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Design Explorations to Support Learner's Mental Health using Wearable Device and GOAL application

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Abstract: Increasing the number of patients with symptoms of depression makes maintaining Mental Health concern in many societies calling for global attention. In children, stress and depression have a detrimental effect on their developmental emotions and physical health. From the perspective of a student, daily stress can affect their learning activities. Hence, to tackle this issue, it is necessary to develop their ability to manage mental health. Self Direction Skills (SDS) can support to develop such an ability. Current wearable devices can acquire physical activity and physiological data to compute stress levels, and sleep quality. While it makes it possible to visualize the amount of stress received in daily life, no such program is linked to the daily learning life of a student. To fill in this gap we extend our earlier developed GOAL system which already synthesizes students' physical activity and learning data and explores possibilities of integrating internet-based Cognitive Behavioral Therapy (iCBT) with our previously proposed DAPER model as an applicable method to deal with daily stress in academic life. We use the wearable devices to automatically track stress levels, and map activities of training students' mental health managing ability to the DAPER phases. Students can make a plan in the GOAL system to reduce stress by selecting a cycle of practice as suggested by iCBT. To inform our system design we conducted a pilot study with 120 students at a junior high school level. This paper presents an exploratory data analysis of 60 students, whose learning performance from english and mathematics courses and stress levels over 133 days were collated.

Keywords: GOAL, Mental Health, Garmin, Self-direction skills, Automated measurement

1. Introduction

Japan faces an increasing number of individuals with mental health issues such as depression and high stress. As of 2008, the total number of patients with depression exceeded one million. (Ministry of Health, Labor and Welfare, MHLW, in Japan 2010). Managing mental health is a very important issue globally and Japan also focuses on it (Mental Health Welfare Measures Headquarters in Japan, 2004). Psychological counseling is a common way to attend to mental health issues, and in Japan elementary and junior high schools have full-time school counselors as staff to support the students. However, individual attention is difficult to scale for such support. Therefore, we consider it important for students to learn how to analyze their mental health, monitor it, and reflect on a healthy state. Various mental health disorders are often the result of daily stress, closely related to sleep and physical activity (Åkerstedt et al. 2007). Wearable devices such as smartwatch compute stress levels based on the individual's physiological parameters like heart-rate. It also records physical activity and sleep-related data. Thus, it becomes possible to measure students' mental state to a greater extent with quantitative data automatically acquired by such wearable devices. We had earlier created a platform called GOAL (Goal Oriented Active Learner) system to support the integration of multiple data sources such as data from learning platforms as well as from activity trackers (Majumdar et al., 2018). The primary objective of GOAL is to support students' acquisition of self-direction skills (SDS) by presenting their log data. In this study, we explore possibilities of extending the GOAL platform to train school children with learning how to manage their stress based on quantitative data gathered from wearable devices. It aims to reduce stress by changing their daily behavior. As a pilot study, we conducted an exploratory data analysis to investigate *the stress patterns of students at a junior-high-school level.*

2. Related Work

Our method advocates automatic data gathering and skill measurement by the system. In this section, we summarize previous studies (see Table 1) that use log data to support mental health. For example, the pattern of spending money on gambling can be used to determine whether the type is easy to waste money. (Auer, Michael, et al. 2017). CrossCheck (Wang, Rui, et al. 2016) uses passive smartphone sensor data (sleep, mobility, conversations) to build inference models capable of accurately predicting aggregated scores of mental health indicators in schizophrenia. However, none of the support methods has improved the way students approach mental health. Many studies use automatic data gathering from self-report to smartphone but seldom do they provide system support for improving the status of the user. To fill the gap, this paper proposes a technology-enhanced approach to support stress management for students. By visualizing the current status to analyze, then planning, and completing a series of actions in the system, the user is expected to grasp and improve their mental health.

Table 1. *Examples of existing technology for mental health support*

Digital Application	*Types of data processed*	*Usage of data*	*Purpose*	*SDS for mental health*
Personalized feedback (Auer, et al. 2017)	The amount of money lost in the gamble	model using machine learning	Solve cognitive dissonance	×
CROSS CHECK (Wang et al. 2016)	passive smartphone sensor data (sleep, mobility, conversations)	track current mental status, and model using machine learning	Early detection of mental health changes for patients with schizophrenia	×
GOAL for mental health (based on Majumdar et al. 2018)	The stress level from the wearable device	Quantification and visualization of current mental state	Improve Self-directed mental health monitoring	○

3. GOAL for self-directed mental health support

3.1 *Tasks for mental health activity based on DAPER model*

Adapting DAPER model, we show the process of improving SDL skills for mental health using the stress data obtained from the wearable device. The DAPER model consists of five phases. Data Collection, Data Analysis, Planning, Execution Monitoring, Reflecting. In the data collection phase, students synchronize activity, sleep, stress level from their wearable devices with the GOAL system. For these data, the values sent from the devices every day are aggregated every day and displayed as a daily average value of one student. In the analysis phase, they can conduct simple analysis tasks to understand their activity trends and identify if there are any issues. Making a SMART (Specific, Measurable, Appropriate, Relevant, and Timely) plan would be the next step. Students can choose to make a plan of step count, sleeping time, or stress level to develop good health habits, and the system uses the average value of a group for comparison. There are three types of tasks: activity, sleep, and iCBT practice. Activity and sleep are compared with the average value of 1 month per class based on the data that can be measured by a wearable device and objectively judged whether the value is small. We also suggest iCBT intervention. In the execution phase, the individual monitors the progress of their plan and in the reflection phase, they review the whole process. It involves evaluating the difficulty of each task and the effort they made to achieve the goal in their chosen activities.

4. Pilot Study for data exploration

In the pilot study, we investigated the distribution of the stress level as collected from the wearable device and its relationship between learning performance behavior. With the understanding of the stress level variation and its relationship to different performance cohorts, can potentially help to decide the support strategy in our future work

4.1 *Context and participants*

We conducted a pilot data collection in a public school in Japan. Garmin Vivosmart3 smartwatch was distributed to 120 students from grade 3 junior high school. Since some students did not wear it or synchronize their data, there was stress data collected in the GOAL system for 60 students. Performance scores of 94 students were collected. and final target students were 60 (21 Males, 39 Females) students. The project was approved by the city school counsel for the pilot study and the GOAL platform pseudonymously connected students' Garmin data. Based on that collected data we analyze the following two research questions:
RQ1: What are the weekly stress patterns for Junior high school students?
RQ2: What are the differences in the stress patterns for different groups of students based on their performance transitions?

4.2 *Dataset and Analysis method*

The data collection period was from November 21, 2019, to April 2, 2020. Over these 99 days, 4054 physical activity data, and 1426 stress data were synchronized in the GOAL server from 60 learners.

The stress level ranges on a scale from 0 to 100 and automatically computed by the Garmin device based on the heart rate measurement (Heart Rate Variability and Stress Level, 2020). It classifies resting state (0 to 25), low stress (26 to 50), medium stress (51 to 75), and high stress (76 to 100) state. Stress duration is the number of seconds in this monitoring period where stress level measurements were in the stressful range (26-100). Daily average, maximum, and total stress values of each user are synchronized in the GOAL server. To answer RQ1 we compute the day-wise distribution of the average stress values and the duration for each day of the week across the period.

Besides the stress data, we also collected students' learning performance data in Mathematics and English subjects across the semester. It consists of two term-tests conducted during 26-27 November 2019 and 25-27 February 2020. To answer RQ2 we use the Stratified

Attribute Tracking (iSAT) approach (Majumdar, Alse & Iyer 2014) to first divide students into four groups based on the changes of their grades over the two-term period. For each of the English and Mathematics subjects respectively, four groups would indicate performance remaining at high or low or improving or deteriorating. Sixteen transition groups were generated considering both English and Mathematics performance. Figure 2a shows the transition patterns of group memberships across the two subjects. From this distribution, we were interested in investigating the difference between students who belonged to the three highlight transition groups: both low performers (n=12), both high performers (n=12), mixed (n=36). Applying the Shapiro-Wilk test, we found the Average Stress level data were normally distributed (p=0.119), but Stress duration was not normally distributed (p=0.0005). Hence ANOVA and Kruskal-Wallis tests respectively were chosen to determine whether Stress levels and Stress duration were significantly different in the three groups.

4.3 *Results*

4.3.1 *Weekly stress patterns*

To answer RQ1, Stress level, Stress duration by day of the week is presented as a box plot in Figures 1a and 1b respectively. In average stress levels, the average second quartile is in the range of 10 to 30 on every day of the week, so half of the students are less stressed. Comparing the stress values of the students who feel the most stress on any day of the week with the stress values of the second quartile, there is a difference of at least 20 and it can be seen that the stress values. In stress duration, it can be seen that the difference in maximum stress time is about 140 minutes, which varies greatly depending on the student.

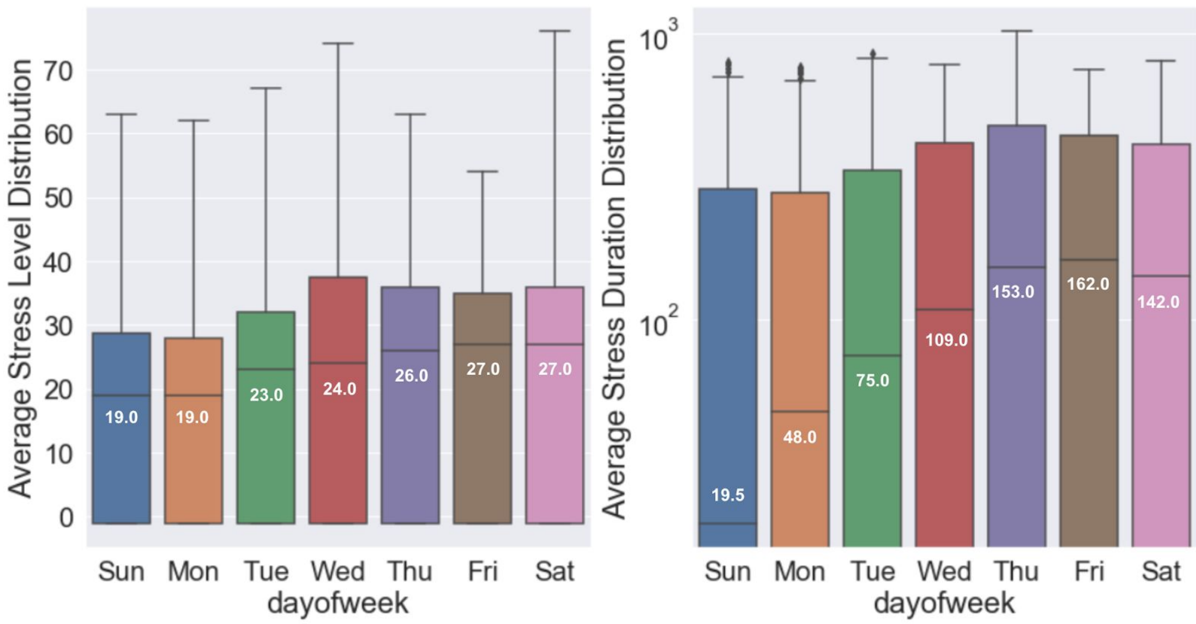

Figure 1. Distribution of average a. stress level across days of week. b. stress duration (minutes)

4.3.2 *Differences in the stress levels of performance cohorts*

Results indicate no significant difference between stress levels of high performance in both subject group (M = 22.6, SD = 14.3), low performance in both subject group (M = 21.0, SD = 12.3) and mixed group (M = 18.6, SD = 11.7), p=0.687. Further, there were no significant difference between stress durations(minutes) of High group (M = 208, SD = 211), Low group (M = 122, SD = 173) and mixed group (M = 130, SD = 160), p =0.772.

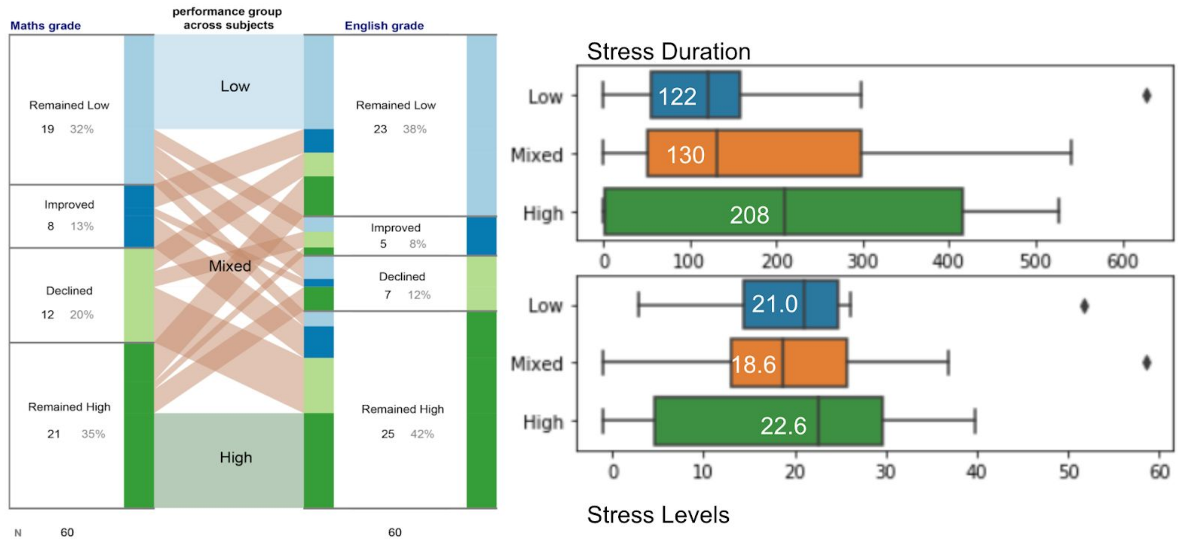

Figure 2a. Groups of grade transitions of exam scores 2b. Stress duration (minutes) 2c. Stress levels

4.4 *Findings from the dataset*

In the results of this pilot study, there was no relationship between stress and performance. However, from Figure 2b and 2c, it can be seen that the highest performing group receives the highest third quartile of stress. Therefore, it can be inferred that a certain amount of stress is associated with improving the grade.

5. **Discussion and Conclusion**

In this paper, we proposed an approach to use wearable technology and GOAL platform to track and support students' self-directed mental health monitoring. In the current times of the COVID-19 pandemic, the situation is even more restrictive and the number of children who were unable to have social interactions is increasing. Self-learning and developing the ability to control one's health can be a very important ability in these uncertain times. An activity based on the GOAL system might prove effective, as learners can use the system and a smartwatch to start their learning cycle. While the pilot data collection focused on familiarising the students with the smartwatches, no specific interventions were given related to reflecting on mental health status. It was also not compulsory for the students to continue wearing watches. Hence only half of the students used the watches and connected to the GOAL system. While the data is synchronized, the reliability is constrained by the physical sensing capacity of the smartwatch and its algorithm used, whose validity we just assumed. The GOAL system enables continuous learning, so we can expect further stress reduction by introducing a more effective iCBT mechanism. Still, due to irregular usage of the smartwatches and the GOAL system, the current dataset might not have shown any strong relations among its various attributes. A more controlled study is planned for the next semester. The device is distributed to all junior high school students as well as some high school students.

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