



Gamification and serious games within the domain of domestic energy consumption: A systematic review



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ABSTRACT

Energy consumption is a significant and critical social issue. Gamification and serious games offer a means of influencing people regarding energy consumption. A systematic review of articles (written in English) was conducted according to the specifications of the PRISMA checklist, in order to examine the literature and assess empirical support for the effectiveness of gamification and serious games in impacting domestic energy consumption. The search strategy included a combination of terms relating to gamification and serious games, and domestic energy consumption. Only primary studies reporting empirical data relating to the value of gamification and serious games on energy consumption were included. More comprehensive selection criteria were applied throughout the selection process (reported in full in the main text). Twenty-five primary studies published in 26 research articles were included in the final review. The findings indicate that gamification and serious games appear to be of value within the domain of energy consumption, conservation and efficiency, with varying degrees of evidence of positive influence found for behaviour, cognitions, knowledge and learning and the user experience. A common feature across many articles reviewed was the limited amount and quality of empirical evidence, which suggests that more rigorous follow-up studies are required to address this gap. The article makes specific recommendations to help address this challenge.

1. Introduction

The conservation of energy constitutes a significant and pressing social issue. Despite efforts to transition to a renewable energy economy, the world is slow to give up its dependency on fossil fuels as its primary energy source. At a time characterised by overpopulation and overconsumption, emission-intensive energy production that drives anthropogenic climate change is a serious global concern. The additional threats of resource depletion and a rapidly emerging energy-hungry middle class in developing economies compounds the seriousness of the issue. Scarcity and an urgent need for energy conservation and reduction manifest at the level of the individual with ever-increasing living costs. This represents another factor in the urgent need to reduce domestic energy consumption, with large proportions of even developed economies living near or even below the poverty line [1,2].

Households represent an important target group, with total energy consumption in the household sector and residential CO₂ emissions rising since 1990 [3]. Human behaviour and its determinants play a key role in energy usage, however, efforts to target behavioural change have produced varying levels of success [4]. An emerging area of focus

is the use of serious games and gamification as tools to motivate, engage and educate people regarding energy consumption and related concerns.

Serious games and the use of gamification share a common goal; to shape human behaviour (or attitude and cognitions) through the intrinsically motivating qualities used in well-designed digital games. Serious games are defined as “any form of interactive computer-based game software for one or multiple players to be used on any platform and that has been developed with the intention to be more than entertainment” [5]. While gamification is most simply defined as “...the use of game elements in non-game contexts to improve user experience and user engagement” [6]. Thus, the distinction between the two is that serious games are fully fledged games (e.g., a digital role-playing game in which the player completes challenges or quests designed to educate them about nutrition), while gamification refers to the application of parts of games in a non-game setting (e.g., a mobile phone app designed to track and encourage exercise that uses levels, points and badges). In practice it is sometimes difficult to reliably distinguish the two as the point where a highly gamified application or tool crosses the line to becoming a game can be blurry and is highly subjective. Regardless, both serious games and gamification capitalise

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on the popularity and engaging nature of recreational (non-serious) digital games with a view to enabling change in the real world. Within the current review the term “applied games” is used to refer to serious games and gamification collectively [7].

As gamification is a relatively new concept, key theoretical understandings are still emerging. One relatively well received notion is that of ‘meaningful gamification’ [8]. Nicholson distinguishes between reward-based gamification (e.g., points, levels, leaderboards, achievements, or badges) and meaningful gamification, which draws on game design elements such as play, exposition, choice, information, engagement and reflection. Based on self-determination theory [9], and the distinction between intrinsic motivation (the drive to do something without external rewards and for its own sake) and extrinsic motivation (performing an activity to attain some separable outcome), Nicholson suggests that rewards-based gamification may be suitable for immediate and short-term changes, but that for long-term change meaningful gamification may be required. This aligns with the point of view of other prominent gamification theorists [10,11] who have likewise proposed that gamification’s effects may be primarily extrinsically (as opposed to intrinsically) motivating and that any changes to motivation may be short term.

Serious games have seen steady interest in industry and academia over approximately the last decade [12] and gamification has become increasingly popular since it emerged around 2010 [13]. However, while both are being widely applied, the empirical evidence regarding their effectiveness is still emerging. The most thorough review of serious games to date was conducted by Connolly and colleagues [12], and while it found support for the effectiveness of game based learning, the authors noted that further research was needed. Similarly, recent reviews of the evidence supporting the effectiveness of gamification, while broadly positive [7,13], note that any positive effects are “... greatly dependent on the context in which the gamification is being implemented, as well as on the users using it” [14].

Regardless, existing reviews either approach applied games across domains (precluding any evaluation of their effectiveness with respect to energy consumption), focus on domains other than energy consumption [15] or look at specific Information Communication Technology mediums [16]. Despite the lack of a clear understanding of the efficacy of applied games in the energy consumption domain, these tools are being utilised to influence domestic energy consumption across a range of academic, governmental and commercial settings. Based on this increasing use of these techniques, the evidence for the context- and audience-specificity of gamification effectiveness, as well as the broader debate about gamification’s overall effectiveness, the current study sought to closely examine the empirical evidence for the effectiveness of applied games in the domestic energy consumption domain.

Our objective was to examine empirical evidence reported on the value of applied games within the domain of domestic energy consumption and conservation (both efficiency gains and actual reduction). In order to achieve this objective we reviewed empirical studies that assessed the impact of applied games on a range of energy-related variables in users. Variables were limited to those determined as relevant to energy consumption occurring within a strictly domestic context. The overarching question we aim to explore in the current review is:

Does current research provide evidence that applied games are effective in influencing users with respect to domestic energy consumption?

2. Methods

2.1. Protocol and registration

The review protocol was developed by the authors to comply with the specifications of the PRISMA checklist [17], a rigorous and widely-

used reporting guideline for systematic reviews. A recently published systematic review of high quality and with a similar research question [12] was used as a template for developing the protocol. All authors were involved in approving the final review protocol.

In the present review, gamification is defined according to Deterding and colleagues [6] as “...the use of game elements in non-game contexts” and serious games are defined as “...game[s] in which education is the primary goal, rather than entertainment” [18]. To enhance clarity and acknowledge significant theoretical overlap, the phrase ‘applied games’ will be used to broadly reference both concepts throughout the review.

Energy in the context of the present review refers specifically to electricity. However, for the purpose of this review we did not exclude studies that deal with electricity as well as other sources of energy in the home such as natural or propane gas. Within a domestic context, energy consumption refers to electricity used for lighting, heating, cooling, cooking, and to power household appliances. Whilst we use ‘energy consumption’ as the umbrella term for all studies relevant to this review’s focus, we distinguish energy conservation between energy efficiency gains and energy reduction. Energy efficiency is the use of less energy to provide the same service and receive the same output, and energy reduction is a decrease in or avoidance of the use of and demand on an energy service. While both mechanisms can contribute to energy conservation, the Khazzoom-Brookes postulate demonstrates a paradoxical relationship between energy efficiency gains and consumption whereby a positive correlation occurs that in fact leads to an increase in energy consumption [19].

2.2. Eligibility criteria

The following inclusion and exclusion criteria were applied to the studies identified in the database search:

Inclusion criteria:

- Peer-reviewed (including peer-reviewed conference papers)
- Full-papers (including full conference papers)
- Explicitly stated and described gamification mechanic/s or elements, game or game elements or activities
- Clearly described outcomes relating to household energy consumption/conservation behaviour, including those related to both energy use and/or efficiency and/or reduction
- Empirical research

- Explained research methods / methodology / analysis

Exclusion criteria:

- Gamification or game element/activity mentioned but not part of the research being conducted
- Energy consumption and/or conservation mentioned but not part of the research being conducted
- Research focusing on environments other than the domestic household (i.e. workplace, school)
- Theoretical, conceptual papers without empirical data
- Short papers reporting on research in progress
- Extended abstracts and posters
- Publications written in a language other than English

2.3. Information sources

Electronic databases were searched in the review, as well as a manual search of the reference lists of key papers. Searches were performed between 27th March and 16th April 2015. The databases searched were those identified as relevant to information technology, social science, interaction design, psychology and environmental science: EBSCOhost (all databases) (n =1061), ProQuest (n =271), ACM (Association for Computing Machinery) (n =151), IEEE Xplore (n =179), Web of Science (n =10), Scopus (n =323) ScienceDirect (n

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