UX Assessment of Mobile Recommender App for Household Electrical Energy Savings

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***Abstract*—In recent times, the use of mobile devices has drastically increased as a result of how feasible it is in utilizing them in solving everyday problems using several applications. One of the recurrent issues in everyday life is electricity consumption and the need for energy savings. This is an enormous issue and challenge faced by the Iraqi's Ministry of Power. Most households in Iraq lack access to information regarding electric energy consumption and the need to save and conserve energy. In addition, there is also a dearth of suitable applications that educate households about energy saving. In the light of this, this study assessed the user experience of a developed mobile recommender application for Iraqis that helps them understand the need for reduction in electricity consumption based meter readings/data supplied by users. This proposed mobile recommender app was assessed by 50 households from the point of view of ease of use, usefulness, ease of learning, and satisfaction. The study's outcome reveals that majority of the participants found that the app was easy to use, useful, easy to learn, and was satisfied with its features and functionalities. The results of the study offer some useful insights and import about the use of mobile recommender app for promoting household's energy consumption management in Iraq and also prompts a good energy savings culture and behaviour among the people.**

***Index Terms*—Electricity Usage; Energy Savings; Recommender App; User Experience.**

I. INTRODUCTION

The needs for ease of access to user services in other to help people manage events in their day to day life have led to consideration of the use of mobile applications. The shift from the computer-mediated environment to the mobile-mediated environment has led to a strong emphasis on the nature of services that support individual needs, especially on the mobile platform [1]. Included is the interest on the association between service and environmental side effects in the context of electricity saving. Prior studies show that insufficient consideration is given to the utilization of mobile apps in the promotion of knowledge building among people in the area of electric energy savings especially in developing countries that are continuously facing power consumption problems [2]. These include the uncontrolled/wasteful use of electric energy on daily basis, which often results in an increase in household electric energy utilization [3]. In Iraq for instance, the current policy focus emphasizes the needs for households to reduce their electric energy consumption rate in other to ameliorate the challenges of power shortages and outages in some parts of the country. To this end, a number of policy measures have been enacted and are been implemented to improve electric energy savings at the household level nationwide.

This study seeks to assess the user experience of a developed mobile recommender application for Iraqis. The app was developed to boost the public's awareness of electric energy consumption culture and power savings behaviour.

II. BACKGROUND

Studies show the need for enlightening the public on the management of power consummation and the proper behavioural culture in energy savings. Nevertheless, many of these researchers largely attempted at explaining households' electric energy consumption behaviour without providing useful solutions for overcoming such behaviour [4, 5, 6]. Furthermore, these studies also stress the need of offering some feedbacks to households in order to curtail their power consumption rates in certain events. This consists of the computation of current energy usage with corresponding standard levels [7].

In addition, the utilization of mobile application can assist in providing the needed elements for providing true context awareness. This can be achieved by ensuring the reliability of information in the presence of uncertain, rapidly changing, and partially true data that is based on the current usage of electricity [8]. The reason behind using mobile apps can be due to its widespread use among people. These apps provide a low-cost solution that can facilitate new social structures.

Furthermore, the task of spreading knowledge among people can be a challenging endeavour and requires solid instruments and services in conveying messages [9]. This notwithstanding, mobile apps can provide telephone, the Internet, and data storage that can significantly reduce dependence on fixed locations, and as a result, can help revolutionize the way people work and learn [10]. A mobile connected society, nevertheless, creates a new training delivery challenges. People are usually more aware of mobile usage in managing and settling their work needs on daily basis and that can be delivered and supported whenever needed [11].

The non-availability of mobile recommender applications for recommending electricity savings among the public especially in Iraqi is the main motivation of this study. The development and availability of mobile recommender apps provide strategic responses to the opportunities and demands of mobile users in homes, workplaces, and for learning, and thus, fosters a potential future trend for mobile usage and about knowledge sharing and building. Mobile recommender application helps in the dissemination of information and educates the general citizenry on energy saving through the provision of recommendations to reduce as well as maintain proper electricity usage culture. In building such applications,

a formative usability and a general assessment of users experience are very important. Consequently, this study aims at assessing the user experience [19-24] of a mobile recommender application that was developed for educating Iraqis on the need and culture of electricity savings to help ensure less energy consumption and proper energy savings.

III. METHODS

This study focuses on a mobile app that helps and guides Iraqi households' on electric energy consumption estimation based on their meter readings and usage recommendations. Two stages were followed in this section. The first is the design and development of the proposed mobile recommender application using the Rapid Application Development (RAD) model as proposed by Martin [12]. The second stage is the evaluation of the proposed application using usability questionnaire adapted from Lund [13]. This stage mainly concerns the estimation of users' usage experience through the measurement of their perception about the ease of use, usefulness, ease of learning, and satisfaction of the app developed. A 7-likert scale was used to answer the items under each construct.

A. Stage One

This study uses a simple and straightforward method for developing the mobile recommender application. First, a review of the literature was done to understand households' electricity consumption behaviour and habits. Then, the requirements of mobile recommender application were identified for electricity consumption by understanding the functional and non-functional requirements to be prepared, elicited and set in accordance to the needs of the household in Iraq.

In this stage, RAD was used to help in the designing and developing of the proposed mobile recommender application. It involves a process outlined in Figure 1. The RAD model consists of phases of requirements planning, system design phase, the phase of system development, and implementation.

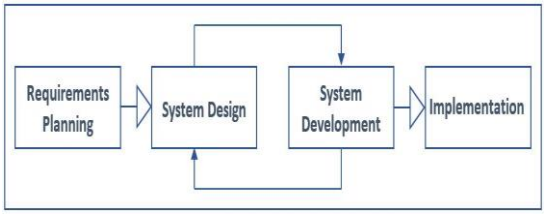

Figure 1: RAD model

B. Requirements Planning

The first phase of RAD model consists of identifying the design requirements of the proposed mobile recommender application. Here, these requirements were identified in terms of the consumption values along with the Tariff obtained from the ministry of power in Iraq (see Table 1).

Table 1
Power Consumption and Tariff

Consumption	Tariff
0001 – 1000	10
1001 – 1500	20
1501 – 2000	40
2001 – 3000	80
3001 – 4000	120
4001 -	200

Furthermore, the calculation parameter of power consumption based on the reviewed literature was developed. This was done by linking the consumption of households with the available devices and time of usage. Meanwhile, the land square meter was used to estimate the consumption for certain areas. The meter-based calculation was estimated as follows:

$$Consumption\ (kWh) = current\ reading - last\ reading$$

$$Cost\ (IQD) = Consumption\ \times Tariff$$

$$Annual\ consumption\ (kWh/y/m^2) = \left(\left(\left[\frac{current\ reading - last\ reading}{current\ reading\ date - last\ reading\ date}\right] \times 365\right) \div used\ space\right)$$

More so, the appliance-based calculation (kWh) was estimated based on the device consumption in hours per day as follows:

$$(rated\ power\ (w) \times uptime\ per\ day\ (hours) \times number\ of\ devices \times 30) \div 1000$$

Also, the appliance-based calculation (kWh) was estimated based on the device consumption in minutes per day.

$$((rated\ power\ (w) \div 60) \times uptime\ per\ day\ (hours) \times number\ of\ devices \times 30) \div 1000$$

Based on these calculations, the electric power consumption recommendation to households was provided.

C. System Design

Figure 2 illustrates the functionalities provided by the proposed mobile recommender application to the users (households). From the figure, it can be seen that users can register and login to the system in order to view the energy usage recommendations. They are required to supply some information related to the current energy consumption along with the square meter of the land.

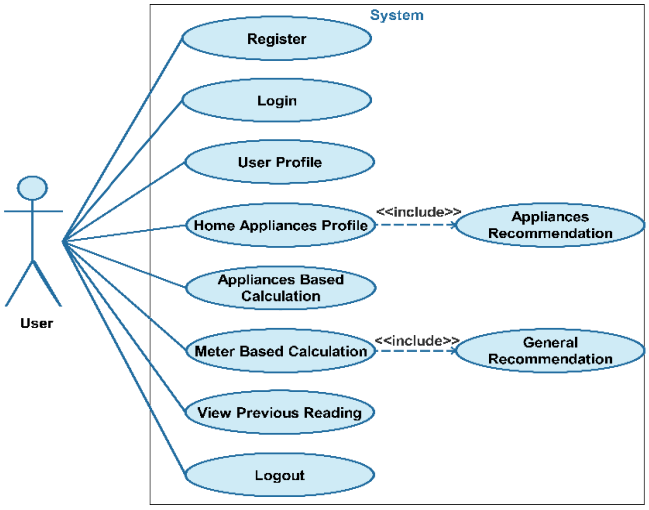

Figure 2: Use case of the proposed mobile application

D. System Development

The development phase consists of the use of programming languages to design and develop the functionalities (see Figure 2) of the proposed mobile recommender application in Android platform. Java language (Eclipse) was used to develop the proposed mobile app while SQLite was used to

build and construct the databases. The development was carried out in Eclipse environment using an Integrated Development Environment (IDE) for the purpose of the development as recommended by Murphy, Kersten, and Findlater [14]. Numerous documents were incorporated to help connect the design of an interface with an action.

E. Implementation

The implementation of the proposed mobile recommender application was facilitated by uploading the application package to a free hosting platform so that users can download and install it easily and affordably. The installation process was similar to that of other mobile applications where users have to provide their personal information to register them in the system.

F. Stage Two

In stage two, a quantitative method based on the use of questionnaire was utilized to assess the usability and user experience of the proposed mobile recommender application. A close-ended questionnaire was distributed to households in Baghdad, Iraq. The reason for this purposive selection of Baghdad is because of the convenience it offers in finding the needed people to participate the study in the city and because as a metropolitan city, Baghdad has the users that have all the characteristics needed for the study of this kind. Fifty (50) participants were selected for the study to elicit and capture their user experience with the mobile recommender application. The questionnaire used in the study was adapted from Lund [13] and contains 30 items. The questionnaire is specially designed to measure the main aspects of households' perception about the application's ease of use (11 items), usefulness (8), ease of learning (4), and satisfaction (7).

IV. Results and Discussion

From the result presented, it can be seen that most of the study participants strongly agreed to use of the proposed mobile recommender app in the management of their electric energy consumption. For instance, most of the participants found the application to be useful (mean=6.64 and Std=0.56) and are effective in successfully recommending energy savings (mean=6.66 and Std=0.55). Furthermore, the result also revealed that participants found that the application meets their needs and fulfils their expectation (mean=6.42 and Std=0.70) and enables them to gain more control over their daily activities (mean=6.20 and Std=0.70). In addition, the participants considered the use of the mobile recommender application to be easy in terms of helping them to use its functionalities/features successfully each time they use them (mean=6.66 and Std=0.55). No inconsistencies were noticed by the participants when using the proposed mobile recommender application (mean=6.60 and Std=0.53). The study participants thus perceived that the proposed mobile application was easy to use (mean=6.56 and Std=0.64) and flexible (mean=6.56 and Std=57). Further still, the users affirmed that the proposed mobile recommender application was easy to learn (most of the participants perceived that they were able to learn it quickly) (mean=6.64 and Std=0.52) and use easily (mean=6.62 and Std=0.53). Lastly, the majority of the study participants perceived that the proposed mobile recommender application was able to meet their satisfaction (mean=6.64 and Std=0.52). They also confirmed that the proposed mobile application was wonderful to use (mean=6.48 and Std=0.67) and works the way they expected it to work (mean=6.43 and Std=0.60).

In addition, the reliability result of all items yields an acceptable Cronbach's Alpha coefficient of 0.8 (for 30 items). Values that are above 0.7 are accepted as good reliability estimates and indicators of good internal consistency of the study instrument. The reliability value for each construct is presented in Table 2 along with the descriptive statistic results for each item

Table 2
Descriptive Statistic Results

Constructs/Items	Mean	Std. Deviation	Crombach's Alpha
USEFULNESS			
It helps me be more effective.	6.66	0.557	0.82
It helps me be more productive.	6.02	0.82	
It is useful.	6.64	0.563	
It gives me more control over the activities in my life.	6.2	0.7	
It makes the things I want to accomplish easier to get done.	6	0.728	
It saves me time when I use it.	6.18	0.72	
It meets my needs.	6.42	0.702	
It does everything I would expect it to do.	6.1	0.863	
EASE OF USE			
It is easy to use.	6.56	0.644	0.78
It is simple to use.	6.44	0.705	
It is user-friendly.	6.34	0.717	
It requires the fewest steps possible to accomplish what I want to do with it.	6.38	0.697	
It is flexible.	6.5	0.647	
Using it is effortless.	6.56	0.577	
I can use it without written instructions.	6.48	0.707	
I don't notice any inconsistencies as I use it.	6.6	0.535	
Both occasional and regular users would like it.	6.2	0.756	
I can recover from mistakes quickly and easily.	6.46	0.676	
I can use it successfully every time.	6.66	0.557	
EASE OF LEARNING			
I learned to use it quickly.	6.64	0.525	0.74
I easily remember how to use it.	6.56	0.541	
It is easy to learn to use it.	6.62	0.53	
I quickly became skilful with it.	6.04	0.781	
SATISFACTION			
I am satisfied with it.	6.64	0.525	0.86
I would recommend it to a friend.	6.22	0.864	
It is fun to use.	5.86	0.926	
It works the way I want it to work	6.42	0.609	
It is wonderful.	6.48	0.677	
I feel I need to have it.	6.14	0.969	
It is pleasant to use.	5.88	0.895	

In this study, a mobile recommender application was designed, developed and evaluated. The application manages and educates Iraqi households on electric power consumption and enables energy savings. The study identifies the current issues and challenges in electric energy consumption among Iraqis. It also helps to foster the need for increased public awareness of electricity energy savings and proper consumer behaviour. The proposed mobile recommender application was assessed by fifty (50) households purposively selected

from different regions in Baghdad, Iraq. The result showed that the proposed application was perceived by users to be easy to use, useful, easy to learn, and as promoting household satisfaction when used in managing electric energy consumptions. The study offers new insights on the potentials of mobile applications in assisting people in their daily lives. It also opens the doors of opportunities for new research in considering mobile computing for regulating power consumption, cutting energy cost and promoting electric energy savings. The study's findings support previous views on the potentials of mobile devices in aiding learning on power/ energy usage behaviour. For instance, it enriches and supports the prior work of Kjeldskov, Skov, Paay, and Pathmanathan [15] who recommended the use of interactive applications for increasing awareness of electricity consumption in people's home and how this may be influenced by design. The study also extends the work of Jacucci et al. [16] who addressed the needs of pervasive household sensoring and feed-backing system to improve the energy conservation practices of the inhabitants. This study further supports the work of Froehlich et al. [17] on how mobile phone application can be used to sense and reveal information about power consumption behaviour through the use of information about active devices and usage period. However, some limitations were observed in the study, for example, the application was limited to certain devices and energy consumption levels. Also, the study was limited to certain group of users who had Android OS.

V. Conclusion, Future Works and Implications

Mobile utilization has rapidly increased as a result of its feasibility in executing different applications that can be used in solving everyday problems. Common issues in daily life include electricity consumption and the need for energy savings. In Iraq, the Ministry of Power faces such issues. This is because most households lack access to information on electric energy consumption behaviour, as well as applications that educate them on electric energy savings. Hence, this study aimed at the development of a mobile recommender application for Iraqi to help them understand the need for conservative electricity consumption based on the meter data supplied by the users per square meter along with the active devices and period of usage. The proposed mobile recommender application was evaluated by fifty (50) participating households along the dimensions of ease of use, usefulness, ease of learning, and satisfaction. The study outcome indicated that most of the participants found that the application was easy to use, useful, easy to learn, and was satisfied with its functionalities/features.

Future studies will investigate the effect of mobile power consumption application in promoting users' usage behaviour and habits. Furthermore, future studies will also consider more usage scenarios and potential differences in usage satisfaction when using Apple IOs and other operating systems. In addition, this study offers some useful insights on the significance of using mobile application for promoting electric power/energy conservative behaviour among households in Iraq. The study provides a mobile tool for distributing power related recommendations and that offers suggestions to users on conservative electricity usage and the need for a savings culture. The assessed application showed that the mobile application is easy to use, useful and user satisfying as the users use the application in managing their daily energy consumptions behaviour.

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