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Exploiting Motivation Subscales for Gamification of Lifelogging Application

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ABSTRACT

Continuous data input is essential for lifelogging services, where users input their daily records. But whether the user can continuously input data depends mainly on the user's motivation. This article presents a new method of introducing gamification in line with the purpose of lifelogging. The authors introduce a comprehensive set of gamification features based on motivation subscales into a lifelogging service. Meanwhile, the authors elucidate which gamification features correspond to which motivation subscales are effective for lifelogging, including intrinsic motivation, introjected regulation, integrated regulation, identified regulation, and external regulation. As a case study, the authors introduce the five gamification features corresponding to each motivation subscale into work support service (WSS) designed to record and review work hours. The authors also compare and evaluate changes in user behavior before and after the introduction of the gamification features. In this way, user motivation for continuous input increases when gamification in the WSS is confirmed.

KEYWORDS

External Regulation, Identified Regulation, Integrated Regulation, Intrinsic Motivation, Introjected Regulation, Visualization, Web Application, Work Support Service

INTRODUCTION

Among the many web services available today, there are lifelogging services in which humans take the initiative in entering their daily records. The primary purpose is to provide a data review of the user's daily activities and use the data for self-management and life improvement. Continuous data input is essential for lifelogging services because the data population determines the utility of the service. Therefore, it is ideal to have more users continue to use the system. However, continuity depends mainly on the motivation of the users themselves. There is a problem that users stop using the service due to boredom, tediousness, and lack of visibility of the effects of the service. Therefore, various studies (Narumi et al., 2015; Tosa et al., 2012) introduce *gamification* (Matallaoui et al., 2016; Hungerbuehler et al., 2021; Moldon et al., 2021) into lifelogging services to promote motivation toward a specific purpose, such as improving motivation for input continuity.

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However, in existing studies, gamification was introduced without a deep discussion of the rationale for its application, and only specific gamification features were introduced and evaluated in specific applications. As a result, the problem remains that it is not clear which gamification features are practical for the application's purpose and which gamification features have led to increased motivation. For this, the authors aimed to develop a method to introduce gamification according to the purpose of lifelogging and to elucidate what kind of gamification features effectively increased motivation for lifelogging. In particular, the motivation that it set contributed to the continuous recording as the target.

The key idea is to introduce gamification features based on five different motivation subscales (Tanouri et al., 2021) into Work Support Service (WSS), a lifelogging service that can create it to record work. By observing which motivation subscales contribute to the continuity of the WSS, the authors solved the traditional technical problem of not knowing which motivation subscales were effective for lifelogging. Moreover, the authors developed a practical gamification feature to improve motivation and contribute to the further development of lifelogging. The authors addressed the following approaches to achieve the objectives of this study:

A1: Experimental evaluation of the regular version of WSS
A2: Implement and deploy five types of gamification features in WSS
A3: Experimental evaluation of gamification version of WSS
A4: Evaluating the effectiveness of gamification implementation

First, in A1, subjects were asked to use the regular version of the WSS without gamification for one week, and logs of the work recorded in the WSS were collected. In addition, at the end of the experimental period, the participants were asked to answer a questionnaire that asked them to rate the *SQuaRE* -based evaluation index (Nakamura, 2017) on a 5-point scale and to provide the rationale for their answers.

Second, A2 implemented and introduced a gamification feature based on the five subscales of motivation (i.e., *intrinsic motivation*, *introjected regulation*, *integrated regulation*, *identified regulation*, and *external regulation*) in the WSS. Specifically, the following gamification features were implemented in the WSS: *look back*, *continuous login record*, *ranking*, *target work time setting*, and *grading in meetings*.

Third, A3 is the same as A1. Subjects used the gamification version of the WSS created in A2 for one week. The work logs and data added in the introduction of gamification were collected. At the end of the experimental period, in addition to the same questions as in A1, the participants were asked to answer a questionnaire that asked them to rate each gamification feature on a 5-point scale and to provide the rationale for their answers.

Finally, in A4, the authors evaluated how the introduction of gamification improved the objectives of the WSS by comparing the data collected in A1 and A3 with the survey results based on four related research questions. The results showed that three gamification features: look back, continuous login record, and ranking, contributed to the motivation to enter the WSS. It indicated that the effective motivation subscales for continuity of input to the WSS were intrinsic motivation, introjected regulation, and integrated regulation. The digest version of this paper has been published as a conference paper (Nagatani, 2022, to appear). Changes made to this version are as follows: (1) the addition of details of WSS, (2) the addition of RQ4 and its experimental evaluation, and (3) discussion of limitations and comparison with related work. The authors believe that these changes are significant for this paper to be a new journal article.

PRELIMINARIES

Lifelogging and Its Challenges

Among the many web services available today, there are lifelogging services in which humans take the initiative in entering their daily records. The primary purpose is to look back on the user's daily activities and use the data for self-management and lifestyle improvement. Continuous data input is essential for lifelogging services because the data population influences the utility of the service, and a large amount of data is necessary to generate new knowledge. Therefore, it is ideal to have as many users continue to use the system as possible. However, continuity depends mainly on the motivation of the users themselves. There is a problem that users stop using the service due to boredom, tediousness, and lack of visibility of the effects of the service. The authors asked laboratory members to use Work Support Service (WSS), a lifelogging service that the authors created to record and review their work hours, and found it challenging to maintain motivation for continuous input.

Introducing Gamification Into Lifelogging

To solve the problem of continuity, the authors considered introducing gamification into lifelogging. In recent years, various studies have been conducted on game lifelogging by introducing *gamification* (Matallaoui et al., 2016; Hungerbuehler et al., 2021; Moldon et al., 2021) and motivating people to achieve a specific purpose. Gamification is a method of gamification services by introducing game-like elements. They are expected to attract users' curiosity, activate their behavior, and bring positive benefits. Examples of gamification features introduced in the lifelogging include the following:

Badge: A reward for evidence of achievement of objectives.
Ranking: Ranking the achievement of specific objectives within the community.
Visualization: Easy-to-read display of accumulated data.
Login Bonus: Login (i.e rewards for ongoing)
Avatar: Alter ego within services.
Reaction: Reactions from others to records.
Collection: Collection elements of certain items within the service.

Sotsuron Watch (Narumi et al., 2015) and *REAL10* (Tosa et al., 2012) are related studies that introduced gamification in lifelogging. The word "Sotsuron'" means the graduation thesis in Japanese.

First, *Sotsuron Watch* is a service that aims to motivate students to write their thesis and to keep track of their mentors' current status. The main gamification features are badges corresponding to achievement items, ranking within the community, and Twitter integration. Figure 1 shows the reference screen for *Sotsuron Watch*.

Figure 1. The reference screen for Sotsuron Watch (Narumi et al., 2015)

Next, *REAL10* is an application that records student activities to enhance student life through gamification. The main gamification features are avatar, friend feature, reactions from other users to records, ranking, and evaluation of actions by reactions. Figure 2 shows the reference screen for *REAL10*.

Figure 2. The reference screen for REAL10 (Tosa et al., 2012)

Finally, *Pikmin Bloom* (2022) is an example of a commercial service that introduces gamification into lifelogging. *Pikmin Bloom* is a lifelogging application that promotes going out and exercising through gamification. The main gamification features include avatars, pikmin walking/collection, step count review, friend feature, photo diary, badges, and location-based errand feature.

Technical Challenges

In the related studies that introduce gamification into lifelogging, there were no studies that considered the motivation subscale and the purpose of lifelogging. Furthermore, gamification had been introduced without a deep discussion of the rationale for its application, and only specific gamification features have been introduced and evaluated for specific applications. As a result, it is not clear which gamification features are effective for the application's purpose, and which features have led to increased motivation. The challenge was to introduce a gamification feature that defined the motivation to be promoted in the lifelogging, and to compare the quality before and after its introduction.

Quality Assessment of the System Before and After Gamification Implementation

In order to evaluate the quality of the system before and after the introduction of gamification, it was necessary to create an index based on *Software Quality Requirements and Evaluation (SQuaRE)* (Nakamura, 2017). SQuaRE is an international standard that defines the various quality requirements of various stakeholders (e.g., users, clients, developers) of systems and software. It provides a common approach for evaluating their implementation. In this study, the authors used *accuracy* from among the models of data quality, and *effectiveness* and *comfort* from among the models of quality in use.

The authors explain each of the detail as follows:

- **Accuracy:** Is the data stored in the service accurate?
- **Effectiveness:** Is the service is beneficial/helpful to the user?
- **Comfort:** Can users use the service comfortably?

Based on the above, a service quality evaluation index was created and set up as a question in the questionnaire. Then, by comparing the questionnaire results before and after the introduction of gamification, the effectiveness of the introduction of gamification was subjectively evaluated.

PROTOTYPE AND OPERATION OF WORK SUPPORT SERVICE

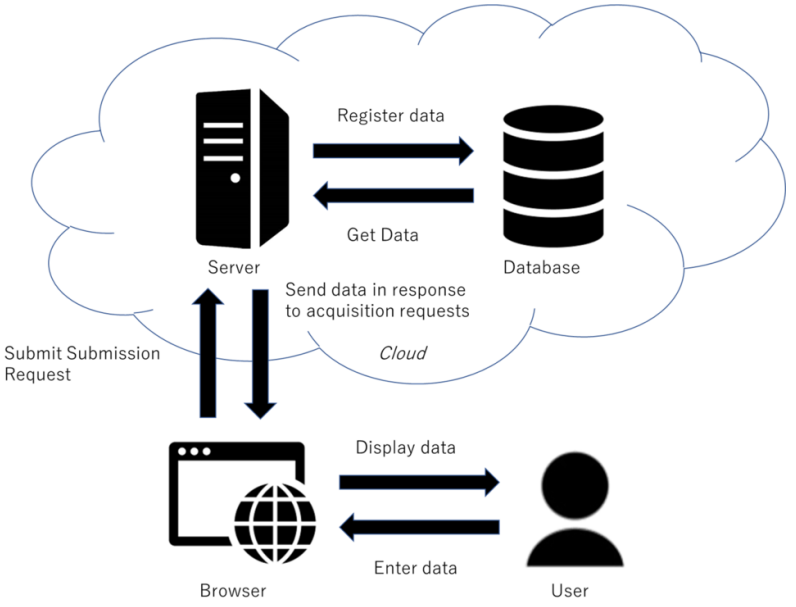
Work Support Service Overview

As an example of a lifelogging service, the authors used the Work Support Service (WSS), which the authors developed for the purpose of recording and reviewing work hours. The WSS can be used from a web browser and is implemented so that its operations allow for registration and retrieval of databases and data via a server. Users can record their work mainly by pressing buttons on the screen. It is also possible to look back on the work logs and check the work status of other users.

Overall Architecture

The WSS system consists of a database, server, and web browser. Figure 3 shows the system configuration of the WSS.

Figure 3. The system configuration of the WSS

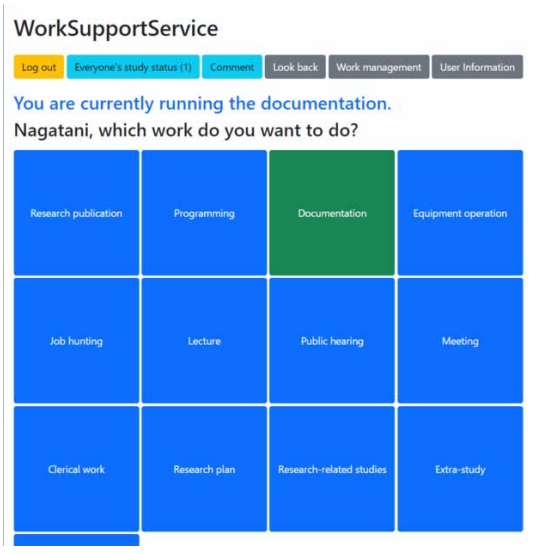


Specifically, when a user records the start and end of a task in a browser, a request is sent to the server to post the task data, and the data is registered in the database. Next, when a user wants to review the work log or check the work status of others, the system sends a request to the server to retrieve the work data, retrieves the work data from the database, and displays it in the browser.

WSS Features

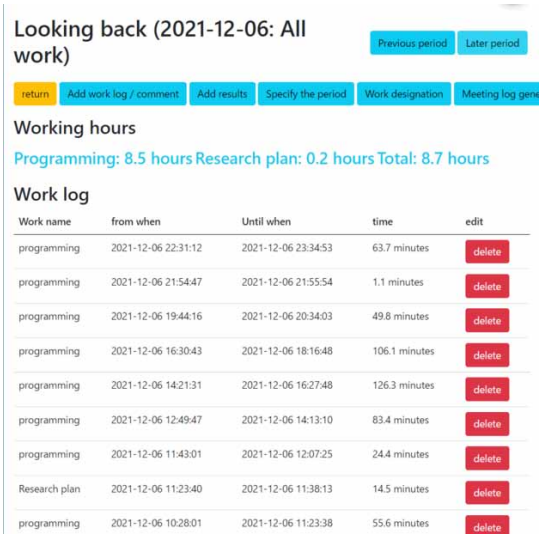
The following diagram illustrates how to use the WSS. Figure 4 shows the home screen of the WSS.

Figure 4. The home screen of the WSS



On the home screen, the time can be recorded in the database by pressing a button when starting or finishing a task. Figure 5 shows the look back screen of the WSS.

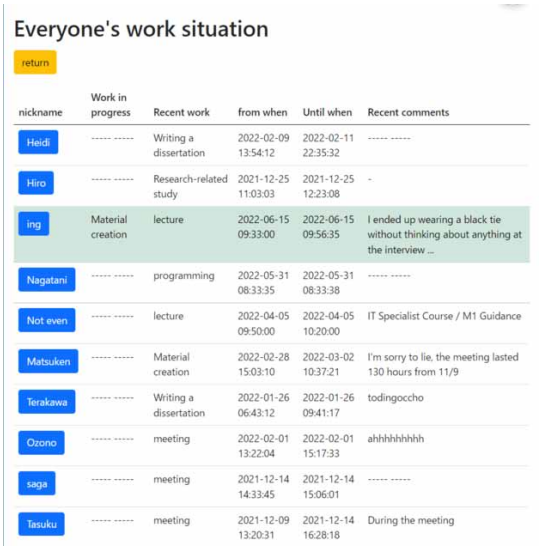
Figure 5. The look back screen of the WSS



The look back screen of work allows the user to review what type of work was performed, when, and how much was done, on a dedicated screen. In addition, it is possible to edit the work record in case of forgotten or incorrect entries.

Figure 6 shows the work status display screen for all users who have disclosed information.

Figure 6. The work status display screen for all users who have disclosed information



The work status display screen allows users to view the work status of other users who have made their information public.

Operation of WSS

The WSS was originally intended to record and review one's work hours. However, in order to make it available to the laboratory members, the authors implemented it as a web application so that they could input data from their homes and laboratories. For the implementation, *MySQL* was installed as the database and *Apache tomcat* was installed as the server on *Linux* (Rusling, 1999), and *Java14* and *Spring Boot* were used to build and deploy the web application on top of it. However, the actual situation in operation was that the number of users gradually decreased, and it was difficult to obtain accurate work logs for users' actual work, making it difficult to maintain motivation for continuous input. Factors that were considered include boredom, tediousness, and lack of apparent effectiveness.

METHODOLOGY: INTRODUCING GAMIFICATION TO THE WSS

Purpose and Key Ideas

To solve the task, the authors developed a method of introducing gamification according to lifelogging. Meanwhile, the authors also elucidated what kind of gamification features effectively improved motivation for lifelogging. In particular, the motivation that contributed to continuous recording was set as the target goal. To achieve this goal, the authors introduced a gamification feature for each of the five motivation subscales into the WSS and observed which motivation subscale contributed to the continuity of input to the WSS.

Motivation Subscales of Gamification

With respect to the five types of motivation, the authors dealt with the following gamification motivations (Tanouri et al., 2021):

- **Intrinsic motivation:** Desire to engage with the game for the sake of the game itself.
- **Introjected regulation:** Playing a game of internal pressures (e.g., curiosity, restlessness, distraction, relief, and anxiety).
- **Integrated regulation:** Engaging in a game because the game has become a part of the person's self, the player believes that the game can make them what they want to be as they are merged with a character in the game.
- **Identified regulation:** Engaging in a game because the game is related to the individual's personal goals.
- **External regulation:** Engaging with the game for external rewards.

By introducing and evaluating the five types of gamification features corresponding to these five subscales in the WSS, the authors elucidated effective motivation subscales to encourage continuous input.

Approach

To achieve the goal of this study, the following approaches were addressed:

A1: Experimental evaluation of the regular version of WSS
A2: Implementation and deployment of five types of gamification features in WSS
A3: Experimental evaluation of gamification version of WSS
A4: Evaluating the effectiveness of gamification implementation

The authors first confirmed the effectiveness of introducing gamification into the WSS by taking these approaches. Furthermore, by elucidating which motivational subscales were adequate for promoting continuity of input to the WSS, the authors solved the traditional technical problem of not knowing which motivational subscales were adequate for lifelogging. The authors believed that doing so would develop a practical gamification feature to improve motivation and contribute to the further development of lifelogging.

A1: Experimental Evaluation of the Regular Version of WSS

First, in A1, the authors asked subjects to use the WSS before introducing gamification for one week and collected the data to grasp the actual conditions of use. The data collected was work logs recorded in the WSS. The work logs consisted of seven attributes: user ID, work type, work start time, work end time, work log creation time, work duration, and whether the work log was entered in real-time rather than later. Table 1 shows an example of the work log data collected.

Table 1. The sample data of work logs

User ID	Work Type	Work Start Time	Work End Time	Work Log Creation Time	Work Duration (Sec)	Real-Time Input or Not
ing	programming	2021/11/10 16:01	2021/11/10 16:16	2021/11/10 16:16	948	TRUE
om	Research-related studies	2021/11/10 11:00	2021/11/10 19:25	2021/11/10 20:00	30300	FALSE
yuyohi	Announcement hearing	2021/11/11 10:38	2021/11/11 11:16	2021/11/11 11:16	2297	TRUE

By collecting these data, the authors were able to grasp the actual situation of the objective use of the regular version of the WSS. At the end of the experimental period, subjects were asked to respond to a questionnaire that asked them to rate the accuracy, effectiveness, and comfort indicators based on SQuaRE on a 5-point scale and provide the rationale for their responses. The questions corresponding to accuracy, effectiveness, and comfort were:

- **Accuracy:** Did you logging exactly what you did?
- **Effectiveness:** Did you find WSS helpful in your work?
- **Comfort:** Were you comfortable using it?

By asking the respondents to answer these questions, the actual subjective use of the regular version of the WSS was determined.

A2: Implement and Deploy Five Types of Gamification Features in the WSS

Next, A2 implemented a gamification feature based on the five motivational subscales and introduced it to the WSS. The gamification features corresponding to the five motivational subscales are:

Intrinsic motivation: Look back (G1)
Introjected regulation: Continuous login record (G2)
Integrated regulation: Ranking (G3))
Identified regulation: Target work time setting (G4)

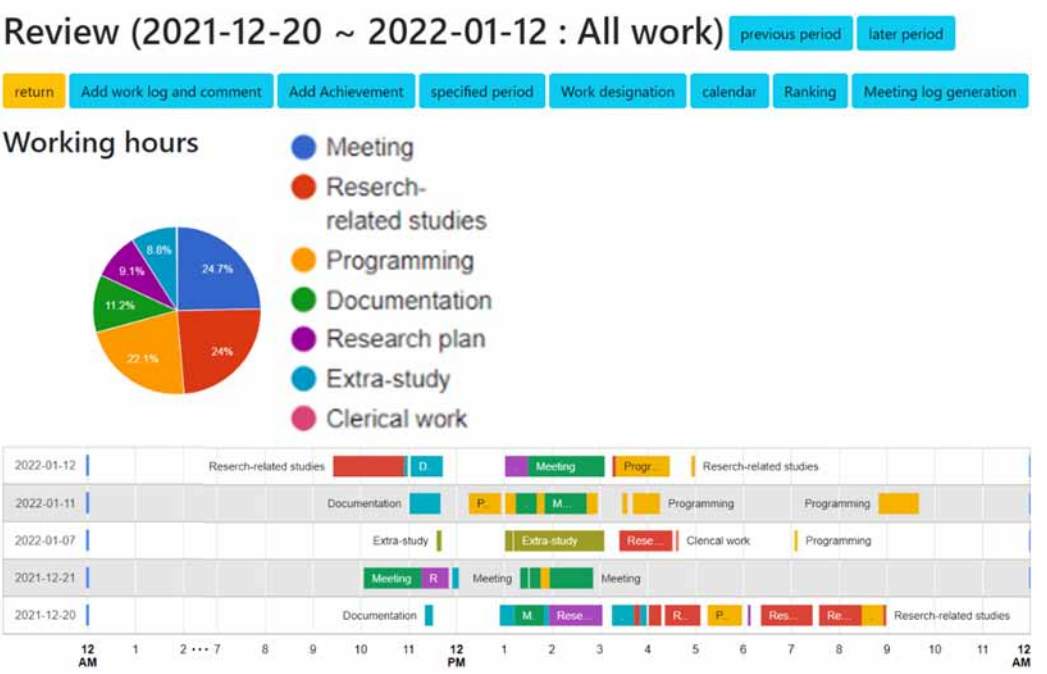
External regulation: Grading in meetings (G5)

With the introduction of these gamification features, the goal of the WSS was to elucidate the motivation subscales that were effective for the continuity of input.

G1: Look Back

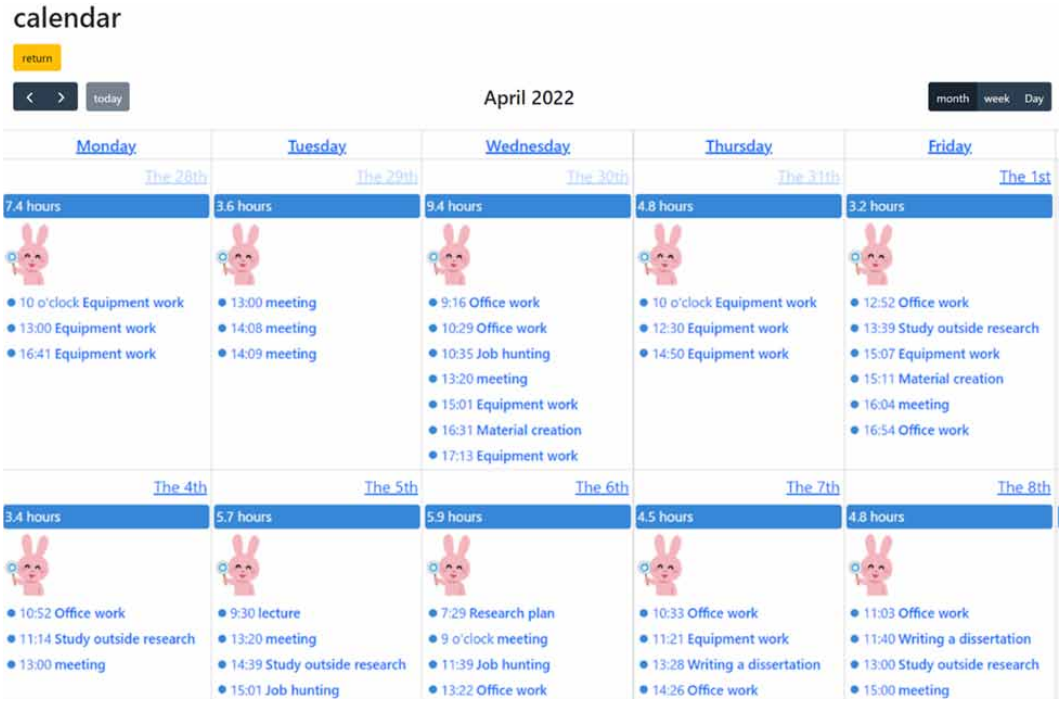
The authors introduced a feature of *look back* as a gamification feature that contributed to intrinsic motivation. This feature added a work time breakdown using a pie chart, and a visualization of work time distribution using a band chart, to the standard version of the WSS's look-back screen. These graphs were implemented using *Google Charts* (n.d.). Figure 7 shows the part of the look-back screen where the visualization of work hours using graphs is displayed.

Figure 7. Display portion of work time visualization using graphs



In addition to graphs, a dedicated screen is provided to display a calendar. This calendar displays work hours, stamps, and work logs on the day the work was recorded. *FullCalendar* (n.d.) implements the calendar. Figure 8 shows the calendar screen.

Figure 8. Calendar screen



The *look back* feature allows users to look back on their work records in an easy-to-understand format, and was thought to provide a sense of accomplishment. Therefore, the visualization of the accumulation of records was expected to lead to an intrinsic motivation to record.

G2: Continuous Login Record

The continuous login record was introduced as a gamification feature that contributed to the introjected regulation. This feature updates the continuous login record at the beginning of the day and displays the current and maximum continuous login records to date. Figure 9 shows the screen when the continuous login record is updated.

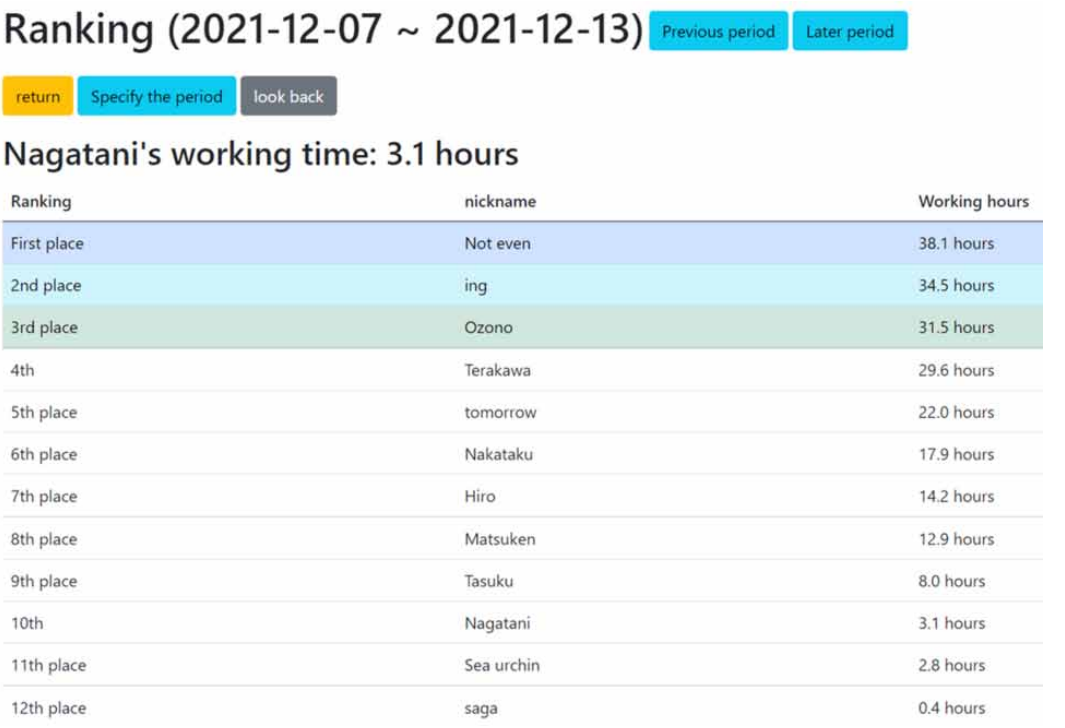
Figure 9. Screen when continuous login record is updated

The continuous login record allows users to be aware of how much effort they are making continuously, and it was thought that they would feel compelled to improve their records. Therefore, it could be expected that the internal pressure to improve the record would keep it going.

G3: Ranking

The authors introduced the feature of *ranking* as a gamification feature that contributed to integrated regulation. This feature provided a dedicated screen that ranked and displayed the work hours of public users for a specified period. Figure 10 shows the ranking screen.

Figure 10. Ranking screen



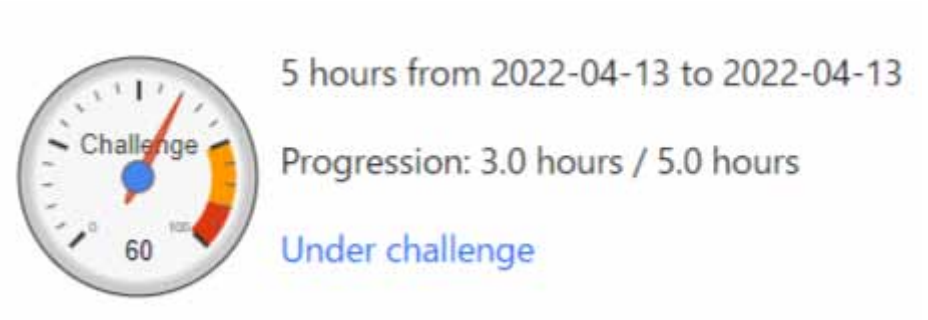
Ranking	nickname	Working hours
First place	Not even	38.1 hours
2nd place	ing	34.5 hours
3rd place	Ozono	31.5 hours
4th	Terakawa	29.6 hours
5th place	tomorrow	22.0 hours
6th place	Nakataku	17.9 hours
7th place	Hiro	14.2 hours
8th place	Matsuken	12.9 hours
9th place	Tasuku	8.0 hours
10th	Nagatani	3.1 hours
11th place	Sea urchin	2.8 hours
12th place	saga	0.4 hours

It was thought that the ranking feature would make users want to aim for higher ranks and avoid lower ranks, and that they would feel inspired, by the efforts of others, to record their work logs accurately. Therefore, it could be expected that the user would accurately record his or her work time through integrated regulation as he or she was compared to others in the WSS.

G4: Target Work Time Setting

The feature of the *target work time setting* was introduced as a gamification feature that contributed to identified regulation. This feature added a form to the home screen of the WSS (Figure 4) that allows users to set their own goals by specifying a period and work hours. It also displayed a gauge of the current progress of the set target work time. This progress indicator was implemented using Google Charts, just like the graph in G1. Figure 11 shows the home screen where the progress of the *target work time setting* is displayed.

Figure 11. Progress display portion of target work time setting



The *target work time setting* feature was thought to motivate users to work with clear goals, and the results were thought to be useful for future work. Thus, it could be expected that identified regulation to set and achieve one's own goals would be activated.

G5: Grading in Meetings

The gamification feature, which contributes to external regulation, is the *grading in meetings*. In this feature, the weekly meeting praises the top rankers for the week. The ranking is done using the gamification feature. It was believed that grading at meetings made users want to be recognized for their efforts and would this feel compelled to record their work accurately. Therefore, with the external reward of an award for one's efforts, it could be expected that one would continue to record through external regulation.

A3: Experimental Evaluation of Gamification Version of the WSS

In A3, as in A1, subjects were asked to use the WSS after the introduction of gamification for one week, and the data was collected to grasp the actual conditions of use. The data collected were the work logs recorded in the WSS, as in A1, and the continuous login records added in the gamification version of the WSS. The continuous login record consisted of four attributes: user ID, current continuous login days, maximum continuous login days, and last login date and time. Table 2 shows an example of continuous login record data.

Table 2. Progress display portion of target work time setting

User ID	Current Continuous Login Days	Maximum Continuous Login Days	Last Login Date and Time
horie	1	4	2021/12/25 12:23
ing	7	7	2022/1/17 13:13
manda	1	6	2022/1/17 12:47

By collecting these data, the authors were able to grasp the actual situation of the objective use of the gamification version of the WSS. At the end of the experimental period, subjects were asked to answer a questionnaire that asked them to rate the accuracy, effectiveness, and comfort of the SQuaRE-based accuracy, effectiveness, and comfort indices on a 5-point scale, along with the basis for their answers, as in A1, as well as a questionnaire that asked them to rate each gamification feature on a

5-point scale and the basis for their answers. The 5-point rating question for each gamification feature in the survey was: "G1: Did the look back feature make you want to use the WSS more than before?"

The same question was asked in G2 through G5. By asking respondents to answer this question, the authors elucidated which gamification feature subjectively corresponded to which motivation subscale and facilitated continued input to the WSS.

A4: Evaluating the Effectiveness of Gamification Implementation

Finally, A4 used the data collected in A1 and A3 along with the responses to the questionnaire to compare how the introduction of gamification had improved the objectives of the WSS. For this purpose, the following research questions were formulated:

RQ1: Has the work log entry improved?
RQ2: Were subjects able to perceive the effects of gamification?
RQ3: Which gamification features did subjects perceive as more effective for continuous input?
RQ4: Did each gamification feature work as expected?

These research questions were used to objectively and subjectively evaluate the effectiveness of the introduction of gamification.

RQ1: Has the Work Log Entry Actually Improved?

In RQ1, by comparing the work logs recorded in the WSS collected in A1 and A3, the authors further subdivided the question of whether the introduction of gamification improved the input of the work logs into four research questions for analysis. The four research questions and their corresponding evaluation indices are listed below:

1. What percentage of subjects used the WSS on a given day? (WSS utilization rate)
2. How many days the subject used the WSS continuously? (Subject average maximum consecutive days of use)
3. How much attention was paid to the WSS when doing the work? (Real-time input rate)
4. Which subjects recorded more frequently to the WSS? (Total number of inputs by subject)

The WSS utilization rate is the percentage of subjects who logged their work to the WSS in a day among all subjects and is compared for all seven days during the A1 and A3 experiment periods, and for five days, excluding holidays. This comparison analyzed how many subjects used the WSS on the day before and after the introduction of gamification.

The subject's average maximum consecutive days of use are the maximum number of consecutive days that a subject logs their work. It was compared for all seven days during the A1 and A3 experiments and five days, excluding holidays. This comparison analyzed how many days the subjects used the WSS continuously before and after the introduction of gamification.

The real-time input rate is the percentage of all work logs recorded in real-time rather than entered later. By comparing these indicators, the authors could analyze how much attention was paid to the WSS before and after gamification.

The total number of inputs by subject is the number of work log entries by the subject during the experimental period. By comparing this index, the authors analyzed how many subjects increased the number of times they recorded to the WSS after the introduction of gamification.

These research questions enabled the authors to evaluate the effectiveness of the introduction of gamification objectively.

RQ2: Were Subjects Able to Perceive the Effects of Gamification?

RQ2 analyzed whether subjects were able to perceive the effect of gamification by comparing the 5-level ratings of accuracy, effectiveness, and comfort indicators based on the SQuaRE that was answered in A1 and A3, and evaluating whether there were significant differences in the evaluation scores by t-test. This analysis allowed authors to evaluate the effectiveness of the introduction of gamification subjectively.

RQ3: Which Gamification Features Did Subjects Perceive as More Effective for Continuous Input?

RQ3 analyzed which gamification features subjects perceived as more effective for continuous input, according to the 5-point rating for each gamification feature they answered in A3. This analysis assessed which gamification features corresponded to which motivational subscales more effectively in maintaining the continuity of input to the WSS.

RQ4: Did Each Gamification Feature Work as Expected?

In RQ4, based on the results of RQ3, the authors analyzed whether each gamification feature worked as expected to promote the corresponding motivational subscales based on a 5-point rating for each gamification feature. This analysis confirmed that each gamification feature was working as expected, and subjectively assessed which motivation subscales were most effective in keeping people engaged in the WSS.

EXPERIMENTAL EVALUATION

Experimental Settings

A1 and A3 of the proposed method were tested for one week each. The duration of these experiments was divided into two consecutive weeks, one week before and after each other, and was designated as the A1 and A3 experimental periods, respectively. These two consecutive weeks were selected as the period during which all the subjects expected little change in the environment. The following are the respective experimental periods for A1 and A3:

A1: December 7, 2021 ~ December 13, 2021
A3: December 14, 2021 ~ December 20, 2021

The subjects were the same 14 individuals in A1 and A3. Information about the subjects was obtained with the help of researchers and members of the authors' laboratory, who were familiar with the subjects.

The breakdown is as follows:

- One 49-year-old male teacher
- Twelve male students in an information systems laboratory, 21 to 25
- One 23-year-old female student in an information technology laboratory

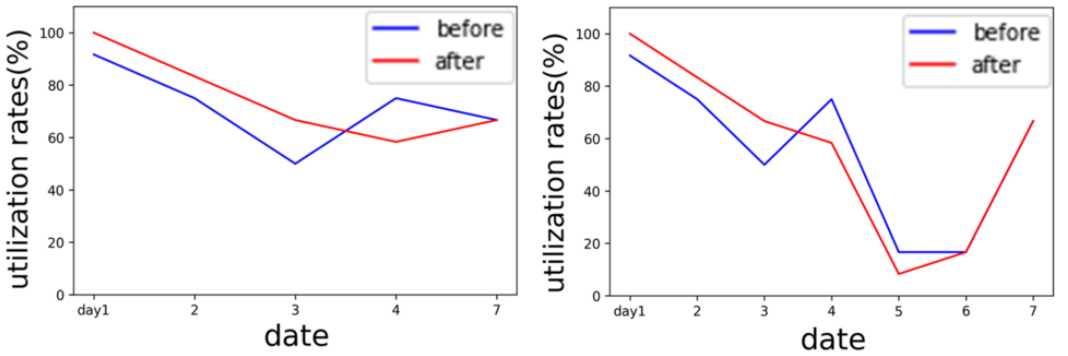
Experimental Results

The results of the evaluation of RQ1 through RQ3, by comparing the data obtained in the A1 and A3 experiments. Comparisons were made with 12 of the subjects to evaluate RQ1, RQ3, and RQ4, excluding one male student whose lifestyle changed significantly during the two weeks of the experiment, and one male student for whom data were lacking. The evaluation of RQ2 was conducted with 11 students. It excluded one male student who did not obtain a questionnaire in A1 out of the 12 comparators in RQ1.

Evaluation of RQ1

Firstly, the authors observed the results for the WSS utilization rate. Figure 12 shows change in the WSS utilization rate before and after the introduction of gamification for all seven days and the five days, excluding holidays. The vertical axis of these figures shows the WSS utilization rate, and the horizontal axis shows the number of days in the experimental period. The blue line represents the data before the introduction of gamification, and the red line represents the data after gamification.

Figure 12. Changes in the WSS utilization rate before and after gamification implementation: (a) all seven days (b) five days excluding holidays



These figures show that before and after the introduction of gamification, the utilization rate decreased as the period progressed, and is higher after the introduction of gamification.

Next, the authors observed the results for the subject average maximum consecutive days of use. The results were analyzed by comparing the mean values before and after the introduction of gamification and whether there was a significant difference using a two-tailed t-test at a significance level of 0.05. Table 3 shows the analysis results of the subject average maximum consecutive days of use.

Table 3. Results of analysis of the subject average maximum consecutive days of use

Period Type	Average Maximum Number of Consecutive Days of Use By Subjects Before Introduction	Average Maximum Number of Consecutive Days of Use By Subjects After Introduction	P-Value By T-Test (Two-Sided)
Total 7 days	2.92	2.92	1.00
Weekday	3.00	3.25	0.709

Table 3 shows that the average maximum consecutive days of use for all seven days of the experimental period did not change before and after gamification. The average maximum consecutive days of use for the five days, excluding holidays, was more significant after gamification. However, since the P-value from the t-test exceeded the significance level, there was no significant difference in the t-test between the pre-and post-gamification periods.

The authors observed the results for the real-time input rate. The real-time input rate before and after the introduction of gamification are shown below:

Before gamification: 53.2%(66 of 124 cases)
After gamification: 64.6%(93 of 144 cases)

The results showed that the real-time input rate improved after gamification.

Finally, the authors observed the results for the total number of inputs by subject. Figure 13 shows the total number of inputs by subject before and after the introduction of gamification. The vertical axis of this figure represents the number of inputs, and the horizontal axis represents individual users. Blue represents the data before the introduction of gamification, and red represents the data after the introduction of gamification.

Figure 13. Total number of inputs by subject before and after introduction of gamification

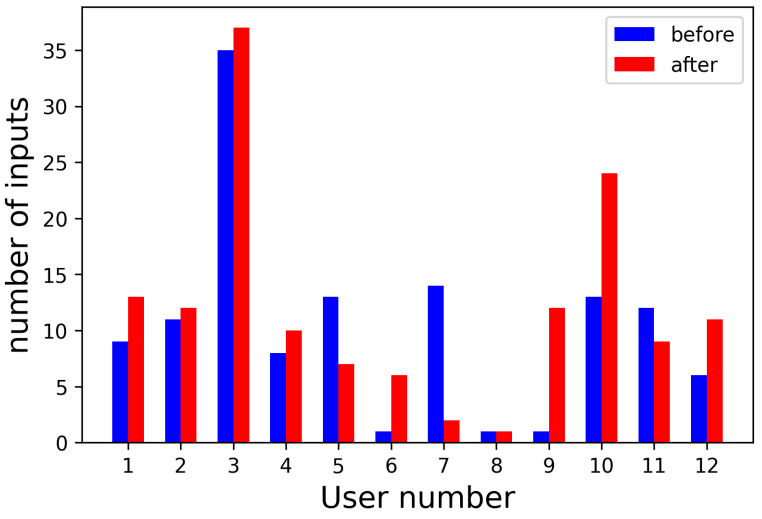


Figure 13 shows that 8 out of 12 subjects increased the number of inputs with the introduction of gamification.

From these observations, it can be said that the introduction of gamification improved the input of work logs.

Evaluation of RQ2

The authors observed the results of a 5-point evaluation of accuracy, effectiveness, and comfort metrics based on SQuaRE before and after gamification. The results were analyzed by comparing the mean scores of each indicator before and after the introduction of gamification. A one-tailed t-test at a significance level of 0.05 was used to determine whether the scores after gamification were significantly higher than those before the introduction of gamification. Table 4 shows the analysis results for the 5-level evaluation of the evaluation index based on SQuaRE.

Table 4. Results of the analysis of the 5-level rating of the evaluation indicators based on SQuaRE

Valuation Index	Average Evaluation Score Before Introduction	Average Post-Introduction Evaluation Score	P-Value By T-Test (One-Tailed)
Accuracy	2.73	3.82	0.0260
Effectiveness	3.55	4.45	0.00237
Amenity	3.36	4.18	0.00237

The table shows that the mean evaluation scores for all indicators of accuracy, effectiveness, and comfort improved, and the P-value from the t-test is below the significance level, indicating that the evaluation scores after the introduction of gamification were significantly greater than those before the introduction of gamification. From these results, it can be said that the subjects could perceive the effect of gamification.

Evaluation of RQ3

The authors observed the results of the 5-level evaluation by gamification feature. The results were analyzed using a box plot of the distribution of evaluation points and a comparison of the average evaluation points for each gamification feature. Table 5 shows the average score of the 5-level evaluation by gamification feature, and Figure 14 shows a box plot of the scores of the 5-level evaluation by gamification feature. The vertical axis of this figure represents the 5-point scale for each gamification feature, and the horizontal axis represents the individual gamification features.

Table 5. Average rating score of 5-point scale by gamification feature

Gamification Feature Name	Motivation Subscales	Average Rating Score
G1: Look Back	Intrinsic motivation	3.50
G2: Continuous Login Record	Introjected regulation	3.67
G3: Ranking	Integrated regulation	4.00
G4: Target Work Time Setting	Identified regulation	2.50
G5: Grading in Meetings	External regulation	3.00

Figure 14. Box plot of the 5-point scale by gamification feature

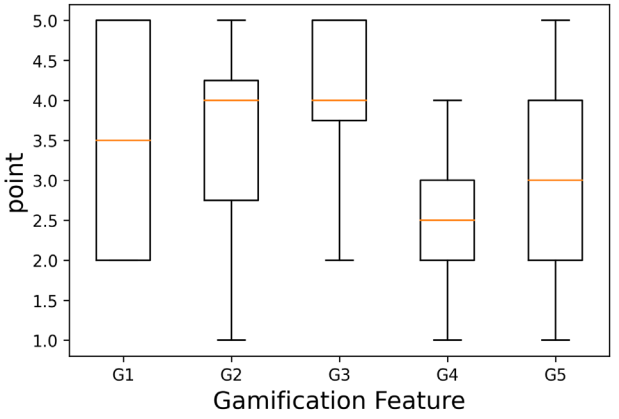


Table 5 and Figure 14 show that the features of *look back, continuous login record*, and *ranking* received high scores, while the feature of *target work time setting* received low scores. From these results, it can be said that subjects perceived the feature of look back, continuous login record, and ranking to be effective for continuous input.

Evaluation of RQ4

Based on the results of RQ3, the authors evaluated whether each gamification feature promoted the corresponding motivation subscales as expected, based the 5-point rating by gamification feature. As for the opinion that the WSS did not lead to continuity of input, the authors will consider improvement plans.

To assess whether the G1 *look back* feature promoted the intrinsic motivation, the expected motivation subscales, the authors observed the rationale for the 5-point rating of the feature of *look back*. Table 6 shows the rationale for the 5-point rating of the feature of *look back*.

Table 6. The rationale for the 5-point rating of the feature of look back

Why the feature of look back made you want to use your WSS more than before?	Why the feature of look back made you feel less inclined to use your WSS than before?
When it was explained to me, I wanted to use Work Support Service because it was cool.	I didn't want to see the actual use of the system because I would see the time I wasn't working on it.
It would be useful for a variety of tasks.	I didn't think about doing this or that even after checking the work ratio and what time of the day they were doing it....
I wanted to reduce the amount of empty time.	I only did programming, so I didn't find the pie charts interesting.
I like how it's presented graphically.	I'd like to see less of a look back feature.
It is nice to be able to see a list of the data that I have entered with great care, and it gives me a sense of accomplishment.	I don't think I'm going to look back on my activity time that much.
Good to visualize the work.	I think it's a useful feature when looking back, but I didn't use it because I didn't feel like looking back on my activities.
I found it easier to visualize my workload than before and thought it was more motivating.	
Easy to keep track of learning. Motivation improves.	

From Table 6, the reasons for wanting to use the WSS more can be summarized as follows: the accumulation and visualization of the work done by the participants led to self-satisfaction. Therefore, it can be said that the feature of *look back* led to the intrinsic motivation to participate in the game. On the other hand, the reasons for not wanting to use the WSS due to the feature of *look back* can be summarized as follows: the visualization of a single task is not interesting because it is simple, and the visualization of what is not being done does not make the user want to look back. The opinion that the visualization of a single task is "uninteresting because it is simple" can be solved by improving the gamification feature introduced so that the visualization becomes interesting even for a single task. The opinion that people do not want to look back because they can visualize what they have not done is not considered to be a problem to be solved in this study.

To assess whether the G2 *continuous login record* feature promoted the introjected regulation, the expected motivation subscales, the authors observed the rationale for the 5-point rating of the feature of *continuous login record*. Table 7 shows the rationale for the 5-point rating of the feature of *continuous login record*.

Table 7. The rationale for the 5-point rating of the feature of continuous login record

Why did the feature of continuous login record make you want to use your WSS more than before?	Why the feature of continuous login record made you feel less inclined to use your WSS than before?
I could open it anyway for the purpose of continuing to log in.	If you don't log in during the holidays, your login continuity will expire.
Knowing that you are continuing to do this every day motivates you.	I didn't think anything of it because there is no reward for logging in consecutively.... I might log in continuously if the laboratory distributes points that can be used for something.... (Like 1 yen worth of points that can be used for shopping)
I wanted to improve my record.	I don't do weekends so I only go max5.
You have to use it every day or you'll lose it.	I was like, "Oh, yeah. I didn't feel anything in particular.
I thought I'd try to log in as continuously as possible.	I thought it would be nice to have a day off to do nothing.
I used to add logs later, but now I can try to log in real time.	
Because it improves motivation.	
The desire not to break the consecutive record arose.	

From Table 7, the reasons for wanting to use the WSS more due to the feature of *continuous login record* can be summarized as follows: the record is extended, which provides peace of mind, and the logins are now entered in real time. Therefore, it can be said that the *continuous login record* function led to the introjected regulation due to the internal pressure to feel secure by extending the record. On the other hand, the reasons for not wanting to use the WSS more with the feature of *continuous login record* can be summarized as: difficulty and lack of interest in extending the record to holidays. The reason that "it is difficult to increase the number of logins on holidays" could be solved by changing the specification so that logins are not counted as consecutive logins on holidays. The lack of interest could be solved by adding an in-game bonus for consecutive logins, or by adding some other element that would attract users' interest.

To assess whether the G3 *ranking* feature promoted the integrated regulation, the expected motivation subscales, the authors observed the rationale for the 5-point rating of the feature of *ranking*. Table 8 shows the rationale for the 5-point rating of the feature of *ranking*.

Table 8. The rationale for the 5-point rating of the feature of ranking

Why did the feature of ranking make you want to use your WSS more than before?	Why the feature of ranking made you feel less inclined to use your WSS than before?
I could work hard to maintain a high ranking.	I didn't think I could rely too much on the ranking because it wouldn't be that accurate based on the level of use of Work Support Service by everyone.
After all, when I see other people working hard, I'm willing to give it a little more effort.	A stranger is a stranger.
If it's just a loose competition, you can see other people's efforts and be inspired.	I've always been a person who doesn't care much about other people. I just do my job whether others are doing it or not. For those who care about others, this may be a motivating factor.
It stands out as not very well utilized.	It's possible that some people aren't entering their work time correctly.
Because it makes me competitive.	
Because the impact of input errors is so great.	
It made me feel like I was doing my best because others were doing their best.	
Because competing with others improves your motivation and creates a sense of urgency for you.	

From this table, the reasons for wanting to use the WSS more due to the feature of ranking can be summarized as wanting to achieve a higher rank, avoiding a lower rank, and being inspired by the efforts of others. Therefore, it can be said that the feature of ranking led to the integrated regulation through the comparison of oneself with others in the WSS. On the other hand, the reasons for not wanting to use the WSS more due to the feature of ranking can be summarized as: doubts about whether other people's work logs correspond to real work, and lack of interest in other people. The authors intend to solve the problem of doubts about "whether other people's work logs corresponded to real work" by developing a gamification function that contributes to the accuracy of the work logs. As for the opinion that the authors are not interested in other people, the authors do not think that this is a problem to be solved in this study.

Next, the authors evaluate the feature of target work time setting, which was not rated highly in the 5-level evaluation by the gamification feature in RQ3, and the grading in meetings. The authors will discuss why these two features in particular were not rated highly in the 5-level evaluation by gamification feature.

First, to assess whether the G4 target work time setting feature promoted the identified regulation, the expected motivation subscales, the authors observe the rationale for the 5-point rating of the feature of target work time setting. Table 9 shows the rationale for the 5-point rating of the feature of target work time setting.

Table 9. The rationale for the 5-point rating of the feature of target work time setting

Why did the feature of target work time setting make you want to use your WSS more than before?	Why the feature of target work time setting made you feel less inclined to use your WSS than before?
I forgot the feature.	I forgot the feature.
It is useful to be able to visualize goals	I haven't used the target work time either.... Maybe for studying or something.
I thought I'd encourage you to achieve your goals.	It's a hassle to register every time.
I knew there was a function, but I had never used it. I am not able to manage my own target work hours because I have to do the work in front of me every day.	Not using target time setting
I thought it was nice to be able to set my own goals.	I thought it would be good if we could set a goal to finish task △ by on the , since we place more importance on the content than on the time required to complete the task.
Because it improves motivation.	Because I didn't use it.
Because making a schedule will help you set a daily work goal.	

The reasons for not wanting to use the WSS more with the feature of *target work time setting* are summarized in Table 9: forgetting about the function, and placing more importance on the content than on the time. The opinion that they had forgotten about the feature could be solved by explaining the function in more detail and by designing a more intuitive screen. The opinion that the contents are more important than the time can be solved by introducing a system that allows users to set not only work time but also work content-related goals. On the other hand, a summary of the reasons for wanting to use the WSS more with the feature of *target work time setting* is that visualization of goals increases motivation to achieve them. Therefore, it can be said that the feature of *target work time setting* led to the identified regulation to setting and achieving one's own goals.

To assess whether the G5 *grading in meetings* promoted the external regulation, the expected motivation subscales, the authors observed the rationale for the 5-point rating of the grading in meetings. Table 10 shows the rationale for the 5-point rating of the grading in meetings.

Table 10. the rationale for the 5-point rating of the grading in meetings

Why did the grading in meetings make you want to use your WSS more than before?	Why the grading in meetings made you feel less inclined to use your WSS than before?
I was happy with the praise and it made me want to keep working hard.	Dr.○○ does the most, so I have mixed feelings.
It doesn't make sense if I say I'm praising you as part of my research. n● ● ● ● Well done! I think it is effective if you praise not only for the research but also for other things. For example, if it were ○ ○, I would say, "Thanks for always taking care of things around the lab! something like that. I don't know...	Because they weren't responding to me.
Become motivated	Giving up on reaching the top
I don't know about this... (^^;)	Because only one grading took place.
We're glad you appreciate it.	
I'm so happy when I get compliments.	

From Table 10, the reasons for not wanting to use the WSS more due to the grading in meetings can be summarized as: not being able to receive praise because they did not reach the top rank, and only one evaluation was given. The reason for not being praised for not reaching the top ranks could be solved by awarding not only the top ranking but also the difference from the last time, etc. The opinion that only one evaluation was given could be solved by extending the duration of the experiment. On the other hand, the reason for wanting to use the WSS more due to the grading in meetings can be summarized as subjects are happy when they are praised for their efforts. Therefore, it can be said that the grading in meetings led to the external regulation through external rewards in the form of commendations for their efforts.

DISCUSSION

Effect

The first assumption from the previous study was whether the introduction of gamification was practical for the continuity of input for the WSS. Based on the results of the following experiment, the authors believe that the introduction of gamification improved the subjects' motivation to continue their input to the WSS based on the following results:

- Increase the WSS utilization rate
- Improved the real-time input rate
- Of subjects, 67% increased their number of inputs
- Improvement in the mean of the evaluation scores in all evaluation indices based on accuracy, effectiveness, and comfort; significant differences

The authors considered whether the gamification feature worked to promote the corresponding motivation subscales as expected. From the evaluation of RQ4, the authors believe that all gamification features promoted the corresponding motivation subscales.

The authors discuss the motivation subscales in line with the objectives of the WSS. From the evaluation of RQ3, intrinsic motivation introjected regulation and integrated regulation corresponding to the feature of *look back*, *continuous login record*, and *ranking* are considered adequate for continuous input, which is the purpose of the WSS. In contrast, the identified regulation corresponding to the *target work time setting* feature is considered less effective for continuous input, which is the goal of the WSS.

Issue

The first issue to be addressed in this study is that there was no significant difference in the subjects' average maximum number of consecutive days of use based on the evaluation of RQ1. This is because a larger number of consecutive days of use is considered to have a positive effect on the continuity of input in a lifelogging. This issue is thought to be due to the fact that the duration of the experiment was only one week, and the total duration before and after the introduction of gamification was only two weeks, making it difficult to see a difference in continuity.

Additionally, the authors were not able to objectively evaluate each gamification feature. Because the gamification features corresponding to the five types of motivation were introduced exhaustively in this study, the work log data collected in A3 was affected by all of the gamification features corresponding to the five types of motivation, thus the authors did not know which gamification feature was effective, and therefore was not distinguished. The evaluation of each gamification feature is only a subjective evaluation.

Finally, the number of subjects was limited. The subjects of the experiments conducted in this study were only members of the information technology laboratory and information technology researchers who knew one another.

Comparison With Related Studies

Sotsuron Watch and *REAL10*, a related study that introduced gamification into lifelogging are compared to this study.

The authors compared the *Sotsuron Watch* with this study. *Sotsuron Watch* describes "the possibility of applying gamification to the highly intellectual activity of research activities." This research is similar to the target lifelogging service in that the purpose of this study is to design a system that turns extrinsic motivation into intrinsic motivation, and to increase the motivation for manual lifelogging by introducing gamification. The approach differs from the present study in that gamification was introduced without discussing the motivation subscales, although it succeeded in improving motivation by introducing gamification in the lifelogging aimed at improving motivation for writing papers. The results of this study differ from those of this study in that the authors asked respondents to answer a questionnaire about their lifelogging after gamification was introduced and evaluated them, but the authors did not evaluate the questionnaire before gamification was introduced, so the authors conducted a questionnaire before and after gamification was introduced and compared the subjective evaluations.

In addition, the authors compared *REAL10* and this study. *REAL10* aims to "activate communication with others and record users' continuous activities in the lifelogging service by adding the characteristics of a SNS." Therefore, *REAL10* is similar to this study, which aims to record users' continuous activities by introducing gamification into lifelogging. This study differs from the present study because it aims to propose a gamification to facilitate continuous lifelogging input, but it does not propose a gamification feature that categorizes motivations and responds to them.

CONCLUSION

In this study, to solve the problem that the gamification feature is not clear following the purpose of conventional lifelogging services, the authors introduced a gamification feature based on motivation subscales to the Work Support Service (WSS), an example of a lifelogging service. Before and after the introduction of gamification, the WSS was subjectively and objectively compared and evaluated. As a result, the authors confirmed that the user's motivation for continuous input increased when gamification was introduced to the WSS, and that it is effective in improving the motivation for the continuity of input in the WSS. The authors were able to elucidate that the motivation subscales were intrinsic motivation, introjected regulation, and integrated regulation. Prospects include investigating the effect of a more extended period on continuity.

The first step to be taken in the future is to investigate the effect of a longer period on the continuity of the experiment. A longer experimental period is expected to have a greater impact on continuity. Next is an experiment by gamification feature based on the motivation subscales. Although the gamification features corresponding to the five types of motivation was comprehensively introduced in this study, it is thought that an objective evaluation of each gamification feature will be possible by conducting an experiment in which the gamification feature to be introduced is divided, and this will provide stronger evidence of an effective motivation subscale for the purpose of the WSS clarified in this study. Third, the results of this study will be used to develop a better gamification feature. Since effective motivation subscales were found to be effective for the purpose of the WSS, a lifelogging, the authors intend to use the results to develop a more effective gamification feature.

Finally, the authors would like to elucidate the motivation subscales for services other than WSS in accordance with the purpose of the service using the approach of this study.

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CONFLICT OF INTEREST

The authors of this publication declare there is no conflict of interest.

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