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Location- and Physical-Activity-Based Application for Japanese Vocabulary Acquisition for Non-Japanese Speakers

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Abstract: There are various mobile applications to support foreign-language learning. While providing interactive designs and playful games to keep learners interested, these applications do not focus on motivating learners to continue learning after a long time. Our goal for this study was to develop an application that guides learners to achieve small goals by creating small lessons that are related to their real-life situations, with a main focus on vocabulary acquisition. Therefore, we present MiniHongo, a smartphone application that recognizes learners' current locations and activities to compose lessons that comprise words that are strongly related to the learners' real-time situations and can be studied in a short time period, thereby improving user motivation. MiniHongo uses a cloud service for its database and public application programming interfaces for location tracking. A between-subject experiment was conducted to evaluate MiniHongo, which involved comparing it to two other versions of itself. One composed lessons without location recognition, and the other composed lessons without location and activity recognition. The experimental results indicate that users have a strong interest in learning Japanese with MiniHongo, and some difference was found in how well users could memorize what they learned via the application. It is also suggested that the application requires improvements.

Keywords: education; foreign language learning; micro-learning; location-based; human–computer interaction

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1. Introduction

Foreign-language learning is a significant challenge for many people. Mobile applications have colorful and game-like user-interface designs to ease the burden of learning and turn it into an enjoyable experience. However, learners still have to face multiple problems when they want to improve their fluency, such as a lack of motivation, differences in grammar and pronunciation, and a lack of context [1]. The lack of context in study materials and losing motivation are two of the most common reasons adult learners find it difficult to continue, particularly for Japanese language learners who are from English speaking countries. One study argued the reason for this is because of the difficulty of Kanji [2]—which are the logographic Chinese characters taken from the Chinese script and used in the writing of Japanese. Due to the rapid development of mobile applications for foreign-language learning, it is difficult for learners to select a suitable one. There are more than 3 million applications available on Google Play as of the first quarter of 2022 [3]. However, most of the applications are for learning multiple languages, so the learning method and lesson design is very general in order to deliver a one-fits-all application. Therefore, there are very few applications that mainly focus on Japanese and have a learning method that is effective only for Japanese. Moreover, the structure of the lessons can be difficult for users to follow: the majority of applications, such as Duolingo [4], display lessons in a leveling-up manner in terms of difficulty. This may be less effective when users only want to learn certain sentences or words to aid them in their daily communications, and these sentences or words are not accessible because the users are currently at a "beginner" level.

We found that vocabulary is one of the most important factors for users trying to master a language [1]. However, learning only new vocabulary is not enough; users should also apply what they learn in daily conversation to receive instant feedback from native speakers. Japanese vocabulary acquisition requires more time because of its complexity in pronunciation and the use of Kanji. Therefore, we aimed to develop an application that specifically caters to vocabulary learning—MiniHongo, a location- and physical-activity-based smartphone application for Japanese vocabulary acquisition for non-Japanese speakers.

MiniHongo is designed for foreigners who are currently studying or working in Japan for without a high level of Japanese. Due to their lack of daily learning time, we focus on providing small lessons that can be accessed throughout the day during their free time. Therefore, the main challenges are finding a way to effectively use users' time and creating approachable lessons. Since users usually only have a short time to study (e.g., while waiting for a bus), the lessons should be relevant to their daily activities and simple enough so that they do not have to spend a large amount of effort to finish them. This is called micro-learning, which involves using multiple small units of focused and condensed learning activities that can be accessed via mobile devices [5]. Our contributions include the following.

- Vocabulary acquisition: MiniHongo was designed and developed for solely vocabulary acquisition, not language learning as a whole because we understand that language learning is a more complex and bigger domain, which requires in-depth literature review and complex implementations to explore.
- Location-based word recommendation: The application runs in the background and constantly tracks users' most current locations to compose lessons that contain words related to the location.
- Effectively using users' time: The effectiveness of micro-learning is maximized by detecting the most suitable time for learning. In this study, we chose resting time, e.g., while they are commuting to work or school. The reason for this choice is the large number of commuters in Japan.
- We applied a micro-learning method to improve the learning experience by creating small vocabulary lessons that can be finished in a short period of time so that users can access the lessons throughout their daily working lives.

The ultimate goal with MiniHongo is to enable users to integrate learning Japanese into their daily lives, making studying a seamless and fun experience. Therefore, MiniHongo will improve and maintain users' motivation.

2. Related Works

Here, we review theories of previous studies that explored location-based and micro-learning contextual data that informed our approach, along with relevant HCI studies.

We conducted searching for literature related to location-based language learning and micro-learning via Google Scholar [6], ACM Digital Library [7]; Google Search Tool; and also a variety of conference proceedings, such as the SIGCHI Conference on Human Factors in Computing System, the International Conference on Computer Science and Software Engineering, the CHI Conference on Human Factors in Computing Systems and the International Joint Conference on Information, Media and Engineering.

2.1. Location-Based Language Learning

There have been several studies conducted on using location in language learning. The most common approach is using location-based data to employ AR to supplement the real-world environment with relevant information. Perry [8] used this approach to develop and analyze two location-based, serious augmented-reality learning games for French second language (FL2) learning in primary schools. The game-play was performed as a learning activity, and the participants were students. In this study, the researchers explored situated learning theory—a theory which supports that learning is socially constructed and naturally embedded within the culture, activity, and context in which it takes

place [9]. Furthermore, this theory highlights the significance of authentic contexts for learning and communities of practice. The result of the study implied that location-based factors play an important part in keeping the students interested in learning, as 20 of the 22 students responded "yes" when asked if being outside of the classroom, in real environments (although only virtually francophone), aided in making their learning more relevant or meaningful.

Another approach for location-based applications is mobile applications. CityCompass [10] was an application designed as a companionship way-finding mission game. The application connected two remote users, one tourist who did not speak the local language and one local native speaker. The two people had to navigate through a city as a tourist and a guide in order to arrive at a preassigned destination. In order to complete the mission, the two people had to conduct multiple way-finding tasks in a 360-degree panoramic map of a city; therefore, they could learn and improve the language by themselves. This research was used by over one hundred students from different countries as an additional classroom activity. However, the learning was not always achievable because the application needed to find two available users at a time. Moreover, it was not real-time-location-based, but rather provides learners a simulated map. There has been another idea: using location via GPS data to build a ubiquitous Japanese translation and studying system [11]. The study included system design and partial implementation of a mobile application that exploited GPS on a Nokia device. However, no testing and results were discussed because the research was still in the early stage. Aside from this, limited literature related to location-based language-learning applications, especially in combination with physical-activity recognition, was found, despite the searching of different journal repositories, conference proceedings, and public stores for applications, such as Google Play.

2.2. Micro-Learning

Micro-learning is a new trend and also a buzzword in the human–computer interaction field. The common features of micro-learning include microcontent, focusing on a single definable idea or topic, and a short learning time (i.e., no longer than 15 min) [5]. Various studies have been conducted to explore micro-learning in different fields [12], such as textiles [13], engineering [14], thermography [15], and language learning [16]. According to existing literature, micro-learning is believed to have several benefits, including better engagement for learners [17], improving learners' motivation [18], and improving learning ability and performance [19]. The attention for micro-learning can be explained by the fact that the average human attention span is decreasing, as per a survey by Microsoft [20] that indicated that the average attention span of a human dropped from 12 to eight seconds, which is shorter than that of a goldfish. On the other hand, micro-learning is reported to be getting popular in work-based learning, as working people do not have much time for studying during their working days. A survey by Mazareanu [21] suggests that 80% of employees are learning when they need to. As a result, we want to facilitate micro-learning for Japanese vocabulary learning because our target users are foreigners who are working and studying in Japan. Dearman et al., developed an application [16] based on micro-learning that displays new words as wallpapers on users' smartphones. It uses implicit interaction with the user's vocabulary learning progress, since all users check their phones. However, the study did not suggest a way for learners to practice what they learned; therefore, it was difficult to examine the effectiveness of the application. The lessons were organized in different domains but not relevant to locations. An interesting finding is that many participants found that a small number of out-of-domain words were particularly memorable when they were put within a larger pool of contextually relevant words. This finding was valuable in choosing lessons for our study.

3. Design and Development

The following sections describe the architecture, technical specifications, and implementation of MiniHongo.

3.1. Workflow of MiniHongo

MiniHongo runs in the background and monitors the user's most current activities. We defined a resting stage as a period when the user does not perform any major activities, such as walking or running.

Figure 1 illustrates the main workflow of the application. Whenever a resting stage is recognized, MiniHongo will trigger the second process to detect the user's current location. It then compares the detected location data with the data stored in its database to determine if the detected location is the user's home. If it is, it loops back to detect the user's activity. If not, it will suggest a lesson related to the detected location and then restart from the beginning.

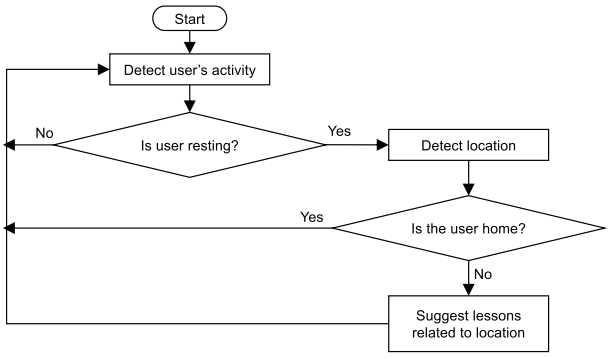

Figure 1. Workflow of MiniHongo.

The application can only work when there is an Internet connection because it requires communication between the application and third-party service providers to identify the user's location and physical activities.

3.2. Application Architecture

Figure 2 shows MiniHongo's current architecture and technology stack. There are three main components.

- Application: It is an Android application written in Xamarin [22]. This component has two layers: an application layer, which is the back-end code in C-sharp, and user-interface layer, which is XAML [23]. These layers can be shared and generated for both Android and iOS applications. However, certain specifications are required to be written in the native Android or iOS language. MiniHongo is executable on Android version 4 or later.
- Third Party APIs (application programming interfaces): The application makes calls to third-party APIs to obtain users' locations and activities and retrieve Japanese words from a database server.
- Amazon Web Service (AWS): We use AWS to host our database. We use Amazon RDS [24], which is a collection of Amazon Services that supports relational databases such as MySQL, SQLite, and Oracle. MiniHongo communicates with AWS via an API by connecting to an Amazon RDS endpoint. We customized the endpoint by following sample structures provided by Amazon.

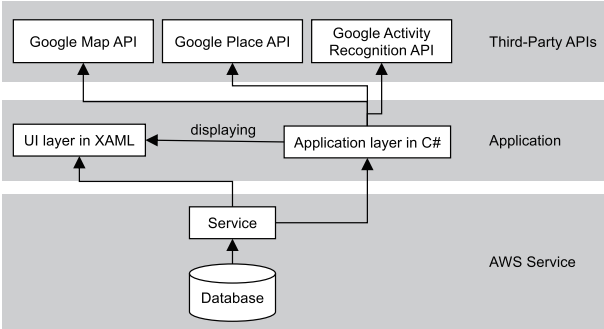

Figure 2. Architecture of MiniHongo.

3.3. Application Database

The relational database used for MiniHongo is SQLite [25]. As we mentioned above, it is hosted on AWS. The database contains Japanese words and users' information and the places used to categorize the list of words.

We created a database of 100 Japanese words, and their pronunciations and meanings, with different levels of difficulty. We referred to the Japanese dictionary Jisho [26] to compose this database.

Database Design

Figure 3 is the logical design for MiniHongo's database. The User table stores all users of the application, along with their information, such as email addresses and passwords. The Words table stores all vocabulary data of MiniHongo. The category column marks which category a word belongs to. More details about categories are discussed in Section 3.4. The Home table stores all users' home locations, which later are used for identifying whether a user is at home or not. In order to identify which words were learned by which users, we used the LearntWords table.

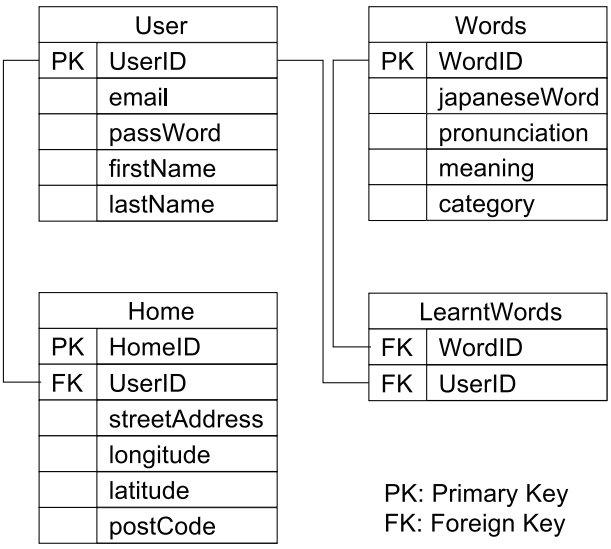

Figure 3. Database design of MiniHongo.

3.4. User-Location Tracking

We used Place APIs [27] to track a device's location. There are two fields in the responses of Place APIs that can be used to identify a place's details: Name and Type. As sometimes names do not provide information about what the place actually is, we combine the data from both fields. We classified the places into the following four categories.

- Restaurant.
- Education.
- Supermarket.
- Coffee Shop.

We also categorized our vocabulary database into these four categories. When MiniHongo detects a user's exact location, i.e., latitude and longitude, it will make another API call using the input of the latitude and longitude to obtain the details of the place. It will then determine if the place belongs to one of the above four categories on the basis of the response of the call and recommend related words from the database.

3.5. User-Activity Detection

The Google Activity Recognition API [28] is a part of the Google Developers Development Kit. In this API, we use an ActivityTransition object to detect when users transit from one activity to another, e.g., when user ends walking and starts standing still. The API supports the following five activity types:

- IN_VEHICLE.
- ON_BICYCLE.
- RUNNING.
- STILL.
- WALKING.

As we mentioned in Section 3.1, there is a resting stage in which users will be notified of lessons. The activity STILL is used for defining this stage. Every time an activity of type STILL is recognized to begin or end, the API sends MiniHongo a notification. The appropriate timing to display the short Japanese lesson will be during a STILL activity.

3.6. User Interface

There are four screens of the user interface of MiniHongo. Figures 4 and 5 are the Login and Landing pages, respectively. When a user first opens MiniHongo, these screens will be displayed once.

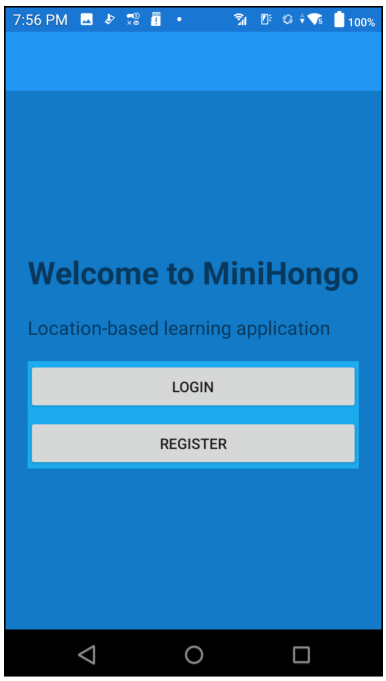

Figure 4. Landing page.

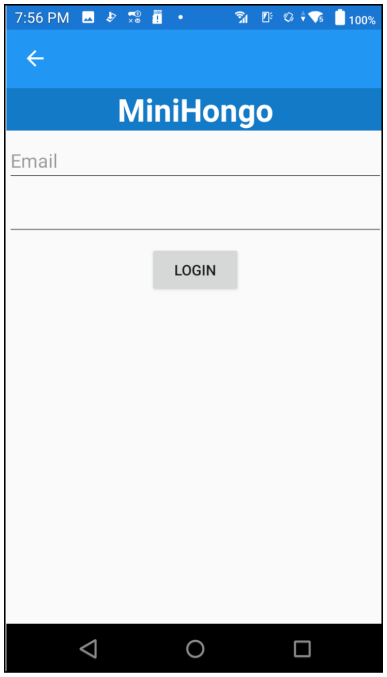

Figure 5. Login page.

When MiniHongo detects a resting stage, it will start to detect the user's location, as shown in Figure 6. Finally, it displays a lesson for the user, as shown in Figure 7. Users can navigate through each word, and if they have memorized the word, they can press "Mark as Learned" to let the application know the user has learned the word. This word will not be shown again in future lessons. If they want to see that word later or move on to the next word, they can press "Next".

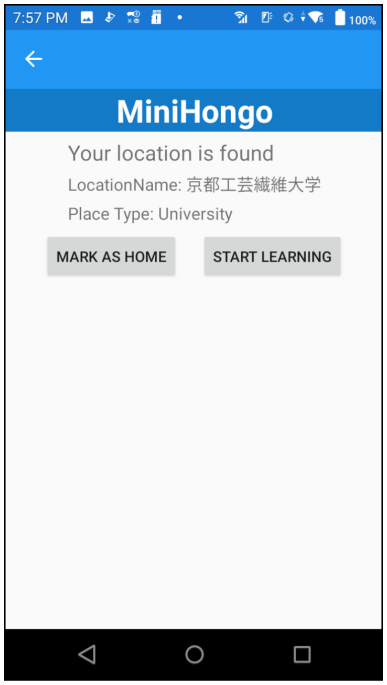

Figure 6. Location-detection page. The Japanese text displayed in the LocationName field refers to the name of the location, which translates to Kyoto Institute of Technology.

Figure 7. Lesson page.

4. Experimental Evaluation

We conducted a one-week experiment to explore how the participants used MiniHongo in their everyday lives, how it affected the participants' learning attitudes and behaviors, and their overall experience with the location- and activity-based process.

We do not intend to change the participants' behavior, which is not possible and desirable when evaluating novel interactions in this context and stage of HCI research [29]. A longitudinal study is required to evaluate the continued effect of an application on users' behavior. Therefore, we collected both qualitative data and quantitative data via a questionnaire to gain a full picture of how the application affects the participants' progress in Japanese language learning.

Regarding the qualitative experiment, we used questionnaires and interviews with the aim of drawing narrative results of thoughts and opinions about MiniHongo as a whole. In the quantitative experiment, we wanted to validate the following two hypotheses.

Hypothesis 1. *Learning Japanese vocabulary via a contextual location-relevant lesson is more effective.*

Hypothesis 2. *Micro-learning for vocabulary can effectively use users' time through activity recognition.*

Hypothesis 1 was selected with reference to Perry et al. [8], who found a positive impact of place-based data on progress in learning the French language. In addition, situation learning theory [9] claims that learning is socially constructed with context and where that context exists. We wanted to validate that by providing location-relevant lessons. We provide a contextual learning interaction for language learning, and hence, it should be more effective.

Hypothesis 2 was selected to validate the impact of micro-learning via physical-activity recognition. We based it on the view of previous studies that micro-learning is beneficial for improving learning ability and performance [19] and motivation [18].

4.1. Participants

We recruited 12 participants who were foreign students and workers living in Kyoto, Japan (4 men, 8 women, ranging in age from 22 to 30 years old, with an average age of 25.3). Before starting the experiment, participants had a 60 min session with us, in which we conducted an interview to determine their current level of Japanese, motivation for studying the Japanese language, nationality, and native language. Ten out of twelve participants were graduate students from our university, and the other two participants were workers in a hotel and a different school in the city of Kyoto. Their main travel routes were repeated on weekdays and were slightly different on weekends. In order to display the participants' different words despite the similar roads they took, MiniHongo has an option to mark a word as "studied". If it is marked that way, the word will no longer appear in the application the next time the participant uses it.

4.2. Study Groups

To evaluate the effects of location- and activity-recognition-based information on the Japanese language learning process, we compared MiniHongo with two other versions without certain functions. We randomly assigned the participants into three study groups. Each group was asked to use one of the following applications.

- MiniHongo: Our application.
- Word-Activity: A version of MiniHongo without location recognition. Instead of showing users a list of words that are related to a location, it displays only a list of random words whenever it recognizes users are STILL.
- Word-List: A version of MiniHongo without both location and activity recognition. It shows users only a list of random lessons when users open the application manually.

4.3. Procedure

We installed the applications on the participants' mobile devices and explained the features of the assigned applications in a 30-min briefing session prior to the experiment. In the briefing session, we also informed them about the purpose of the study, how to use the applications, and what they should do in the next step of the experiment. As MiniHongo is currently an Android application, we provided Android devices for participants who did not have them.

All participants were fully informed about the research, its purpose, and its duration. They had the right to decline to participate and to withdraw from the research once participation began. They were also provided with the opportunity to ask any questions of us and receive answers from us.

During the study, participants completed a 1 min daily check-in survey to provide feedback about their on-going progress with the assigned application. The survey was conducted between us and participants via LINE [30]. The daily survey was just a question from us: "Did you use the application today?", which required a yes/no answer from the participants. The survey was sent to each participant's LINE account every day at 10 PM.

After one week of using the assigned applications, participants were invited to a 60 min interview, during which they were asked about their overall experience with the assigned applications, their motivation, and their feelings while using the application. We also asked the participants to complete a survey questionnaire consisting of ten different questions about the application and a small test of what words the participants had studied to assess how many words they could memorize in one week. Entry and exit data were recorded on paper due to the participants' unwillingness to have their faces being recorded during the study.

4.4. Questionnaire Design

We adapted 2 different frameworks to design the questionnaire that was used for both qualitative and quantitative studies. We decided to use perceived usability to assess the application because the data were collected as interviews with participants, moreover,

perceived usability is also considered as an important component of the higher-level construct of usability [31]. We used the standardized questionnaire System Usability Scale (SUS) [31] to evaluate MiniHongo's perceived usability. The SUS questionnaire is very precisely short and positive in wording. It is a light-weight solution, which was needed for our research, as our testing was conducted at a very early stage. We selected 4 out of 10 questions, questions 1, 3, 9 and 10 in SUS, for our research. The full version of SUS is displayed in Figure 8, which consists of 10 questions and a scale from 1 to 5. In order to test the application's perceived quality in terms of functionality and information, we used the Computer System Usability Questionnaire (CSUQ) [32]. Figure 9 shows a full version of CSUQ, which consists of 16 questions and a scale from 1 to 7. The CSUQ produces 4 criteria:

- Overall: averaged responses for items 1–16 (all the items).
- System Usefulness: average of items 1–6.
- Information Quality: average of items 7–12.
- Interface Quality: average of items 13–15.

		Strongly disagree 1	2	3	4	Strongly agree 5
1	I think that I would like to use this system frequently.					
2	I found the system unnecessarily complex					
3	I thougt the system wa easy to use.					
4	I think that I would need th support of a technilcal person to be able to use this system.					
5	I found the various functions in the system were well integrated.					
6	I thougt there was too much inconsistency in this system.					
7	I would imagine that most people would learn to use this system very quickly.					
8	I found the system very awkward to use.					
9	I felt very confident using the system.					
10	I needed to learn a lot of things before I could get going with this system.					

Figure 8. The standard SUS.

		Strongly disagree 1	2	3	4	5	6	Strongly agree 7
1	Overall, I am satisfied with how easy it is to use this system.							
2	It is simple to use this sytem.							
3	I am able to complete my work quickly using this system.							
4	I feel comfortable using this sytem.							
5	It was easy to learn to use this system.							
6	I believe I became productive quickly using this sytem.							
7	The system gives error messages that clearly tell me how to fix problems.							
8	Whenever I make a mistake using the system, I recover easily and quickly.							
9	The information (such as online help, on-screen messages and other documentation) provided with this system is clear							
10	It is easy to find the information I needed.							
11	The information provided with the system is effective in helping me complete my work.							
12	The organization of infromation on the system screen is clear.							
13	The interface of this system is pleasant.							
14	I like using the interface of this system.							
15	This system has all the functions and capabilities I expect it to have.							
16	Overall, I am satisfied with this system.							

Figure 9. The standard CSUQ.

We selected 6 items from CSUQ for our testing—6, 10, 11, 12, 13, and 14—in order to assess the system's usefulness (item 6), the information quality (items 10 and 11), and the interface (items 13 and 14). We changed the wording of the questions selected from the 2 standard questionnaires in order to make them suitable to our study of MiniHongo. The scale that we selected was from 1 to 6 because it is in between the values of the scales of SUS and CSUQ. The questionnaire that we designed for MiniHongo is displayed in Figure 10.

		Strongly disagree 1	2	3	4	5	Strongly agree 6
1	I think that I will use this application frequently.						
2	I thougt the application was easy to use.						
3	I felt very confident using the application.						
4	I needed to learn a lot of things vefore I could get going with this application.						
5	I believe I can study Japanese productively using this application.						
6	It is easy to learn the lesson I need.						
7	The lesson provided by the application was effective in helping to learn Japanese.						
8	The organization of the information on the application screen is clear.						
9	The interface of the appication is pleasant.						
10	I like using the interface of the application.						

Figure 10. The questionnaire used to test MiniHongo.

5. Results

We collected qualitative and quantitative data from the participants, even though we did not focus on how MiniHongo can change people's behavior regarding language learning.

5.1. Qualitative Findings

We focused on descriptive findings and personal feedback from the participants' everyday learning activities and how motivated and engaged they were with the applications. To describe participants' experience, we illustrate our results with participants' quotes and our interpretations based on our thematic analysis.

We wanted to prove that MiniHongo motivates users to better learn Japanese because of the location-focused lessons and activity recognition. Thus, we expected to receive more positive feedback of MiniHongo than the other two applications.

5.1.1. Motivation toward Learning Goal

We first describe how MiniHongo impacted participants' motivation for learning Japanese.

During our 30 min briefing session prior to the experiment, participants expressed different motivations. Ten of the twelve participants wanted to learn Japanese because they wanted to talk to locals and enjoy their lives in Japan. One participant expressed a strong interest in Japanese language and culture, which is also the reason he decided to come to Japan. Another participant wanted to learn Japanese to become qualified to work in Japan. Interestingly, during our one-week experiment, one participant who was assigned MiniHongo said he wanted to learn Japanese with MiniHongo because it requires him to walk or move around the city: "I enjoy walking and I think learning some new Japanese words while walking makes me feel like I have achieved something". As a result, this participant tried to go out more than usual to learn from the lessons and used MiniHongo five times during the week.

Users assigned to Word-List showed lower interest in learning. Despite the fact that they opened the application, they eventually lost their motivation during the week. One participant said: "I opened the application and studied because it was a part of your experiment, not because I wanted to learn Japanese".

5.1.2. Feelings toward and Frequency in Using Applications

To understand users' engagement with the applications, we conducted interviews about the participants' frequency of using the applications.

Via interviews and daily check-ins, we found that the participants using Word-List had a much lower rate of use during the week. Two participants from this group used the application only once. One participant said he forgot to use the application because it gave him no notification: "I was so busy with my studies that I did not think about the application at all". The participants using MiniHongo and Word-Activity said that receiving notifications of the short lessons while waiting or walking was very useful. One participant using Word-Activity said, "It feels great when I can study something new instead of just browsing TikTok".

We also interviewed participants on how they felt about the applications during the experiment. Overall, participants thought it was a straightforward application and easy to use. However, the user interface was not attractive; therefore, some participants did not feel like MiniHongo was a real application: "The design looks so simple that I feel like it is an experimental application rather than something I will actually use in real life". This is something that we can improve upon, since the user interface can also impact how often users use an application and how positively they feel about it.

5.2. Quantitative Findings

In order to assess the effectiveness of MiniHongo quantitatively, we used the following three metrics.

- The rate of memorized words among learned words: We tracked how many words the participants learned with the application they were assigned (N1), and then found how many words they had memorized by giving the participants a test at the end of the experiment (N2). Finally, we calculated the rate by dividing N2 by N1. For example, if a participant learned 20 words and memorized 8 words, the rate would be $\frac{8}{20} \times 6 = 2.4$.
- The number of application uses: Every time a participant opened the application and went to the Lesson Page, it would be counted as one use.
- Ease of use: We asked the participants to rate how easy it was to use the application assigned to them on a scale from 1 to 6 (1: very difficult, to 6: very easy).

We did not track the users' use time in order to track their study frequency because MiniHongo and Word-Activity only recommend the lessons when users go out for non-studying purposes. In the times of rest between their daily errands, users can study. On the other hands, we are still exploring different technical solutions using Xamarins to track if users spend their time on the devices for studying or for different activities, and developing more advanced features of MiniHongo to cater to deeper learning.

Table 1 lists the results.

Table 1. Experimental results.

Application	Participant ID	No. of Words Learned ($N1$)	No. of Words Memorized ($N2$)	Rate of Memorized ($N2/N1$)	No. of Application Uses (N_{use})	Ease to Use (1: Very Difficult–6: Very Easy)
MiniHongo	1	15	10	0.67	18	4
	2	21	17	0.81	13	4
	3	18	18	1.00	7	3
	4	15	10	0.67	8	4
Word-Activity	5	20	10	0.50	15	3
	6	20	13	0.65	12	4
	7	10	4	0.40	6	4
	8	20	10	0.50	7	3
Word-List	9	22	18	0.82	6	5
	10	12	4	0.33	8	4
	11	12	4	0.33	3	4
	12	14	7	0.50	2	4

To validate Hypothesis 1, we measured the rate of memorized words among learned words and compared the rate achieved with MiniHongo to that achieved with Word-Activity. Figure 11 shows the results. The mean of the rate with MiniHongo (0.79) was significantly larger than that of Word-Activity (0.59). We used the Welch two sample t-test ($t(5.1633) = 2.8974, p = 0.03 < 0.05$). These results support Hypothesis 1.

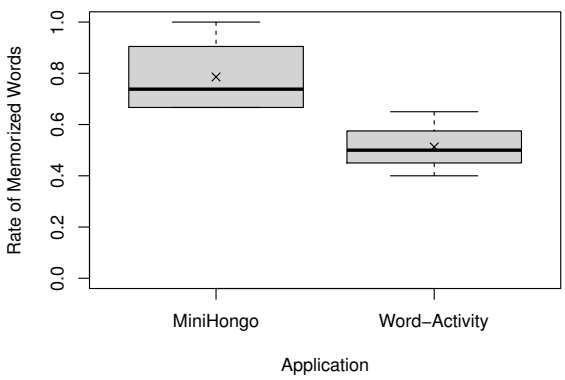

Figure 11. Rate of memorized words among learned words.

To validate Hypothesis 2, we measured the number of application uses and compared that number for Word-Activity with that for Word-List. Table 1 and Figure 12 show the results of Word-Activity and Word-List. As shown in Figure 12, the mean of the number of Word-Activity uses (10.00) was larger than that of Word-List (4.75), though the difference was only marginally significant (Welch two sample t-test, $t(5.1467) = 2.0759$, $p = 0.09 < 0.1$). These results partially support Hypothesis 2.

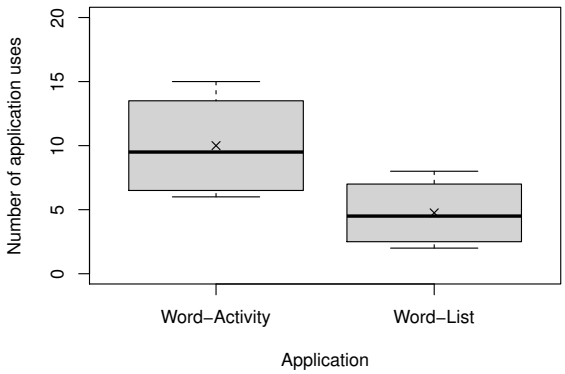

Figure 12. Number of application uses.

The distribution of the level of ease of use is illustrated in Figure 13. The unit on the vertical axis is how easy it was for the participants to use the application. The means of MiniHongo, Word-Activity, and Word-List were 3.75, 3.50, and 4.25, respectively. However, there was no significant difference among the three groups ($F(2, 9) = 2.10$, $p = 0.178$).

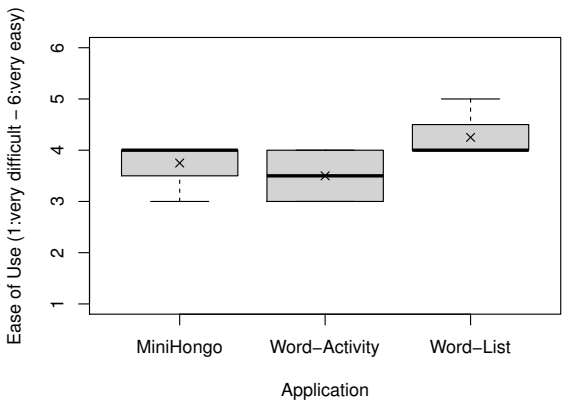

Figure 13. Ease of use.

There was no difference in the user interface among the three applications, but there were some differences in function. This is the reason there was no significant difference in ease of use.

6. Discussion

6.1. Interpretations on Our Findings

After our one-week experiment to evaluate MiniHongo, we evaluated both qualitative and quantitative findings of the application. Via qualitative evaluation, the participants expressed interest in using the application to learn Japanese. Especially, users said they feel more motivated when using MiniHongo: "I enjoy walking and I think learning some new Japanese words while walking makes me feel like I have achieved something". This finding is similar to the previous one of Nikou et al. [18], as it is said to be "a blended learning environment and to enhance perceived autonomy, competence and relatedness".

In the quantitative evaluation, different results were explored. Regarding the fact that we had a limited sample size and experimental period, some difference was found statistically. In detail, Hypothesis 1 was supported and Hypothesis 2 was partially supported. We argue that contextual learning plays an important role in making MiniHongo more effective that the other two applications. Hypothesis 1 indicates that context-tightening lessons are critical to maintaining learners' ability to retain learned vocabulary, which was reflected in the number of words memorized by the participants at the end of the experiment. On the other hand, Hypothesis 2 was partially supported, and we argue that the micro-learning-based approach for vocabulary acquisition was shown to be effective at maintaining the participants' motivation for studying. This is similar to previous conclusions from Mohammed [19], as they stated that micro-learning improves the students' learning motivation and activity. We believe that one possible reason for Hypothesis 2 being only partially supported was the short experimental time period. It is acknowledged that further and deeper experimentation should be conducted in order to gather stronger results for clearer interpretations. Moreover, more exploration should be performed regarding tracking users' usage time—the amount of time they spend on studying with the application—in order to obtain deeper results.

There was also no significant difference regarding ease of use among the three applications because there was no difference in their user interfaces. In brief, we realized that users prefer an application that can detect their free time and notify them of new lessons, rather than an application that requires them to manually open and study. Without notifications, users will likely forget about the application and abort their learning.

6.2. Threats to Validity

Despite the fact that we presented some statistical differences and validation for Hypothesis 1 and Hypothesis 2, there were several threats to validity [33] that should be considered due to the experiment being conducted with a sample size of 12 participants over a one-week period. Some potential threats to validity were:

- Sampling bias: There is a possibility that the 12 participants chosen for the experiment may not be representative of the larger population. This could have led to overestimation or underestimation of the results, and limit the generalizability [33] of the findings.
- Selection bias: We did not have many options for selecting the participants for the experiment because of the limited networking of foreign students in our institute; therefore, there may be a bias in the sample that could affect the validity of the results.
- Small sample size: A sample size of 12 is relatively small and may not be sufficient to provide accurate or reliable results. This can lead to a lack of statistical power, which makes it difficult to detect true effects or relationships between variables.
- Short experiment period: One week is a relatively short period of time, and it may not be long enough to observe significant changes or effects. This can limit the ability to draw meaningful conclusions from the results.

Overall, while the results of the experiment were supportive and we found some significant differences statistically, it is important to interpret them with caution due to the above potential threats to validity.

7. Conclusions

We presented a mobile application called MiniHongo that uses location- and physical-activity-based data to compose and recommend Japanese lessons to foreigners living in Japan. Our application was guided by theories and persuasive research and literature on foreign-language studies and HCI. In our experiment involving 12 participants in 3 different study groups, we evaluated the participants' use of MiniHongo in their daily lives and received their personal feedback. Based on our findings, we identified the strategies and obstacles for developing location- and physical-activity-based mobile learning applications. We also assessed the application quantitatively by trying to validate two hypotheses. As a

result, Hypothesis 1, "Learning vocabulary via a contextual location-relevant lesson is more effective", was supported, and Hypothesis 2, "Micro-learning for vocabulary can effectively use users' time through activity recognition", was partially supported. We found that delivering lessons to users using automatic notifications and free-time optimization using activity recognition is effective at helping users maintain their learning progress.

We also found opportunities to improve MiniHongo and any future research around this topic. A necessary next step of this research is to undertake a longitudinal experiment on a larger number of participants and reconstruct the functionalities and user interface of the application. MiniHongo would require a field study lasting at least two months to test whether users will continue using or abandon the application (like other language-learning applications) to examine human behavior and habits towards this interaction. Moreover, there is an opportunity to deepen the application with more complex design and the use of narrative in learning to keep users motivated [34]. For instance, in addition to location- and physical-activity-based recognition, users will go through the story of an imaginary character as they progress with their learning. If they abandon the learning, the character may die or have difficulties in the story, which may encourage users to continue their studies because they want to see the character have a happy ending.

On the other hand, we also realized an opportunity to use this location-based and physical-activity-recognition approach for different languages, especially Asian languages with similar writing systems, such as Chinese or Korean, with a new selection of words for the database. In addition, the micro-learning approach in this study can also be adopted for teaching other subjects and fields to working people who wish to maximize their free time [5]. A possible solution can be integrating micro-learning with the employees' corporate calendars, so that the application can identify free time between the employees' work and meetings to use it for learning. The learning content can vary from languages to technical and social skills, such as programming and presentation skills. Finally, we acknowledge that we need to explore methods of implementing MiniHongo on a large scale via web-service hosting and the App Store. In conclusion, we hope our insights will be useful in helping to improve users' motivation and promoting language learning via mobile applications.

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Abbreviations

The following abbreviations are used in this manuscript:

HCI	Human–Computer Interaction
API	Application Programming Interface
AWS	Amazon Web Service
RDS	Relational Database Service
SUS	System Usability Scale
CSUQ	Computer System Usability Questionnaire
ACM	Association for Computing Machinery

References

1. Dornyei, Z. Motivation and 'Self-Motivation. In *The Psychology of the Language Learner: Individual Differences in Second Language Acquisition*; Mahwar, N.J., Ed.; Lawrence Erlbaum: Mahwah, NJ, USA, 2005.
2. Rose, H. *The Japanese Writing System: Challenges, Strategies and Self-Regulation for Learning Kanji*; Multilingual Matters: Bristol, UK, 2017. [CrossRef]
3. Ceci, L. Topic: Language Learning Apps, Statista. Available online: https://www.statista.com/topics/8425/language-learning-apps/ (accessed on 26 January 2023).
4. Von Ahn, L.; Hacker, S. Duolingo. Available online: https://www.duolingo.com/ (accessed on 26 January 2023).
5. Buchem, I.; Hamelmann, H. Microlearning: A strategy for ongoing professional development. *eLearning Pap.* **2010**, *21*, 1–15.
6. Google Scholar. Available online: https://scholar.google.com/ (accessed on 26 January 2023).
7. ACM Digital Library. Available online: https://dl.acm.org/ (accessed on 7 March 2023).
8. Perry, B. Gamified Mobile Collaborative Location-Based Language Learning. *Front. Educ.* **2021**, *6*, 689599. [CrossRef]
9. Dunleavy, M.; Dede, C.; Mitchell, R. Affordances and Limitations of Immersive Participatory Augmented Reality Simulations for Teaching and Learning. *J. Sci. Educ. Technol.* **2009**, *18*, 7–22. [CrossRef]
10. Pekka, K.; Sumita, S.; Markku, T. CityCompass: A Collaborative Online Language Learning Application. In Proceedings of the 19th ACM Conference on Computer Supported Cooperative Work and Social Computing Companion, San Francisco, CA, USA, 26 February–2 March 2016; pp. 94–97. [CrossRef]
11. Bartholomäus W.; Werner, W. Enhancing language learning and translation with ubiquitous applications. In Proceedings of the 8th International Conference on Advances in Mobile Computing and Multimedia (MoMM '10), Paris, France, 8–10 November 2010; Association for Computing Machinery: New York, NY, USA, 2010; pp. 195–202. [CrossRef]
12. Leong, K.; Sung, A.; Au, D.; Blanchard, C. A review of the trend of microlearning. *J. Work.-Appl. Manag.* **2020**, *13*, 88–102. [CrossRef]
13. Buhu, A.; Buhu, L. The Applications of Microlearning in Higher Education in Textiles. *eLearning Softw. Educ.* **2019**, *3*, 373–376.
14. Said, I.; Çavuş, M. ALU design by VHDL using FPGA technology and micro learning in engineering education. *Br. J. Comput. Netw. Inf. Technol.* **2018**, *1*, 1–18. [CrossRef]
15. Nilsson, R. Designing an Interactive Micro-Learning Application: A New Way to Learn Thermography. Master's Thesis, Deptartment of Information Technology, Uppsala University, Uppsala, Sweden, 2021.
16. Dearman, D.; Truong, K. Evaluating the implicit acquisition of second language vocabulary using a live wallpaper. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12), Austin, TX, USA, 5–10 May 2012; pp. 1391–1400. [CrossRef]
17. De Gagne, J.C.; Park, H.K.; Hall, K.; Woodward, A.; Yamane, S.; Kim, S.S. Microlearning in health professions education: Scoping review. *JMIR Med. Educ.* **2019**, *5*, e13997. [CrossRef] [PubMed]
18. Nikou, S. A micro-learning based model to enhance student teachers' motivation and engagement in blended learning. In Proceedings of the Society for Information Technology and Teacher Education International Conference, Association for the Advancement of Computing in Education (AACE), Las Vegas, NV, USA, 18 March 2019; pp. 509–514.
19. Mohammed Wakil, G.S.K.; Nawroly, S.S. The effectiveness of microlearning to improve students' learning ability. *Int. J. Educ. Res. Rev.* **2018**, *3*, 32–38. [CrossRef]
20. Gausby, A. Microsoft Attention Spans Research Report. 2015. Available online: https://dl.motamem.org/microsoft-attention-spans-research-report.pdf (accessed on 26 January 2023).
21. Mazareanu, E. Time Employees Take to Learn Worldwide. 2019. Available online: https://www.statista.com/statistics/885973/time-employees-take-to-learn-worldwide/ (accessed on 26 January 2023).
22. Xamarin. Available online: https://dotnet.microsoft.com/apps/xamarin (accessed on 26 January 2023).
23. XAML Overview (WPF .NET). Available online: https://docs.microsoft.com/en-us/dotnet/desktop/wpf/xaml/ (accessed on 26 January 2023).
24. Amazon RDS. Available online: https://aws.amazon.com/rds/(accessed on 26 January 2023).
25. Hipp, R.D. SQLite. Available online: https://www.sqlite.org/index.html (accessed on 26 January 2023).
26. Jisho.org: Japanese Dictionary. Available online: https://jisho.org/ (accessed on 26 January 2023).
27. Google Places API. Available online: https://developers.google.com/maps/documentation/places/web-service/overview (accessed on 26 January 2023).
28. Google Activity Transition API. Available online: https://developers.google.com/android/reference/com/google/android/gms/location/ActivityTransition (accessed on 26 January 2023).
29. Klasnja, P.; Consolvo, S.; Pratt, W. How to Evaluate Technologies for Health Behavior Change in HCI Research. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Vancouver, BC, Canada, 7–12 May 2011; pp. 3063–3072. [CrossRef]
30. Line. Available online: https://line.me/en/ (accessed on 26 January 2023).
31. Brooke, J. SUS: A retrospective. *J. Usability Stud.* **2013**, *8*, 29–40.
32. Lewis, J.R. IBM computer usability satisfaction questionnaires: Psychometric evaluation and instructions for use. *Int. J. Hum. Comput. Interact.* **1995**, *7*, 57–78. [CrossRef]

33. Leung, L. Validity, reliability, and generalizability in qualitative research. *J. Fam. Med. Prim. Care.* **2015**, *4*, 324–327. [CrossRef] [PubMed]
34. Murnane, E.L.; Jiang, X.; Kong, A.; Park, M.; Shi, W.; Soohoo, C.; Vink, L.; Xia, I.; Yu, X.; Yang-Sammataro, J.; et al. Designing Ambient Narrative-Based Interfaces to Reflect and Motivate Physical Activity. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (CHI '20), Honolulu, HI, USA, 25–30 April 2020; pp. 1–14. [CrossRef]

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