Gamified Web Application for Facilitating Zero Carbon Activities by Local Government

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Abstract. In recent years, Japan has been actively pursuing the realization of zero carbon cities. However, significant challenges persist, including a lack of effective methods for local governments to communicate zero carbon initiatives to their citizens. This has resulted in limited awareness among citizens about how to participate in zero carbon initiatives. To address these issues, the authors develop a gamified application aimed at promoting zero carbon activities in this research.Through a case study conducted in Sanda City, Hyogo Prefecture in Japan, the authors report the progress of its social implementation.

Keywords: Zero carbon, zero carbon city, gamification, web application, local government.

1 Introduction

The concentration of CO_2 in the atmosphere has been increasing since the Industrial Revolution, and global warming is progressing. Various effects of global warming, such as rising temperatures, rising sea levels and the impact on crops, have begun to be observed, and countermeasures against global warming have become an urgent issue on a global scale.

Therefore, in recent years, *zero carbon city* initiatives, in which local governments aim to achieve zero carbon emissions as a countermeasure against global warming, have been expanding in Japan. Efforts to achieve zero carbon city include the substitution of renewable energy sources, energy conservation and a shift to low-carbon transport[1], in addition to these approaches, the participation of citizens is essential.

However, the following problems exist between local governments and citizens with regard to the zero carbon activities.

P1: There is no established method for local governments to disseminate information to citizens on how to initiate zero carbon

P2: Citizens are not clear on how to get involved in zero carbon and activities are not widespread

Therefore, measures are needed to solve these problems.

In order to solve the above problems, this research aims to establish a method for local governments aiming to achieve zero carbon cities to spread the zero carbon activities among citizens and to create opportunities for citizens to engage in zero carbon initiatives. As a key idea to achieve this purpose, the authors develop a web application that introduces *gamification*[2]. Specifically, the feature implementation is be based on the following approach.

A1: Realization of the ability of local governments to provide zero carbon information to citizens

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A2: Gamification to make it easier for citizens to engage in zero carbon initiatives

First, A1 aims to establish a method for local governments to provide information to promote the zero carbon activities, and proposes features such as F1: Administrator and F2: Article in a web application.

Next, A2 proposes a feature that lowers the barrier for citizens to engage in zero carbon initiatives and allows them to continue to do so. Specifically, the authors propose the following features: F3: Login, F4: Mission, F5: Quiz, F6: Level, F7: Map, and F8: Visualization of zero carbon initiatives.

As a case study, these approaches actually was implemented in Sanda City, Hyogo Prefecture in Japan. Specifically, the authors implemented the *Sanda Zero Carbon Challenge*, a web application that promotes the zero carbon activities among Sanda citizens. The authors also used the implemented Web application to exhibit at events and conduct demonstration tests at the city hall, and based on the user feedback got, the authors examined the effectiveness of the Web application and improve its features.

2 Preliminaries

2.1 Zero Carbon Cities and Their Challenges

In recent years, *zero carbon city* initiatives, in which local governments aim to achieve zero carbon emissions as a countermeasure against global warming, have been expanding in Japan. *Zero carbon* means that CO_2 emissions from businesses and households are reduced to a level equal to or less than the amount of CO_2 absorbed by forests[3]. As the Government of Japan aims to achieve carbon neutrality in 2050, local governments are also mainly aiming to achieve zero carbon cities by 2050[4].

Efforts such as transitioning to renewable energy, energy conservation, and the shift to low-carbon transportation[1] are being made to realize zero carbon cities. However, in addition to these approaches, citizens participation is essential. Due to the nature of projects conducted by local governments, they are closer to citizens and more likely to involve them than projects led by the national government. Therefore, it is important for local governments to encourage citizens to work on zero carbon.

However, the following problems exist between local governments and citizens regarding the zero carbon activities.

P1: There is no established method for local governments to disseminate information to citizens on how to initiate zero carbon

P2: Citizens are not clear on how to get involved in zero carbon and activities are not widespread

Because of these problems, local governments are working towards achieving zero carbon cities, although citizens lack information on how to engage in zero carbon initiatives and find it difficult and intimidating to participate. Therefore, measures are needed to solve these problems.

2.2 Web-based Data Collection

In order to solve the problems between local governments and citizens described in Section 2.1, the authors consider the use of the Web. By using the Web, local governments can provide citizens with information on zero carbon initiatives. In addition, citizens can collect information on zero carbon initiatives from anywhere.

By implementing an appropriate web application, local governments can continuously update their zero carbon contents. Furthermore, by recording the actions of citizens regarding zero carbon, local governments can understand the efforts of citizens regarding zero carbon and utilize the data. For example, by analyzing citizens' zero carbon behavior, local governments can determine what kind of initiatives they should take to promote zero carbon.

In addition, the analyzed and tabulated data can be visualized and fed back to citizens in an easy-to-understand form, enabling them to recognize the current status of the zero carbon activities as a whole and to evaluate its effectiveness.

2.3 Gamification

In order to encourage more citizens to use the Web applications described in Section 2.2, the authors consider the use of *gamification*[2]. Gamification is a method of turning a service into a game by introducing game-like elements, which are expected to stimulate users' curiosity, activate their behavior, and bring positive benefits to them.

In the context of related research that incorporates gamification into web applications connecting local governments and citizens, the example of the*Sanda Machiaruki App*[5] [6] is illustrated. Sanda Machiaruki App is an application for promoting town walking among tourists in Sanda City, Hyogo Prefecture in Japan. The features implemented as an introduction to gamification include a feature to receive points for visiting specific spots in Sanda City using GPS, a present feature using points, and a quiz feature about the spots.

Numerous related research, including the Sanda Machiaruki App, have shown that gamification introduced into Web applications is effective in encouraging user behavior.

3 Proposed Method

3.1 Purpose and Key Ideas

In order to solve the issues in Section 2.1, this research aims to establish a method for local governments aiming to achieve zero carbon cities to spread the zero carbon activities among citizens, and to create an opportunity for citizens to engage in zero carbon activities. As a key idea to achieve this purpose, the authors develop a web application that introduces gamification as described in Section 2.3.

3.2 System Overview

The requirements for a Web application to achieve the purpose of this research as described in Section 3.1 include the following.

R1: Ability to present zero carbon information from local governments to citizens
R2: There must be an easy mechanism for citizens to engage in zero carbon initiatives

Therefore, the authors implement the features based on the following approach in this research.

A1: Realization of the ability of local governments to provide zero carbon information to citizens
A2: Gamification to make it easier for citizens to engage in zero carbon initiatives

By developing the Web application based on these approaches, local governments can easily encourage citizens to participate in zero carbon activities.

3.3 A1: Realization of the Ability of Local Governments to Provide Zero Carbon Information to Citizens

In this approach, the authors aim to establish a method for local governments to provide information to promote the zero carbon activities, and propose features such as F1: Administrator and F2: Article in the web application.

F1: Administrator As described later, this application has various features for providing zero carbon information from local governments to citizens. In order to make appropriate approaches to citizens, it is necessary to have an administrator feature to post, edit, and delete information. The administrator feature should be restricted to only local government officials.

F2: Article This is a feature for local governments to disseminate information on zero carbon to users. By linking to zero carbon contents created by local governments and various useful contents published on the Web, information can be provided to users. In addition, by displaying the title, summary, and image of the linked page, the application can be used as an entry point to create an opportunity for users to get more information on zero carbon.

3.4 A2: Gamification to Make It Easier for Citizens to Engage in Zero Carbon Initiatives

In this approach, the authors propose a feature that lowers the barrier for citizens to engage in zero carbon initiatives and allows them to continue to do so. Specifically, the authors propose the following features: F3: Login, F4: Mission, F5: Quiz, F6: Level, F7: Map, and F8: Visualization of zero carbon initiatives.

F3: Login This is a feature for identifying users who use the application. Users can use the application by entering the required information and logging in. This is a necessary feature for getting information on each user's zero carbon actions and providing various gamification features.

F4: Mission This is a feature that presents missions for citizens to undertake in order to achieve zero carbon cities and encourages users to undertake them in a game-like manner. The purpose of this feature is to create an opportunity for citizens to engage in zero carbon activities by showing them specific measures to participate in zero carbon activities and encouraging them to continue to do so. To this end, the feature presents the significance of the mission, the amount of CO_2 reduction and the amount of money saved associated with the actions related to the mission, and awards points that increase the level described later when the mission is achieved, aiming to improve users' motivation for zero carbon activities. The achievement status of the mission is aggregated for each individual and used to calculate the level described later and visualize the initiatives.

F5: Quiz This is a feature that presents quizzes to test users' knowledge of zero carbon. By answering the quiz correctly, users can get points that increase their level. The purpose of this feature is to learn about zero carbon while maintaining users' motivation by making it a game. Quizzes are presented in different levels of difficulty, allowing users to learn step by step.

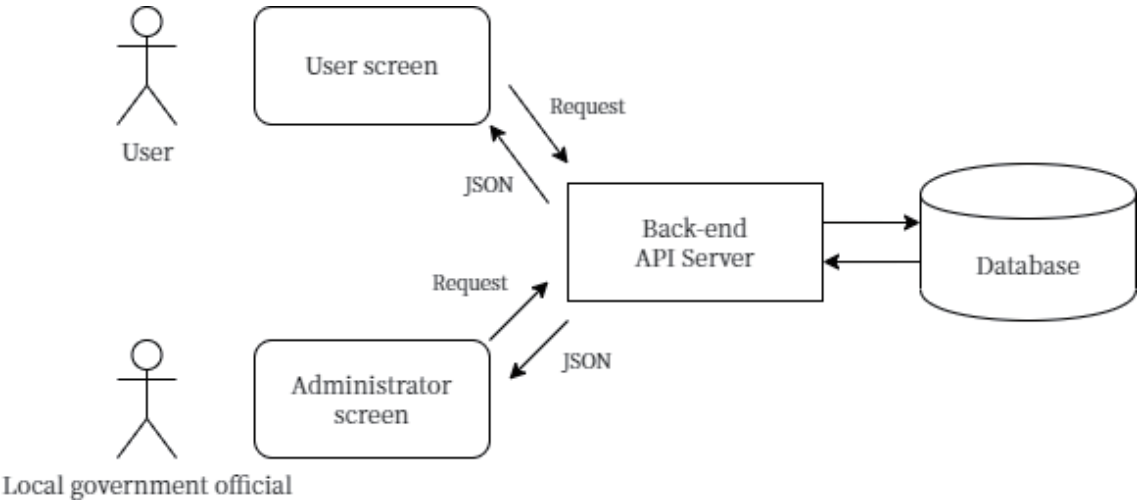

Fig. 1. Architecture of the proposed application

F6: Level This is a feature for visualizing users' zero carbon initiatives. The user's level is calculated based on the user's mission achievement status and the number of correct answers to the quiz. The user's level is used not only to visualize the user's initiatives, but also to expand the viewing range of the map described later according to the user's initiatives, contributing to the improvement of the user's motivation.

F7: Map This is a feature that displays a map that is opened according to the value of the level described above in order to visualize the user's zero carbon initiatives. Users can enjoy game elements such as exploring the map according to their level of zero carbon initiatives, contributing to the improvement of their motivation. By allowing users to explore the map of the local government that provides the service, it is possible to attract users' interest and contribute to a better understanding of the area in which they live.

F8: Visualization of Zero Carbon Initiatives This is a feature that visualizes the amount of CO_2 reduction and the amount of money saved per user aggregated by the mission feature described in Section 3.4. Users can check the amount of CO_2 reduction and the amount of money saved per week for each user, and the purpose is to maintain their motivation by knowing the specific contribution to zero carbon. In addition, by visualizing the amount of CO_2 reduction and the amount of money saved for all users, it is possible to increase users' awareness of their contribution to zero carbon city.

3.5 Architecture

The overall architecture of the proposed application is shown in Figure 1. This Web application is assumed to be operated by local government officials for a long period of time. Therefore, the authors design the database so that the missions, quizzes, and articles, which are elements of gamification, can be changed dynamically.

4 Case Study: Sanda Zero Carbon Challenge

4.1 Implementation

Sanda City, Hyogo Prefecture in Japan, has declared that it will realize zero carbon city status by 2050. Therefore, as a case study, this research implements the proposed method

described in Section 3 for realizing the zero carbon city of Sanda City. Specifically, the authors implement a web application called *Sanda Zero Carbon Challenge* to encourage Sanda citizens to engage in zero carbon activities.

The programming languages and technologies used for implementation are shown below.

- Backend
  - Java
  - SpringBoot
  - MySQL
- Frontend
  - TypeScript
  - React

The authors use these programming languages and technologies to implement the case study in Sanda City.

Prior to the explanation in the next section, the home screen that is displayed when a user logs into this application in the Sanda Zero Carbon Challenge is shown in Figure 2. The menu bar at the top of the home screen exists on each screen, and users can navigate to each feature screen by pressing the buttons on the menu bar.

From here, implementation of each feature is explained.

F1: Implementation of Administrator Feature Administrators can view user information, view, create and edit missions, quizzes, articles and tags on the administrator screen. The tag feature allows users to intuitively add icons to the user screen by setting tags for missions, quizzes, and articles.

F2: Implementation of Article Feature Users can view the article screen by pressing the "Information" button on the top menu bar of the home screen shown in Figure 2. Figure 3 shows the article screen. Administrators can set articles on zero carbon that they want citizens to read, and by clicking on the article, users can access external sites. In addition, administrators can set articles that they want citizens to read in particular as "Important notice" in the administrator screen described in Section 4.1, and display them at the top of the screen. The important notice is assumed to be used to provide information that requires citizens participation, such as announcements of zero carbon events in Sanda City.

F3: Implementation of Login Feature Users can log in to this application by creating an account with a username and password. The actions taken in this application, such as completed missions and quiz answers, are recorded in association with this username.

F4: Implementation of Mission Feature Users can view the mission screen by pressing the "MISSION" button on the screen that transitions to the mission screen by pressing the "Play" button on the top menu bar of the home screen shown in Figure 2. Figure 4 shows the mission screen. The contents of the mission is to encourage users to take actions that can easily reduce CO_2. Six missions per day are displayed in three levels of difficulty, and users can get points by practicing the actions presented and achieving the missions. In addition, administrators can set the points, the amount of CO_2 reduction, and the amount of money saved that can be got when a mission is achieved in the administrator screen

Fig. 2. Sanda Zero Carbon Challenge User Screen: Home Screen

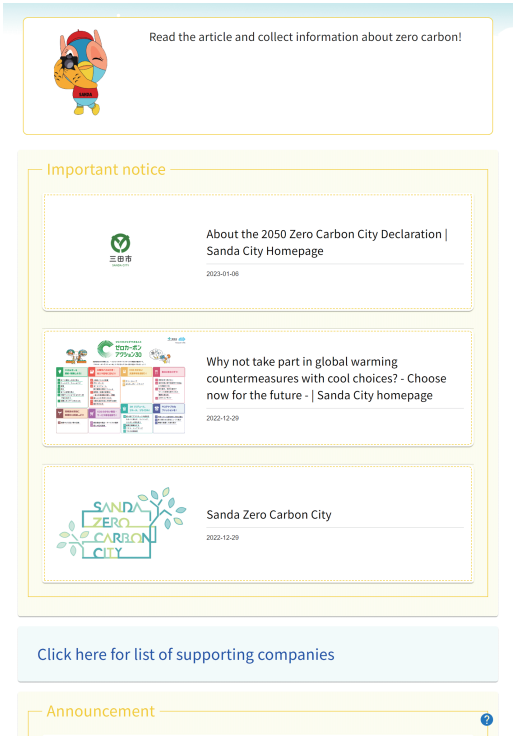

Fig. 3. Sanda Zero Carbon Challenge User Screen: Article Screen

described in Section 4.1, so that users can check them before achieving the mission. In this research, missions are created based on the information on "Zero Carbon Action30" [7] and "Energy saving at home" [8] published by the Japanese Ministry of the Environment and the Ministry of Economy, Trade and Industry, and their effects are defined.

F5: Implementation of Quiz Feature Users can view the quiz screen by pressing the "QUIZ" button on the screen that transitions to the quiz screen by pressing the "Play" button on the top menu bar of the home screen shown in Figure 2. Figure 5 shows the quiz screen. The contents of the quiz is assumed to be questions on zero carbon and environmental issues. Three quizzes per day are displayed in three levels of difficulty, and users can get points by answering them correctly. In this research, quizzes are created based on the information on "Challenge! Global warming quiz" [9] published by the Japanese Ministry of the Environment.

F6: Implementation of Level Feature Users can increase their level by completing missions and answering quizzes correctly. As with the home screen shown in Figure 2, the level is always displayed in the upper right corner of each screen. Below the level is the progress to the next level. In addition, the number of points required to increase the level increases as the level increases. By increasing the level, users can clear the clouds on the map of Sanda City on the map screen.

F7: Implementation of Map Feature Users can view the map screen in the center of the home screen shown in Figure 2 by pressing the "Home" button. The map is created based on the actual map of Sanda City. By pressing the "Back/Advance" button, users

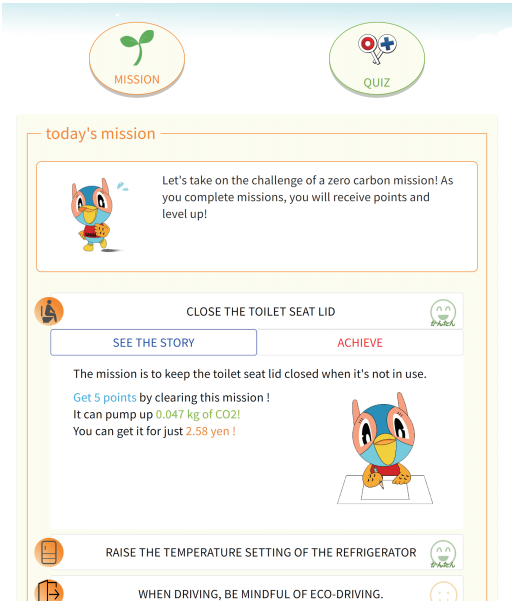

Fig. 4. Sanda Zero Carbon Challenge User Screen: Mission Screen

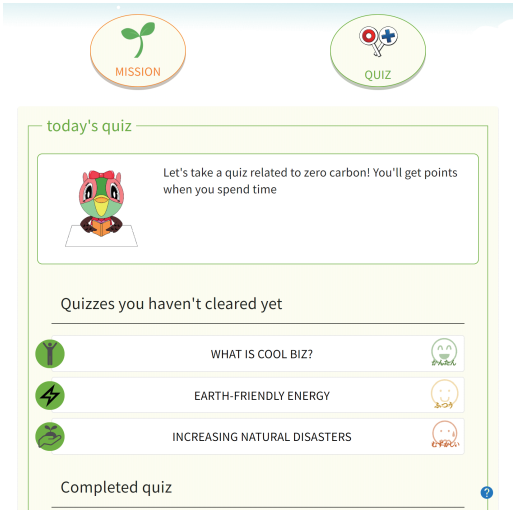

Fig. 5. Sanda Zero Carbon Challenge User Screen: Quiz Screen

can move the position of the character on the screen, and by pressing the magnifying glass button, they can check the famous places at the current position of the character. Figure 6 shows an example of a famous place displayed when the magnifying glass button is pressed. Users can clear the clouds on the map of Sanda City and move to a new location by increasing their level.

F8: Implementation of Visualization Feature of Zero Carbon Initiatives Users can view the look back screen by pressing the "Lookback" button on the top menu bar of the home screen shown in Figure 2. Figure 7 shows the look back screen. Users can check the missions achieved and the graphs of the points, the amount of CO_2 reduction, and the amount of money saved per week. In addition, the total amount of CO_2 reduced by the mission achievement of all users is displayed at the bottom left of the home screen shown in Figure 2. By pressing the corresponding part, the display period can be switched between "whole period" and "this week".

4.2 Demonstration Experiment

The authors conducted two demonstration experiments by exhibiting at the zero carbon event in Sanda City and by local government officials to confirm the operation of Sanda Zero Carbon Challenge in the production environment and to evaluate each feature from the user's perspective. Based on the feedback got through each demonstration experiment, the authors discussed the effectiveness of the application and implemented improvements to the features and additional features.

Experimental Procedure The experiment procedure of the two demonstration experiments described in Section 4.2 is explained below.

First, the participation in the zero carbon event is explained. In this experiment, the authors participated in the Sanda Zero Carbon City Forum held in Sanda City[10] and

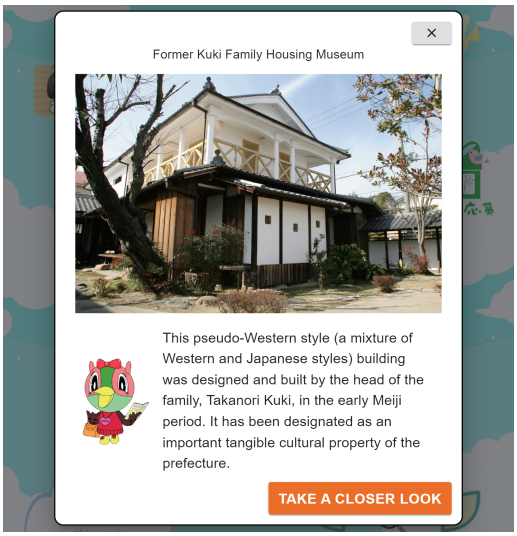

Fig. 6. Sanda Zero Carbon Challenge User Screen: Example of a famous place on the map

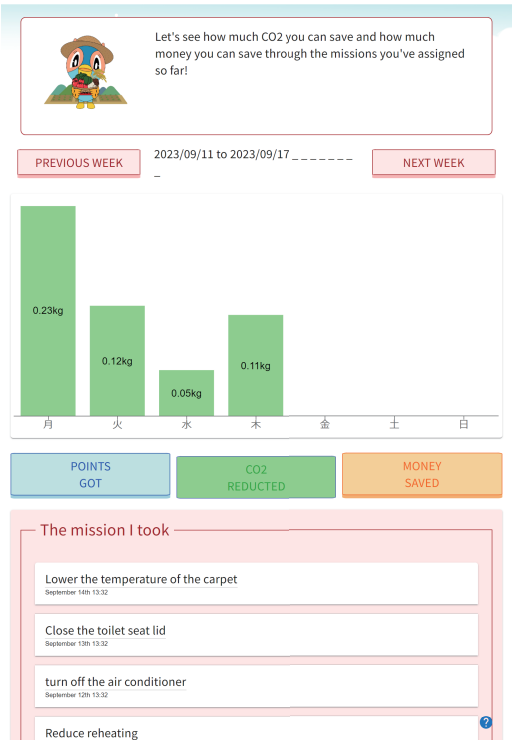

Fig. 7. Sanda Zero Carbon Challenge User Screen: Look back Screen

exhibited Sanda Zero Carbon Challenge. Sanda citizens actually operated the application, tested the operation of the application, and collected feedback from users.

Next, the demonstration experiment by Sanda City officials is explained. The authors conducted two demonstration experiments by local government officials using the application under development. For about two weeks, the authors actually asked the officials to use the application and pointed out improvements.

Experimental Results The results of the demonstration experiment got by the experimental method described in Section 4.2 are explained below.

Table 1 shows the appreciated points and problems of Sanda Zero Carbon Challenge from the feedback got from the demonstration experiment. The points appreciated in the demonstration experiment are the design of the application. It is considered that the design is easy to use and friendly because the main target is elementary school students. In addition, it is considered that the concept and purpose of the application are sufficiently conveyed from the feedback such as “easy to use” and “can learn about environmental issues in a fun way.” Next, the points to be improved are the usability of the application. Table 2 shows the improvements made to each problem based on the feedback.

5 Discussion

5.1 Technical Issues

The application developed in this research has the following technical issues.

First, there is a data collection issue. In this application, users register and log in with any username and password. This is to minimize the information that users have to enter

Table 1. Feedback got from the demonstration experiment

Appreciated points	Problem
It has a friendly design.	Difficult to understand how to create an account and log in.
Easy to use.	Difficulty in noticing level up and map release.
A fun way to learn about environmental issues.	Large amount of missions/quizzes.
Provides an opportunity to talk about environmental issues with the family.	Difficult to understand the controls when playing for the first time.
There was a lot of content of interest to children.	Many Chinese characters, some of which children cannot read.

Table 2. Improvements made to each problem based on the feedback

Problem	Solution
Difficult to understand how to create an account and log in.	Login screen, modification of items required for login.
Difficulty in noticing level up and map release.	Provide direction at level-up and map liberation.
Large amount of missions/quizzes.	Random daily missions/quizzes are displayed.
Difficult to understand the controls when playing for the first time.	Implement a tutorial function to explain how to operate the system.
Many Chinese characters, some of which children cannot read.	Convert complex kanji characters in a text into hiragana.

and reduce the burden on users. On the other hand, this specification narrows the scope of data analysis accumulated in the application. For example, it was initially envisioned that users would be asked to register their age in order to analyze user behavior by age group, although this was no longer possible because age registration was not required in order to lower the barrier to user registration.

Next, there is an operational issue. This application is developed by a team with programming knowledge, and local governments operate it by entering content. Therefore, the development team needs to respond to improvements in features other than content and the implementation of additional features each time, and if they cannot respond, the operation of the application may be delayed. In the case of this research, it is almost impossible to operate for a long time due to the difficulty of handover due to graduation of students, personnel changes in Sanda City, and lack of personnel.

5.2 Comparison with Existing Solutions

The application developed in this research has the following features compared to existing solutions.

First, the difference in the scale of zero carbon initiatives can be mentioned. As existing initiatives for local governments to realize zero carbon cities, the targets are often local governments themselves and companies, and there are many large-scale initiatives such as the establishment of ordinances and policies. There are also many initiatives to encourage citizens to switch to electric vehicles and other things that greatly change their lifestyles[11]. On the other hand, the application developed in this research assumes small-scale initiatives that citizens can easily work on. For example, it is easy to work on in daily life, such as using public transportation and changing the setting temperature of the air conditioner.

Next, the difference in the target of citizens who work to realize zero carbon cities can be mentioned. As mentioned above, the target of the existing initiatives for local governments to realize zero carbon cities is considered to be adults. On the other hand, the application developed in this research mainly targets elementary school students. This is because it is possible to give a chance for family and surrounding adults to work on zero carbon by getting elementary school students interested in it. In fact, this application uses designs and texts that are easy for elementary school students to use.

6 Conclusion

In this research, the authors considered the following problems in local governments aiming to realize zero carbon city. 1. There is no established method for local governments to disseminate zero carbon initiatives to citizens. 2. Citizens do not know how to work on zero carbon, and their activities do not spread. Therefore, in order to solve these problems, the authors proposed a web application development introducing gamification as a proposed method. In addition, by actually implementing the proposed method as a case study in Sanda City, Hyogo Prefecture in Japan, the authors were able to clarify its effectiveness and improvement points by exhibiting at events and conducting demonstration experiments in the city hall.

For future prospects, it is possible to publish Sanda Zero Carbon Challenge to citizens with the cooperation of Sanda City Hall and analyze its effects, and to improve the features.

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References

1. A. Zarba, A. Krzemińska, and J. Łach, "Energy sustainable cities. from eco villages, eco districts towards zero carbon cities," in *E3S Web of Conferences*, vol. 22. EDP Sciences, 2017, p. 00199.
2. A. Nagatani, S. Chen, M. Nakamura, and S. Saiki, "Exploiting motivation subscales for gamification of lifelogging application," *International Journal of Software Innovation (IJSI)*, vol. 10, p. 27, December 2022, dOI: 10.4018/IJSI.313445.
3. L. Chen, G. Msigwa, M. Yang, A. I. Osman, S. Fawzy, D. W. Rooney, and P.-S. Yap, "Strategies to achieve a carbon neutral society: a review," *Environmental Chemistry Letters*, vol. 20, no. 4, pp. 2277–2310, 2022.
4. K. SHIGE and O. N. Yoshiteru SAKAGUCHI, Takashi SAKAMAKI, "Proposal of "local carbon cycle rate" for utilization in small municipalities declaring zerocarbon city," in *Journal of Environmental Information Science, Vol. 35 (2021 Environmental Information Science Research Presentation Conference)*. Center for Environmental Information Science, Tokyo, 2021, pp. 149–154.
5. T. AKASHI, H. OURA, H. OZONO, T. NARIMATSU, R. YAMANA, T. NAKAI, and M. NAKAMURA, "Prototype of a quiz rally platform for motivating local understanding based on gamification," in *IEICE Technical Report*, vol. 121, no. 229. Institute of Electronics, Information and Communication Engineers, November 2021, pp. 31–36, online.
6. T. AKASHI, H. OURA, T. NAKAI, and M. NAKAMURA, "Survey of citizens ' attitudes toward the community and analysis of their behavior using a quiz rally platform," in *IEICE Technical Report*, vol. 121, no. 415. Institute of Electronics, Information and Communication Engineers, February 2022, pp. 41–47, online.
7. "Zero carbon action 30 | cool choice choose now for the future." `https://ondankataisaku.env.go.jp/coolchoice/zc-action30/`, accessed on 14 September 2023.
8. "Agency for natural resources and energy," `https://www.enecho.meti.go.jp/category/saving_and_new/saving/general/howto/index.html`, accessed on 14 September 2023.
9. "Challenge! global warming quiz — cool choice choose now for the future." `https://ondankataisaku.env.go.jp/coolchoice/quiz/`, accessed on 14 September 2023.
10. "Saturday 21 january 2023: The sanda zero carbon city forum was held!" `https://www.city.sanda.lg.jp/soshiki/41/gyomu/kankyo_hozen/energy/21422.html`, accessed on 14 September 2023.
11. Chenmin He, Kejun Jiang, Sha Chen, Weiyi Jiang, Jia Liu, *Zero CO2 emissions for an ultra-large city by 2050: case study for Beijing*, *Current opinion in environmental sustainability*, **36**, 141–155 (2019), Elsevier.

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