MindNavigator: Exploring the Stress and Self-Interventions for Mental Wellness

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ABSTRACT
Mental wellness is a desirable health outcome for students. However, current personal informatics systems do not adequately support students in creating concrete mental health–related goals and turning them into actionable plans. In this paper, we introduce MindNavigator—a workshop in which groups of college students were invited to generate behavioral change goals to manage daily life stress and practice personalized interventions for two weeks. We describe the manner in which participants identified both stressors and pleasures to create actionable, engaging, and open-ended behavioral plans that aided in stress relief. We found that the social nature of the workshop helped participants understand themselves and execute self-intervention in new ways. Through this practice, we build on prior studies to propose an analytical framework of personal informatics for mental wellness.

Author Keywords
Mental wellness; personal informatics; lived informatics; self-tracking; stress management.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Mental wellness is a clearly desirable health outcome. A state of positive mental wellness enables us to build resilience against daily stress [14]. While stress affects people of all ages, college students are particularly vulnerable to stress as they experience increased workloads and pressure [51]. To shed light on student life, HCI researchers in the field of have investigated approaches to assess an individual's mental health state (e.g., stress, loneliness, depression) by tracking smartphone usage as a proxy for consequential daily mental health–related behaviors [57] and by synthesizing multiple stress signals from self-reported, physiological sensing data and social media logs [38]. Much of the work, however, concentrates on data for assessment, prediction, and diagnosis. This approach may present a risk of missing subjective, anecdotal, and impressionistic data that could help individuals reflect on their daily lives. Thus, we need a better understanding of methods to empower individuals to produce, interpret, and reflect on personal data in an empirical way, as presented in [17].

Personal informatics (PI) systems have gained popularity, as they support data-driven self-insight practices, not always but often, to help individuals change behaviors [15,28]. People are interested in various domains in which they can improve the quality of their lives with PI systems, such as productivity [29], sleep hygiene [49], finances [51], menstrual cycles [20], and emotions [34], which are largely associated with mental wellness. While recent PI systems have enabled users to monitor behaviors and set goals to address target behaviors [22,36,42,53], these systems do not adequately account for an approach for creating highly subjective stress-related goals and turning them into actionable plans. We aim in this work to explore design opportunities of PI systems for mental health, especially for students' management of daily stress. In this context, we limit our review of mental wellness to the issue of stress, which we define to include a variety of negative experiences and feelings that, while sometimes adaptive, could turn into severe mental health problems if not addressed [32,41].

In this work, we envision a system that allows individuals to explore the causes of stress; create their own behavioral strategies, which we call self-intervention plans, to cope with the stress; and examine how these plans impact their lives. We follow in the line of speculative design research methodology to envision experiences surrounding suggested services [16,17,24,45]. Thus, we propose MindNavigator—an engagement workshop in which groups of students were invited to generate behavioral change goals to manage the stress of daily life and practice personalized interventions over a two-week period.

To examine PI practices for mental wellness among students, we draw on findings from the workshop to characterize types of stressors, behavioral plans and strategies related to stress management as well as the consequences of the two-week self-intervention practice, which included a chance to revise goals. Building on prior studies and our results, we propose an analytical framework—PI as a navigation system—to

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illuminate how PI systems for mental wellness should be designed to help users in navigating the process from identifying underlying stress factors to experimenting with personalized coping strategies. In particular, we discuss several design suggestions that take into account the nature of the mental wellness–related goal-setting process, which is inherently open ended, engaging, and self-soothing for stress management.

The contributions of this work are threefold:

- An empirical study with 23 university students resulting in a rich description of the subjective views and perceptions of individual students about stress management, goal-setting strategies, and the benefits and challenges of self-intervention toward stress management
- Design of a worksheet that facilitated our fieldwork, produced a large empirical dataset about stress, and enabled our participants to speculate about the design spaces of future technology that will support them in devising creative self-intervention plans for stress management
- A high-level analytical framework that could better inform design of personal informatics for mental wellness and specific design considerations of a specialized goal-setting process that encompass the unique characteristics of stress management

RELATED WORK

Understanding Stress

Researchers have attempted to identify the context of stress using various instruments and proxies, such as smartphone usage logs [57], biosensors [38], and sleep patterns [52]. However, stress by definition is the result of an individual's perception. Thus, an event regarded as stressful by one individual may not be stressful for another [46]. Previous approaches to understanding student life and stress have predominantly relied on a quantitative assessment approach [11,18,40], while few have adopted a qualitative approach to explore the context of and issues underlying an individual's stress. There has also been a lack of empirical work examining the strategies used by individuals to reduce stress except [28]. In this work, we propose a methodological approach to examine the elicitation of an individual's stressors, emotions evoked when facing stressful situations, strategies to cope with stressors, and perception of the benefits of the strategies.

Personal Informatics in General

PI practice includes the activity of collecting one's personal information and reflecting on it. Self-tracking technologies, an instantiation of PI, have been widely developed and adopted with the desire of understanding oneself [10]. In this regard, many researchers have proposed frameworks or models to better describe the practice of PI [2,21,35]. Building upon traditional PI models highlighting an iterative cycle of preparation, data collection, reflection and action, researchers have taken into account the entire PI user experience, ranging from deciding to track performance to lapsing or resuming the use of tracking tools [21]. Several results indicate that curiosity about one's daily life became an important reason to use PI systems [53]. Thus, users are no longer relying on a single activity tracker to understand themselves [22]. To meet users' varying goals, researchers have suggested flexible PI systems and approaches to reflect on various aspects of life (e.g., Metadating [17]). For instance, a mobile self-tracking system, OmniTrack [30], enables users to construct their own trackers by customizing tracking items and presenting micro, but interesting, aspects of an individual's daily activity, such as coffee intake or beer review. In line with this work, we are interested in the development of such casual PI practices to support users' reflections on the various aspects of their daily experiences and underlying emotions. Since stress is intertwined with our daily lives, we are particularly interested in investigating PI for stress management.

Personal Informatics for Mental Wellness

Research on achieving an in-depth understanding of one's mental health has become a critical part of the HCI community [4,6,28,56]. Approaches to achieving a state of positive mental well-being have been suggested as a form of mindfulness [44,60], and methods for relieving stress and depression [32] and for obtaining pleasure have been provided [56]. A recent study shows that self-tracking—a primary PI practice—could foster mental wellness in people living with unpredictable chronic physical conditions [3]. PI systems also directly support users with mental health problems. Work in this space has shown the potential of self-tracking technologies (e.g., MONARCA [23], MoodRhythm [39]) to assist individuals with bipolar disorder in keeping track of their mood and experiences. However, researchers have determined that self-tracking for daily stress brings unique challenges because stress involves highly subjective, social, and environmental factors [28]. Thus, we want to investigate how people decide what factors to track to reflect on their daily stress and how or whether they could cope with stress using a PI practice.

Self-Experimentation and Goal-Setting

The primary purpose of PI systems is commonly described as providing users with data-driven self-insight to help them change their behavioral patterns for the better [15]. Prior works have demonstrated that setting behavioral change goals could motivate and encourage people to achieve better health outcomes [10,12,13,31]. The self-experimentation approach has been introduced to engage people in the process of behavioral change by involving end users in the design and customization of sleep-related behavioral change goals and interventions [33]. While researchers have investigated goal-setting based on observational activities such as food intake or sleep hygiene, little is known about which behaviors related to mental wellness people desire to change, how they develop behavioral change strategies to attain mental wellness, and how such behavioral changes impact their mental health. Thus, we wanted to explore the topics above through an engagement workshop in which people participate in the PI practice from the identification of mental health problems through self-reflection on the impact.

METHOD

In this section, we outline the processes involved in our stress management workshop, giving particular attention to how the worksheet was designed, how participants produced data during and after the workshop, and how we analyzed the resulting data.

MindNavigator Workshop

MindNavigator workshop consisted of a series of events from exploring the nature of stress to generating personalized strategies to deal with the stress in their daily lives as a form of self-experiment [33]. We took into account a co-design approach used in [54] to personalizing behavioral interventions that could address personal distress.

The Design of the MindNavigator Worksheet

Since stress is the enduring aspect of everyday life, coping strategies play a key role in an individual's well-being[18,46]. Thus, cognitive behavioral therapy (CBT), a widely adapted evidence-based practice for mental well-being, was used as the basis for the design of our worksheet [7]. We incorporate the behavioral approaches of CBT to stress management that contains the practices of (1) recognizing stressors, (2) changing perceptions, and/or (3) adopting alternative behaviors to deal with personal distress in designing the worksheet.

Before proceeding with the workshop, we conducted a pilot test with three individuals over three days to examine the study's feasibility and improve our initial stress management worksheet mainly focusing on the goal-setting process. The pilot participants liked the objective of the workshop. Each participant was able to generate three to five goals to manage stress and track his or her goal achievements. Even though we asked them to use supplemental tools (e.g., write a memo using a smartphone calendar app) to record their behaviors, they preferred writing a diary on the worksheet provided. They also reported that it was somewhat difficult to come up with goals for relieving stress without knowledge about how they deal with the stress. In turn, the goals were likely to be in the form of a "to-do list" of tasks to be achieved in the short term, which turned out to be another source of stress. Pilot participants also suggested a goal-revision process after a couple of days of exploration. In sum, we recognized that the original worksheet lacked engagement factors, especially when creating a stress profile and generating "mind" goals that can impact stress relief. The modified A2-sized double-sided worksheet consisted of four parts: (A) creating a stress profile; (B) identifying stressors and relievers; (C) setting goals; and (D) planning, tracking, and revising goals, as presented in Figure 1.

A. Stress profile: Inspired by the Metadating workshop [17], in which participants were invited to create a data profile for speed dating, we offered a similar opportunity for participants to build a "stress profile" to help participants familiarize themselves through personal data collection and visualization on the MindNavigator worksheet. The profile section included scaffolded questions that could help individuals reflect on themselves by focusing on daily activities and habits related to stress. Participants were asked to create a profile using data

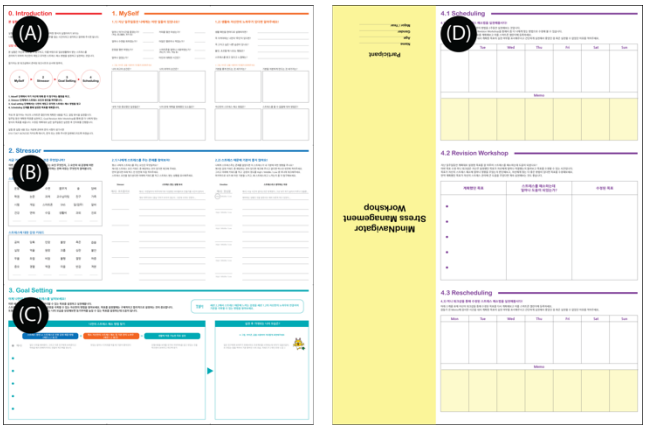

Figure 1. The worksheet of MindNavigator

that present various aspects of their daily lives (e.g., in the last week, what did you do in your leisure time? how many hours did you sleep? how many times did you work out? how many times did you eat breakfast? how long did you interact with others? and so forth). In addition, the profile structure led them to depict their best and worst moments. Following this basic stress profile, the form provided a space to specify pleasures that make the participant happy and to share personalized ways to make him or her stress free. To best describe themselves and these activities, some participants used visualization, as presented in Figure 2 and Figure 3.

B. Stressors and underlying emotions: This section was designed to identify factors that make the participants stressed. To help individuals explore the underlying reasons for stress, a predefined set of stressor keywords was provided. General stressor keywords related to student life, such as health, academics, social relationships, and lifestyle, were extracted from a recent study [9]. Participants were asked to either choose the most pressing stressors or suggest their own stressors. They then contextualized each stressor by describing their own experiences and emotions in reacting to it.

C. Goals: In this context, a goal is a form of specified self-intervention plan for stress management. To avoid the generation of plans involving a to-do list, we encouraged participants to ideate new types of plans to cope with negative emotions. The worksheet was structured to develop actionable plans by devising personal coping strategies discovered in Section A to deal with the stressors identified in Section B. Participants specified up to five goals that they would try to track. In addition, participants were asked to imagine their future selves once they achieved the goals by leveraging the strategies introduced by [50].

D. Plan, track, and revise: In this section, the participants integrated the goals into their schedule by making a daily plan. Once participants completed goal-setting, they were asked to determine *when* and *how* often to execute their specific plans using a calendar template. The calendar was also used as a space for open-ended journaling to record the daily goal achievement and describe the context of goal achievement or

failure. The revision section enabled participants to review whether their plans worked or not and to modify the plans if necessary.

Recruitment

We advertised our workshop as a self-experimentation for stress management and sought students who felt overwhelmed by stress and who wanted to explore the causes of stress, implement coping strategies, and try out those strategies. The workshop event was advertised through flyers, word of mouth, social media, and a local university's online forum. Ninety-five people expressed their willingness to participate in the experiment, and twenty-three ultimately participated (fourteen males and nine females, with a mean age of 21.0). All were college students, including one graduate student. Our workshop participants had various areas of study, including biology, business, chemistry, design, and chemical engineering. Participants each received $60 for two weeks of participation in the workshop.

Ethical Considerations

Our study was approved by IRB, and informed consent was obtained from each participant. Due to the nature of the sensitive topics involved, our source for the design and the study protocol includes peer-reviewed literature [7,18,46] and the recommendations of authorities such as guidelines from the National Center for Complementary and Integrative Health [43]. We also maintained a close partnership with a university's healthcare center. Our study materials and protocols were thoroughly investigated by a group that included a psychiatrist, a clinical psychologist, and a counselor prior to the study. During the study, participants were informed that the workshop was not a "clinically" validated tool kit. We urged our participants to immediately visit the counseling center if they became aware of severe symptoms of stress during this study. We also highlighted that the workshop was

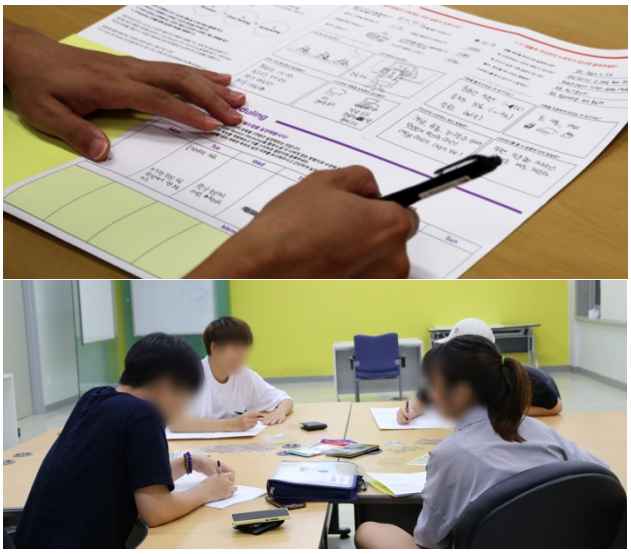

Figure 2. The workshop of MindNavigator.

designed to collect empirical design evidence for future technologies to improve mental wellness. The study was conducted with regard to each participant's motivation. Thus, participants were strongly encouraged to create goals that could address personal challenges. They were also allowed to pause or quit the study at any time. We remarked that participants did not need to feel obligated to do a better job on the study.

Study Procedure

We conducted a two-week workshop with 23 university students to understand how they understand and manage their stress with MindNavigator. All participants met with the research personnel three times in workshop to set goals, revise the goals, and reflect on the MindNavigator experience. In addition, there were two weeks of self-intervention between

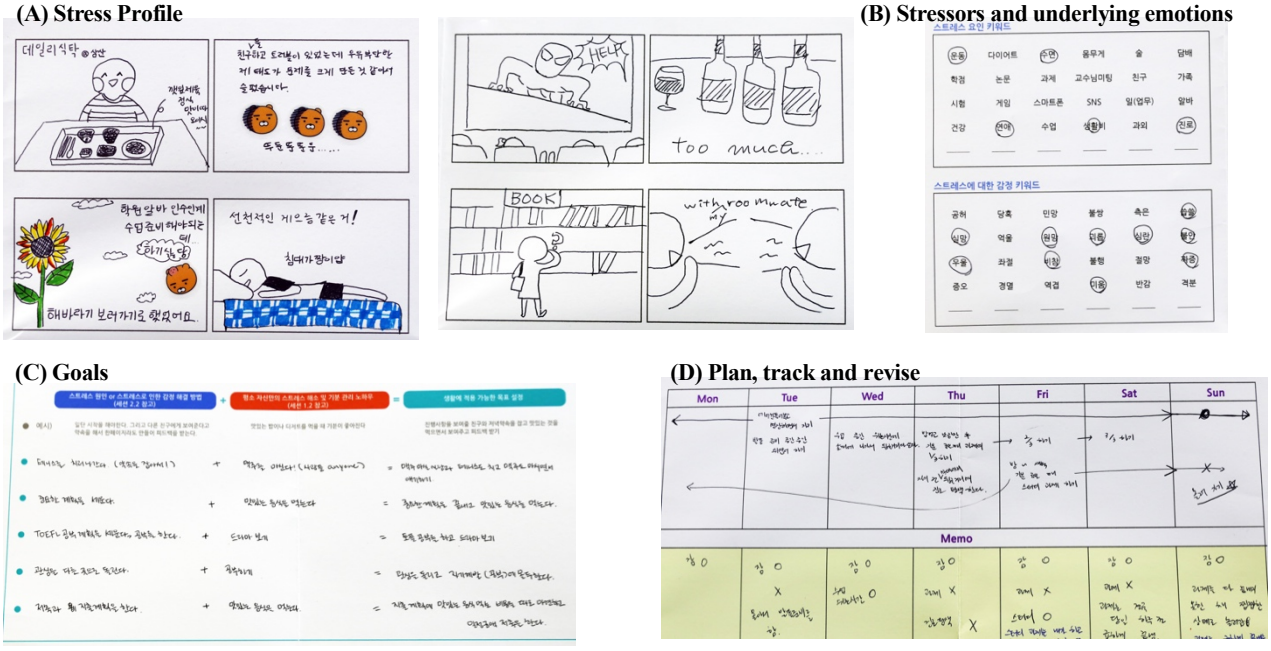

Figure 3. A snapshot of data from the worksheet of participants.

meetings with the researcher. A week of self-intervention provided a chance to try out behavior change goals set during the first meeting. Participants also had one more week to use the revised goals from the second meeting. Finally, participants were invited to the last meeting, in which they shared collected data and reflected on the results. In this workshop, we included not only the activity of enacting behavioral goals using the MindNavigator worksheet in a group setting but also the activity of reflecting on goals and experiences through one-on-one interviews. The complete study procedure is summarized in Table 1.

In the first session, participants were grouped together to jointly participate in an instruction session and activities to fill out the MindNavigator worksheet. Among the twenty-three participants, three groups composed of three to four members who knew each other applied for our study as a team. The remaining participants were randomly assigned to four teams. Participants were asked to complete a Perceived Stress Scale (PSS) survey [11] consisting of ten items to determine how they had recently experienced stress. The PSS score could range from 0 to 40. They took part in activities for navigating everyday stress and setting appropriate behavioral change goals through the MindNavigator worksheet (Figure 1). While filling out the worksheet, participants were encouraged to think aloud and present their worksheets to others.

In the second session, our participants spent first self-intervention period following their daily or weekly plans to achieve goals. Each participant filled out a worksheet to set goals in the first session and took it with him or her for later reference and journaling. They kept track of how well their plan worked for them. They also wrote short journal entries indicating the reasons for goal achievement or failure to assist in revising their goals later.

After the first intervention week, the participants attended a second meeting (Session 3) to improve their goals based on their first intervention experience through Session 2. Each participant brought the worksheet to the meeting to present his or her progress. Since some participants were reluctant to discuss personal details in a group setting, we decided to conduct the second meeting in a one-on-one interview format. We went over each goal with participants and allowed them to modify any of their goals for the next week's intervention. Participants then took part in another week of self-intervention (Session 4) with their revised goals.

In the final session, we invited all participants to a one-on-one interview in order to reflect upon the resulting data after the second week of self-intervention. Participants first completed a PSS survey to examine the impact of the stress management practice. We left the room to give the participants privacy. We then started reviewing the participant's worksheet together.

We walked through the worksheet to ask how well the participant achieved his or her revised goals compared to the original goals. We also asked for impressions about the MindNavigator workshop, such as the workshop's impact on stress management, the perceived challenges hampering behavioral change, and the likelihood of sustaining changed behavior throughout the two-week workshop period.

Session (Period)	**Goals and Activities**
Session 1: Focus Group (~one and half hour)	• Focus group interview of seven teams (3~4 individuals assigned to a group) • Goal: Understand the nature of student stress and types of goals related to stress management • Activities: (1) Measure the level of perceived stress (2) Fill in the MindNavigator worksheet (3) Make a daily and weekly plan
Session 2: 1st Intervention (One week)	• Each individual applies plans to a daily life • Goal: Explore feasibilities, opportunities, and challenges of MindNavigator • Activities: (1) Record the daily goal achievement. (2) Write reasons why they could/couldn't achieve the goal (3) Rate goal's effectiveness on stress management
Session 3: 1:1 Interview (One hour)	• Individual interview • Goal: Examine the types of goals that participants attempted to revise • Activities: (1) Brief the experience of the 1st week (2) Revise goals or action plans
Session 4: 2nd Intervention (One week)	• Each individual applies revised plans to his/her daily life • Goal: Explore the effectiveness and engagement of the revised goals • Activities: (1) Record the daily goal achievement. (2) Write reasons why they could/couldn't achieve the goal (3) Rate goal's effectiveness on stress management
Session 5: 1:1 Interview (half an hour ~one hour)	• Individual interview • Goal: elicit feedback about the overall experience of the MindNavigator study and examine the study's impact • Activities: (1) Measure the level of perceived stress (2) Review the worksheet and discuss the benefits and challenges of the study

Table 1. MindNavigator study procedure.

Analysis

We video-recorded the first meeting for focus groups and audio-recorded the second and final meetings for individual interview. We also created observational field notes for each meeting and generated transcripts of 46 interviews. To ensure the anonymity of the data, we eliminated any identifiable information from the raw data. We conducted a thematic analysis of our data [8]. Our primary interests were in (1) the type of stressors that could affect a student's mental wellness, (2) the kind of goals and actionable plans students created to

manage stress through the workshop, and (3) the impact of PI practice for stress management implemented via the workshop. Thus, we proceeded by categorizing and open-coding data based on our primary interests. With the open codes, we conducted axial coding using affinity diagramming to understand the main themes across the field notes and interview data, narrowing the codes [55].

FINDINGS

With the worksheet, we were interested in the kind of data people chose to represent in the stress profile and how they would generate a personalized intervention by leveraging the stress profile. By doing this, we could characterize (1) the types of stressors and relievers, (2) behavioral change goals to eliminate the stressors or leverage the stress-relievers, and (3) strategic plans unique to stress management for different participants.

General Orientation

As shown in our recruitment process, a large number of students (n=95) expressed interest in our study, resulting in the closing of online applications for participation after only three hours. No participant dropped out of the study, which produced a large amount of data (23 worksheets and about 2,700 minutes of workshop and interview transcripts), indicating that our participants fully received and engaged in the practice of stress management through the MindNavigator workshop.

While participants varied in their motivation, there were common interpretations of why they participated in the workshop. Most of the participants were aware that they felt overwhelmed, as shown in their PSS assessment results (Mean: 21.13, SD: 6.25), indicating that the participants were under a high level of perceived stress. More importantly, the PSS scores of 15 participants (65%) were above 21, indicating that our study might have drawn the attention of students who were suffering from stress at the moment of recruitment. Participants mentioned that the study itself seemed to be "*interesting*" (P8) and "*informational*" (P1). One student mentioned, "*I became aware that I'm insecure due to high pressure on my academic performance. I don't have any idea how to deal with it*" (P19). Another indicated, "*I am interested in stress management. I have sought information from books, but in many cases, it's just a program or general guideline. So, I am here to see whether I can build my own routine*" (P1). While some individuals already had their own routines, they wanted to examine whether their routines actually worked to reduce stress.

The analysis of dialogue in the workshops and the worksheets presented a landscape of the stress perceived by the students (Table 2). We categorized the stressors into ten key stress topics. The dominant causes of stress included health, academics, career, and relationships, which overlapped with the results of previous studies about stress experienced by college students [38,51].

Main Causes of stress (N=105)	Details
Academic (N=18, 17.0%)	Exam, field of study, project due
Professional (N=3, 2.8%)	Part-time job, research assistant
Career (N=16, 15.1%)	Getting a job, military duty
Chores (N=9, 8.5%)	Laundry, cleaning
Others (N=3, 2.8%)	Weather, mosquitos
Financial (N=13, 12.3%)	Tight budget, bad spending habits
Health (N=20, 18.9%)	Gaining weight, sleep deprived, fatigue
Leisure (N=9, 8.5%)	Smartphone overuse, games
Personal Trait (N=2, 1.9%)	Self-confidence, appearance
Relationships (N=13, 12.3%)	Roommate, family, advisor

Table 2. Main causes of stress of MindNavigator participants.

Identifying Stressors and Relievers

Data from the worksheets provided insight into the range of students' perceptions regarding stressors and stress-relievers. Our participants identified a variety of primary stressors and clarified whether the source of the stress was because of intrinsic factors (e.g., personality) or extrinsic (e.g., limited financial resources) factors. Stressors also often appeared as a combination of intrinsic and extrinsic factors. The questions about pleasures in the worksheet's stress profile also revealed two types of stress-relievers: those unrelated to the stressors and those designed to offset them.

Intrinsic Stressors

Some participants were more vulnerable to stress as a result of their personalities and/or habits. For instance, participants felt stressed due to bad habits such as "*pulling an all-nighter*" (P14) and "*wasting a whole day on a smartphone*" (P1, P20, P13, P17). One student (P3) reported an "*uncertain future after graduation*" as a major source of his stress, which he initially considered to be an external factor. However, he figured out, "*In fact, I usually mess around without making any preparation for my future. I should work more productively."* Another participant who was also concerned about his career said, *"Due to fear of failure, I am always procrastinating. It's a problem that stems from myself"* (P6). We found that intrinsic stressors led participants to have negative feelings about themselves, represented as self-reported emotions associated with the stressors in language such as "*[I am] disappointed with myself*" (P8) and "*[I] feel stupid*" (P11).

Extrinsic Stressors

Our participants also identified extrinsic stressors that were associated with matters outside of their direct control. Examples included "*sick and tired of the university cafeteria's same meal plan*" (P9), "*living on a tight budget*" (P22), "*conflict with a roommate snoring*" (P10), and "*a super demanding advisor*" (P8). P8 added, "*Before doing this workshop, I believed that I couldn't change the situation because my stress came from a relationship with my advisor.*" We found that extrinsic stressors evoked feelings such as "*upset*" (P9) and "*hopeless*" (P8), indicating that participants became frustrated because they could not get rid of the stressors by themselves. However, they could identify strategies to cope with challenges caused by these extrinsic stressors, as discussed below.

Relievers Isolated from Stressors

Participants were able to list stress-relief methods in the form of favorite objects, hobbies, and leisure activities. Examples included "*Amazon box just delivered*" (P23), "*delicious foods*" (P5), "*online shopping*" (P21), "*YouTube's short video clips*" (P3), "*a conversation with my best friend*" (P14), "*a sip of coffee*" (P12), and "*sing[ing] a song*" (P20). These relievers were not directly associated with the stressors, and although they did not directly address the problems the individuals were experiencing, the participants considered them as effective ways to reduce the negative feelings the stressors caused.

Relievers to Offset Stressors

While they were constructing their stress profiles, the participants identified another type of stress-reliever that could offset the effects of the stressors. Participants listed a number of activities that were directly related to the context causing the stress, for instance, "*a cold beer after work*" (P15), "*listening to energetic songs while doing a reading assignment*" (P9), "*an evening walk on campus after an exhaustive class*" (P2), and "*taking a nap if I get stressed*" (P7). These relievers were often paired with stressors to offset any negative effects.

Setting Goals and Self-Intervention Plans

We now focus on how the participants created goals to cope with problems or negative feelings. A majority of participants revisited their stress profiles to get inspiration for creating feasible and/or pleasurable self-intervention plans. They then generated goals by reflecting upon the stressors and relievers listed in the profiles. In this way, our participants created 85 self-intervention plans to eliminate stressors, enhance behavior with relievers, set goals as a "bucket list," change their mindsets, and anticipate the consequences of self-intervention.

Eliminating Stressors

Eliminating or reducing environmental stressors was the most frequently mentioned goal for stress management, which could easily be achieved by taking direct action. Once participants identified stressors that could be removed, they attempted to tackle them. For instance, by virtue of this workshop, one depressed participant realized that she suffered from insomnia due to the extremely hot and humid weather at the time. She then came up with a coping strategy: "*I will turn on an air conditioner 30 minutes before going to sleep*" (P20). Procrastination was an intrinsic stressor tackled by another of our participants (P6). To reduce his tendency to put off work, he set a goal: "*slice a big task (make a portfolio) into micro tasks and then do this every night*."

Enhancing Behavior Using a Personalized Reward

As illustrated above, an individual's bad habit was a typical intrinsic stressor because changing such a behavior is difficult [25]. Our participants often felt obligated to change their habits but found it hard to initiate the behavioral change due to a fear of failure. Therefore, some participants tried to change these habits by offering various incentives, ranging from tangible rewards, such as gifts and food, to favorite activities, such as hanging out with friends or taking a nap. One participant (P5), who depicted herself as a "foodie," had recently gained weight, but thinking of dieting turned out to be her stressor. To mitigate her concerns about dieting, she utilized her stress-reliever, "*eating delicious food*," but only on Saturdays while she was on a diet. Similarly, an online-shopping lover (P23) leveraged his hobby to serve as reinforcement for studying for a final exam: "*I'm going to order a small item that has been on my wish list for a while if I can finish this chapter*."

Setting Goals as a "Bucket List"

Rather than creating a "to-do list," which implies an obligation to follow through on the listed goals, participants created a list of things they would like to do, more similar to a bucket list. The goals consisted of pleasing activities that could motivate individuals to take action and further keep track of their goal achievement. P1 noted, "*I had to give up what I like if I had something to do. But through this experiment, I could purely focus on activities that I really want to do and that I can do. I'm very excited about my plan.*" To make a desirable and favorable self-intervention plan, each participant also prioritized goals with respect to his or her individual preferences and adjusted the frequency of such actions to suit his or her own pace. Thus, a successful plan allowed for flexibility and reduced the burden on the participant where necessary.

Changing One's Mindset

As an extension of the bucket-list-style plan, some participants considered "doing nothing" as a deliberate choice for achieving mindfulness. Similarly, "*lying in bed*" (P21), "*zoning out*" (P4), and "*listening to ambient sound for relaxation*" (P6) were goals directly related to addressing stress-induced feelings. Unlike traditional goal-setting processes addressing goal effectiveness, the goals our participants created were more likely to reduce negative feelings through pleasing activities, as P15 said: "*We're living in a society where we're expected to improve ourselves. Before doing this study, I used to set goals for fulfilling my social responsibilities as a dedicated student, as a good son, and so forth. But goal-setting in this workshop was quite different. Honestly, it was the first time I focused on myself and came up with ideas about how to make myself 'feel' better regardless of others. Thanks for offering a great opportunity!*" (P15).

Anticipating Results from the Behavioral Change Plan

MindNagivator's worksheet provided participants with an opportunity to imagine a future for themselves after two weeks of addressing the stressors in their lives. This activity also led participants to assess the consequences of behavioral change. P8 said, "*If I abandon myself to the stressors, I will be devastated.*" Our participants anticipated the outcome of the plans they designed. P11 noted, "*This anticipation section helps me think in advance about whether the method will work for me.*" Thus, when formulating their goals, participants relied not only on current stressors and relievers but also on expected outcomes and projections of their future selves.

Monitoring and Revising

Two one-week explorations with the goals created through MindNavigator revealed both the benefits and challenges of

personalized self-intervention. Despite the lack of pressure to commit to the interventions, our participants were highly engaged in the self-intervention phases.

Monitoring for Plausibility

Participants described the first week of self-intervention as an "experimental" period allowing them to monitor their behaviors and identify chances to revise their original goals. P22 noted, "*The situation around me always changes. For instance, a goal like 'go to the gym with my roommate at least three times' was dependent on his availability.*" He tweaked the plan a little and finally was satisfied with the revised goal. He also mentioned, "*The revision process is the essence of this experiment. Unless you try it out, you never know whether the original goal would be plausible and achievable.*"

Replacing, Refining, Removing Goals

While many participants continued to maintain their original goals, others decided goal revision was necessary for a variety of reasons, for instance, "*too tight schedule*" (P8), "*unrealistic plan*" (P10), "*unexpected events*" (P5), "*did not fit into my lifestyle*" (P21), and "*no impact on reducing stress"* (P16). Our participants stated that the experimental self-intervention allowed them to examine their own individual know-how and to revise their goals to achieve a better outcome by replacing, refining, or even removing the original plans. One participant modified the amount, frequency, and intensity of his plan because of its perceived burden. "*I am not a multitasker, but I put all five goals in my schedule, and therefore, doing this study made me feel overwhelmed*" (P20). Another participant replaced her goal to "*block out from 2 pm to 3 pm to do assignments on a regular basis*" with "*do assignments two hours before hanging out with friends*." According to her, "*Through this study, I became more aware of myself and what drives me to work. Though I am such a 'last-minute' person, I just wanted to know if I could change myself because I used to miss deadlines. Well, the original plan did not work because my productivity increases under pressure. So, I decided to tweak the plan to fit into my personality*" (P21).

REFLECTION ON MINDNAVIGATOR

Our participants were highly engaged in the entire process of exploring both the sources of stress and the strategies for relieving it, implementing actionable plans by alleviating the stressors with the relievers, and reflecting on their behaviors with the MindNavigator worksheet. In this section, we consider some broader reflections about how MindNavigator worked.

An Exploratory Approach to Personalized Intervention

The results of the PSS assessment presented a significant difference between the scores (Mean: 21.13, SD: 6.25) measured before the MindNavigator workshop took place and the scores (M: 15.26, SD: 5.96) measured after the workshop occurred ($t=5.1062$, $p<.0001$). More importantly, fifteen of our participants who were in the high-risk group at the pre-workshop PSS assessment presented a decrease in stress at the post-workshop PSS assessment, while only four remained at high risk. We, however, could not confirm whether the changed behaviors from the MindNavigator process were the cause of the stress reduction. Furthermore, we could not make any conclusions about the positive impact of the MindNavigator workshop on stress due to the small sample size and a number of factors, such as individual differences and context, that might affect the PSS scores. To complement our results, we conducted in-depth interviews to reveal the participants' subjective views and how they perceived the impact of navigating the nature of stress through MindNavigator.

Our interviews confirmed that many of the participants had a positive experience with the MindNavigator study. They reported that the preparation process was as effective as the actual self-intervention process. Our participants valued the process of presenting data about stressors and stress-relievers. This activity provided a source for creating concrete goals to tackle stressors and making a favorable, motivating plan using relievers. P13 expressed his desire to continue with the intervention he created: "*I feel I have my own toolkit for stress management. I will try to develop a couple more plans using this method.*" More importantly, some participants were able to change their attitudes toward stress through the experiment: "*When I felt stress, I thought it was because of someone or something I could not control. So I used to do nothing for it even though I got depressed. This experiment taught me that I can take a 'detour' around stress that I cannot get rid of*" (P8).

Creation of the Worksheet Perceived as Therapeutic

As a previous study on stress indicated [51], concentrating solely on quantitative data grounded in self-assessment does not reflect on subjective and anecdotal data. Unlike traditional stress measurement instruments, MindNavigator provided insight into explaining why stress exists and how and what the participants experienced as being stressful. The MindNavigator workshop also engaged them in creating their own map for stress management in a new way. They visualized a variety of stressors and stress-relievers through the creation of their stress profile. The majority of participants agreed that the stress profile section was the most engaging part of the workshop. The set of self-reflection activities allowed them to become better acquainted with themselves. More importantly, the participants appreciated that they could handle the negative impact of the stress themselves by externalizing the primary stressors that had affected their emotions and applying the stress-relievers to address them. "*This workshop gave me an opportunity to think about what I really like. In particular, I liked those questions about my favorite things and the best moment in my life. I felt really good while doing this workshop by recalling positive things*" (P12).

During the intervention, none of the participants used personal trackers or digital technologies to record their behaviors. Instead, they kept their worksheets and wrote a short description of their experiences and emotions. Prior studies have found that the expressive property of a life journal could play a therapeutic role [34] and support people as they cope with negative thoughts [58]. Our journaling approach also

facilitated self-reflection while monitoring and reporting behaviors.

The Social Nature of the Workshop

The format of the workshop was designed to provoke conversations among participants. We found that the social nature of the workshop facilitated the entire process of self-intervention for stress management, ranging from identifying stressors to executing self-intervention plans. Participants often tried to reflect on their behaviors, habits, and even their pleasures by engaging others. Some participants were able to capture specific aspects of themselves with the help of their friends. Participating in the workshop with friends also helped one participant (P18) be more honest when presenting data. We also found that an interesting conversation occurred in a group of three close friends:

(P13): "*Do you know how I am when I get nervous? I don't know what to write here [on the stress profile]!*"

(P12): "*Well... I think you become quiet. When you get nervous or depressed, you'd rather not too talk much.*"

In addition, participants were curious about the data, especially the stress profile, generated by others whom they did not know. Some participants sought out others who might suffer from similar problems, as P8 noted: "*I wonder if there are people like me, who have the same concerns. Is it only hard for me? I wonder how others accept it. I really wanted to look at others' cases.*" P16 added, "*My profile looks boring. I need a fresh perspective on this.*"

Our participants wanted to better design their own plans by browsing behavioral strategies developed by others, as P14 noted: "*It's difficult to make goals from scratch. Can you tell me how others did it, any examples?*" Conversely, some participants expressed willingness to share inspirational sources and strategies. When we reviewed the outcomes at the last workshop together, P15 said, "*This was the best goal I ever had. It worked well. I really want to recommend this for others.*" When practicing their plans, participants expected to motivate themselves while performing their goals with others who had a similar goal or those who were suffering from similar problems. P20 mentioned, "*It would be good to team up with people to practice the similar goal together. We can help each other.*"

DESIGN IMPLICATIONS

MindNavigator study is a formative study to create evidence-based frameworks that might better inform the design of digitized PI systems for stress management. Much of the prior PI's work addressed the importance of understanding the required procedures and strategies for behavioral interventions [21,35,53]. In our analysis of the participants' experiences with MindNavigator, we could characterize the types of stressors the students experienced, identify behavioral plans and strategies related to stress management, and examine the perceived impact of the self-intervention plan and execution process. Building upon these findings, we extend our discussion by proposing an analytical framework of PI for stress management as well as design considerations for advancing PI systems for mental wellness.

Personal Informatics as a Navigation System

Through our workshop dubbed the MindNavigator, we were interested in how people could **navigate** from identifying underlying stress factors to experimenting with personalized coping strategies. In line with this work, many researchers have viewed PI as a journey by an individual to change behavior for the better [21,26,35,53]. Models are varied, but most works occur under an iterative cycle of preparation, data collection, reflection, and action [35]. In this paper, we proposed a speculative approach to answer this question—how might we design a PI system to address mental health problems, especially daily stress? Reflecting upon the existing PI model's metaphor—navigating the journey to behavioral change—we suggested an analytical framework of PI for mental wellness to encompass unique properties of stress management.

While constructing the stress profile on MindNavigator, people should collect information about themselves, which is a critical part of the preparation phase [10]. This process could be understood as the way we can use a navigation system to get to the final destination. For instance, navigation starts from the question, **"Where am I?"** to find the current location of a user. With this beginning point, our participants could figure out the current situations in their lives that cause stress and the underlying emotions evoked by those stressors.

Once the user knows his or her current location and the desired final destination, the next step follows with the question, **"How can I get there?"** The system suggests optimal routes regarding traffic and preferred transportation. Using MindNavigator, people identify behavioral strategies to relieve stress, taking into account a variety of personal and contextual data. Our participants generated personalized goals with regard to stressors, relievers, schedules, and personalities. Recent studies suggest that users no longer rely on a single activity tracker to understand themselves [22]. Rather, flexible PI systems have been suggested to reflect on various aspects of a person's life [17,30].

While navigating an analogous transportation system, a user may face unexpected situations, such as routes under construction and schedule changes. At this point, the user should ask **"How can I take a detour?"** by searching for alternative routes or methods. Likewise, our participants often faced unexpected challenges to keeping up with their original plans due to both internal and external factors. Prior studies have discovered that self-experimentation—an iterative process executed by users to formulate, textualize, and revise behavioral change plans—has brought about desirable behavioral outcomes [33]. The one-week monitoring of the self-intervention allowed participants to identify what and why goals could or could not work for them. By replacing, refining, and removing the original goals, participants personalized their goals to be more favorable and achievable based on empirical data.

Continuous monitoring is required to respond to contingencies and reflect on goal achievement [5]. Recent PI systems have supported an unobtrusive self-tracking approach through automation [57]. However, self-tracking may not always be beneficial to those who are experiencing mental health problems [28]. Tracking of negative behaviors (e.g., an obsessive food journaling of an individual with eating disorder) may worsen the problem, and, in turn, lead to negative health outcomes. To help users track behaviors consciously and anticipate the outcome of behavioral change, we provided a journal style of MindNavigator worksheet. Although MindNavigator did not support automatic, technology-mediated tracking, it afforded participants a vehicle to record and digest data in a deliberate way.

In sum, our analytical approach could provide a general guideline for PI practices targeted for stress management. The guideline includes: 1) identifying the properties of stress (intrinsic or extrinsic factors) to create behavioral strategies for stress-relief; 2) designing favorable, desirable, and self-soothing interventions based on one's pleasures, personality, and situations; and 3) formulating actionable personalized intervention plans through iterative self-experimentations. Keeping this high-level framework in mind, we move on to discuss several design considerations for PI systems used for goal-setting to achieve mental wellness.

Designing Goal-Setting for Mental Wellness

Our work introduced an approach to creating personalized goals that address personal distress using the participant-oriented worksheets. Goal-setting for mental wellness was perceived as an open-ended, engaging, and self-soothing practice by our participants. While conventional goal-setting processes focus on task accomplishment and improved productivity, goal-setting for mental wellness is more likely to emphasize the positive feelings of the individuals involved. A notable approach to developing an actionable plan is leveraging pleasures to meet the challenges presented by stress, for instance, allowing favorite activities to offset the negative feelings evoked by a stressful experience. Without the imposed pressure to become a better person for others, our participants engaged in trying out plans and foreseeing consequences for themselves resulting from changed behaviors or mind-sets. In addition, the participants appreciated that they were asked to answer the question of "how well your plan worked for you" instead of "how well you kept to the plan." Thus, we propose a system that helps a user personalize plans by visualizing stressors, pleasures, habits, and preferences collected through a variety of data sources, including self-report, social media, and even other people. Additionally, the proposed PI system could help the user track behavioral data by prompting questions about how the plan affected emotions, not asking whether the user followed the plan.

PI services are increasingly considered social [1,19,27,37,59]. Researchers have investigated how the creation and sharing of data could mediate communication. A large body of research on the social properties of PI has involved examining the practices of collective data collection [47], social sharing of personal data [1,19], and social sense-making of collected data [48]. However, few studies have addressed how goal-setting could be social, with the exception of a single study about generating dietary, physical, and financial behavioral change plans with friends and workers recruited from a crowdsourcing platform [1]. Our study demonstrates that goal-setting requires a prior understanding of one's own behaviors, preferences, and personality. These attributes are often provided by social actors, such as friends, who "informally" track an individual. We propose a peer-sourcing system that enables users to assist each other in recognizing stressors, pleasures, and specific behavioral patterns that an individual cannot identify by him/herself. In addition, we imagine a feature providing a repository of others' behavioral change plans and curating stories, in response to our participants' desire to learn how others experiencing similar daily challenges have formulated their plans and obtained positive outcomes.

LIMITATIONS AND FUTURE WORK

Our study demonstrated some limitations and challenges. First, we recognized that our study population could have been biased, as our recruitment materials were likely to draw people who were already interested in stress management. It is also possible that such participants were especially eager to relieve stress through this opportunity. Thus, the reposted PSS data might not appropriately indicate the impact of the MindNavigator workshop. Second, our self-reporting method also contains several limitations. Our participants relied solely on memories to create data, and the time constraints of the workshop made it difficult to describe their data. Further work should leverage various data collection methods to address this weakness in our research, combining the worksheet with existing self-tracking capabilities to track psychological and physiological changes.

CONCLUSION

We propose the MindNavigator—an approach to exploring the landscape of students' stress and implementing personalized interventions for stress management through an engagement workshop. Our work provides insights into the landscape of students' stress, including their stressors, stress-relievers, goal-setting strategies, and goal-revision strategies. By illuminating how students manage stress with personalized interventions and describing the results using an analytical framework, we can better inform the design of PI systems for mental wellness. In our future work, we will implement our approach on a computing platform and will examine the long-term impact of MindNavigator on stress.

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