Empowering Energy Conservation in Buildings Through Gamification: Insights from Diverse Applications

Wee Siaw-Chui, Choong Weng-Wai, Low Sheau-Ting, Razlin Binti Mansor

Department of Real Estate, Faculty of Built Environment and Surveying, University Technology Malaysia, Malaysia

***Corresponding author**

DOI: https://dx.doi.org/10.47772/IJRISS.2025.908000090

Received: 21 July 2025; Accepted: 28 July 2025; Published: 29 August 2025

ABSTRACT

Energy shortages, high energy prices, and environmental problems associated with the rising energy consumption are global concerns. Particularly, buildings are among the major contributors to the total energy consumption. The energy consumption of a building largely depends on how its users utilise the energy. Energy-saving campaigns, a common initiative aimed at fostering behavioural change among users, are less effective due to a lack of motivation. Therefore, this paper studies a behavioural change intervention – Gamification, to encourage energy conservation behaviour among building energy users. In this paper, a review of various empirical studies is conducted to study the application of gamification in promoting behavioural change in different contexts and propose a variety of game design elements that could be adopted for fostering energy conservation behaviour among building energy users. Data collection is conducted on Web of Science and SCOPUS, and the final set of 32 eligible papers for this review is determined by applying several layers of eligibility criteria assessments. The overall findings indicate that gamification has substantial potential when applied in the context of energy conservation and identify 20 game design elements for consideration in further implementations. This paper offers new insights for stakeholders on the application of gamification in fostering energy conservation behaviour, serving as a guideline for future researchers on the available game design elements that can encourage energy conservation behaviour among building energy users.

Keywords; Gamification; Game design elements; Energy conservation; Behavioural change; Engagement

INTRODUCTION

The increasing trend of world energy consumption has become a global concern due to the numerous energy issues and environmental impacts it has brought (Kong et al., 2017; Singh and Bajpai, 2010; Kofi Adom et al., 2012; San et al., 2012). In most countries, buildings are responsible for at least 40% of energy consumption, underscoring the need for building energy efficiency regulations to promote energy conservation and reduce global carbon emissions (Hartungi and Jiang, 2012). Managing energy consumption in buildings effectively and efficiently is crucial for conserving energy, sustaining the availability of energy resources, and reducing environmental impacts and financial costs (McKay and Khare, 2004).

Two types of strategies can be used to reduce energy use: technology-based strategies and behaviour-based strategies (Gandhi and Brager, 2016). While energy-efficient tools (e.g., LED lighting, energy-efficient electrical appliances) installed through technology-based strategies are familiar to most people, behaviour-based strategies that promote and foster behavioural change among energy users are also essential in tackling rising energy consumption (Pasini et al., 2017). Behavioural change is necessary because technical efficiency gains from the installation of technology tools tend to be overtaken by consumption growth. Building users' energy consumption behaviour largely determines a building's energy usage, and those who do not change their behaviour during the building's operation will continue to waste energy in the same way (Tang et al.,

2019; Li et al., 2019; Li et al., 2017; Lopes et al., 2012; Kok et al., 2011; Abrahamse et al., 2005). Ouyang et al. (2009) demonstrated that 10% of building energy use could be reduced by improving building users' behaviour. Thus, developing effective behaviour-based strategies to foster energy conservation behaviour among building users is essential for reducing overall energy consumption (Xu et al., 2021).

Although awareness campaigns are a common initiative to foster energy conservation behaviour among building users, most campaigns are information-intensive and unsuccessful in inducing behavioural change (McKenzie-Mohr, 2000). The focus is often on providing mass information to users and assuming that enhancing users' knowledge and awareness will lead to behavioural change, but environmental awareness does not necessarily translate into environmental behaviour (Fu et al., 2020; Li et al., 2019). The gap between awareness and behaviour should not be overlooked, and further behavioural intervention may be needed to motivate energy users to take action.

In recent years, gamification has emerged as a behavioural intervention tool to facilitate behavioural change among people, using game elements to induce behavioural change in real-life contexts. Its adoption has been recommended for environmental applications (Simoes et al., 2013), and game-based approaches have great potential in inducing behavioural change for environmental good (Ro et al., 2017). Moreover, gamification has been found to foster energy conservation behaviour among users (Morganti et al., 2017). However, there is limited literature on how to adopt gamification to foster energy conservation behaviour. Thus, this paper aims to study the application of gamification in fostering behavioural change in various contexts and propose how it can be adopted to foster energy conservation behaviour among building energy users.

Gamification – An approach to foster behavioural change

The changes in society's lifestyle have made the video game industry grow rapidly and become mainstream entertainment among the younger generations. Along with the increasing popularity of video games, a movement emerged to defend the extension and application of elements normally presented in video games to the real world and in areas very far from video games and entertainment (Simoes et al., 2013). This movement has led to the emergence of a new concept called gamification.

The term "gamification" was first introduced in the early 2000s, with its first documented use in 2008. However, it did not receive significant attention until several industry players and conferences popularised it in the second half of 2010 (Groh, 2012; Deterding et al., 2011). Several definitions (Deterding et al., 2011; Zichermann, 2011; Schacht and Schacht, 2012; Sheth et al., 2012; Visch et al., 2013) of gamification have been proposed by researchers, and notably, the core idea proposed by researchers in defining gamification is the concept of applying or using game design elements in non-game contexts, rather than create a real game, to create an enjoyable environment to increase user experience and thus user engagement. Notably, the most common, useful definition adopted by most of the gamification practitioners is that of Deterding et al. (2011): "the use of game design elements in non-game contexts".

A common phenomenon observed in gaming environments is that people are motivated by specific game design elements, including different levels of challenges, rewards to collect, and friendly competition. Gamification is therefore intended to simulate a game-like environment in a non-game platform using game design elements, to motivate people's engagement (Johnson et al., 2017). Gamification is an application of game-like principles, without necessarily building a 'complete' game (Betts et al., 2013). It is a concept that focuses on adopting the motivation elements from the game context in a non-game real-life context to motivate people's engagement in a desired behaviour.

Gamification has gained popularity in recent years due to its potential to motivate and engage users in various activities, including those that may be traditionally perceived as mundane or uninteresting. Its application has been explored in different fields, such as education, healthcare, marketing, and sustainability. Gamification has been shown to increase user engagement, promote positive behaviours, and enhance learning outcomes (Hamari et al., 2014).

One of the key benefits of gamification is its ability to leverage the motivational and emotional aspects of games. Games often provide users with a sense of accomplishment, satisfaction, and enjoyment through rewards, feedback, and social interaction. By applying game design elements in non-game contexts, gamification aims to create a similar experience that can motivate users to engage in certain activities or behaviours (Landers et al., 2019). This engagement can be particularly useful in promoting sustainability and environmental conservation, where users may not have a strong intrinsic motivation to act sustainably.

In addition, gamification provides a platform for experimentation and learning. Games often allow users to try different approaches, learn from their mistakes, and receive immediate feedback on their progress. Gamification can provide a safe and engaging environment for users to experiment with sustainable behaviours and learn about the impact of their actions on the environment (Hsu et al., 2019).

According to Pasini et al. (2017), energy users could be motivated and encouraged towards energy conservation through a gaming environment. Gamification, a concept that utilises motivation elements from games, could then be used to enable users to engage in energy conservation activities. Gamification may foster energy conservation behaviour among users in a fun game-like environment and is thus worth exploring. A deeper understanding of the variety of game design elements and their characteristics is vital to determine how they can be adopted to foster behavioural change among energy users.

Therefore, this paper reviews the application of gamification in fostering behavioural change from different contexts and proposes a variety of game design elements that could be adopted for promoting energy conservation behaviour among building energy users. The research goals have been formalised into the following research questions:

1. How are the applications of gamification in fostering behavioural change across different contexts?
2. What are the game design elements that could be adopted for fostering energy conservation behaviour among building energy users?

By answering these research questions, the study aims to provide insights into how gamification can be used to foster behavioural change in non-game contexts across different contexts and how it could be applied in the context of energy conservation.

METHOD

The literature search for this review was conducted through the two most acknowledged databases: Web of Science and SCOPUS (Silva et al., 2019). The search string used was *gamification* AND *behaviour* AND *change* OR *game* AND *design* AND *element* AND *behaviour* AND *change*. Additional studies were identified by conducting a manual search of the reference lists of the relevant studies identified from the database search.

Inclusion and exclusion criteria

The duplicates were removed from the list. The inclusion and exclusion criteria were set to identify the relevant studies for the review.

The papers that fulfilled the following inclusion criteria (ICs) were included:

- IC1. Full papers (Including full conference papers)
- IC2. Written in the English language
- IC3. Explicitly stated and described gamification as the research subject and design strategy, in any context, for the purpose of behavioural fostering

- IC4. Clearly stated and described gamification elements (also known as game design elements)
- IC5. Empirical research

Criterion 1 was to ensure that the full length of the original studies was reviewed. Criterion 2 was to ensure that the author fully understood the contents of the papers and collected the correct information. Criterion 3 was to ensure that the papers focused on gamification as their research interest. Considering the limited gamification studies on the energy conservation context, and to understand the application of gamification from various perspectives as a whole. Criterion 4 was to ensure that the papers reported on gamification and not serious games, which were sometimes mislabelled as gamification. Criterion 5 was to ensure that empirical data supported the credibility of the research.

The papers that fulfilled at least one of the following exclusion criteria (ECs) were excluded:

- EC1. Written in a language other than English
- EC2. Short papers (1 – 4 pages, e.g., extended abstract or research in progress)
- EC3. Mentioned gamification, but not as part of the research being conducted
- EC4. Presented based on a prototype, framework, proposal, or concept
- EC5. No empirical data

Data analysis

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guideline (Moher et al., 2009) was utilized in this study as the main structure for gathering data and documenting the review procedure. The review process encompassed multiple stages, including article identification, screening for duplicates, evaluating eligibility, and selecting articles for inclusion or exclusion. The raw data (downloaded papers) were subjected to a few layers of eligibility assessments to determine the final set of eligible papers for the review in this paper. Content analysis was employed to achieve the outcomes of this study (Snyder, 2019).

RESULTS

The flow chart of the review process for this paper is presented in Figure 1. The review started with a literature search on the electronic databases by applying EC1 and yielded 838 articles. Twenty-one articles were excluded because of EC1. The title and author screening removed 224 duplicate articles in the Web of Science and SCOPUS databases. The 593 nonduplicated articles were then subjected to title and keyword screening by applying the ICs and ECs. After applying EC3 and EC4, 382 articles were excluded. The remaining 211 papers were screened based on their abstract and content, and because of EC2, EC3, and EC4, 138 articles were excluded. A total of 73 articles were assessed in more detail by reviewing their full text, resulting in the exclusion of another 42 articles because of EC3, EC4, and EC5. Throughout the reviewing process, reference tracking was conducted to identify additional potential papers. One more article that fulfilled the ICs was included from reference tracking. The final number of articles in this review was 32. Table 1 presents the empirical studies included in this review.

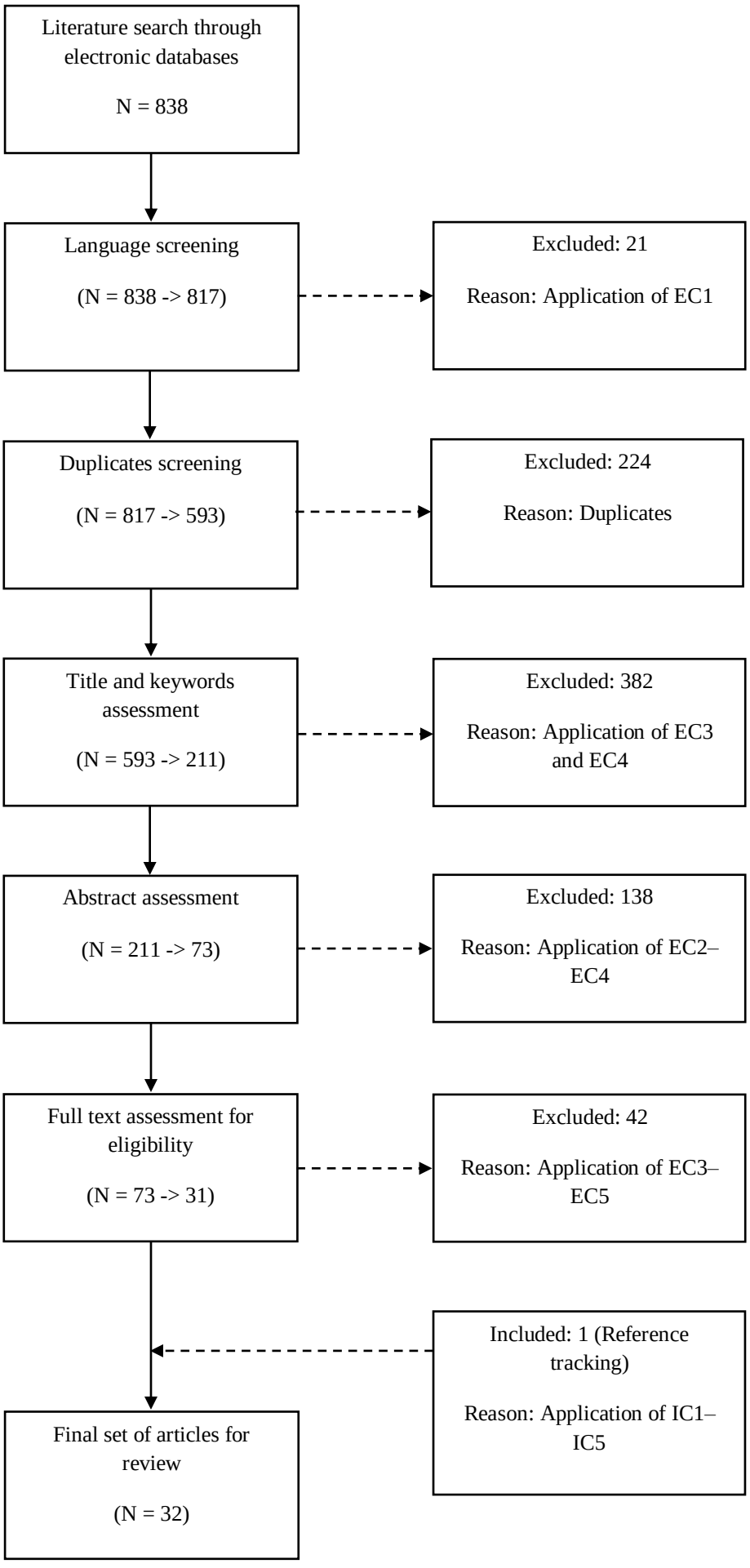

Figure 1 PRISMA framework for reviewing process

Table 1 Empirical studies included in this review

Author	Area	Objective	Game Design Element	Data Collection	Result
Iria et al., 2020	Energy conservation	To foster the adoption of energy-efficient behaviours in office buildings through a mobile gamification platform	• Dashboard • Leaderboard	Experimental setting + Monitoring	Results suggest electricity savings of 20%
Huang et al., 2019	Littering	To reduce the cigarette butt littering behaviour in a campus environment	• Target setting • Audio feedback	Experimental setting + Observation	Results show a reduction in cigarette butt littering among the observed students, especially male students
Ismail et al., 2019	Education	To improve the academic performance of diploma-level students	• Points	Experimental setting + Observation	Results suggest that gamification has the potential to significantly improve students' academic performance
Patel et al., 2019	Healthy lifestyle	To increase physical activity among overweight and obese adults	• Support • Collaboration • Competition	Experimental setting + Monitoring	Results show that all three gamification interventions significantly increased participants' physical

					activity, and competition was found to be most effective
Luo et al., 2019	Energy conservation	To increase energy awareness and support energy conservation in workplaces	• Cooperative	Experimental setting + Survey	Results show that, in general, gamification could help increase energy awareness and support short-term behavioural change
Ferron et al., 2019	Sustainable mobility	To promote a positive behavioural change in mobility habits	• Points • Badges • Prizes • Challenges • Leaderboards	Experimental setting + Survey	Results show a behavioural change towards more sustainable mobility patterns in general
Wemyss et al., 2019	Energy conservation	To reduce household electricity consumption	• Challenges • Points • Feedback	Experimental setting + Monitoring + Survey	Results show that the intervention achieved positive, encouraging short-term results
Berger, 2019	Eco-friendly food choice	To examine the effectiveness of social norm information in increasing eco-friendly food choices	• Social norm-based feedback	Experimental setting + Survey	Results show that social norm-based feedback is effective in encouraging individuals to make an eco-friendly food-purchasing

					decision
Lowenstein et al., 2019	Workplace wellness	To evaluate a gamified workplace wellness programme	• Goal setting • Leaderboards • Badges • Challenges • Social influence	Experimental setting + Observation	Results show that gamification has the potential to support long-term participation and behavioural change in a workplace wellness programme
Wemyss et al., 2018	Energy conservation	To test the effectiveness of a competitive, collaborative approach to engaging individuals to change household electricity-use habits	• Competitive • Collaborative	Experimental setting + Monitoring + Survey	Results show that both competitive and collaborative interventions contribute to electricity savings
Meder et al., 2018	E-commerce	To analyse the impact of gamification in the e-commerce domain and compare the effectiveness of tangible versus intangible rewards	• Voucher • Points • Badges • Levels • Feedback	Experimental setting + Monitoring	Results show that both tangible and intangible rewards increased user engagement, with tangible rewards driving more user engagement
Haruna et al., 2018	Education	To improve the sexual health education of adolescent	• Badges • Leaderboard • Points	Experimental setting + Survey	Results show that gamification teaching methods could

		students			effectively deliver and improve the sexual health knowledge of secondary school adolescents
Ro et al., 2017	Energy conservation	To reduce household energy consumption	• Points • Leaderboard	Experimental setting + Observation	Results show behavioural change in the participants who consume the highest amount of energy before the intervention
Kelders et al., 2018	Healthcare	To explore the direct impact of gamification on behavioural, cognitive, and affective engagement in the context of a web-based mental health intervention	• Visualised map • Progress Bar • Avatar • Badges	Experimental setting + Survey	Results suggest that gamification can have a positive impact on cognitive engagement, but did not seem to increase behavioural and affective engagement as such
Patel et al., 2017	Healthy lifestyle	To increase families' physical activity	• Goal • Feedback • Points • Levels	Experimental setting + Observation	Results show increments in physical activity among families in the community

Ryan et al., 2017	Healthy lifestyle	To examine user engagement, compliance, and retention by applying a gamified physical activity intervention	• Goal • Virtual medal • Discussion board • Tally board • Weekly email feedback	Experimental setting + Observation	Results show gamification may enhance engagement among males, traditionally recognised as a difficult demographic group to engage
Mitchell et al., 2017	Healthy lifestyle	To investigate the effect of gamification on consumers' motivation and behaviour to engage in physical activity	• Levels • Choice • Feedback	Experimental setting + Survey	Results show that gamification can facilitate both an initial behavioural change and the maintenance of the behavioural change
McKeown et al., 2016	Healthcare	To engage clinicians in the adoption of sepsis identification and management	• Points • Badges • Leaderboards • Quests • Social networking	Experimental setting + Observation	Results show a significant reduction in severe sepsis mortality and improvement in the process of care
Millonig et al., 2016	Cycling	To promote cycling activity for fostering sustainable and healthy modes of transport in	• Competition • Cooperation	Experimental setting + Survey	Results show that competition served as an initial trigger for signing up for the

		urban areas			activity and that collaboration within teams was the main driver for continued participation
Lessel et al., 2015	Waste separation	To improve individuals' recycling capabilities	• Points • Score list • Feedback	Online questionnaire that mimics waste classification process	Results show improvement in individuals' waste separation
Attali and Arieli-Attali, 2015	Education	To examine the effect of the gamification element of points in a mathematics assessment in terms of accuracy and speed of response	• Point • Immediate feedback	Experimental setting + Monitoring	No effect was found *on the accuracy of response* among participants, but the *speed of response* was found to increase
Landers and Landers, 2014	Education	To improve students' course performance	• Leaderboard	Experimental setting + Monitoring	Results show improvement in course performance among students
Zuckerman and Gal-Oz, 2014	Healthy lifestyle	To promote routine walking	• Points • Leaderboard	Experimental setting + Survey	Results show effectiveness in promoting physical activity: walking
De-Marcos et	Education	To test and compare the	• Level	Experimental setting +	Both approaches

al., 2014		effect of social networking and gamification in an undergraduate course	• Badge • Leaderboard • Discussion forum	Monitoring	presented better performances than a traditional e-learning approach in academic achievement for practical assignments, but traditional e-learning was better in knowledge acquisition
Betts et al., 2013	Education	To improve participation in online learning among students	• Points • Levels	Experimental + Monitoring	Results suggest that gamification can improve the learning experience and the resulting performance for groups of students
O'Donovan et al., 2013	Education	To improve lecture attendance, content understanding, problem-solving skills, and general engagement	• Storyline • Goals • Points (rewards) • Badges (rewards) • Progress bars • Leaderboard	Experimental setting + Monitoring + Survey	Gamification techniques significantly improved students' understanding and engagement
Hamari, 2013	Enterprise service	To study the effects of gamification on user	• Badges	Experimental + Observatio	Users who actively monitored their badges

		retention (user activity) within a service		n	and those of others showed increased user activity
Herzig et al., 2012	Enterprise service	To evaluate an ERP (enterprise resource planning) gamification prototype	• Virtual reality • Challenges • Levels • Star • Cash	Experimental setting + Survey	Gamification objectively yielded improvements in software enjoyment, flow experience, or perceived ease of use
Thom et al., 2012	Enterprise service	To examine patterns of user activity in an enterprise social network service after the removal of a gamification system	• Point • Badges • Leaderboard	Experimental setting + Monitoring	The removal of the gamification system reduced overall participation
Fitz-Walter et al., 2011	University orientation	To test and explore new students' experience on a mobile application with game design elements	• Goals • Immediate feedback	Experimental setting + Survey (Small samples)	Game elements on the mobile application were generally well received by the students, and their functions were useful for university orientation

Witt et al., 2011	Online idea competition	To provide insights into the effect of gamification within an online idea competition	• Points • Leaderboards	Experimental setting + Survey	Results indicated that gamification may be a solution to promote participation in an online idea competition

FINDINGS AND DISCUSSIONS

The findings reveal that, among the 32 reviewed studies included, approximately 94% show a positive effect on the targeted outcome and approximately 6% show a partial effect. Figure 2 presents the statistics on the overall effectiveness of gamification. The studies are labelled as having a 'partial effect' because they provide insufficient support for the effectiveness of gamification but demonstrate positive impacts in certain areas. Two studies, Kelders et al. (2018) and Attali and Arieli-Attali (2015), do not fully support the effectiveness of gamification because it had a minor effect on achieving their targeted aims. Kelders et al. (2018) found that gamification has a positive impact on the cognitive engagement of the individuals towards the gamification intervention; however, no increment was observed for behavioural and affective engagement. In another study that evaluated the effect of gamification elements on students' assessment performance in terms of accuracy and response speed, Attali and Arieli-Attali (2015) found an effect on response speed but not on accuracy.

In general, most of the gamification studies demonstrate considerable evidence on its effectiveness in motivating and fostering behavioural change and engagement in different contexts. Gamification thus has shown great potential to be an effective application. The finding suggests that gamification may promote engagement and behavioural change, which is essential in the energy conservation context to foster behavioural change among energy users in support of environmental sustainability. This result is further supported by Iweka et al. (2019) and Morganti et al. (2017).

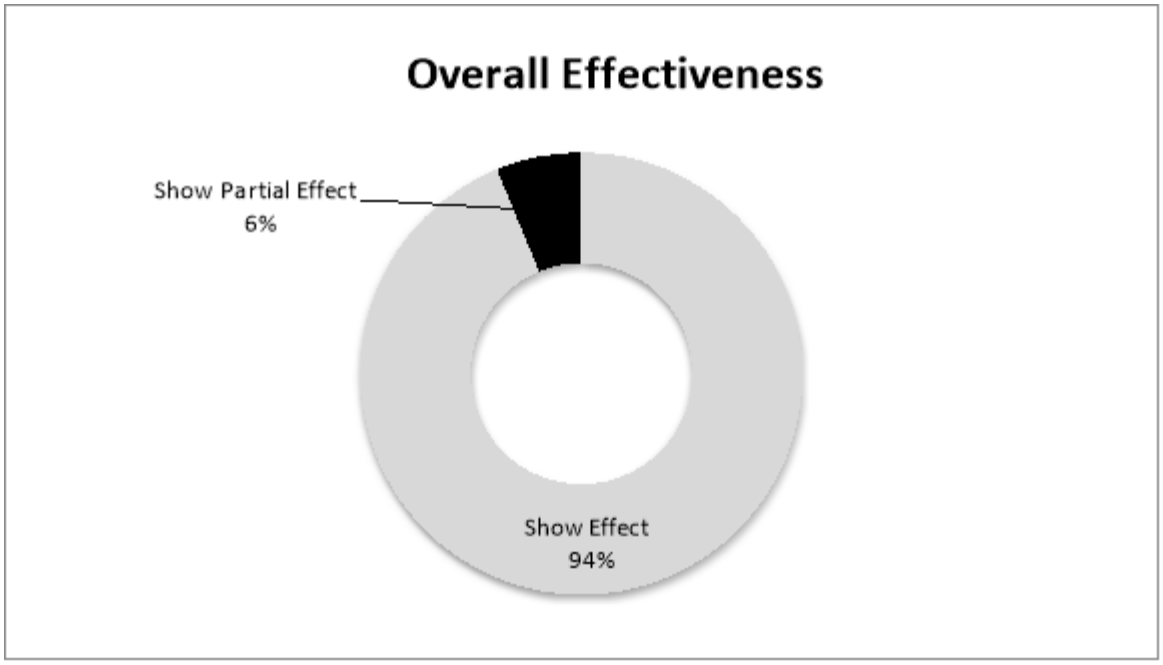

Figure 2 Overall effectiveness of gamification application

Besides, this research also explored the applications of gamification in fostering behavioural change across different contexts, and the findings are presented in a Sankey diagram as Diagram 1. The findings of this study show that the application of gamification in the energy conservation context is an emerging interest among researchers and is not rare. Diagram 1 presents the distribution of gamification studies in different fields. 16% of the reviewed studies are in the energy conservation context, which is the third-most applied gamification concept among the different fields. The fields that most apply gamification are education (22%) and healthy lifestyle (19%). This finding further confirms the insights of Simoes et al. (2013), who extended the potentiality of gamification to areas such as health, environment, and education.

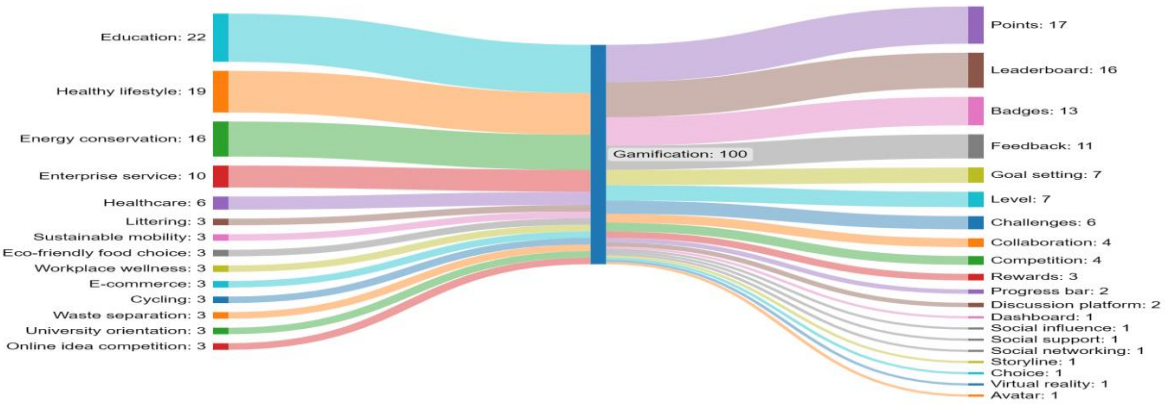

Diagram 1 The applications of gamification in fostering behavioural change across different contexts and its elements

Nonetheless, the gamification studies in the energy conservation context apply a digital setting, namely, a mobile-app or computer-app platform (Iria et al., 2020; Wemyss et al., 2019; Luo et al., 2019; Wemyss et al., 2018; Ro et al., 2017). For instance, in Iria et al. (2020), a gamification mobile platform was used to promote energy efficiency by presenting a dashboard for disseminating energy information and a leaderboard for promoting peer comparison and competition among office building users. Wemyss et al. (2019) applied game design elements to a Social Power App to promote energy saving among households where the household electricity consumption was fed back to the household through an app and the energy-saving challenges were displayed on the app. The software EnerSpace was also developed and integrated with cooperative game design elements to motivate office workers' energy saving (Luo et al., 2019).

Undoubtedly, promoting energy conservation through digital settings is beneficial and easy to manage; however, it may be unsuitable for small-scale organisations or communities with limited budgets for energy-conservation interventions. The designation and development of a software-app can be costly, not to mention the ongoing maintenance costs for the app. In such circumstances, gamification could go further with the creativity of the researchers to integrate gamification into existing real-life settings, without the assistance of a digital tool. For instance, instead of creating a new digital app as a platform to display a leaderboard to motivate users to act in a competitive environment, the researcher could use the existing webpage or publicly accessible notice board to display the leaderboard. Gamification in the energy conservation context is thus a topic worthy of further research by expanding and exploring its potential beyond software-apps for bridging the knowledge gap.

The initial findings of the content analysis find 38 named game design elements in the 32 eligible papers; however, researchers find that many of them have the same function and definition but a different name, for instance, "*collaboration* (Patel et al., 2019), *collaborative* (Wemyss et al., 2018), *cooperation* (Millonig et al., 2016) and *cooperative* (Luo et al., 2019)"; "*competition* (Shameli et al., 2017), and *competitive* (Wemyss et al., 2018)"; and "*target setting* (Huang et al., 2019), *goal setting* (Lowensteyn et al., 2019), and *goal* (Patel et al., 2017; Ryan et al., 2017)". Researchers have further reviewed the definitions and characteristics of the identified game design elements in the literature and grouped the similar game design elements under a name

that is more commonly known. The grouping further categorises the game design elements into 20 game design elements that can be considered for motivating energy conservation behaviour: points, leaderboard, badges, feedback, goal setting, challenges, level, collaboration, competition, rewards, progress bar, discussion platform, dashboard, social influence, support, social networking, storyline, choice, virtual reality, and avatar. The identified game design elements are analysed in terms of their frequency of adoption in gamification studies. Figure 4 presents the frequency of the application of the identified game design elements.

Based on the findings, points, leaderboard, badges, feedback, goal setting, and level are the six most commonly applied game design elements in promoting practice engagement and behavioural change. Points are usually rewarded to individuals upon completion of a goal and can be accumulated (Ismail et al., 2019; Ferron et al., 2019; Haruna et al., 2018; etc.). Leaderboards are used to track and display users' performance and achievement (Iria et al., 2020; Ro et al., 2017; McKeown et al., 2016; etc.). Badges indicate users' achievement and may be awarded based on accumulated points (Kelders et al., 2018; De-Marcos et al., 2014; Hamari, 2013; etc.). Feedback is provided to users to inform them how much they have progressed and what they have performed (Wemyss et al., 2019; Patel et al., 2017; Mitchell et al., 2017; etc.). Goal setting refers to the goals set or provided to individuals for them to achieve (Lowensteyn et al., 2019; Patel et al., 2017; Ryan et al., 2017, etc.). Level indicates the difficulties of the goal, and individuals can climb through different levels of goals (Mitchell et al., 2017; De-Marcos et al., 2014; Betts et al., 2013; etc.).

Notably, points, badges, and rewards exhibit a similar nature in the operation of gamification applications, where they are typically awarded to users upon completing a task, goal, or challenge. Nonetheless, they can be categorised into two types: intangible and tangible rewards. Points and badges function as intangible rewards, whereas the rewards identified in this paper refer to tangible rewards, for example, cash, vouchers, and prizes. Both tangible and intangible rewards are found to be able to increase individuals' engagement in the targeted thing (Meder et al., 2018). However, careful consideration should always be taken when applying tangible rewards, because they may become an extrinsic motivator for the individuals to act such that it reduces individuals' motivation to continue to engage if such a reward is removed. Particularly, tangible rewards always require monetary support, and such support is usually difficult to maintain in the long term. The removal of such a reward may result in withdrawal among the targeted individuals before the behavioural change occurs.

By contrast, virtual reality and avatar are virtual elements created with software and may be less suitable to adopt without the assistance of a digital tool. Virtual reality and avatar are the elements that are rarely transformed into a physical, real-life setting. A closer examination of the natures and characteristics of these virtual elements demonstrates that they are indeed the elements that are created by software to present an ideal condition and aim to disseminate information and guide individuals on some actions (Kelders et al., 2018; Herzig et al., 2012). If an organization is equipped with sufficient financial resources, the researcher may consider the game design elements of virtual reality and avatar for disseminating energy information and guiding energy users in energy conservation. However, if the plan is otherwise, these elements should be excluded from consideration due to the digital support necessary.

Excluding virtual reality and avatar, 18 game design elements can be considered for fostering energy conservation behaviour among building energy users in a real-life setting. The suggested game design elements in this review could be implemented to motivate energy conservation behaviour among building energy users through physical game playing. The fundamental settings of every game design element are described in the following section.

Game Design Elements

Points – Points can be an effective way to encourage energy conservation behavioural change among building users. It typically involves assigning points to building users who take actions that reduce energy consumption, such as turning off lights when leaving a room or adjusting the thermostat to save energy. The management may provide points to participants upon completion of the energy-saving goal

Leaderboard – A leaderboard can be set up to track and display the energy consumption of different floors or sections of the building. The leaderboard can then display the rankings of the floors or sections that are using the least amount of energy, encouraging healthy competition and collaboration among building occupants. The management could display a leaderboard on a publicly accessible platform, such as a notice board or an official website, to display the achievements of the building users

Badges – The badges can be provided to building users when they accumulate a targeted number of points or achieve specific goals or milestones related to energy conservation, such as reducing their energy use by a certain percentage. The badges can be displayed on the building users' designated space or workstations, showcasing their achievements and serving as a reminder of the importance of energy conservation.

Feedback – Feedback can be delivered in various ways, such as through email, mobile apps, or digital displays. Feedback can include information on energy usage, energy-saving tips, and progress towards energy reduction goals. By providing occupants with real-time information about their energy consumption and the impact of their energy-saving behaviours, feedback can increase awareness and motivation to reduce energy use.

Goal setting – Goals can be set for individual occupants, teams, or entire buildings, depending on the scale of the initiative. For example, an individual occupant might set a goal to turn off all lights and unplug electronics when leaving the office, while a team might set a goal to reduce the overall energy consumption of their floor by 10% over the course of a month.
Challenges – Challenges can be given to the participants, with an increase in the difficulties in achieving the energy-saving goals. Set a goal for the building to reduce its energy consumption by a certain percentage over a specified period. Different energy-saving goals can be given to the building users, such as a reduction of energy use by 5%, 10%, 15%, etc.

Level – Set different levels of achievements for building users to unlock; this may coincide with challenges. Set incremental goals for reducing energy consumption in the building over time. For example, the first level could be to reduce energy consumption by 5%, the second level by 10%, and so on.

Collaboration – Allow group activities where collaboration in achieving energy-saving goals can be conducted. Collaborative initiatives can provide opportunities for building occupants to learn from each other, work together towards common goals, and share in the rewards of energy conservation. Encourage building occupants to share energy-saving tips and strategies with each other through a peer-to-peer sharing platform. This platform can be an online platform or a physical bulletin board where occupants can share their ideas and experiences.

Competition – Create a competitive environment through competition activities between individuals or groups. Organize energy reduction competitions between different departments or floors of the building. These competitions can include challenges to see who can reduce energy consumption the most or who can achieve the highest level of energy savings.

Rewards – Provide tangible rewards (e.g., cash, vouchers, prizes) to participants for completing the tasks. By offering rewards to building occupants who demonstrate energy conservation behaviour, it can create a sense of motivation and recognition.

Progress bar – Create a progress bar to indicate the overall progress of building users in achieving the ultimate energy-saving goal. A progress bar with poor, good, and excellent indicators can be displayed on the official website to indicate the performance progress of building users in doing energy conservation.

Discussion platform – Create a discussion platform to encourage participants to discuss energy-saving and problem-solving strategies. Building occupants can use the discussion platform to share tips and best practices for reducing energy consumption. This discussion platform can create a sense of community and shared responsibility for energy conservation.

Dashboard – Create a corner on a notice board or a publicly accessible platform to serve as a dashboard, displaying energy-related information and knowledge to participants. Setting up an information corner in a publicly accessible area within buildings can help inform building users about the latest energy-related information or energy conservation tips.

Social influence – Appoint ambassadors or influencers to lead the participants in energy saving by example. In the building, the management may appoint a few ambassadors among the building users to plan energy conservation strategies and lead their team in implementing these strategies. Those ambassadors will serve as role models, positively influencing other users to conserve energy.

Support – Develop a support team to monitor user progress and performance, and provide support to participants as needed, encouraging them to save energy. By providing necessary support to building users, they may feel more empowered to adopt energy-saving behaviours and motivated to reduce their energy usage.

Social networking – Building an online community where building users can share tips, experiences, and success stories related to energy conservation can create a sense of social support and motivation for energy-saving behaviours. Creating a social networking platform, similar to a WhatsApp or Facebook group, can help gather all users on the same platform and keep them connected.

Storyline – Design and create a series of sequenced tasks to lead the participants in achieving a targeted goal. It is believed that in a building, there might be users who are not aware of energy usage information and are not actively practicing energy conservation. In such circumstances, instead of setting a big energy-saving goal for them to achieve, they could be led by energy conservation ambassadors to practice energy conservation by telling them which task to start with and what task to do next.

Choice - Offer participants more options for energy conservation, rather than limiting them to specific actions. By offering building users a choice in how they want to conserve energy, they can feel more empowered and invested in their efforts. For example, offering different energy-saving options such as turning off lights when leaving a room, setting thermostats to a certain temperature, and using energy-efficient appliances can give building users a sense of control over their energy usage.

Last but not least, it is worth noting that the setting of game design elements is subjective and changeable based on the creativity of the implementer. The designation and presentation of each game design element depend on the implementer's preferences and suitability for the targeted building's energy users. Implementers may base their selection and design of game elements on their understanding and observations of the target group to motivate energy conservation behaviour among the building energy users.

CONCLUSION AND RECOMMENDATION

This study aims to review the application of gamification in fostering behavioural change among people from different contexts and propose a variety of game design elements that could be adopted for fostering energy conservation behaviour among building energy users. Overall, the findings indicate that the application of gamification in the physical setting for energy conservation is uncommon and therefore support exploration in this field. This review proposes a list of game design elements that can be considered for motivating energy conservation behaviour among building energy users, and the proposed game design elements in this paper are identified from empirical studies. There is no fixed design or presentation style for every game design element within a gamification application because it is always subject to the design and presentation preferences of the implementers, as long as the game design element serves its intended function within the application.

This review offers stakeholders an insight into a promising new approach for fostering energy conservation behaviour among building energy users. Most existing energy–saving initiatives, such as energy-saving campaigns, are information-intensive and less motivating for energy users to adopt energy conservation practices. The behavioural change intervention of gamification may then help to motivate the action from

energy users. Adding game design elements to energy-saving activities can create an enjoyable environment for participants, thereby enhancing their engagement in energy conservation behaviour.

This literature review has limitations. First, only two databases—Web of Science and SCOPUS—are used; thus, eligible papers from other databases might have been overlooked. Further, the findings of this review were limited by the search terms used, where behavioural change is the area of study interest and adopted as the key term for searching. Thus, further reviews should include additional databases for data collection and expand the search terms to other relevant terms such as 'engagement' and 'motivation'.

For future research, it may also be worthwhile to conduct an experimental study to examine the effects of setting the game design elements in fostering energy conservation behaviour among building energy users. Although gamification has the potential to make the behavioural fostering process more meaningful, it is possible that the design and setting of the game elements must be different for different target groups. Future researchers could build upon the list of game design elements suggested in this review to explore the design of game elements for different building energy users.

ACKNOWLEDGEMENT

The author acknowledges the Fundamental Research Grant Scheme (FRGS), grant number FRGS/1/2023/SS10/UTM/02/3, funded by the Ministry of Higher Education (MOHE), Malaysia, and part of this research is supported by the UTM Encouragement Research, grant number Q.J130000.3852.31J22 University Technology Malaysia.

REFERENCES

1. Abrahamse, W., Steg, L., Vlek, C., and Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. Journal of Environmental Psychology, 25(3), 273 – 291.
2. Attali, Y., and Arieli-Attali, M. (2015). Gamification in assessment: Do points affect test performance?. Computers & Education, 83, 57 – 63.
3. Betts, B. W., Bal, J., and Betts, A. W. (2013). Gamification as a tool for increasing the depth of student understanding using a collaborative e-learning environment. International Journal of Continuing Engineering Education and Life Long Learning, 23(3), 213 – 228.
4. Berger, V. (2019). Social norm-based gamification to promote eco-friendly food choice. Journal of Consumer Marketing, 36(5), 666 – 676.
5. De-Marcos, L., Domínguez, A., Saenz-de-Navarrete, J., & Pagés, C. (2014). An empirical study comparing gamification and social networking on e-learning. Computers & education, 75, 82-91.
6. Deterding, S., Khaled, R., Nacke, L. E., and Dixon, D. (2011). Gamification: Toward a definition. In CHI 2011 Gamification Workshop Proceedings. Canada.
7. Ferron, M., Loria, E., Marconi, A., & Massa, P. (2019). Play&Go, an urban game promoting behavioural change for sustainable mobility. Interaction Des. Archit. J., (40), 24-25.
8. Fitz-Walter, Z., Tjondronegoro, D., & Wyeth, P. (2011, November). Orientation passport: using gamification to engage university students. In Proceedings of the 23rd Australian computer-human interaction conference (pp. 122-125).
9. Fu, L., Sun, Z., Zha, L., Liu, F., He, L., Sun, X., & Jing, X. (2020). Environmental awareness and pro-environmental behaviour within china's road freight transportation industry: Moderating role of perceived policy effectiveness. Journal of Cleaner Production, 252, 119796.
10. Gandhi, P., & Brager, G. S. (2016). Commercial office plug load energy consumption trends and the role of occupant behaviour. Energy and Buildings, 125, 1-8.
11. Groh, F. (2012). Gamification: State of the art definition and utilization. Proceedings of the 4th Seminar on Research Trends in Media Informatics 2012, 39 – 46.
12. Hamari, J. (2013). Transforming homo economicus into homo ludens: A field experiment on gamification in a utilitarian peer-to-peer trading service. Electronic Commerce Research and Applications, 12, 236 – 245.

13. Hartungi, R., and Jiang, L. (2012). Energy efficiency and conservation in an office building: A case study. International Journal of Energy Sector Management, 6(2), 175 – 188.
14. Tang, Z., Warkentin, M., & Wu, L. (2019). Understanding employees' energy saving behaviour from the perspective of stimulus-organism-responses. Resources, Conservation and Recycling, 140, 216-223.
15. Haruna, H., Hu, X., Chu, S. K. W., Mellecker, R. R., Gabriel, G., & Ndekao, P. S. (2018). Improving sexual health education programs for adolescent students through game-based learning and gamification. International journal of environmental research and public health, 15(9), 2027.
16. Herzig, P., Strahringer, S., & Ameling, M. (2012). Gamification of ERP systems-Exploring gamification effects on user acceptance constructs. In Multikonferenz Wirtschaftsinformatik (pp. 793-804). GITO Braunschweig.
17. Hu, H., Fang, W., & Yu, X. (2020). Enhancing individual commitment to energy conservation in organizational settings: Identity manipulation for behavioural changes. Resources, Conservation and Recycling, 156, 104720.
18. Huang, S., Scurati, G. W., Elzeney, M., Li, Y., Lin, X., Ferrise, F., & Bordegoni, M. (2019, July). AIM: an interactive ashtray to support behaviour change through gamification. In Proceedings of the design society: international conference on engineering design (Vol. 1, No. 1, pp. 3811-3820). Cambridge University Press.
19. Iria, J., Fonseca, N., Cassola, F., Barbosa, A., Soares, F., & Coelho, A. (2020). A gamification platform to foster energy efficiency in office buildings. Energy and Buildings, 110101.
20. Ismail, M. I., Bakar, N. A. A., & Mohamed, M. (2019). Assessment and Modulation of Student Behaviour Through Persuasive Design. Asian Journal of University Education, 15(3), 117-128.
21. Iweka, O., Liu, S., Shukla, A., & Yan, D. (2019). Energy and behaviour at home: a review of intervention methods and practices. Energy Research & Social Science, 57, 101238.
22. Johnson, D., Horton, E., Mulcahy, R., & Foth, M. (2017). Gamification and serious games within the domain of domestic energy consumption: A systematic review. Renewable and Sustainable Energy Reviews, 73, 249-264.
23. Kelders, S. M., Sommers-Spijkerman, M., & Goldberg, J. (2018). Investigating the direct impact of a gamified versus nongamified well-being intervention: an exploratory experiment. Journal of medical Internet research, 20(7), e247.
24. Kofi Adom, P., Bekoe, W., Amuakwa-Mensah, F., Mensah, J. T., and Botchway, E. (2012). Carbon dioxide emissions, economic growth, industrial structure, and technical efficiency: Empirical evidence from Ghana, Senegal, and Morocco on the causal dynamics. Energy, 47(1), 314 – 325.
25. Kok, G., Lo, S. H., Peters, G.-J. Y., and Ruiter, R. a. C. (2011). Changing energy-related behaviour: An intervention mapping approach. Energy Policy, 39(9), 5280 – 5286.
26. Kong, L., Hasanbeigi, A., Price, L., & Liu, H. (2017). Energy conservation and CO2 mitigation potentials in the Chinese pulp and paper industry. Resources, Conservation and Recycling, 117, 74-84.
27. Landers, R. N., & Landers, A. K. (2014). An empirical test of the theory of gamified learning: The effect of leaderboards on time-on-task and academic performance. Simulation & Gaming, 45(6), 769-785.
28. Lessel, P., Altmeyer, M., & Krüger, A. (2015, April). Analysis of recycling capabilities of individuals and crowds to encourage and educate people to separate their garbage playfully. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (pp. 1095-1104).
29. Li, D., Menassa, C. C., & Karatas, A. (2017). Energy use behaviours in buildings: Towards an integrated conceptual framework. Energy Research & Social Science, 23, 97-112.
30. Li, D., Xu, X., Chen, C. F., & Menassa, C. (2019). Understanding energy-saving behaviours in the American workplace: A unified theory of motivation, opportunity, and ability. Energy Research & Social Science, 51, 198-209.
31. Li, J., Zhang, D., & Su, B. (2019). The impact of social awareness and lifestyles on household carbon emissions in China. Ecological Economics, 160, 145-155.
32. Lopes, M. A. R., Antunes, C. H., & Martins, N. (2012). Energy behaviours as promoters of energy efficiency: A 21st century review. Renewable and Sustainable Energy Reviews, 16(6), 4095-4104.
33. Low, S. T., Hakim. A., Choong, W. W., & Alias, B. (2010). Facilities management: Paths of Malaysia to achieve energy sustainability. International Journal of Facility Management, 1(2).

34. Lowensteyn, I., Berberian, V., Berger, C., Da Costa, D., Joseph, L., & Grover, S. A. (2019). The Sustainability of a Workplace Wellness Program That Incorporates Gamification Principles: Participant Engagement and Health Benefits After 2 Years. American Journal of Health Promotion, 33(6), 850-858.
35. Luo, Y., Lundström, A., Comber, R., & Bogdan, C. (2019). Gaming at Work to Save Energy-Learnings from Workers Playing a Cooperative Game. In ICT4S.
36. McKay, S., and Khare, A. (2004). Awareness development for an energy management program for social housing in Canada. Energy and buildings, 36(3), 237 – 250.
37. McKenzie-Mohr, D. (2000). New ways to promote PR environmental behaviour: Promoting sustainable behaviour: An introduction to community-based social marketing. Journal of Social Issues, 56(3), 543 – 554.
38. McKeown, S., Krause, C., Shergill, M., Siu, A., & Sweet, D. (2016, March). Gamification as a strategy to engage and motivate clinicians to improve care. In Healthcare management forum (Vol. 29, No. 2, pp. 67-73). Sage CA: Los Angeles, CA: SAGE Publications.
39. Meder, M., Plumbaum, T., Raczkowski, A., Jain, B., & Albayrak, S. (2018, October). Gamification in E-Commerce: Tangible vs. Intangible Rewards. In Proceedings of the 22nd International Academic Mindtrek Conference (pp. 11-19).
40. Millonig, A., Wunsch, M., Stibe, A., Seer, S., Dai, C., Schechtner, K., & Chin, R. C. (2016). Gamification and social dynamics behind corporate cycling campaigns. Transportation research procedia, 19, 33-39.
41. Mitchell, R., Schuster, L., & Drennan, J. (2017). Understanding how gamification influences behaviour in social marketing. Australasian Marketing Journal (AMJ), 25(1), 12-19.
42. Morganti, L., Pallavicini, F., Cadel, E., Candelieri, A., Archetti, F., & Mantovani, F. (2017). Gaming for Earth: Serious games and gamification to engage consumers in pro-environmental behaviours for energy efficiency. Energy Research & Social Science, 29, 95-102.
43. O'Donovan, S., Gain, J., & Marais, P. (2013, October). A case study in the gamification of a university-level games development course. In Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference (pp. 242-251).
44. Ouyang, J., Gao, L. L., Yan, Y., Hokao, K., and Ge, J. (2009). Effects of improved consumer behaviour on energy conservation in the urban residential sector of Hangzhou, China. Journal of Asian Architecture and Building Engineering, 8(1), 243 – 249.
45. Pasini, D., Reda, F., & Häkkinen, T. (2017). User engaging practices for energy saving in buildings: Critical review and new enhanced procedure. Energy and Buildings, 148, 74-88.
46. Patel, M. S., Small, D. S., Harrison, J. D., Fortunato, M. P., Oon, A. L., Rareshide, C. A., ... & Kalra, P. (2019). Effectiveness of behaviourally designed gamification interventions with social incentives for increasing physical activity among overweight and obese adults across the United States: the STEP UP randomized clinical trial. JAMA Internal Medicine, 179(12), 1624-1632.
47. Patel, M. S., Benjamin, E. J., Volpp, K. G., Fox, C. S., Small, D. S., Massaro, J. M., ... & Manders, E. S. (2017). Effect of a game-based intervention designed to enhance social incentives to increase physical activity among families: the BE FIT randomized clinical trial. JAMA internal medicine, 177(11), 1586-1593.
48. Ro, M., Brauer, M., Kuntz, K., Shukla, R., & Bensch, I. (2017). Making Cool Choices for sustainability: Testing the effectiveness of a game-based approach to promoting pro-environmental behaviors. Journal of Environmental Psychology, 53, 20-30.
49. Ryan, J., Edney, S., & Maher, C. (2017). Engagement, compliance and retention with a gamified online social networking physical activity intervention. Translational behavioural medicine, 7(4), 702-708.
50. San, V., Sriv, T., Spoann, V., Var, S., and Seak, S. (2012). Economic and environmental costs of rural household energy consumption structures in Sameakki Meanchey district, Kampong Chhnang Province, Cambodia. Energy, 48(1), 484 – 491.
51. Schacht, M. and Schacht, S. (2012). Start the game: Increasing user experience of enterprise systems following a gamification mechanism. A. Maedche, A. Botzenhardt, & L. Nee.(Eds.) Software for People, Management for Professionals (pp. 181–199). Springer Berlin Heidelberg.
52. Shameli, A., Althoff, T., Saberi, A., & Leskovec, J. (2017, April). How gamification affects physical activity: Large-scale analysis of walking challenges in a mobile application. In Proceedings of the 26th international conference on world wide web companion (pp. 455-463).

53. Sheth, S. K., Bell, J. S., and Kaiser, G. E. (2012). Increasing student engagement in software engineering with gamification. Columbia University Computer Science Technical Reports.
54. Simoes, J., Redondo, R. D., and Vilas, A. F. (2013). A social gamification framework for a K-6 learning platform. Computers in Human Behaviour, 29, 345 – 353.
55. Silva, R., Rodrigues, R., & Leal, C. (2020). Gamification in management education-A literature mapping. Education and Information Technologies, 25(3), 1803-1835.
56. Singh, S., and Bajpai, U. (2010). Integrated energy planning for sustainable development in rural areas: A case study from Eastern Uttar Pradesh. International Journal of Energy and Environment, 1(6), 1083 – 1096.
57. Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. Journal of Business Research, 104, 333-339.
58. Thom, J., Millen, D., & DiMicco, J. (2012, February). Removing gamification from an enterprise SNS. In Proceedings of the acm 2012 conference on computer supported cooperative work (pp. 1067-1070).
59. Visch, V., Vegt, N., Anderiesen, H., and van der Kooij, K. (2013). Persuasive game design: A model and its definitions. In CHI 2013, Changing Perspective. Paris, France.
60. Wemyss, D., Cellina, F., Lobsiger-Kägi, E., De Luca, V., & Castri, R. (2019). Does it last? Long-term impacts of an app-based behaviour change intervention on household electricity savings in Switzerland. Energy Research & Social Science, 47, 16-27.
61. Wemyss, D., Castri, R., Cellina, F., De Luca, V., Lobsiger-Kägi, E., & Carabias, V. (2018). Examining community-level collaborative vs. competitive approaches to enhance household electricity-saving behaviour. Energy Efficiency, 11(8), 2057-2075.
62. Witt, M., Scheiner, C. W., & Robra-Bissantz, S. (2011, October). Gamification of online idea competitions: insights from an explorative case. In GI-Jahrestagung (p. 392).
63. Xu, Q., Lu, Y., Hwang, B. G., & Kua, H. W. (2021). Reducing residential energy consumption through a marketized behavioural intervention: The approach of Household Energy Saving Option (HESO). Energy and Buildings, 232, 110621.
64. Zichermann, G., and Cunningham, C. (2011). Gamification by design: Implementing game mechanics in web and mobile apps. Canada: O'Reilly Media.
65. Zuckerman, O., & Gal-Oz, A. (2014). Deconstructing gamification: evaluating the effectiveness of continuous measurement, virtual rewards, and social comparison for promoting physical activity. Personal and ubiquitous computing, 18(7), 1705-1719.