A Social-centred Gamification Approach to Improve Household Water Use Efficiency

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Abstract— **The research community is showing a growing interest in gamification and there are works showing the usefulness of gamification in different problem domains. Recently, a special interest has been given to the gamification design on systems addressing natural resource consumption issues such as to encourage efficient household water consumption. Despite the potential benefits, the gamification design method for such system is not conclusive. In this paper, we proposed a social-centred gamification approach to improve household water use efficiency. The approach firstly identified the water use related social network activities based upon existing popular social network activities. The approach then gamified each identified activity in terms of traditional instruments for improving water use efficiency and gamification rewards. The approach also used a set of indicators to explicitly detect and monitor both online social network activities and offline water use activities. With this approach the gamification effectiveness can be better traced and evaluated.**

Keywords— *gamification, social network gamification, gamification design, efficient water use*

I. INTRODUCTION

The persuasive technologies are emerging as useful tools to support behavioural change in daily life [13]. In recent years, a special interest is given to the technologies designed to support natural resource consumption behavioural change such as efficient household water use (e.g. [16] [17]). Thanks to the advancement of digital sensors, researchers and companies are developing smart metering systems that can collect real life water consumption data and present to users in different visualised formats. E.g. in [24] and [25], individual household water use data can be collected from smart meter and water use information can be further presented to users based upon the collected data. Such kind of system can be named 'personal informatics system' according to Li et al.'s work [14], which is defined as collecting personally relevant information for the purpose of gaining self-knowledge. The personal informatics systems allow users to explore and reflect the collected information and the reflection can lead the individual to reconsider and possibly change attitudes or behaviours [15]. A more recent development trend of persuasive technology is to present the systems to users in a game like manner, which is called the gamification. Gamification is generally defined as the use of game design elements in non-game contexts [18]. With a growing popularity of gamification systems in the markets and research fields, gamification is argued to be a next generation method for marketing and customer engagement [20] and has been proposed as a design pattern for persuasive systems [22].

Despite the envisioned benefits brought by gamification, there are still challenges with respect to the gamification design and evaluation. The gamified systems are argued to be neither a pure functional software nor a full-fledged game [23] and hence there are no well-established methods to design such systems. In Hamari et al.'s work [21], 24 research works were reviewed in terms of the effectiveness of gamification. Even though the majority of the reviewed studies reported positive results from gamification, the authors concluded there were still limitations that might affect the qualification of the previous works' results. E.g., one of them is that controls between implemented elements of gamification were often lacking, so multiple elements were investigated as a whole. As a result, it remains unclear how gamification can be used and evaluated to support natural resource consumption behavioural change.

In the light of the criticisms and challenges on the gamification design and evaluation, we proposed a social-centred gamification design approach to develop the gamification specially for improving household water consumption efficiency. Our proposal is researched and developed in the context of the FP7 EU Project ISS-EWATUS [31], where a social network (SN) platform is provided to increase water consumption awareness and improve household water use efficiency. One of the fundamental differences between a SN based persuasive system such as in ISS-EWATUS and a sensor based individual persuasive system is the former entails additional set of user-user activities that are envisioned can enable offline water use change. Hence, it firstly requires SN activities to be defined and mapped in the context of problem domain, i.e. water use efficiency, so that the activities can be better justified to engender the target behavioural change. In order to implement the gamification and to evaluate the gamification effectiveness in such SN platform, there should also be mechanisms to link users' online activities and offline water use, i.e. the activity is not only merely between online users and the SN, but also the between the external, physical systems and the users. This aspect is of course specially complicated, in particular when the external system interfaces are unknown or incompatible with the SN system interfaces.

In this paper, a social-centred gamification approach is presented to address these gamification design and evaluation challenges, i.e.

- to define social activities used in a SN to enable user behavioural change
- to gamify the SN activities to incentivise SN users to enact expected online activities and offline water use change.

The approach is currently being used in the ISS-EWATUS project for promoting efficient household water consumption behaviour. There are also important issues such as the impact of privacy and the cultural considerations on designing gamification for a SN platform which are outside the scope of this work.

The rest of the paper is organised as follows. In section II, Related works are firstly reviewed. The proposed approach is presented in Section III. Section IV concludes and outlooks the work.

II. RELATED WORK

There are lots of research works on using ICT tools to promote efficient water use. Here, we reviewed the most relevant works starting with social networks and behavioural change and then we reviewed the gamification motivational affordance on social networks.

A. Social Networks and Behavioural Change

Behaviour can be influenced through **social norms**: people are more likely to participate in an activity if others around them are participating in the same activity [5] [4]. In [26], it showed that water conservation could be influenced by the presence of people modelling the promoted water saving action of turning off the shower while soaping. It was found that before the study 6% of shower users carried out the action while 93% were aware of the sign suggesting the action. Following the presence of one model 49% carried out the action. The presence of two models resulted in 67% participation. Studies including [7] [12] have also indicated that SNs can be used to motivate or to give certain pressure to people to behave in certain ways.

Behaviours can also be influenced via **designed intervention**. In Rolls' work [8], a concept called CBSM (Community Based Social Marketing) referred to those intervention programs that attempt to apply a structured approach and the insights of social psychology when influencing community behaviour. CBSM involves fours steps including: 1) to identify barriers which prevent the action, e.g. installing a low-flow showerhead, from being taken, 2) to design a programme to overcome the selected barrier to achieve the behavioural change. The important aspect of the design stage is to target interventions very specifically towards the identified barriers, drawing on social-psychological devices such as commitments, prompts, or signals, to promote the desired behaviours. 3) To pilot and test the programme and 4) evaluate its effectiveness before it is applied on a wider scale. Based on CBSM, Jackson [27] further found that

habitual or routine change is much more difficult to influence compared to changing a one-off behaviour.

B. Gamification Motivational Affordance on Social Networks

Gamification is commonly known as the use of game design elements in non-game contexts [18]. Gamification is also defined as a process of enhancing services with affordances in order to invoke gameful experiences and further behavioural outcomes [19]. Reward, as a motivational affordance [28], is one of the key composing elements in a gamification system. In [9] it was found that behavioural change was more likely to occur if **physical (i.e. real) rewards** were offered, e.g. it was illustrated that more actions were taken on use of free products compared to personal initiatives. **Virtual reward** systems (such as scores, stars, reputations and badges) are a common practice in many gamified SN systems. Reasons of why such a reward system is successful can be explained by using the behavioural model proposed in [3]. However, the model in [3] also argued that an activity that is easy to do, such as play an online game, will require only a low level of motivation for a person to do it. When an activity is more challenging to do, it will require a much higher motivation. The virtual reward systems can be also viewed as a motivational affordance to trigger social comparison which refers to the process of evaluating one's own abilities and opinions by comparing them to the abilities and opinions of others [30]. The underlying assumption is that users would become more physically active in order to outperform others. Another type of reward is the **private personal rewards** which are dependent upon individuals and they do not have explicit forms. These rewards can be i) the gratification received from entertainment, ii) information and knowledge retrieval, and iii) social activity [11] [2].
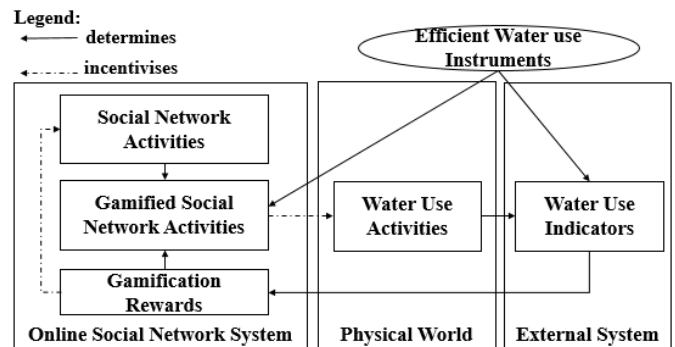
III. SOCIAL-CENTRED GAMIFICATION APPROACH

Fig. 1 Overview of Social-centred gamification approach

The proposed approach (See Fig. 1) models five components distributed across online SN system, physical world and external system. It also models the efficient water use instruments as an external input to contextualise the SN activities in efficient water use domain. The approach aims to transform the existing SN activities to 'SN version' efficient water use instruments supported by gamification. It also aims to support gamification evaluation, i.e. better trace and monitor the gamification via links between individual gamification process and individual SN activity (SNA). In the next few sections, we start by defining efficient water use instruments

and then each of other components will be elaborated respectively.

A. Efficient Water Use Instruments

In water use domain, the WCM (water conservation management) instruments [6] is a well-known water use management theory. The WCM provides a good theatrical base for designing efficient water use instruments. The **efficient water use instruments** therefore can be categorised into five Es: 1) engineering (i.e. physical WCM equipment); 2) economics (i.e. water price related information such as rebates); 3) enforcement (i.e. penalty measurements on water waste); 4) encouragement (i.e. endorsement on water conservation behaviour); 5) education (i.e. raising efficient water use awareness).

B. SN Activities

In the ISS-EAWATUS, we entail a selected list of common activities extracted from a comprehensive list of **SN activities** (SNAs) identified in [1]. Each of these activities are tailored to a set of water user related SN activities which were supported by potential system users in Greece Poland and UK [31]. (See **Table 1**).

Table 1 SN Activities

#	Common SNAs	Water Use Related SNAs
1	Sharing information	Sharing water use pattern to friends; Sharing water bills with friends
2	Getting recommendations	Water use tips search
3	Organising social events	Water use topics discussion e.g. surface water drainage rebate
4	Playing games	Completing a task driven water use activity, e.g. start a shower between 8pm and 8:30pm and finish it less than 10 minutes
5	Keeping in touch with friends	Inviting friends to take part in water use related SN activities.

C. Gamified SN Activities and Gamification Rewards

Gamified SN activities (GSNAs) are a set of social activities that can be used to incentivise online and offline activities. A GSNA is determined by both a SNA and gamification rewards, hence defining a GSNA can be viewed as a two-step process.

The first step is to classify the defined SN activities in terms of the efficient water use instruments. As an example, Table 2 shows how SNAs in Table 1 are defined in ISS-EWATUS as GSNAs. The second step is to associate a GSNA with the **gamification rewards**. The decisions on which types of reward to be used, as reviewed in section III.B, depend upon the instrument nature of a SNA, e.g. the physical rewards could be more suitable for engineering instrument related SN activities whereas private personal rewards may apply to all instruments. For the evaluation purpose, the assignment of

rewards should also take account of the relationship between rewards so that rewards can be traced down to specific SNA.

In ISS-EWATUS [31], each GSNA is assigned a distinguishable rewarding mechanism, i.e. different rewarding scores/badges for different achievements for an activity. As part of the evaluation process, we will evaluate the effectiveness of rewards or reward conversions by using both qualitative approach such as survey and interview and quantitative approach in which gamification rewards data and real water consumption data will be retrieved from both the online SN system and external systems (See section D).

Table 2 ISS-EWATUS GSNAs (See **Table 1** for social activity ids)

Related Efficient Water Use Instruments	GSNAs (Table 1)
Engineering	(4)
Economics	(1) (3)
Enforcement& Encouragement	(2)
Education	(5)

D. Water Use Activities and Indicators

To enable water use behaviour change, **water use activities** should be detected and monitored. However, the monitoring task is beyond the boundary of an online SN system and it is usually difficult to learn the exact water use activity without consulting the users.

Here, we use indictors to explicitly assess whether an expected offline water use task has been done. The **indicators** refer to the quantitative measurements associated with specific GSNA. In ISS-EWATUS, the calculation of a GSNA's gamification rewards are associated with the indicators. E.g. if the GSNA is to share water meter readings with friends, then the indicators can be the frequency of uploading a user's water readings and the number of people shared with. The indicators can also be retrieved from external systems, and this is especially true for the offline water use activities. E.g., in the water use related activity (4) demonstrated in Table 1, the water use patterns in terms of time and total water use from a smart water meter can be the indicators in this case.

IV. CONCLUSION AND FURTHER WORK

We presented a social-centred gamification approach helping the design, implementation and evaluation of a SN system for promoting household water use efficiency. We demonstrated how the proposed approach is used in the ISS-EWATUS project via modelling the gamified social network activities, gamification rewards and indictors used for monitoring both online SN activities and offline water use activities.

The next research task is to evaluate the proposed approach. We aim to find out how effective the designed GSNAs can help change households water use pattern and we will also assess the effectiveness of each individual GSNA. This will be done via two methods, one is via continuous collecting and analysing the quantitative data from the systems including both SNs and associated external systems; and the other is to

analyse the qualitative data periodically retrieved from questionnaires and focus groups within and outside the project consortium

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