Assessing changes in stress levels through competitive gamification of a time management focus technique

Riya Singh[†1]
慶應義塾大学環境情報学部

Gao Zexiong[†2]
東京大学大学院学際情報学府

乾 雄貴 [†3]
慶應義塾大学環境情報学部

柄澤 匠 [†4]
慶應義塾大学大学院政策・メディア研究科

大越匡 [†5]
慶應義塾大学環境情報学部

中澤仁 [†6]
慶應義塾大学環境情報学部

1. Abstract

University students lead a hectic lifestyle juggling academic commitments, part-time work, and internships, often encountering stress that impacts their well-being. While external factors contribute to stress, such as part-time jobs, societal pressures, etc., university-specific stressors like assignments and tests also play a role.

This paper introduces a gamified app based on the Pomodoro focus technique, allowing students to challenge each other in studying or task completion. Analyzing two weeks of data from participants using both the normal and Challenge Pomodoro Timers revealed that, on average, participants utilized the Challenge Timer more frequently, resulting in increased motivation, improved time management, and reduced stress levels. Moreover, participants reported higher self-satisfaction with their motivation and time management skills, indicating an intrinsic boost influenced by extrinsic factors.

2. Introduction

Students face the challenge of balancing their academic and personal lives, with academic stress often leading to prioritization of success over health and sleep[1].

The Pomodoro focus technique proves effective in managing time by utilizing specified work intervals followed by designated break periods, fostering a sense of urgency for task completion. This technique is recognized for enhancing time management skills[2].

In this study, we developed a gamified iOS application for the Pomodoro focus technique using Flutter Dart, Xcode, and Firebase for real-time data storage. Our research involved implementing ethical procedures, including research methods and survey designs, to conduct a 2-week study with 10 participants. The collected data was thoroughly analyzed and presented to contribute valuable insights into the effectiveness of the Pomodoro technique in the context of student stress management.

3. Background

As mentioned before, a lot of students struggle to deal with stress in which some are directly or indirectly caused through time management. If time is managed properly, students will find a successful way and strategy to organize schedules, test, exams, etc.

Competition promotes students towards a "need-to-be-first" mentality which, in a way, forces students to work a lot to achieve the first spot. Through the Pomodoro focus technique - that utilizes time management, and through competition - that utilizes motivation inducement, our hypothesis is that students could experience a boost in

Assessing changes in stress levels through competitive gamification of a time management focus technique

[†1] RIYA SINGH, Faculty of Environment and Information Studies, Keio University
[†2] GAO ZEXIONG, Graduate School of Interdisciplinary Information Studies, University of Tokyo
[†3] INUI YUKI, Faculty of Environment and Information Studies, Keio University
[†4] TAKUMI KARASAWA, Graduate School of Media and Governance, Keio University
[†5] TADASHI OKOSHI, Faculty of Environment and Information Studies, Keio University
[†6] JIN NAKAZAWA, Faculty of Environment and Information Studies, Keio University

motivation to follow a time management routine to get things done to reduce their stress levels.

4. Previous Studies

As for choosing the Pomodoro focus technique and not another focus technique, a learning assessment conducted among students showed that there is a huge significant difference in students' score from when they did not utilize the Pomodoro focus technique to when they did[3] and has been highly appreciated for its effectiveness in reducing procrastination[4].

There has also been quite a few attempts on gamification for the purpose of improving education or academic areas. For example, a specially developed calendar was presented that aims to help the student to manage stress through taking control over the main stressors and shifting their mindset about stress[5]. They used logical and smart methods like showing the deadline of an assignment a week before it was due to reduce stress towards the deadline date.

It has also been seen that gamification, especially in leaderboard, leads to competitive students being energetic and determined to learn and increases their motivation in online courses[6].

5. System Overview

The app has 4 main pages - the home screen, the users page, the leaderboard page, and the challenge page.

5.1. Home Page

After being prompted to sign in for the first time, the home page displays the user's name, the points that they have accumulated so far, a focus time option, and a sign out option (see Fig1). The focus time page sets 25 minutes as the focus time and 5 minutes as the break time by default with a set count as 4 as well (as seen in Fig2). However, users have the options to customize it based on however they wish and can change the value of the minutes and set count themselves.

Users will get points based on how many minutes they focus for. The timer page also has a "Strict Mode" which enabled, freezes the pause button and the only way a user can stop the timer is through pressing the "Reset" button.

Fig1 Home Page

Fig2 Focus Page

5.2. Users Page

In this page, the user can see all online users available to be able to challenge. If the user wants to request a challenge, they will be prompted to input how long they would like to challenge the other user for.

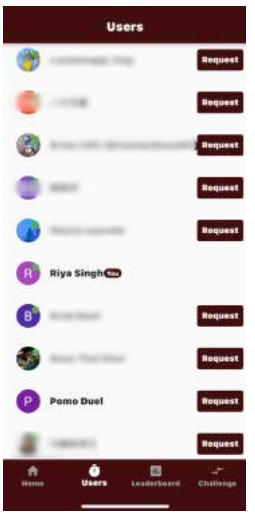

Fig3 Users Page

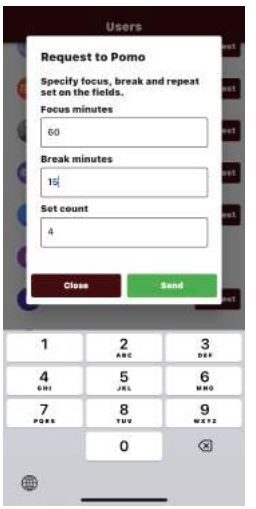

Fig4 Prompt for challenging

5.3. Leaderboard Page

The leaderboard page shows all the users in a ranking system that are ranked in the order of the scores that they have accumulated throughout using either the normal Pomodoro timer or the Challenge timer (mentioned in detail later).

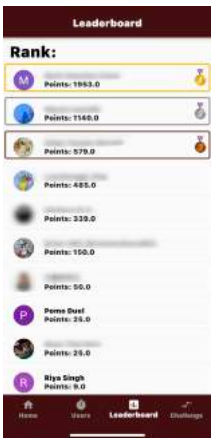

Fig5 Leaderboard Page

5.4. Challenge Page

This is where all the challenges related to the user i.e. challenges they have sent and challenges that they have received appear.

Fig6 Challenge Page

Fig7 Challenge in motion

If a challenge has just been sent, it shows "request" until the challenge receiver accepts on their end. If a challenge has been sent to the user, an "accept" status shows on the button.

Once the challenge in accepted, both users will be able to access the "challenge in motion" page (see Fig7). In this page, users can see the timer functioning in real-time. The users can start the timers at their own convenient availability to participate in such a challenge environment.

Once the challenge is completed, the status button appears as "done".

The challenge resets to the original number of sets that was requested by the challenging user to the accepting user if either one of them leave the challenge page. If the user leaves the challenge page a couple sets in, they will still get points for the respective focus minutes they focused for.

6. Preparation of study

To properly approach the ethical and appropriate way to conduct the study, this was the flow of the steps that were taken to ensure a smooth flow to the study.

6.1. Research Methodologies

There are 3 main types of research methods: quantitative, qualitative, and mixed[7].

A mixed research method - which adopts features of both quantitative and qualitative methods - was decided to be the approach of this study for the following two reasons:

- to collect numerical data (quantitative data) through close-ended questions for a proper process for data analysis and conclusion

- to collect narrative data (qualitative data) through open-ended questions for understanding participant insight that makes room for improvement for the system

6.2. Questionnaire Design

Questionnaire design is one of the most crucial aspects of a study as it is what determines how the user responds. It should be ensured that there is no room for biased response by forming the questions on the questionnaire appropriately.

All the forms below were formed by the initiative of making questions simple to read, making it brief, properly ordering questions, and forming questions by using subjective statements and applying the 5 scale likert system to convert these statements to quantitative data for data analysis[8].

For this study, 6 Google Forms were prepared:

6.2.1 Recruitment Form

This was to be distributed to as many students as possible to find potential participants through questions regarding their current stress levels, motivation levels to get tasks done, struggles with time management skills,

the device they own, and mentioning the procedure of the study and their duties as a participant for the study.

6.2.2 Consent Form

This was to inform the selected participants about the data that would be collected, their acknowledgment of the study procedure, and their oath in answering the questions with honesty.

6.2.3 Pre-Study Assessment Form

This was to collect initial data regarding the participant's current motivational levels, current effectiveness in time management, current stress levels, and their satisfaction with their motivation levels and time management ability.

6.2.4 Timer Form

This was to gather data regarding the participant's current motivational levels, current effectiveness in time management, current stress levels, and the effectiveness of the Pomodoro timer on their time management ability.

6.2.5 Challenge Timer Form

This was to gather data regarding the participant's current motivational levels, current effectiveness in time management, current stress levels, and the effectiveness of the Challenge Pomodoro timer on their motivational levels.

6.2.6 Post-Study Assessment Form

This was to gather data regarding their current stress levels and satisfaction with their motivation levels and time management ability along with their reflection on improvement on these factors and their overall impressions of the app through questions asking if they had any issues with the app, if they would recommend the app to their friends, if they would continue using the app, and if they had any feedback or suggestion for the app.

6.3. Data Visualization

After gathering data, the next step is to properly analyze and present it.

To analyze the data, Excel was used to create color-coded tables for the different timelines, groups of participant, and the flow of the study respective to those groups that appropriately have the required reported data necessary to draw conclusions from.

The first stage of this phase is to visualize the data gathered and collected. The decided approach to visualizing the data was to use graphical methods as they help in identifying patterns or relationships between variables and serve as a powerful diagnostic tool to confirm assumptions[9].

Through looking into types of charts and their purposes, it was appropriately decided to use bar charts as they allow comparison of data among various categories and line charts as they are useful in comparing data and seeing changes or trends in data over a period of time.

6.4. Statistical Analysis

Statistical analysis was performed on the common variables throughout different time periods of the study to look into the distribution and correlations using Python and Excel database manipulation.

6.5. Distribution of the system

All the participants that were selected were asked to submit their email address for system distribution. The system was then distributed through TestFlight by sending an invitation to these email addresses.

7. Study Procedure

The study was decided to be conducted for 2 weeks. Through the Recruitment Form that was given out, 10 participants who reported to struggle with stress management, had difficulty in raising their motivation to get tasks done, and struggled to effectively manage time were selected.

These 10 participants were given the Consent Form along with the invitation to install the app using TestFlight on their iOS devices.

The participants were then given the Pre-Study Assessment Form and based on their responses, were divided into 2 groups of 5 and were given specific instructions on how and what features of the app they are expected to use.

- Group A: participants who struggled mostly with their time management ability were told to use the Pomodoro Timer for Week 1 and use the Challenge Pomodoro Timer for Week 2

- Group B: participants who struggled mostly with their motivation levels were told to use the Challenge Pomodoro Timer for Week 1, use the Pomodoro Timer for Week 2

Group A was given the Timer Form while Group B was given the Challenge Timer Form after Week 1 and vice

versa for Week 2.

After completion of the 2 weeks, the groups were given the Post-Study Assessment Form.

The quantitative data from these forms were then put into the Excel table that was mentioned earlier and further analysis was performed.

8. Results I - Data Visualization

8.1. Group-wise comparison

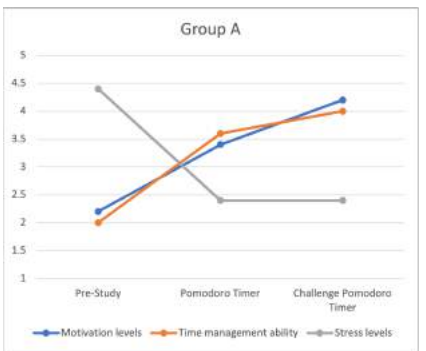

Fig8 Group A line chart

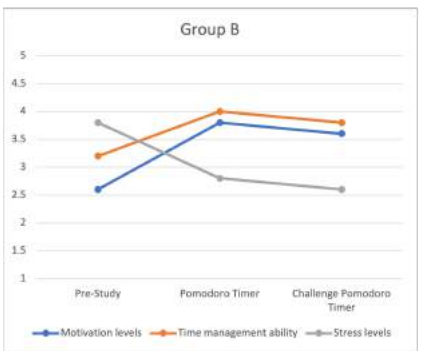

Fig9 Group B line chart

Both the graphs show each groups motivation levels, time management ability, and stress levels during the 3 main phases of this study - before the study began ("Pre-Study"), while using the normal Pomodoro Timer ("Timer"), and while using the Challenge Pomodoro Timer ("Challenge") in the respective order mentioned.

As seen, both Group A and Group B have similar graphs with upward slopes for motivation level and time management ability and downward slope for stress levels.

Looking deeper into Group A' s result, we can see that the stress levels drastically decrease after they start using the timers. Their motivation levels and time management ability increase throughout the study significantly.

As for Group B, they seemed to overall perform better using the Challenge Pomodoro Timer since their stress levels increase by a value when they use the normal Pomodoro timer after the Challenge Pomodoro Timer. Although this group relatively struggled with motivation more, their time management ability along with motivation level is shown to be improved significantly as well.

8.2. Timer-wise comparison

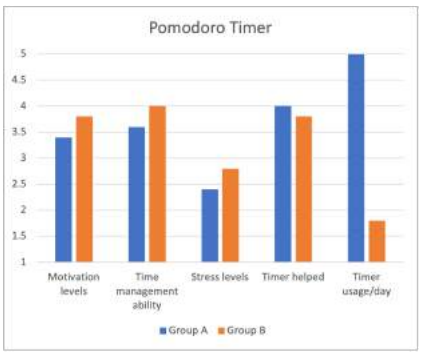

Fig10 Pomodoro Timer

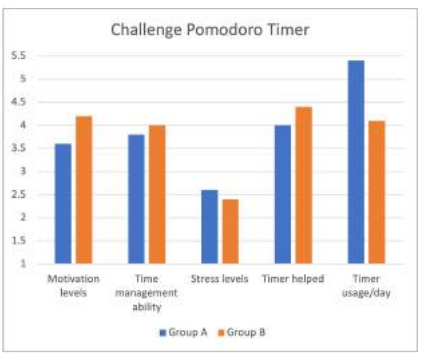

Fig11 Challenge Pomodoro Timer

Each graph above shows how both the groups performed in terms of 5 factors - their motivation levels, time management ability, stress levels, how much the timer helped them, and how often (on average) they used the timer in a day.

As for the Pomodoro Timer, Group B seems to have experienced a slightly higher increase in their motivation levels and time management ability compared to Group A. It can also be seen that Group B did not use the timer as much as Group A as their daily average of timer use was around 2 times a day compared to Group A' s 5 times a day. Group A' s stress levels are seen to be lower than

Group B’ s stress levels as well.

As for the Challenge Pomodoro Timer, Group B seems to have a higher increase in their motivation levels and time management ability as well. It also seems that the degree at which Group B agreed that the timer helped them is slightly more than Group A as well. It can also be seen that Group A used the timer more at a daily average of around 5 times a day compared to Group B’ s 4 times a day. Group B’ s stress levels seem to be lower than Group A.

8.3. Pre-study vs Post-study

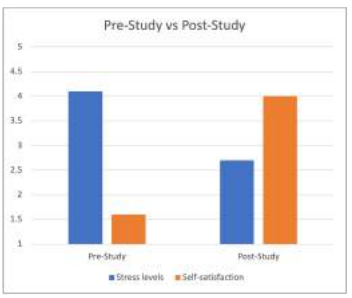

Fig12 Comparing the stress levels and self satisfaction values before and after the study

It can be seen in Fig12 that the average stress levels of the participants decreased from before the study to after the study with a value of 1.4 while the average self-satisfaction value, which is a variable to quantify how satisfied the participants felt regarding their motivation levels and time management ability, shows an increase after the study by a value of 2.4.

9. Result II - Statistical Analysis

As mentioned previously, Python was used to perform statistical analysis by extracting the data from Excel. An important point to be noted is that due to the size of participants and the data gathered from them, the options of statistical analysis’ that is appropriate to perform is limited. With respect to this study, only correlation analysis was performed to see the strength and direction of relationships between variables and correlation heatmaps were accordingly made to visualize some correlation matrices.

To pursue analysis, the various time periods from the data frame of the Excel data were stored as panda series within the time period lists.

The lists were as follows:

- prestudy = [motivation1, time1, stress1, satisfaction1]
- timer = [motivation2, time2, stress2, help1, usage1]
- challenge = [motivation3, time3, stress3, help2, usage2]
- poststudy = [stress4, satisfaction2]

The following categories of statistical analysis were then performed and looked into:

9.1. Descriptive Statistics

To continue with analysis, it is important to know how the data is distributed. If the data is normally distributed, not only is it rare, but it indicates to a data that has its mean equal to median and a standard deviation of 1.

As seen in the descriptive statistics for the pre-study phase (refer to Appendix A Table1), none of the variables have a normal distribution for the pre-study phase. Although stress1 has only a 0.1 difference in its mean and median values, the standard deviation is half of what its supposed to be for a normal distribution.

As seen in the descriptive statistics for the timer phase (refer to Appendix A Table2), none of the variables have a normal distribution for the Pomodoro Timer phase either. The variable stress2 has a distribution closest to a normal distribution. Variables like motivation2 and help1 also have close to normal distribution.

As seen again in the descriptive statistics for the challenge phase (refer to Appendix A Table3), none of the variables have a normal distribution for the Challenge Pomodoro Timer phase. The variable motivation3 has a distribution closest to a normal distribution while the variable usage2 has the highest standard deviation.

It can be seen in the descriptive statistics for the post-study phase (refer to Appendix A Table4) how satisfaction2 has almost a normal distribution with its mean and median values being the same. However, with its standard deviation of 0.77, it is again, not a normal distribution just like the other variable stress4.

These descriptions give us an insight of how the data is distributed for the variables during the pre-study phase, timer phase, challenge phase, and post-study phase.

9.2. Group-wise statistical analysis

The analysis for both groups was done by finding the average motivation, time, and stress variables throughout

the pre-study phase, timer phase, and challenge timer phase. We used the spearman correlation instead of the pearson correlation since the pearson correlation assumes linearity in the variables and is more suited to normally distributed data.

Table1　Correlation Matrix for Group A

	Motivation	Time	Stress
Motivation	1.00	1.00	-0.87
Time	1.00	1.00	-0.87
Stress	-0.87	-0.87	1.00

Table2　Correlation Matrix for Group B

	Motivation	Time	Stress
Motivation	1.00	1.00	-0.50
Time	1.00	1.00	-0.50
Stress	-0.50	-0.50	1.00

As shown, the perfect positive correlation of 1.0 between Motivation and Time for both groups suggests a perfect positive monotonic relationship between motivation levels and time management ability. As motivation levels increase, time management ability tends to increase monotonically, and vice versa.

For Group A, the strong negative correlation of -0.87 for between Motivation and Stress and between Time and Stress implies a strong negative monotonic relationship between them. This indicates that higher motivation levels are associated with lower stress levels, and vice versa and the same can be interpreted about time management ability and stress levels.

For Group B, the negative correlation of -0.50 for between Motivation and Stress and between Time and Stress indicates a moderate negative monotonic relationship between them. Higher motivation levels are associated with lower stress levels, and vice versa and the same can be interpreted about time management ability and stress levels.

It can be safely interpreted that for people that use the Pomodoro Timer first and then the Challenge Pomodoro Timer have a stronger negative correlation between [motivation levels and stress levels] and [time management and stress levels].

9.3. Timer-wise statistical analysis

Correlation heatmaps were made accordingly for the different timer phases and since correlations between Stress, Motivation, and Time have already been discussed previously, this section will focus more on the correlation between all the variables and Usage (how often the timer was used).

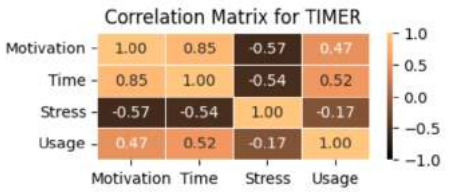

Fig13　Heatmap for Pomodoro Timer

- Moderate positive correlation of 0.47 between Motivation and Timer Usage suggests that more the timer is used, the more motivated the user gets.

- Moderate positive correlation of 0.52 between Time and Timer Usage suggests that with more timer usage, time management ability increases.

- Weak negative correlation of -0.17 between Stress and Timer Usage suggests that with more timer usage, stress levels might decrease.

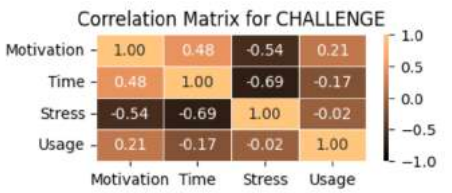

Fig14　Heatmap for Challenge Pomodoro Timer

- Moderate positive correlation of 0.21 between Motivation and Timer Usage suggests that more the timer is used, the more motivated the user gets.

- Weak negative correlation of -0.17 between Time and Timer Usage suggests that with more timer usage, time management ability might decrease.

- Very weak (almost no) negative correlation of -0.02 between Stress and Timer Usage suggests that with more timer usage, stress levels might decrease.

The correlation between timer usage and time management is contradictory for the two timers. This could be due to difference in user experience and/or user preference.

9.4. Pre-study vs Post-study statistical analysis

Upon correlating Stress and Self-satisfaction from pre-study and post-study, we found that the correlation be-

tween the two increased from -0.22 to -0.30. Although the magnitude of this increase is less, it can still be safely interpreted that through using the different timers, when stress levels decrease, self-satisfaction levels might increase.

10. Result III - Notable Participant Data

10.1. Pre-study

All of the participants reported that they get distracted easily either due to conditions like ADHD or due to not being able to focus for long without going on their phones which affects their motivation to do tasks. Most of the participants also reported saying they procrastinate and have a lot of tasks piled up which leads to their poor time management abilities.

10.2. Post-study

All participants reported that they felt their motivation levels, their time management ability, and their stress levels improve after the study period.

They all also reported that they seeing their names and position on the leaderboard helped them improve their motivation levels and time management ability that lead to reduced stress levels. However, specifically, 88.9% of the users reported that the study improved their motivational level much more than their time management ability with a user even saying "The game aspect motivated me".

All participants reported that they felt a sense of community through the challenge - looking at all the other users on the active users page and leaderboard. A user elaborated on this topic by saying "It was nice to see that other people were also studying at the same time as I was."

All users reported that they would recommend the app to their other friends that they know who struggle with stress management and that they would continue using the app.

11. Conclusion

For participants that struggled with time management much more than motivation levels, after using the Pomodoro timer first, an increase can be seen in their time management ability to a value higher than their increase in their motivation levels. For participants that struggled mostly with motivation levels, it can be seen that they had a major increase in their motivation levels than time management skills after using the Challenge Pomodoro Timer first.

All participants, on a daily average, used the Challenge Pomodoro Timer more than the normal Pomodoro timer.

Through correlation analysis, it was also found that stress levels have a generally negative association with motivation levels and time management ability. Motivation levels and time management ability was shown to generally have a positive association.

It was also seen that there is a positive association between how often the timer was used with motivation levels and time management ability (except for the weak negative correlation between time management ability and timer usage for the Challenge Pomodoro Timer). A negative association, although weak, was found between timer usage and stress as well that increased by a small value from before to after the study.

Overall, all participants experienced a rise in their motivation levels and time management ability that helped lead to reduced stress levels. The participants also showed higher self-satisfaction levels of their motivation skills and time management skills which indicates to intrinsic boost in motivation through extrinsic motivation as well.

12. Future Work/Limitations

This study only included 10 participants due to time constraints. We could expand the participant sample to gather more data which could give us a better insight on the relationship between stress, motivation, competition, and self satisfaction in a general aspect.

Furthermore, more gamification methods could be added to the app to evaluate more concretely how different gamifications have different effects on stress levels.

Acknowledgement This work was partly supported by National Institute of Information and Communications Technology (NICT), Japan. (Grant Number: JPJ012368C05401). This work was supported by JST CREST Grant Number JPMJCR19A4 Japan. This work was supported by JSPS KAKENHI Grant Number JP21K11853.

References

[1] Shannon Rodgers Queensland University of Technology, et al. “Managing Stress, Sleep and Technologies: Proceedings of the 28th Australian Conference on Computer-Human Interaction.” ACM Other Conferences, 1 Nov. 2016

[2] Wang, Xiaofeng, et al. “Turning Time from Enemy into an Ally Using the Pomodoro Technique.” SpringerLink, 1 Jan. 1970

[3] Education, Jefferson Costales Information Technology, et al. “A Learning Assessment Applying Pomodoro Technique as a Productivity Tool for Online Learning: 2021 13th International Conference on Education Technology and Computers.” ACM Other Conferences, 1 Oct. 2021

[4] R.J. Dizon, et al. ”The Effects of Pomodoro Technique on academic-related tasks, procrastination behvaior, and academic motivation among college students in a mixed online learning environment” Globusedujournal.In, 28 Aug. 2021

[5] University, M. Berehil Mohammed First, et al. “Gamified Stress Management Calendar for Higher Education Students: Proceedings of the 2nd International Conference on Big Data, Cloud and Applications.” ACM Other Conferences, 1 Mar. 2017

[6] Anh Thi Van Pham, et al. “How Gamification Enhances Student Motivation in Online Courses: Proceedings of the 6th International Conference on Digital Technology in Education.” ACM Other Conferences, 1 Sept. 2022

[7] Williams, Carrie. “Research Methods.” View of Research Methods, Mar. 2007

[8] Kelley-Quon, Lorraine I. “Surveys: Merging Qualitative and Quantitative Research Methods.” Seminars in Pediatric Surgery, 30 Oct. 2018

[9] Chambers, John M., et al. “Graphical Methods for Data Analysis, 22 Dec. 2017

AppendixA.

Table1　Descriptive statistics for Pre-study period

Pre-Study	Descriptive Statistics
Motivation1	Mean: 2.4
	Median: 2.0
	Standard Deviation: 0.80
	Minimum: 1
	Maximum: 4
	Skewness: 0.33
	Kurtosis: -0.34
Time1	Mean: 2.6
	Median: 2.0
	Standard Deviation: 0.92
	Minimum: 2
	Maximum: 5
	Skewness: 1.65
	Kurtosis: 1.82
Stress1	Mean: 4.1
	Median: 4.0
	Standard Deviation: 0.54
	Minimum: 3
	Maximum: 5
	Skewness: 0.08
	Kurtosis: 0.30
Satisfaction1	Mean: 1.6
	Median: 2.0
	Standard Deviation: 0.49
	Minimum: 1
	Maximum: 2
	Skewness: -0.41
	Kurtosis: -1.83

Table2　Descriptive statistics for Pomodoro timer usage period

Timer	Descriptive Statistics
Motivation2	Mean: 3.6
	Median: 3.5
	Standard Deviation: 0.66
	Minimum: 3
	Maximum: 5
	Skewness: 0.66
	Kurtosis: -0.63
Time2	Mean: 3.8
	Median: 4.0
	Standard Deviation: 0.75
	Minimum: 3
	Maximum: 5
	Skewness: 0.34
	Kurtosis: -1.15
Stress2	Mean: 2.6
	Median: 2.5
	Standard Deviation: 0.92
	Minimum: 1
	Maximum: 4
	Skewness: 0.09
	Kurtosis: -0.90
Help1	Mean: 3.9
	Median: 4.0
	Standard Deviation: 0.70
	Minimum: 3
	Maximum: 5
	Skewness: 0.14
	Kurtosis: -0.96
Usage1	Mean: 3.4
	Median: 2.0
	Standard Deviation: 3.41
	Minimum: 1
	Maximum: 10
	Skewness: 1.27
	Kurtosis: -0.08

Table3 Descriptive statistics for Challenge Pomodoro timer usage period

Challenge	Descriptive Statistics
Motivation3	Mean: 3.9
	Median: 4.0
	Standard Deviation: 0.83
	Minimum: 2
	Maximum: 5
	Skewness: -0.86
	Kurtosis: 0.49
Time3	Mean: 3.9
	Median: 4.0
	Standard Deviation: 0.70
	Minimum: 3
	Maximum: 5
	Skewness: 0.14
	Kurtosis: -0.96
Stress3	Mean: 2.5
	Median: 2.0
	Standard Deviation: 0.92
	Minimum: 1
	Maximum: 4
	Skewness: 0.38
	Kurtosis: -0.84
Help2	Mean: 4.2
	Median: 4.0
	Standard Deviation: 0.60
	Minimum: 3
	Maximum: 5
	Skewness: -0.11
	Kurtosis: -0.44
Usage2	Mean: 4.75
	Median: 3.0
	Standard Deviation: 3.91
	Minimum: 1
	Maximum: 10
	Skewness: 0.39
	Kurtosis: -1.65

Table4 Descriptive statistics for Post-study period

Post-study	Descriptive Statistics
Stress4	Mean: 2.7
	Median: 3.0
	Standard Deviation: 1.19
	Minimum: 1
	Maximum: 5
	Skewness: 0.24
	Kurtosis: -0.58
Satisfaction2	Mean: 4.0
	Median: 4.0
	Standard Deviation: 0.77
	Minimum: 3
	Maximum: 5
	Skewness: 0.00
	Kurtosis: -1.33