

Development of an Android based Game Interfaced with QR Codes for a Gamified Power Management System

MARIANO JESUS M. CAYABYAB JR., MARIA ROSA T. SANTIAGO,
SAMUEL MATTHEW G. DUMLAO, ROSULA S. J. REYES

ECCE Department
Ateneo De Manila University
Quezon City PHILIPPINES

m.cayabyab@obf.ateneo.edu, maria.santiago@obf.ateneo.edu, sdumlao@ateneo.edu, rsjreyes@ateneo.edu

Abstract: - Filipinos are under the threat of an energy shortage. While efforts are being done both in the public and private sectors in developing alternative solutions to ease the shortage, it will take several years before this will come to full implementation. Conservation of energy through power management is the simplest and closest to implement at this time. Filipino households need to be motivated to use smart energy conservation. The introduction of Gamification as a method of motivations has found its use in many applications. In this study the possibility of Gamification to encourage the use of smart energy conservation is tested. In this study three game elements were used to develop the model for the game; these elements include incentives, competition and feedback. These three elements were implemented in an android game through a three step process; namely the Game Design where the theoretical framework of the game was created' Game Implementation where the researchers create the functions for the game using the Java language and Eclipse IDE, and the Game Deployment where the researchers perform a bug test and advertise the project using Social Media and Live Advertising. The use of QR Codes was implemented for the participants to control switching on and off of appliances in the selected rooms.

Key-Words: - Smart Energy Conservation, Gamification, QR Codes, Positive Reinforcement, Game Design, Game Implementation, Game Deployment

1 Introduction

The Philippines is in threat of an incoming energy shortage. [1] Meralco believes that there will be an energy shortage on the summer of 2015. The energy shortage is slowly rising. This is seen in the rotating black outs that areas in the Philippines experience. Smart energy conservation is a solution to the energy shortage threat. The researchers intend to use Gamification as a solution for energy conservation. Gamification is a newly practiced study that involves applying game elements to real life situations. [2] The aim of Gamification is to motivate a group of people to adjust their behaviour on issues that the society is facing. Gamification is a system that applies positive reinforcement to a group of people when they perform tasks that improve the situations Gamification is applied to. Gamification is applied over a set period of time with a variety of tasks to ensure that the tasks turn into habits Effective game elements are applied to these situations such as incentives, competition and feedback. For this study, gamification will be applied to Power Management. Power Management refers to the use of energy conserving tasks to minimize the use of electricity. Positive

reinforcement will be applied to the participants of the study when they do power management tasks.

In this study, a gamified environment in the form of a game was deployed. [3] The general objective of the study for deploying the game is the application of positive reinforcement on students to encourage them to practice smart energy conversation and the development of a platform for future Gamification studies in the department. This was accomplished through three specific objectives. First, the researchers designed a theoretical framework for the game based on Gamification. In this phase, the researchers made decisions on which platform the game was played, how the game was played and what game elements were applied on the game. Second, the researchers created the actual game based on the theoretical framework. In this phase, the researchers coded the functions based on the flow of logic for the game created on the Game Design phase. Finally, the researchers tested the game for bugs then distributed the game to participants after testing. In this phase, the researchers finalized the deployed game through bug testing. Once bug testing was done, the game was distributed to the participants.

The study was done because the researchers observed through statistics that Filipino households do not practice smart energy conservation. [4] Filipinos commonly use electricity on mostly unnecessary activities. The most common use of electricity lights, 79% use it on entertainment and 66% use it on space cooling. Filipino households needed to be encouraged to reduce their energy consumption for unnecessary applications of electricity. Gamification was chosen because it was observed to be an effective means of motivation compared to the standard smart energy conservation campaigns. These campaigns would be simple messages given to a set of households in an attempt to convince them. [5] As shown in Alex Laskey's study, the simple message distribution is not an effective approach. Alex Laskey and his team were only able to successfully encourage households to conserve energy when he encouraged them to compete against each other. The group has decided to use Gamification to solve the problems in motivating people to practice energy conservation.

2 Review of Related Literature

2.1 Power Management

Other researchers attempted to address the power management problem. [6] Roslan Norhayie created an Energy Saving Control System. He created the system because he noticed that students would forget to turn off the lights or aircon when leaving the room. Body heat sensors were placed inside a room. When the sensors do not detect human body heat within the room, the air conditioners and lights will automatically close 10 minutes after the student leaves the room. This study monitors human activity within a room instead of power consumption.

Another study by Han, et. al is a smart home energy system. [7] The system is capable of monitoring the energy consumption of each participating household based on a standard created by the study group called Energy Measurement and Communication Unit. Each participating household has a server that stores data on the energy consumption of each appliance on the household. The data from each household server is then sent to a Remote Energy Management. A website that the group built displays the energy consumption of each participating household and compares them. This is to motivate each household to reduce their energy consumption.

The use of solar systems as energy was studied by Mocanu, et. al. [8] A set of thermoelectric generator was placed in a house to utilize the Seebeck effect. The Seebeck effect refers to the conversion of heat energy to electrical energy thus creating electric heat. The efficiency of and feasibility of solar energy in a house were determined through the study. The technology used by the researchers was observed to be more efficient later on in the future since it was continuously improving and evolving.

The Unified Power Flow Controller or UPFC was studied by Abada, et. al. [9] The UPCF is a system that controls the power flow in transmission systems. The researchers studied the efficiency of this system through a simulation. The system was simulated using Matlab and Simulink. Results showed that the system was effective in controlling real and reactive power through the line. The system was able to follow their references and absence of the system caused insufficient power to be delivered to the load. There were coordination problems encountered in the simulation. Nevertheless, the system was efficient in controlling both active and reactive power flow.

The use of an alternative energy source, wind energy, was studied by Alaya, et. al. [10] They focused on a wind energy conversion system based on the double fed induction generator (DFIG). The researchers observed the behaviour of the system in their study. The system was also optimized through a simulation the researchers performed and their proposed strategies yielded a good performance from the generation system.

Another study applies Gamification on Power Management. [11] A group of researchers from Delft University of Technology in the Netherlands created an online game called Energy Battle. Energy Battle displayed the household's energy consumption, household ranking based on energy consumption and tips on reducing energy consumption. The group provided a prize of kitchen appliances for the household that ranks 1 at the end of four weeks. At the end of the study, the households were able to maintain their reduced energy consumption. It was even observed that the energy saving tips became habits.

A mobile application called Joulebug applies Gamification on power management. [12] Joulebug displays a list of tasks that the user can do to reduce energy consumption. Once of these tasks is done,

the user completes an achievement that he or she can take a picture of and share with friends. The user earns points by completing these tasks and the points are ranked according to who has the highest. The ranked users include only the user and his or her friends.

2.2 Adjusting Behavior

A popular behavior adjustment method in the field of psychology is operant conditioning. [13]B.F Skinner developed the operant conditioning model to modify behavior based on consequences to that behavior. The results in studies showed that behavior that is followed by pleasant consequences tends to be repeated while behavior that is followed by unpleasant consequences tends to not be repeated. A variation of operant conditioning is positive reinforcement. The positive reinforcement model when applied to a subject is to provide that subject with rewards when emitting a desired behavior. This makes the desired behavior occur more often. Another variation is punishment which applies negative stimuli to subjects who emit undesired behavior.

3 Game Design

During this phase of the study, the group created a theoretical framework of the game based on Gamification. Gamification bridges the gaming world and the real world. Its aim is to adjust behavior by applying game elements in the form of either positive reinforcement or punishment. Known game elements are incentives, competition and feedback. Incentives refer to rewards given to the player after accomplishing certain tasks. Competition occurs when players are ranked against each other and encouraged to compete for higher ranks. Feedback is a method of showing the player his or her performance in the game. The three game elements are applied to real world situations to motivate people.

The researchers created guide questions as a basis for decisions on the theoretical framework of the game. The questions are as follows:

- Where will the game be played?
- How will the game be played?
- What are the incentives?
- How will competition be applied?

First is to decide on what device the game can be played on. It starts with if the game will be played on a computer or mobile device then from there the group will need to decide on which platform the game would run on. The next concern would be the gameplay. The game needs to attract the users and avoid the users from losing interest on the game. Included in the gameplay is the formation of the tasks. The tasks need to be instructed to the participants and participants must be rewarded. The researchers need to take notice of the application of the incentives. The researchers need to decide on incentives that will attract users and motivate them. The researchers would then need to apply a system that implements competition on the game. The incentives will act as the feedback for the game.

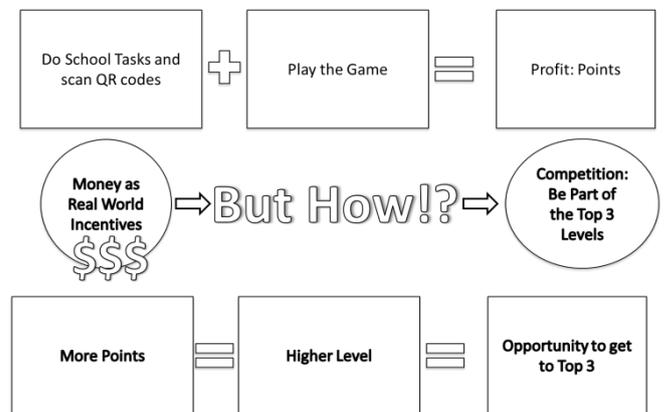


Fig. 1: Game Elements Diagram



Fig. 2: QR Code

Fig. 1 shows the intended application of game elements on the study. The game will be played on a mobile application since mobile devices

can be brought by users where ever they go. The chosen mobile platform is Android since it is the most popular mobile platform. [14] 61.2% of mobile users were reported to have installed android last June 2013. The researchers are going to use two forms of incentives, one for the game and one for the real world. The game incentives are points that the user earns by playing the game or doing the school tasks. These points are classified according to experience, energy, achievement and special. Experience points are converted into a level system where users level up after earning a certain amount of points to give users more goals in the game. Experience points were set as the basis for the user ranking. Energy points are used as a currency within the game. Achievement and Special points are used for prize exchange. QR Codes are implemented for users to scan when they finish the tasks. Fig. 2 shows the QR Code design that was created by the group. Once all QR Codes have been scanned, the users can claim their rewards and repeat the process on the same class on a different day. The QR Code is a means to receive bonuses and is not required to play the game. It is advised that players scan it to get more points than their competitors but the game can stand alone even without the QR Codes. The real world incentive is monetary rewards which the user earns by being part of the top 3 levels. This applies both competition and incentives by using the incentives to spark the competition. Users must compete for the money by gathering more experience points than their competitors.

losing their attention from the game is the application of a decay system for planted crops. The punishment model is applied to users to encourage users to keep their eyes on the game. Another is the profit in the game where harvesting short time crops multiple times tends to give more profit than harvesting a long time crop. The positive reinforcement model is applied to Farmville users here. For this game, the users will be building structures that generate resources. An online database and phone database need to be created to store information. The online database will store the points so users can view it online while the phone database will store game resources for easy access.

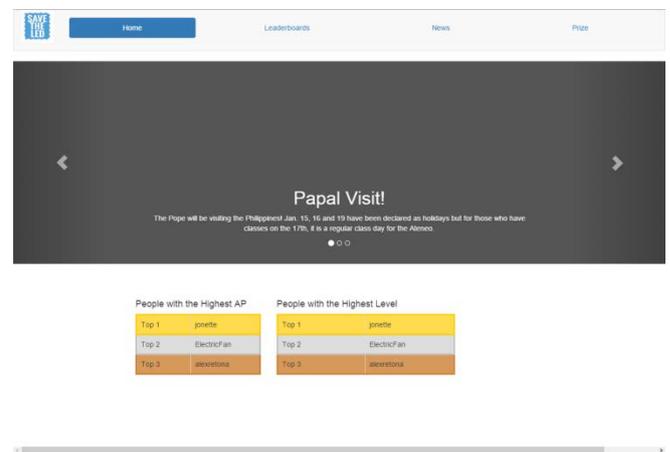


Fig. 4: Website Homepage

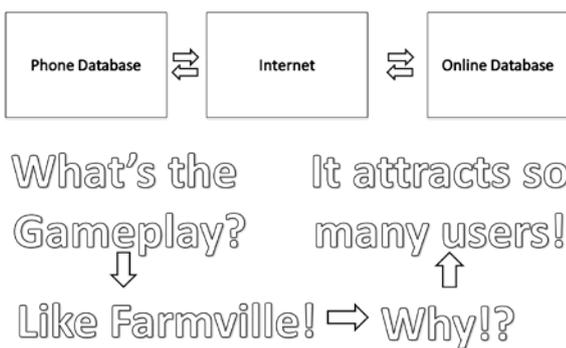


Fig. 3: Gameplay Diagram

Fig. 3 shows the decision on the main game's gameplay. [15] The researchers found that the Facebook game Farmville is very popular, pulling in millions of users daily. Techniques from Farmville were taken note of and applied to the game plan. A technique used by Farmville to keep users from



Fig. 5: Leaderboards page

The website plans are shown on Figs. 4 and 5. The homepage must show the top 3 users in both levels and achievement points and display the three recently uploaded news articles. The leaderboards needs to have 2 tables that sort users according to level and achievement points.

The designed framework was based on the three game elements observed from previous studies. Incentives were provided in the form of game points and real world money. Competition was encouraged through the leaderboards and the prizes. The users were pushed to keep their attention on earning points on the game and made the tasks very important factors for victory. The users must keep on trying to get ahead of the other user to win the prizes. The third is the feedback which is given to the users based on the number of points they earn and their standing on the leaderboards. The researchers decided on the target audience as students in 3rd floor Faura classes. The next step for the group is to implement the game based on the framework.

4 Game Implementation

In this phase, the group built the game based on the theoretical framework. Games are either built from scratch or with programs that assist the developer in creating games. Games are usually built by a huge game development team. The development team is then divided into smaller teams depending on their task for the game. There is a team that is responsible for creating the art in game, a team for programming the game and a bug testing team. Due to their large numbers and experience, the development team is capable of producing games with amazing art and gameplay. Different versions of the game are also created so that the game can be played on different devices. Mobile games are developed faster than games on high end consoles. Mobile games tend to have simpler functions and are easier to build.

The researchers used Eclipse IDE and Java platform to develop the android mobile application, SavetheLED. The whole game system shown on Fig. 6 was coded using Java. Several functions were developed and reused across the class files. The Game User Interface and Background was created by manipulating the properties of shapes in Microsoft Powerpoint. The buildings, research and resource icons were created using a combination of the free icons Google released, Adobe Photoshop and Microsoft Powerpoint.

HTML, CSS, Javascript and PHP were used to design the website. The bootstrap css was used to make the website more attractive. The navigation bar, carousel and tables were all programmed with the help of bootstrap. The PHP files are used for the website and mobile application to interact with the

online database. The data obtained from the database is converted to JSON Format. The data in JSON Format was accessed through the javascript functions and converted to standard text. The HTML file was prepared to display the text obtained from the javascript functions. A free webhosting site called 000webhost was used to store all the website files and database.

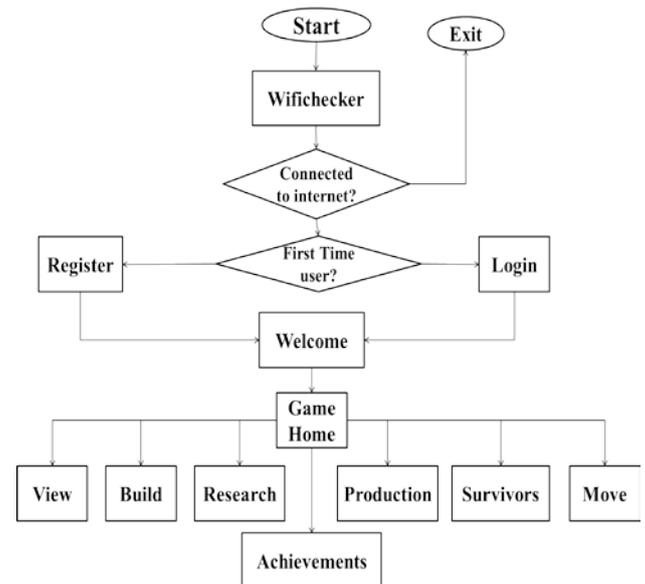


Fig. 6. Game Flowchart



Fig. 7: Registration Pop-up Window



Fig. 8: Login Pop-up Window

Fig. 7 shows the first pop-up window for users who do not have an account registered to their android device yet. This is the registration pop-up window that users must fill up to create an account on both the phone and the online database. If the user already has an account on their device, then users are directed to the login pop-up window shown on Fig. 8. Users must fill up the correct username and password of the account registered with their device otherwise it will reject them. Newly registered users were given starting resources. All users who log-in will encounter the welcome pop-up window shown on Fig. 10. Clicking the Bonus Claim Button will check if the user has both done the daily quest and claimed the daily free reward. This information is obtained from the online database. The free daily reward is based on a random number system that randomly selects a reward package from a set defined by the developers. The quest reward is a set amount of points given to the user provided that the quest was done. Once the users are done with the daily rewards, users can press the dismiss button to remove the pop-up window and enter the game home screen shown on Fig. 11. Areas on the game home screen can be selected by tapping the area.

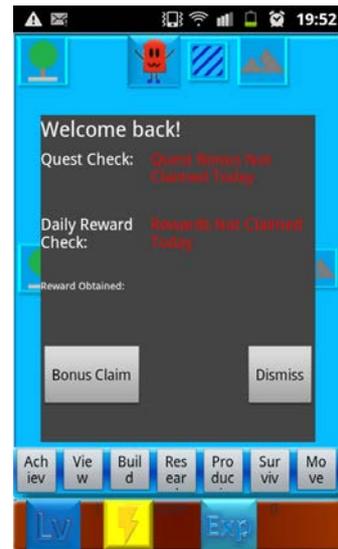


Fig. 10: Welcome Pop-up Window



Fig. 11: Game Home Screen



Fig. 12: Build Pop-up Window

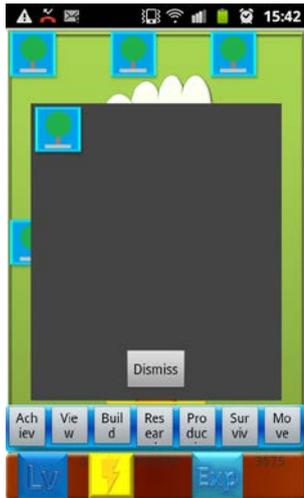


Fig. 13: View Pop-up Window

The researchers placed goals inside the game for users. These goals are the source of the in game incentives for the users. The main goal of the game is to continue building structures in the available areas in a map. Structures are built through the build pop-up window shown on Fig. 12. The users have a wide selection of structures. It is up to them on what structures they want to build. Users are encouraged to plan out the structures they build in order to be ahead of the other users. There is a limit on how many structures can be built in on area. There are also structures that require the presence of a natural structure for it to be built. Users are given a preview of the natural structures and the player-made structures on the screen. To display all the structures on the selected area, the user can tap the View Button on the menu bar. The view pop-up window is shown on Fig. 13.

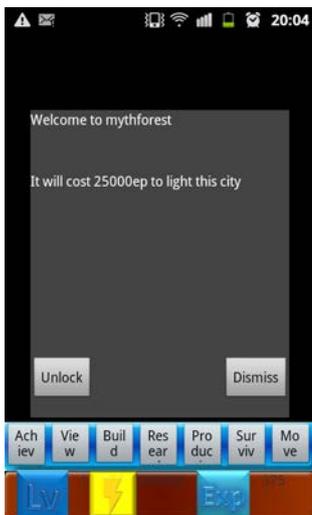


Fig. 14: Locked Map



Fig. 15: Unlocked Map

Users can then go to other maps in the game but before they can use the map they must first unlock it. A screenshot of a locked map is shown on Fig. 14. A pop-up window will display the requirements for unlocking the map. Once unlocked, users are given bonuses in points and research. An example of an unlocked map is shown on Fig. 15. The unlocked map will give the users more areas to build structures on. The points needed to unlock a map are based on the impact of the map on the user's points. Some maps have a huge number of slots and a good number of natural structures that would greatly benefit the user.



Fig. 16: Production Pop-up Window



Fig. 17: Research Pop-up Window

A requirement for building structures is the resources provided by the researchers as the in game incentives. Resources are obtained through the production pop-up window shown on Fig. 16. The production pop-up window computes the amount of resources and energy points you receive every 12 hours through the number of buildings you have. It also displays the current number of resources that the user has. The user can select a claim time for their resources. Users are given more resources if they claim the reward repeatedly at less time compared to a 12 hour claim. The production rate is boosted by the user's research levels. This is shown on the research pop-up window on Fig. 17. Research levels are obtained based on the educated survivors resource, research laboratory structure and the bonuses from unlocked maps.



Fig. 18 Power Management Tips

Educated survivors are displayed on the survivors pop-up window shown on Fig. 18. The user can educate uneducated survivors obtained from production and rewards. Users can also convert their Iron Ore to Steel. These resources are needed for certain structures to be built. The Iron Ore to Steel conversion is based on the conversion package selected by the user and the Forgery research. The researchers placed power management tips into the game. Whenever users use the Educate function, they are given necessary resources and a power management tip. An example of the power management tip is shown on Fig. 18. The users can also learn from the game.

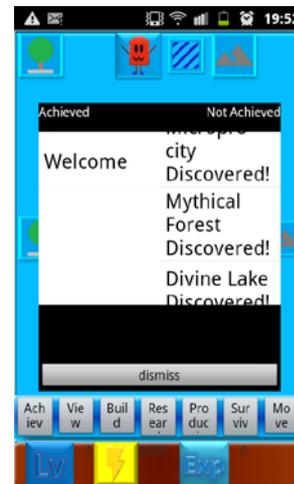


Fig. 19: Achievements Pop-up Window

Achievements were placed to give the user more goals and means of obtaining points. The achievements pop-up window is shown on Fig. 19. Users can check the achievements they've accomplished and the ones they haven't accomplished. The requirements for accomplishing the achievements are shown on the bottom of the pop-up window.

The game also has a special QR Code Scanner that the user needs to use to scan the QR Codes. The special QR Code scanner is accessed through the move pop-up window. Once the QR Codes have been scanned, the user can claim his Quest Rewards in the form of points. The QR Code scanner was created using the Zxing library.

The website is shown on Figs 5 and 6. All of the pages have a navigation bar that has links to the other pages and the logo. The homepage contains the top 3 users according to level and achievement points. Three of the recent news is also shown in a carousel. The leaderboards contain two tables where

the left table has a list of users ranked according to level while the right table has a list of users ranked according to achievement points. The news page contains a list of all the uploaded articles that the users can view by pressing buttons. The prizes page shows the available images of prizes and how to get them. The final step for the group is the Game Deployment phase.

5 Game Deployment

The final part of game development is releasing the game. The method of release depends on the operating system or device the game is meant for. Mobile applications are usually distributed through the android market or google playstore. They can be distributed privately through e-mail or dropbox. Before release, the development team deploys the game to a certain number of people who were hired bug testers or volunteered to be bug testers. They will play the game for a set period of time and the bug tests will report on any bugs found. The game is also tested on phones of different resolutions and android os versions to make sure that the game runs on the all sdk versions from minimum to target. When the game is cleared of bugs, the development team or gaming company launches an advertisement campaign on the game's first release.

Each of the game functions were tested for bugs. The wifi checker was the first to be tested. Each of the functions was run with the wifi adapter disabled. Afterwards, the login and registration functions were checked. Registration was tested by entering an existing and a non-existing username. The login was tested by entering the username and password of a different account and the username and password of the registered account on the phone.

The next function that the researchers tested was the claim rewards function. A tested scenario was before and after the daily reward was claimed. Another scenario was before and after the QR codes were scanned. Using the high starting energy points, all the maps were unlocked and checked if the unlock pop-up windows and map initialize functions work.

The researchers set the resources to high values for the series of tests that followed. The build function was checked by building all of the available buildings with and without the proper resources. The research function is tested by simply opening the pop-up window and checking if the right values based on the applied algorithm are

correct. Production was checked if the production rate algorithm worked properly and synchronized well with the claim time set by the user. The achievements pop-up was checked by looking at the details that pop out when pressing each of the achievements. Achievements were also checked if they were accomplished after fulfilling the requirements. Finally, the move function was checked if each of buttons led to the right maps.



Fig. 20. Game Poster

Once the bug testing was accomplished, the researchers looked for participants who have android phones and distributed the application to them privately. The poster in Fig. 20 was used as an advertisement. The application was placed inside dropbox and the link sent to the participants through e-mail. The e-mail came with a link to the application, facebook page for the instructions and the website link for the leaderboards. The researchers advertised the game by visiting classes. The participants were given links to a feedback form that asked if the objectives were fulfilled and to comment on the game.

Preliminary bug testing was successful. The researchers checked the feedback for the gathered data. The data the researchers had so far suggested that the incentives were effective in motivating the students to play the game. A platform for Gamification studies was developed.

6 Results and Analysis

The game possessed several features that focused on gathering and motivating users. The application

was built for the popular mobile platform, android. The minimum sdk for the game was set for low versions while the target sdk was set for the latest. A wide range of android users were accepted by the application. The user had several goals in the game that rewarded them with points. Users are given free rewards daily. There are non-free rewards earned by building structures, accomplishing achievements and doing quests. Users were also given a boost in the points they earn within the testing period. Users were informed of monetary rewards that they would earn if they reach the top 3. The ranking system was implemented to encourage users to get ahead of their competitors. The game can also interact with an online database.

7 Acknowledgements

We would like to thank the panelists, Mr. Daniel Lagazo, Dr. Erees Macabebe and Engr. Maria Leonora Guico for their comments and suggestions that helped improve the study. We would like to thank Ms. Monica Mae Sacramento for lending us her graphic design skills in the Poster and QR Code Design. To the B.S. Computer Engineering and B.S. Electronics and Communications Engineering students who participated in playing the game, our gratitude for your help in the testing of the game. And to the faculty and staff of the Department of Electronics, Computer and Communications Engineering our heartfelt thanks for all the technical support they have provided towards the development of this study.

8 Conclusion and Recommendation

Based on the gathered data the researchers have, the researchers were able to successfully motivate participants to play the game using the incentives they have provided. The researchers were able to develop a platform for future gamification researchers to use for their study. The game is able to incorporate power management by providing tips and tasks. Future researchers need to develop a thorough design plan for the game before proceeding. It is also recommended that future researchers have a longer test period for longer period of data collection. The researchers would like to suggest that future researchers launch a closed beta phase of their application. Closed beta phase is a pre-deployment phase done by game companies where they ask players to participate in bug testing in exchange for game rewards. The study could also be interfaced with other energy conservation

systems such as the solar energy system by Mocanu, et. al, the wind energy system studied by Alaya, et. al. and the UPCF system studied by Abada et. al. Suggested interface of these systems into the project is using as special tasks that will grant them points upon implementation of the systems into their households.

References:

- [1] "Summer of 2015: Expect brownouts | ABS-CBN News." [Online]. Available: <http://www.abs-cbnnews.com/focus/07/21/14/summer-2015-expect-brownouts>. [Accessed: 19-Aug-2014].
- [2] "On Gamification | Doodle Alley." [Online]. Available: <http://doodlealley.com/2013/11/04/on-gamification/>. [Accessed: 19-Aug-2014].
- [3] M.J. Cayabyab, M.R. Santiago, S.M. Dumlaio, R.Reyes. "Designing a Gamified System using QR Codes via an Android Application for Power Management", Proceedings, WSEAS 9th International Conference on Circuits, Systems, Signals and Telecommunications (CSST '15), Dubai, United Arab Emirates, February 22-24, 2015.
- [4] "Electricity is the most common source of energy used by households | National Statistics Office." [Online]. Available: <http://www.census.gov.ph/content/electricity-most-common-source-energy-used-households>. [Accessed: 19-Aug-2014].
- [5] T. Ha, "The psychology of saving energy: Alex Laskey at TED2013." [Online]. Available: <http://blog.ted.com/2013/02/27/the-psychology-of-saving-energy-alex-laskey-at-ted2013/>. [Accessed: 19-Aug-2014].
- [6] N. Roslan, "Energy Saving Control System Application in Lecture Hall," Universiti Malaysia Pahang, 2008.
- [7] C.B. Mocanu, et. al. "Modeling a Thermo - Electrical Concentrating Solar System for Heat and Electricity of a House." INTERNATIONAL JOURNAL OF ENERGY 6, no. 3 (2012): 97-104. Accessed March 31, 2015. <http://naun.org/main/NAUN/energy/16-269.pdf>.
- [8] DIB Djalel, A. Rezaiguia, Z. Abada. "Improving the Electric Power Quality by UPFC Systems in Electrical Networks." INTERNATIONAL JOURNAL OF ENERGY 6, no. 4 (2012): 115-22. Accessed March 31, 2015.

<http://www.naun.org/main/NAUN/energy/16-058.pdf>.

- [9] "Steady-State Analysis of DFIG for Wind Power Generation System Drive." INTERNATIONAL JOURNAL OF ENERGY 6, no. 4 (2012): 123-32. Accessed March 31, 2015.
<http://www.naun.org/main/NAUN/energy/16-064.pdf>.
- [10] J. Han et. al, "Smart Home Energy Management System, Including Renewable Energy Based on Zigbee and PLC," in IEEE International Transactions on Consumer Electronics, Vol. 60, No. 2, May 2014.
- [11] "Green Gamification: Could the Green Button Be the Killer App for Consumer Energy? | Industry Market Trends." [Online]. Available: <http://news.thomasnet.com/IMT/2012/04/10/update-on-green-gamification-could-the-green-button-be-the-killer-app-for-consumer-energy/>. [Accessed: 19-Aug-2014].
- [12] "About - JouleBug." [Online]. Available: <http://joulebug.com/about/>. [Accessed: 19-Aug-2014].
- [13] "Operant Conditioning | Education.com." [Online]. Available: <http://www.education.com/reference/article/operant-conditioning/>. [Accessed: 22-Jan-2015].
- [14] "Platform numbers for June 2013: Android 4.x on the rise, 2.3 holding strong | Android Central." [Online]. Available: <http://www.androidcentral.com/platform-numbers-june-2013-android-4x-rise-23-holding-strong>. [Accessed: 22-Jan-2015].
- [15] "Gamification Examples | PlayGen." [Online]. Available: <http://playgen.com/gamification-case-studies-and-examples/>. [Accessed: 22-Jan-2015].