Creating Awareness of Sleep-Wake Hours by Gamification

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Abstract. Gamification can be used to motivate people to carry out hard-to-perform tasks. It can help in changing undesirable habits and in improving a person's subjective well-being. Sleep-wake behaviors are important determinants of day-to-day well-being. This study aims to find out whether it is possible to modify sleep-wake habits using gamification. To this end, a gamified alarm clock app, *Sleepy Bird*, was designed and tested in a user study with thirteen participants using gamified and thirteen participants using non-gamified versions for two weeks. The results indicate that the participants of the gamified version were more motivated to start the day at required times than the participants of the non-gamified version. The participants of the gamified version were also observed to have made desirable modifications to their sleep-wake habits.

Keywords: Gamification · Sleep-wake habits · Habit modification · Subjective well-being

1 Introduction

As one of the critical dimensions of subjective well-being, management of sleep-wake habits of people is an area that can benefit from gamification. Waking-up and sleeping at required hours can be considered as difficult-to-perform tasks (at least for some). This study aims to find out whether it is possible to modify sleep-wake habits and improve people's subjective well-being using gamification. A gamified alarm clock app, *Sleepy Bird*, was designed and tested in a user study to investigate whether the app can create positive feelings and better awareness of sleep-wake habits.

1.1 Gamification

The popularity of gamification derives from the popularity of playing games. The Global Games Market Report [17] indicates that globally, 1.2 billion people had played games by 2014. Playing has the power to trigger new behaviors against previous habits [3]. Gamification is a useful strategy that can influence people positively in the activities that they ignore, find boring, tiresome or even difficult to achieve. Gamification is based

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on the usage of game design elements in non-game contexts [6]. It has the potential to persuade people to take actions about undesirable but necessary activities [2] making them more appealing to people by creating *extrinsic* and *intrinsic* motivations [21]. An extrinsic motivation [16] satisfies needs with tangible outcomes such as reputation, titles, money and real rewards, whereas an intrinsic motivation symbolizes the satisfaction from an interesting and enjoyable activity. The success of a gamified tool comes from the satisfaction of intrinsic motivation and self-defined goals of players [21]. In this study, gamification is used as a motivation tool to regulate sleep-wake habits of people in order to improve their well-being.

1.2 Sleep-Wake Habits

Sleep-wake habits play an important role in happiness and long-term well-being. The more efficiently the subject sleeps, the higher the emotional, psychological and social well-being becomes. Thus, if sleep problems are reduced, both emotional and psychological well-being will improve [8, 9].

Sleep duration is also related to psychological health. Although it may differ for different age groups, nominal adequate sleep duration is 6 to 8.5 h. Optimal sleepers are known to have lower rates of incidence for depression due to possessing higher amounts of mastery, self-confidence and social relations, whereas insufficient sleep causes depression, stress and both physical and cognitive fatigue during the following day [15] and is known to deteriorate the learning performance of adolescents [19].

There are examples of mobile apps or alarm clocks that use gamification to track people's sleep-wake habits, and to ease waking-up times and prevent snoozing. For instance, '*Gun O'Clock*' aims to wake people up with a game which the user has to shoot the clock with a toy gun; or the users of '*Helicopter Alarm Clock*' need to catch a flying helicopter and put it on its nest to stop the alarm [4]. '*Zeo Sleep Manager*' is another example that tracks sleep cycles using wearable devices [14]. It has sensors on its headband to measure the electrical current during sleep phases. Then, it wirelessly sends the information to the mobile platform to make users aware of their sleep-wake habits and health conditions.

Some of the apps come with gamified features as well. People need to follow instructions offered by the mobile apps in order to go-to-bed, wake-up on time or to have enough sleep. '*Early Bird'*, developed for Starbucks, tries to persuade people to start their day on time with feedback messages and a reward system on a social platform [20]. When people use this alarm app without snoozing, it gives achievements to users. The achievement system is implemented with points, stars, social sharing and a cup of coffee, which is available for an hour after getting out of the bed.

Existing hardware/software solutions either compel people to wake-up at adjusted hours or use wearable electronics rather than using the power of persuasive design. Without using persuasive design and a '*fun factor*' effectively, gamified apps remain inadequate in influencing sleep-wake habits in a profoundly positive way. Tracking sleep through an app can help people to become aware of their sleep-wake habits. This can help to improve their sleep-wake behaviors positively in the long run [11].

2 Methodology

With the evidence from literature that sleeping and waking-up are important everyday behaviors and that gamification could potentially increase subjective well-being, the present study explored the effects of gamification on the attainment of the following goals: (1) increasing the motivation of participants for waking-up, (2) creating better awareness of sleep-wake habits, and (3) creating positive attitudes towards sleeping and waking up at optimal times.

The study required an understanding of people's existing sleep durations and waking-up times. A mobile alarm clock app, which allows remote data collection, was considered to be an appropriate tool to track sleep-wake habits of the participants. A specially designed gamified alarm clock app–*Sleepy Bird*– was used to track and collect sleep-related data in order to determine the effects of gamification.

2.1 Development of the Mobile App

Sleepy Bird was designed specifically for the present study, by modifying an existing popular game with alarm features. It was considered that in platform games, the quantitative progression of players can be observed easily. *Flappy Bird* [7] is a popular game which was downloaded up to 3 million times per day. Owing to this popularity, *Flappy Bird* was selected as a starting point for a gamified alarm clock app.

For the technical development of the app, Java language and `libgdx` graphics library were used. The entire *Flappy Bird* game was redesigned and redeveloped for the Android platform with embedded alarm functions, feedback, and calculations.

Both a gamified (G) and a non-gamified (N-G) version of *Sleepy Bird* were used in the study. The differences between the versions can be seen in Table 1. Since gratifying feedback was suggested to motivate participants intrinsically, both versions of the app offered personal feedback messages and insights about wake-up times, snooze actions, and sleep durations.

Table 1. Differences between G and N-G versions of *Sleepy Bird* app

Gamified Version (Experiment Group)	Non-Gamified Version (Control Group)
Alarm time and sound	Alarm time and sound
Going to bed hour and sleep duration	Going to bed hour and sleep duration
Feedback about wake/sleep actions	Feedback about wake/sleep actions
Revised *Flappy Bird* game	N/A
Game elements (e.g. visual elements, lives, points, feedbacks, leader board)	N/A

As *Sleepy Bird* aimed to create positive feelings while starting the day, color choices and graphics design were carefully made. The *Sleepy Bird* character was designed to

have a big red eye to emphasize its level of drowsiness. The game also used light to set an ambience, informing participants that the sun had risen that morning.

The app was designed with a Turkish language interface to fit the target user group of the study. At the top of the game screen, the score and remaining lives were displayed (see Fig. 1). For the gamified version, *Sleepy Bird* was designed to have four buttons on the main screen, which were grouped into two with color coding. OYNA (*play*) and (EN İYİLER) (*leader board*) buttons were related to gaming; ALARM KUR (*set alarm*) and UYKUYA DAL (*sleep*) buttons were related to sleeping-waking up. For the non-gamified version 'play' and 'leader board' were removed.

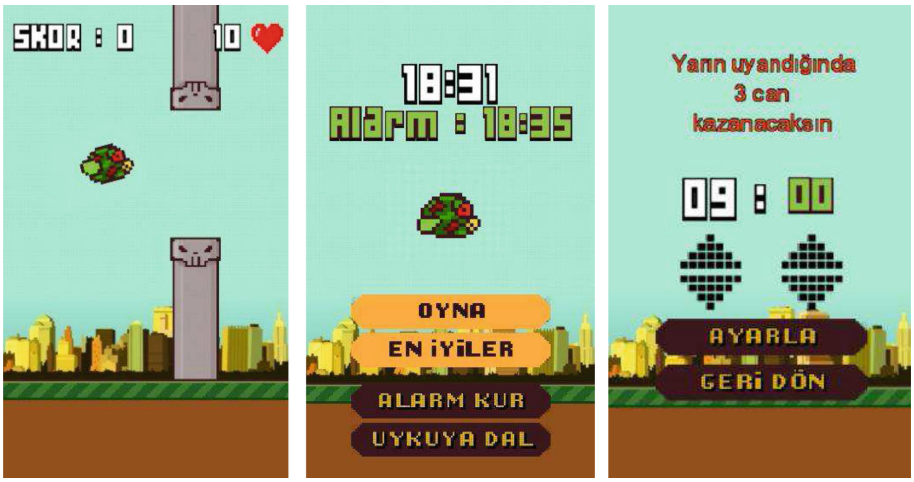

Fig. 1. Example screenshots from '*Sleepy Bird*'

The game provided personal feedback messages when, for example, the participants set the alarm or wanted to sleep. The messages aimed to create awareness about sleep-wake habits and were shown in red color to draw attention. If the feedback message was relatively long, a pop-up screen opened just as *Sleepy Bird* communicated with the users about their action.

The *Sleepy Bird* character appeared on the main screen to remind users to set their alarms for the following day and not to sleep late in order to wake-up easily next morning. Depending on the wake-up time set by the participants, the app showed them the score award for the next day. In order to record the sleep duration, the users needed to tap on the sleep button. After the alarm went off and awakened them in the morning, they played the game whenever they wanted during the day. The interface enabled the participants to check the leader board as a way to self-assess their standing among other players. The non-gamified version only required setting the alarm and sleep hours.

Decisions Behind the Design of 'Sleepy Bird'. In the development process of the app versions, the following considerations were taken into account:

- ideal wake-up time was set to be between 6.00-8.00 am and at least 1.5-2 h before the work time [5].
- adequate sleep duration was set as 7 h for the target group [22].
- game elements such as points, lives and leader boards were used to motivate participants [13].
- continuous feedback messages about personally required sleep-wake hours were provided [16].

The game rules were set as:

- The game gave '10 lives' by default.
- When participants woke-up at their optimum hours they won the maximum number of lives. Reward with '30 lives' was found as an appropriate solution to alleviate the tradeoff between enhancing the fun and keeping the value in the gameplay. The worst condition of wake-hour rewarded the user with '3 lives'.
- Work/school time was important for the background calculations of the app. It gave maximum game lives when there was a 1-2 h time gap between wake-up and work start hours. If participants did not wake-up at the right time they lost '1 life' for every 5 min of delay.
- Snoozing the alarm negatively affected participants in the competition. Each time the participants snoozed the alarm, they fell 25 m back in the game.
- If participants went to bed too early or too late, the speed of *Sleepy Bird* (character) increased to make the game more difficult.

2.2 Data Collection Tools

Data were collected via pre-use questionnaire (delivered prior to the use of the app), post-use questionnaire (delivered on the completion of the predetermined usage period), and usage logs. The pre-use questionnaire aimed to select and group the participants according to their scores. The post-use questionnaire aimed to collect usage-related information. The questionnaires also helped to compare relevant data between G and N-G versions of the app. Sleep-wake habits, moods and awareness levels were collected. Four scales were implemented in the questionnaires to collect personal evaluations. These were Epworth Sleepiness Scale (ESS), Pittsburgh Sleep Quality Index (PSQI), Morningness-Eveningness Questionnaire (MEQ), and Delighted-Terrible Scale.

2.3 Selection and Distribution of the Participants

The call for recruiting participants was made via word of mouth, e-mails and social media channels. Eligible participants were required to fit the following criteria:

- using of an alarm to wake-up.
- being within the age group of 18–35 (with similar sleep-wake habits).
- possessing average awaking difficulty.
- having a mobile phone running on Android platform.
- having no particular aversion to the *Flappy Bird* game.

A pre-use questionnaire was sent to qualifying volunteers. Candidates without sleep-related problems or with serious medical problems were excluded from the study. Selected participants were divided into two groups to use either G or N-G versions of the apps. Since the game in the app was a modified form of *Flappy Bird,* participants' approaches to the game played a significant role in deciding the group divisions. If participants had positive attitudes towards *Flappy Bird*, they were assigned to the G version of the app. If they were not interested in *Flappy Bird*, they were given the N-G version. An equal number of participants were allocated to each group. In total, 26 participants took part in the study (13 G; and 13 N-G users). Prior to finalizing the details of the main study, as a piloting, different user groups utilized the app in different time periods during the development stages. This helped to detect and correct possible functional errors, to improve the app's performance, choose appropriate statistical analysis methods, and decide on the number of participants that would be recruited for the study.

3 Results and Analysis

The results of the pre-use questionnaire, computer logs and post-use questionnaire were analyzed as described in the following sections.

3.1 Pre-use Questionnaire

The pre-use questionnaire is organized in three parts to assess the suitability of the candidates for the study and then to collect relevant information about them.

(i) Part 1. In Part 1, the Epworth Sleepiness Scale (ESS) was used to gather information on the candidates' subjective evaluations of sleep levels [12]. A total score was evaluated as participants having 'average sleep problems' (scores between 4 to 9); 'sleep problems' (10–14); and 'requiring professional medical help' (15 +). If the score was medium level (4–14), the participants were considered to have the right level of sleep problem to take part in the study. In the ESS results, the minimum total score was 4, and the maximum score was 13, with a mean score of 7.76 within the selected group of participants. Of the volunteers, six received ESS scores lower than 4, and were not included in the tests as they presented no sleep problems.

(ii) Part 2. In this part, the participants' sleep, work and snooze behaviors were evaluated. Some questions included in this part were adapted from the Pittsburgh Sleep Quality Index (PSQI) to obtain information about participants' subjective sleep-wake evaluations [18]. This part of the study aimed to assess pre-use sleep patterns of the participants. They were also asked the time of the day that they start working, to correctly calculate their appropriate wake-up hours. It was observed that 92 % of the participants started their school or work between 8.00–10.00 am.

(iii) Part 3. This part of the questionnaire focused on the participants' personal assessments about their wake-up attitudes and motivations. The questions regarding sleep-wake habits were obtained using the Morningness-Eveningness Questionnaire (MEQ) [10]. The

26 participants assigned scores ranging from 1 to 5 (1 being 'strongly disagree' to 5 being 'strongly agree') to each of the following six questions. All scores given in brackets are out of 130 (the sum of G and N-G = 26 × 5).

- Q1 asked whether participants believed it was easy to wake-up in the morning, and the answers showed the lowest total score (54/130).
- Answers to Q2 proposed that G app would help to wake-up more easily (*81/130).
- Q3 (63/130) and Q4 (74/130) focused on the degree of being wakeful or tired after waking-up.
- Q5 received the highest total score (99/130) indicating that the participants had positive feelings when they started the day at a correct time.
- Q6 received a high score (87/130) implying that G app would motivate participants to start the day at a correct time.

The results of Part 3 of the pre-use questionnaire are later compared with counterparts from the post-use questionnaire, to examine whether a positive change in participants' attitudes could be established.

3.2 Computer Logs

Computer logs were used to collect each of the 26 participant's sleep-wake actions quantitatively. After the installation of *Sleepy Bird* on their phones, the usage data were automatically gathered in a database, and all the actions taken in the app were remotely recorded in the system. The logs were related to wake-up time, sleep time, sleep duration and number of snooze actions.

The participants were required to set the alarm clock every day for the next morning before going to bed. When the alarm setting was forgotten, participants' data were not useful for the evaluations of that day. Therefore, at 10.00 pm every evening, reminders about alarm-setting were displayed by both versions of the app.

At the end of the study, a total of 325 samples (i.e. number of total actions related to wake-up hours, sleep duration, and number of snoozes) were gathered from the participants. Data comparisons were made based on the app version (G or N-G), and each participant's habits relative to the first- and second-half usage periods and the usage time (weekend or weekdays). Differences between the following were determined:

- number of snoozes,
- wake-up time (deviation from *personalized* optimum time),
- going to sleep time (deviation from *personalized* optimum time),
- sleep durations (deviation from *personalized* optimum duration).

The usage frequency between G and N-G versions showed a slight difference: G alarm provided a total usage data of 170 (52.3 %) samples, whereas N-G alarm provided a total of 155 (47.7 %) data.

Analysis Strategy for the Logs. In order to analyze the computer logs, data were analyzed in SPSS to find out: the mean, range, minimum and maximum values of wake and sleep time, snooze actions, sleep durations, and difference from optimum cases.

In order to establish the presence of any statistically significant values, a full factorial ANOVA model was obtained. The model included (i) game version, (ii) first and second half of usage; and, (iii) weekend vs. weekday usage as variables. All the tests were designed with 95 % confidence interval to have a margin of error less than 5 %, to reach a high level of reliability.

(i) Game version. An important goal for the study was to investigate the possible effects of gamification. Table 2 summarizes a descriptive statistics of snooze numbers, difference from optimum wake/sleep time and difference from sleep durations for G and N-G versions. The mean of snooze numbers (0.74) and difference from optimum sleep duration (which is 0) of the G version (24.33 min) was lower than mean values for the N-G version (46.33 min). Moreover, going-to-sleep time was closer to optimum (which is 0) for the G version, with a mean deviation of -11.75 min, whereas it was -36.85 min for the N-G version.

Table 2. Group statistics of actions by app version (G/N-G) for 26 participants

	Version*	Total no. of Samples	Mean	Std. Deviation	Std. Error Mean
Snooze	G	170	**0,74**	**1,373**	0,105
	N-G	154	**1,19**	**1,604**	0,129
Difference_optimum_wake	G	170	13,18	56,324	4,320
	N-G	154	9,77	59,607	4,803
Difference_optimum_sleep	G	169	**-11,75**	**84,303**	6,485
	N-G	150	**-36,85**	**76,252**	6,226
Difference_optimum_duration	G	169	**24,33**	**88,391**	6,799
	N-G	149	**46,33**	**84,928**	6,958

*G: gamified; N-G: non-gamified.

In order to see whether there was a statistically significant difference of sleep-wake habits between the G (experiment) and N-G (control) users, one-way ANOVA was used. The difference was statistically significant for three actions according to post-hoc comparisons. As can be observed from Table 2 (text in **bold**), *Sleepy Bird* resulted in significant differences between the G and N-G versions in terms of snooze action; go-to-sleep hours; and sleep durations.

Both subjective questionnaire evaluations and computer log results showed that wake-up hours changed in a positive way for participants of the G version. Participants of N-G also changed their wake-up hours with the help of feedback from the app. Participants of G version (7.24 h) became closer to optimum sleep durations (7 h) than participants of N-G version (7.46 h) at the end of the study. Going-to-sleep time changed in a personally-positive way for participants of both G (from 01.13 am to 00.19 am) and N-G versions (from 00.32 am to 23.53 pm).

(ii) First and Second Half of Usage Period. Since the participants used the apps for different numbers of days, the median value was different for each participant. The app usage ranged from 8 to 22 days between the participants. Average values of the date set

(i.e. wake-up time, sleep time, sleep durations, snooze numbers) of the first half of the usage period was compared to that of the second half. In the second half, mean values for the tested dependent variables approached zero. Thus, all of the actions had a positive progression in the duration of the study.

For G users, all the mean values became closer to zero in the second half, which indicated the optimal case. At the beginning of tests, participants snoozed the alarms more (0.99 times in average), woke–up later (17 min later than their personalized optimum time), slept earlier (15.49 min earlier than their personalized optimum time), and slept more (32.86 min more than their personalized optimum durations). According to post-hoc comparisons, gamification resulted in statistically significant differences in terms of snooze action ($p = 0.008$) between first half usage of gamified and second half usage of gamified versions.

(iii) Weekend vs. Weekdays. Participants used *Sleepy Bird* most frequently on Tuesdays and Wednesdays (18 %) and least frequently on Saturdays (9.5 %). The alarm was set 70 times (21.8 %) during the weekends compared to 250 times (78.2 %) in school/work days. For G users, 133 action data events on weekdays and 37 action data events at weekends were collected. According to post-hoc comparison results, differences in the snooze action while using the gamified version of *Sleepy Birds* was statistically significant ($p = 0.036$) between weekdays and weekend usage. For N-G users, 120 data events in weekdays and 34 data events at weekends were gathered. According to post-hoc comparisons, the N-G version of *Sleepy Bird* caused statistically significant results in terms of difference from optimum going-to-sleep time ($p = 0.035$) between weekdays and weekend.

3.3 Post-use Questionnaire

The post-use questionnaire enabled data comparisons between G and N-G versions of app users in response to whether a gamified alarm app created positive feelings and awareness for sleep-wake habits.

(i) Part 1. This part revealed the emotional experience related to the usage of the app. Delighted-Terrible Scale [1] (one question to select one of the facial expressions) was used to measure short term subjective well-being after the usage of *Sleepy Bird*. One participant (4 %) felt very delighted due to *Sleepy Bird*. Six participants (23 %) felt delighted during usage and 15 participants (58 %) pointed out that they felt happy due to this special alarm design. Four participants (15 %) felt neutral. The average feeling for the gamified version was between a delighted and happy, whereas the average feeling for the non-gamified version was between a happy and neutral.

(ii) Part 2. This part was used to measure changes in participants' awareness levels regarding their sleep-wake habits after the usage of the app. It consisted of four questions focusing on: wake-up hours (Q1), sleep durations (Q2), the interval between waking-up and starting to study/work (Q3), and number of snoozes (Q4). G users scored a total of 177 points, whereas N-G users scored 124 points, indicating that awareness levels of

sleep-wake habits reached a higher level for the participants of G version. Q2: in relation to participants' awareness on sleep duration, both G and N-G users scored a total of 80 points, which was the maximum score received within this part of the questionnaire. Q3 & Q4: total scores for both questions were identical for G and N-G users (75). This indicated that the *Sleepy Bird* app helped to increase participants' awareness for the time interval between wake and work time, and snooze action. Q1: total score for this question had the minimum value (71), which was about awareness level to start the day at correct hours.

When results were analyzed in SPSS using a t-test, awareness levels on sleep-wake habits between G and N-G showed some statistically significant differences for all of the questions (Q1: $p = 0.010$; Q2: $p = 0.042$; Q3: $P = 0.004$; Q4: $p = 0.011$). Participants of the G version gained a significant awareness as a result of app usage.

(iii) Part 3. This part was used to analyze participants' self-evaluations of their wake-up attitudes and motivations after using *Sleepy Bird*. In contrast with the same part (Part 3) of the *pre-use* questionnaire results, the scores were higher in total as indicated in Table 3 (text in **bold**). G users evaluated themselves as relatively more successful, more motivated and feeling more positive in terms of waking-up at early hours. These participants gave the highest score to Q1 (54 points), indicating how much they thought that they were waking-up at the correct time in the morning. G group also scored higher than N-G for Q5 (52) and Q6 (50) in the post-use questionnaire indicating that the app made them feel psychologically better and more motivated to wake-up at required hours. Q2 (40) showed that G group could not wake-up so easily during app usage. Score of Q3 and Q4 (36) showed that G group did not feel that awake, well-rested and lively after getting out of the bed.

Table 3. Total scores received for six questions in pre- and post- questioannires

	Pre-Questionnaire		Post-Questionnaire	
No.	G	N-G	G	N-G
Q1	27	27	**54**	**49**
Q2	45	36	40	**41**
Q3	31	32	**36**	**34**
Q4	37	37	36	33
Q5	53	46	52	43
Q6	49	38	**50**	**44**
Total Score	242	216	**268**	**244**

Although the total scores for G and N-G groups increased in the post-use questionnaire, only one question was calculated at the statistically significant level. According to separate t-test analysis, Q1 showed a significant change in G ($p = 0.00$) and N-G ($p = 0.001$) groups. Moreover, the total score of questions for both groups ($p = 0.012$) showed statistically significant changes between pre-use and post-use of the app. This result showed that the app provided motivation and positive attitudes on sleep-wake habits, especially for (Q1) waking-up at correct hours.

(iv) Part 4. This part was used to understand participants' tendency to change their sleep-wake habits as well as their suggestions for new app features. Open-ended questions were used to collect participants' comments on positive and negative aspects of *Sleepy Bird*. In total, 17 participants (65 %) stated that a gamified app would change sleep-wake behaviors in the long term. The 'leaderboard' was interpreted as the most attractive part for competition. Example comments from the participants of the gamified version were:

– "I decreased my snooze habit for the game success. I confess that I dismissed the alarm of *Sleepy Bird* once and set the alarm of my phone again in order not to lose game lives in the app." (Participant 8)
– "During the usage period, the app said to me that I will be either fresh or fatigued the following day. When it said that I will be fresh, I was really fresh. Conversely after the notification of tiredness, I felt tired the next day." (Participant 13)

4 Discussion and Conclusions

This paper investigated the practical outcomes of gamification informed by domain knowledge in sleep medicine. It provided a broader attention to the relationship between gamification, and sleep-wake habits. The aim was to examine whether gamification can create motivation and awareness to improve sleep-wake habits, so as to positively influence subjective well-being in the long term.

The study utilized gamification with a shift from *an extrinsic reward system* to *an intrinsic feedback system*. *Sleepy Bird* app was designed to focus on 'intrinsic motivations' with its gratifying feedback system. With its feedback and notifications, the app gave information on optimum wake and sleep hours to improve users' awareness of sleep-wake habits. The results revealed that gamification can be useful for the creation of positive feelings and better awareness about sleep-wake habits. Gamification also helped the study participants to start their day at required hours, since the app notified them about their required sleep-wake hours and sleep durations. A gamified alarm app also encouraged participants to not snooze their alarms.

The results provide insights for game developers. Computer logs allowed collection of game-related data concerning the numbers of game lives, game points and top scores. Time, sequence and frequency of actions taken by 'players' can be tracked through such an app design. The feedback messages about competition and leaderboard results were useful ways to concentrate users' attention to their sleep-wake habits indirectly so that they may become better in the game.

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