts facilitates emotional processing.

Research shows that personalized feedback is another factor for the enhancement of self-reflection skills [17]. The repetitive consequence of action and feedback is the core of any learning-based activity [12]. Moreover, feedback provided just after a behavior would encourage individuals to acknowledge the necessity for change [10]. Additionally, technology is a powerful tool to support chronic healthcare conditions by offering flexible and rich information delivery styles (i.e., text, image, video) [14].

2.1 Study Objectives

This present paper describes the design and implementation of the Thought Journal App and a field study to explore perceived benefit, motivation and user engagement. Based on the study, we have redesigned the layout and functionality of the app. The app is now ready to be integrated with a sleep self-management tool.

Research Questions: (1) What are the perceived effect and benefit of using thought journal components? (2) What factors motivate users to commit to the thought journal components? (3) In which ways does the thought journal fit into a broader digital sleep support structure?

3 Thought Journal App

The app helps users to keep track of their thoughts and get an overview of dominating patterns. There are three main functions of the app: *a thought entry*, *a though display* and *summary displays*. See Figure 2 for the screenshots.

3.1 Concept Development

We carried out a cultural probe, and then evaluated the concept with user studies. The ideation and concept development process is published in [25].

Cultural Probe: Special notebooks (i.e., probes) were prepared for 11 participants, where they can report the situation, thoughts, and emotions. The results showed that constant reporting increased awareness, curiosity, and consciousness over thought patterns.

There were two main considerations for designing the visuals. (1) Balancing the content among different screens. (2) Presenting the data with personalized visualizations. The elements are designed with common elements of social media like "note-taking" and "hashtag labeling." Furthermore, we have chosen a scale with facial icons as a probe to indicate the type and intensity of feelings. The human brain has innate skills to link mood with facial expression; therefore, facial images would facilitate labeling emotions with accuracy[24].

User Study: The concept was visualized as an interactive mock-up, evaluated with a usability study and clinical reviews. For the clinicians, the tool can educate people on cognitive aspects of sleep issues. For target users, the app was easy to use; visuals were clear and visually pleasing.

The initial idea was collecting thoughts with a mobile app and provide visualized feedback through a web platform. Then we decided to design all the components as a mobile

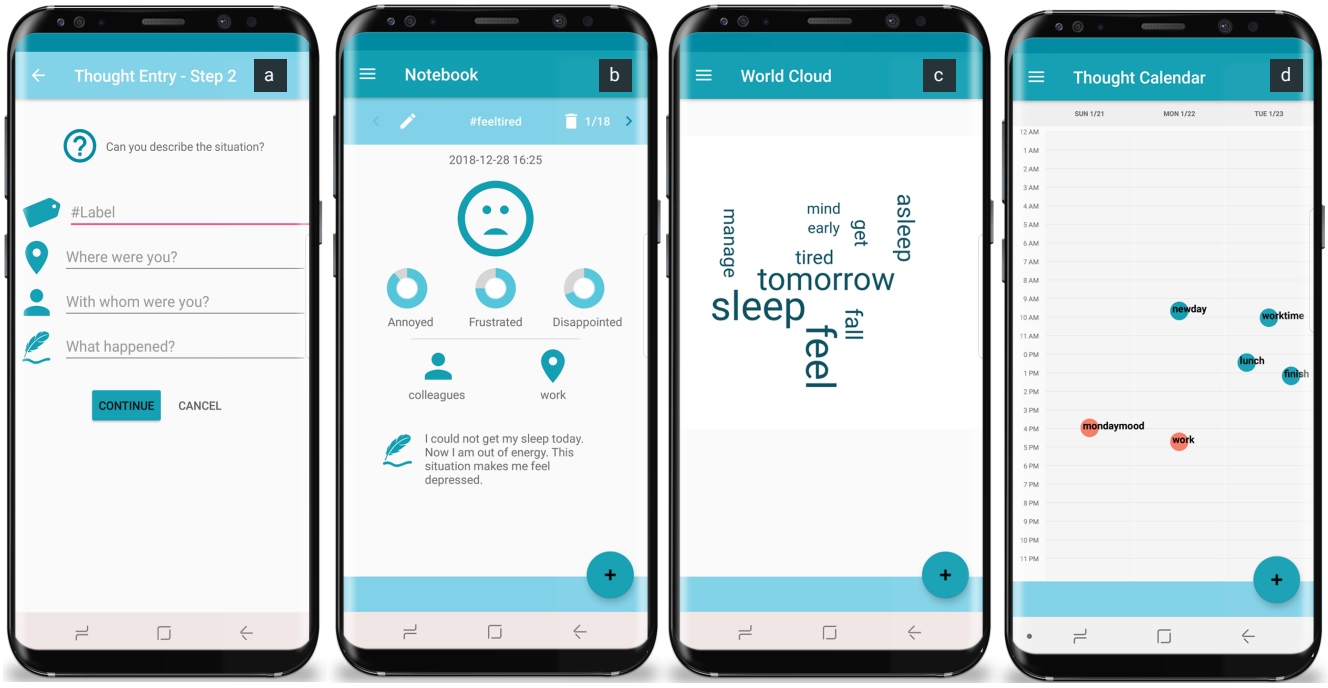

Figure 2. Screenshots from Thought Journal App: (a) entry, (b) thought display, (c) calendar summary, and (d) word cloud summary.

app. In this way, the feedback will be delivered immediately, which also means instant gratification for the users.

Thought Entry: There are three steps to record a thought: In Step 1, users select the type of emotion by clicking one of the two icon images: cheerful and moody. In Step 2, users provide the sequence of a label location, details, and situation entry. In Step 3, users indicate the intensity of their emotions with three scales. If positive: enthusiastic, satisfied, and motivated; and if negative: annoyed, frustrated, and disappointed. This set of adjectives are chosen from a comprehensive list of emotions [8].

Thought Displays: The details of recorded entries are displayed as *mood state*, *intensity rating*, *details of the environment*, *location*, and *situation*. Users can navigate through the screens, and view the previous entries by clicking on the arrow button (See Figure 2, B). Users can record a new thought entry by clicking the plus icon, which is present on all the screens.

Summary Displays: There are four types of visualized summaries, where two of them are implemented, and two are presented as a concept (i.e., static image). (1) *Calendar Visualization* – Thought types and their timing is mapped on a calendar-based layout (See Figure 1, C). Three days can be viewed in each display. (2) *Word Cloud Visualization* – Most frequently used ten words are visualized as a word cloud in different sizes based on its frequency (See Figure 1, D). (3) *Intensity Chart Visualization* - Daily average intensity levels are shown as bar charts. (4)*List Visualization* – Date, time, location, and labels are described, and the type of thought is indicated with color-coding (i.e., positive – blue and negative – red).

3.2 User Profile

Target users are individuals who are not satisfied with their sleep and have a tendency to ruminate over situations. The use case of the app is explained with a persona.

Persona: Jane Smith is a 32-year-old woman, an assistant professor who lives in the United States. Jane experiences issues with sleep. In the evening, her thoughts about not getting sleep become disturbing, and she becomes aroused. Jane realized her thinking patterns with Thought Journal App, and now she is ready to confront her dysfunctional thoughts. Figure 3 illustrates a storyboard of Jane's journey with using the app.

3.3 Implementation Details

The application is developed using Android Studio, which supports the Android mobile operating system (the minimum version is 6.0). The software is programmed in Java [1].

Model – View – Presenter (MVP) is chosen to structure the architecture of the app (See Figure 4) [19]. The Model layer is responsible for managing databases. It communicates with API and exchanges the data. In our system, we have one source of data that is retrieved from the Thought Journal.

Figure 3. A use case example for Thought Journal App and it's potential benefit. ©Begum Erten Uyumaz

The View receives interactions from the user and sends it to the Presenter. The view in our data is Thought Calendar and Word Cloud. The presenter layer is responsible for communicating the user interactions, which then updates the View if needed. Diary manager is the only component in our model.

Thought Journal and Word Cloud displays are adapted from external source libraries in Github: for Thought Calendar, (https://github.com/alamkanak/Android-Week-View), and for Word Cloud, (https://github.com/jasondavies/d3-cloud).

4 User Study

A one-week trial was carried out to explore *perceived benefit*, *motivation* and *user engagement*. The findings served for the refinement of design and functionality.

4.1 Methods

Participants: There were 16 participants:nine females, seven males, age range between 26 to 41. Nine of the participants were scored higher on Insomnia Severity Index [3]. The participants volunteered to participate in the study and signed a consent form. All the participants had a high affinity with

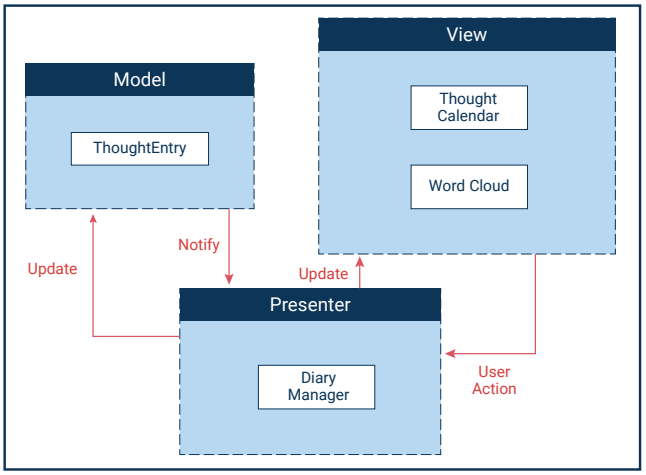

Figure 4. The architecture of the Thought Journal App.

technology and owned a smartphone. The average smartphone usage duration was 8.25 years (SD=3.5), and the average daily time spent on social media (e.g., Facebook, Instagram) was 1.91 hours (SD=1.12).

Materials: Two inventories were used for the study: Insomnia Severity Index (ISI) and User Engagement Scale (UES). ISI is a 7 item Likert-scale rating questionnaire that evaluates the perception of sleep onset maintenance, awakenings, and their impact on daytime functioning [15]. UES is a 27-items standardized rating inventory to capture perceived opinions on visual appearance, perceived usability, and focused attention[18].

Procedure: The study consisted of an introduction session (20 minutes), an app trial (7 days), and an exit session (30 minutes). In the introduction session, the participants were invited to the meetings one-by-one, asked to fill out an ISI inventory, introduced to the app. The app was installed on the personal device if it was Android. Otherwise, the experimenter provided an Android device. At the end of the trial, participants filled out a UES inventory and participated in the interview session. The interview was semi-structured; discussions were carried out regarding users' experience with the app and the perceived benefit of the tool.

Data Processing: The participants' data consisted of survey results, audio records, and interview transcriptions. The data was processed with confidentiality by assigning a unique ID for each participant.

The experimenter listened to the audio pieces multiple times while taking notes. Then, the data is transcribed following the rules of intelligent transcription [7] and resulted in a document of 9,196 words. The transcriptions were divided into two sections: *perceived benefit* and *user engagement* (motivation, commitment, and usability), and evaluated with the NVivo software package.

Table 1. Themes and sub-themes emerged for perceived benefit and effect of using the app.

Theme	Sub-Theme	Percentage Coverage	Description	Example Quotes
Influence	Awareness	10.92%	(1) The tool stimulated self-reflection and helped to realize negative and positive mood patterns. (2) Self-reflection skills increased over time.	"I am more pleased to see that my life was mostly positive. Plus, its enhanced awareness of the things that made me happy. (P6)"
	User Interest	14.15%	(1) Interested in the screens where thoughts are registered. (2) Visual elements make it more interesting. (3) Too much intrusiveness could reduce the interest of the app.	"I found the visuals helpful to see my accomplishments. I was using the app to learn about myself, and I have a real commitment to it. Visualizations motivated me. (P15)"
	Perceived Effect	14.93%	(1) The app encouraged reflections and made the users more aware of emotions. (2) The app gave the users a chance to connect with feelings.	"It influenced how I evaluate myself from day to day. Normally I don't care how I am feeling, however, using this app encouraged me to evaluate myself. (P3)", "The app made me more mindful. I think this app would make people feel good. (P7)"
Registration	Instructions	11.05%	(1) The app is simple to use with clear instructions. (2) Keywords and hashtags make the app simple to use. (3) It is not possible to register the level of mood. (4) The connection between thoughts and sleep is not apparent.	"I found the app easy to use, the instructions were clear. (P5)","I am not sure how using the app would increase my sleep quality? (P16)"
	Logging	13.46%	(1) It takes a while to make reporting a habit, and logging becomes effortless over time. (2) A recording is more about noting emotions. (3) Three continua of emotions were not sufficient to describe a situation. (4) Having the app on a second device, and lack of reminders was a significant drawback.	"My behavior to record my mood increased from the first to the last day. I wanted to record all the small subjects of occurrences. Later I slowed down by registering that it became a more common habit after four days of use. (P7)"
Thoughts	Sharing	3.15%	(1) Maintaining privacy is important. (2) Information could be shared with the others in a controlled way.	"I would not be comfortable if I knew that the information is going to someone else. (P11)"
	Writing Down	3.89%	(1) Writing down is easy, yet evaluating oneself is difficult. (2) Writing helps to rethink about the events. (3) Reporting an entry on real-time is not possible most of the time.	"Actually, I am surprised about it. I usually don't like to type, yet for this case, I found it useful to describe the situation. (P4)"

The experimenters processed transcriptions with the standard rules of open coding methodology [7]. A thematic structural analysis was carried out to identify themes and subthemes. [5]. One experimenter coded the audio themes, and a second one checked whether the themes matched with the content.

4.2 Results

Perceived Benefit and Effect: Table 1 lists the three themes that are emerged from thematic structure analysis: influence (awareness, interest, perceived effect), registration (instructions, logging), and thought-related (sharing, writing down). The most emphasized sub-themes were perceived effect (14.93%), interest (14.15%), and logging (13.46%). For

the participants, the app was interesting and helped to understand the cause of their feelings.

Motivation and User Engagement: Participants logged on average 19 thoughts and it ranged from 4 to 28. In general, the tool was found playful and it encouraged users to reflect on ongoing situations. Reasons for non-commitment were stressful events happening around, lack of reminders, and usability issues. Additionally, the participants had difficulties in understanding the relationship between thoughts and sleep.

According to the UES ratings, the participants perceived aesthetics as high (5.20/7), involvement and endurability were slightly lower (4.28/7) which followed by focused attention (3/7). It was not entirely clear for the users about navigation among the displays.

Table 2 lists the structure of themes for user engagement: *user experience* (strength, limitation, perceived effect) and *interaction quality* (usability, future add-ons). The most emphasized sub-themes were future add-ons (21.39%), limitations (17.43%), and strengths (10.76%). Not being able to edit time and date was a barrier for engagement.

4.3 Redesign

Functional and visual refinements were made based on the information gained from the user study. Figure 5 shows the screens from the updated version of the app. We have enhanced the design of diary entry (1, 2), list (3), and visualized summaries (4, 5).

Diary Entry: A significant concern among participants was there are too many steps to register a thought, and it was perceived as annoying since "we always want to do things fast" (P3). Step 1 include hashtag registration and describing thoughts. In Step 2 feelings are indicated and rated. Color coding is used to represent emotions green for positive, and yellow for neutral, and pink for the negative state.

Notebook View (Main Screen): The notebook display is redesigned as list of cards based on users needs to have an overview of the entries.

Visualized Summaries: The calendar view is simplified with clustering the same type of thoughts together. We included the cloud display in the new version of the design and removed the intensity chart concept since the users perceived them as too complicated. Additionally, we added a daily notification to remind users with a message, "How are you? Have you experienced any situation that influenced your feelings today?".

5 Discussion and Conclusion

Research shows that a cognitively aroused mind influences the quality of sleep [4]. Motivated by this, we have developed a thought journal app that encourages self-report and feedback. Engagement, perceived motivation, and benefit are the main focus of the design. An achievement was that we adapted to simple, appealing, and personalized design concepts.

The findings highlight a set of conclusions: (1) *Perceived effect and benefit:* The thought journal trained for self-reflection skills. The act of writing down helped to acknowledge how situations influenced emotions. (2) *Motivation and user engagement:* Visualized summaries promoted curiosity. Users highlighted the necessity of having reminders to adopt the habit of thought reporting. (3) *Integration with a sleep support app:* The presence of a particular reason to use the app as having a health issue was a strong reason to get motivated. Therefore, users must be clear on how keeping a thought journal would help with sleep.

Our findings align with previous research. Reminders are essential to adopt the habits of logging in a CBT-I based app [13]. The topic of habit creation emerged of being relevant in our findings, as well as in another study, which indicates that MHealth apps are beneficial for creating emotional awareness and good habits, especially with challenging cognitive misperceptions about sleep [6].

Overall, the main implications of our work are twofold. Firstly, e-therapy is a promising direction, provided full advantage is taken of the features of digital media, for instance, not copying existing in-person or paper-based solutions. Secondly, the effect of a thought journal will not emerge as a standalone tool but gain effectiveness when integrated with a sleep support tool.

5.1 Limitations and Future Directions

The duration of the trial was short (one week), given that it takes time to make self-reporting a regular habit. The instruction to log thoughts was left flexible in exploring the level of commitment, and the results showed diversity on number of entries during the trial having ranged from 4 to 32. Having only a few entries for some participants was an obstacle to receive meaningful visualizations.

In a follow-up study, the participants could be instructed to log a new entry at least once a day so that they would get a chance to experience the potential impact of visualized summaries. Moreover, two of the visualized summaries (intensity chart and list) were presented as static images which might have been a limitation for users to get the full experience. Finally, all the participants were high education background and this might limit the generalizability of the results.

Our main contribution is the design and evaluation of the Thought Journal. The future step is to integrate the design with a sleep support app, carry out studies with a larger sample over a more extended period (at least a month). The app is not intended to be used as clinical support, but as an add-on to commercially available digital sleep support products. The present work provides rich information to

Table 2. Themes and sub-themes emerged for perceived user engagement of the app.

Theme	Sub-Theme	Percentage Coverage	Description	Example Quotes
User Experience	Strength	10.76%	(1) The list gives a good overview, and the location information can help understand the situation. (2) The calendar view is a simple way to check the connections and distribution of emotions. (3) Word cloud provides personalized feedback because it extracts information from user entries.	"I like the calendar visualization the most, and I was checking it from time to time. I can see the connections immediately. (P4)", "I like the idea of having the list. It helps to understand the distribution of emotions. (P8)"
	Drawbacks	17.43%	(1) The intensity chart is found to be crowded and confusing. (2) Lack of notifications weakened engagement. (3) There are too many steps to enter a thought. (4) It isn't very easy to maintain commitment during weekends. (5) When to register a new entry is not clear.	"I would be more motivated to use if the app is installed on my phone. (P1)", "With whom are you is redundant, I can explain that information if necessary when describing the situation. (P3)"
	Feedback Effect	6.09%	(1) Thought calendar gives the impression of self-observation. (2) Word cloud helps to evaluate oneself. (3) At least a week of entry is needed for meaningful visualizations. (4) The list is informative regarding providing entries in the same view. (5) The intensity chart is perceived as complicated.	"I liked word cloud the most because it displays the majority of the situations, having this gives you an opportunity to evaluate yourself, (P3)" "I love word cloud very much. I can see what influenced my day. (P8)", "The intensity chart is too scientific, looks serious, and difficult to understand. (P3)"
Interaction Quality	Usability	4.57%	(1) The app is easy and straightforward to use. (2) The intensity scale starts from the middle. Instead, it should start from zero. (3) Not being able to edit time was an obstacle to commitment.	"I could not change the time of the thought, which reduced my motivation. (P14) ", "There are too many steps for registration which is annoying since we always want to do things fast" (P3).
	Design Opportunities	21.39%	(1) Adding features for self-report of perceived sleep quality and feedback. (2) Having informative reminders such as a recap of the day, progress meter. (3) Social sharing without violating privacy. (4) The home screen can be made as a list. (5) Auto-registering location information by using the GPS system. (6) Auto-completion option for the hashtags.	"I would expect to have the list as the home screen because the previous entries are summarized, and seeing this gives interesting insights. (P6)" "Adding notifications, for instance, summarizing my progress, could be helpful. (P1)"

future designers and user experience researchers who work on the development of digital sleep support products.

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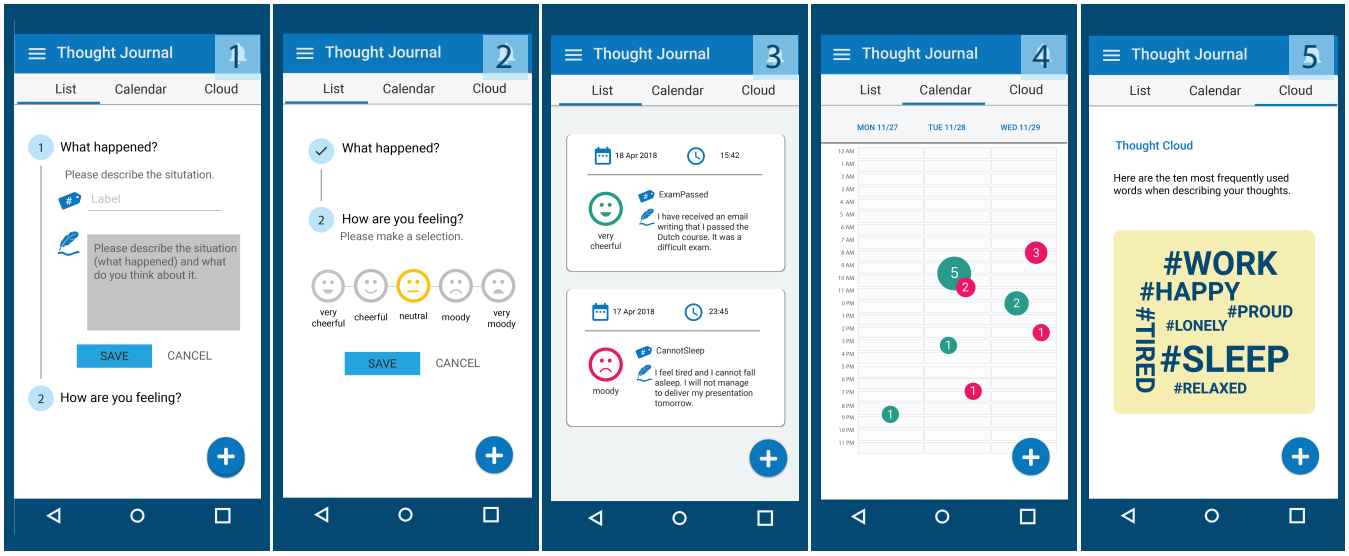

Figure 5. Refined design and layout of Thought Journal App. From left to right, Diary Entry (1,2), List (main screen) (3), Calendar (4) and Cloud View (5).

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