Development of Energy Saving Application through Gamification-Factors: A Systematic Review

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ARTICLE INFO	ABSTRACT
	Multiple approaches can be applied to raise the awareness about energy conservation, especially when engaging the younger generation. To date, there is a lack of a comprehensive review on the development of energy-saving applications through a gamification approach among undergraduate students. Thus, this study aims to systematically review the factors that influence the development of energy-saving applications using the PRISMA framework. The works of literature assessed in the study are indexed by Scopus, Mendeley and ERIC databases. This paper reviewed the related studies done by previous researchers related to the energy saving factors and how the application through gamification would impact the learners. Three themes are discussed in the current work: the awareness of energy saving, the effectiveness of the gamification application towards energy and behaviour among undergraduate students towards energy saving.

1. Introduction

Gamification is a technique for encouraging users to use a programme consistently, often over an extended period, as they perceive the value in the incentives [1]. Malaysia stands as a significant consumer of energy. Like most developing countries, Malaysia has experienced economic growth. However, the gross domestic product (GDP) volumes and energy demand are directly correlated since economic growth increases energy use. Blohm and Leimeister [2] suggested that "gamification attempts to influence user behaviour by activating individual motives via game-design elements".

Energy efficiency should be introduced in educational institutions, with a notable emphasis on preschool children who exhibit a considerable capacity for fostering energy-saving habits during their early years [3-8]. Education is a crucial tool for influencing human behaviour, and customers worldwide are demonstrating a deeper concern about the environment and sustainability. This trend can be evidenced by the increasing number of businesses devoted to promoting sustainability in their

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supply chains [9,10]. By influencing customers' behaviour to achieve ongoing energy savings and promoting supportable designs, energy consumption can be dramatically decreased [4,7,11-13].

The rationale of this study is to discover user-centred design prospects for linking gamification to cultivate energy-saving behaviour [14]. The initial findings substantiate the importance of investing in gaming for household energy efficiency. Moreover, these studies also presented favourable concepts and strategies that can be integrated into developing future serious game initiatives to enhance their effectiveness. The application of gamification could encourage energy conservation behaviour in house occupants is an emerging field of research [2,6,8,15-18]. In previous studies, energy-efficient appliances and the production of renewable energy have been promoted due to mounting environmental problems, including the depletion of energy resources and global warming. The problem can be addressed using an evolutionary game. The results show that a pertinent policy is more effective than a mere subsidy in encouraging traditional energy providers to turn green [19]. The policy also enables governments to address attainable objectives [3,20].

According to the research, imitating existing behaviours in designing energy-related appliances is important to impact the users' motivation towards energy conservation. Due to that, the following research question is established: what factors could influence the development of energy-saving applications through gamification among undergraduate students? The development of this product could inspire energy-saving behaviour among them, setting a standard for developing an effective gamification application that promotes energy conservation.

2. Methodology

This part addresses the necessity for a systematic investigation of the energy-saving and gamification strategy among undergraduate students. This systematic review comprises four key phases: identification, screening, eligibility, and data abstraction and analysis. The pre-recording systematic reviews and meta-analysis (PRISMA) approach has been chosen for this analysis as a distributed standard for conducting a systematic literature review. In general, publication standards are required to evaluate the relevance and rigours of a review. All the phases are elucidated in the subsections as follows.

2.1 Step 1 - Identification

Selecting relevant published works for the systematic review was done using three main steps. The first step is keyword detection, which may involve exploring related and comparable terms using the thesaurus, dictionaries, encyclopedias, and prior research. After selecting all relevant terms, search strings for the Scopus, ERIC, and Mendeley databases were produced. These three databases (Table 1) were chosen since they were the only top three databases with the bulk of linked articles based on the keyword searching criterion. The current research endeavour effectively retrieves 762 papers from three databases in the initial stage of the systematic review process.

Table 1
The search strings

Scopus	TITLE-ABS-KEY ((gamification OR game*) AND "energy saving" AND behaviour) AND (LIMIT-TO (PUBSTAGE, "final")) AND (LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020)) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (SRCTYPE, "j"))
ERIC	https://eric.ed.gov/?q=(gamification++OR++game*)++AND++%22energy+saving%22++AND++behavior)+&ff1=pubJournal+Articles&ff2=dtySince_2021
Mendeley	(Gamification OR game*) AND "energy saving" AND behaviour) https://www.mendeley.com/search/?page=1&publicationType=journal&publicationYear=2021|2020&query=gamification%20AND%20energy%20saving%20AND%20behaviour&sortBy=relevance (Gamification AND energy saving AND behaviour)

2.2 Step 2 - Screening

Upon screening, duplicated papers will be removed at the preliminary stage. At this stage, 386 articles have been screened based on the requirements listed in Table 2. Every article's titles and main points were meticulously examined to confirm that the inclusion criteria met and aligned with the research objectives. Literature (research articles) is the first criterion utilised because it is the primary source of useful guidance. Aside from the most recent research, it also covers systematic reviews, reviews, meta-synthesis, meta-analyses, books, book series, chapters, and conference proceedings. In addition, the review was restricted to works published in English. Moreover, only research undertaken in Malaysia was. Upon removing duplicated articles, only 386 remained for further examination.

Table 2
The selection criterion is searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline	2020-2022	< 2020
Literature type	Journal	Journal
Publication stage	final	final

2.3 Step 3 - Eligibility

In the third step, referred to as eligibility, 385 articles have been identified. All papers' titles and key content were thoroughly scrutinised, ensuring that the inclusion criteria were met and the research objectives were achieved. As a result, 369 articles were removed since the full-text version is unavailable. Finally, only 16 articles are eligible for further review (see Figure 1).
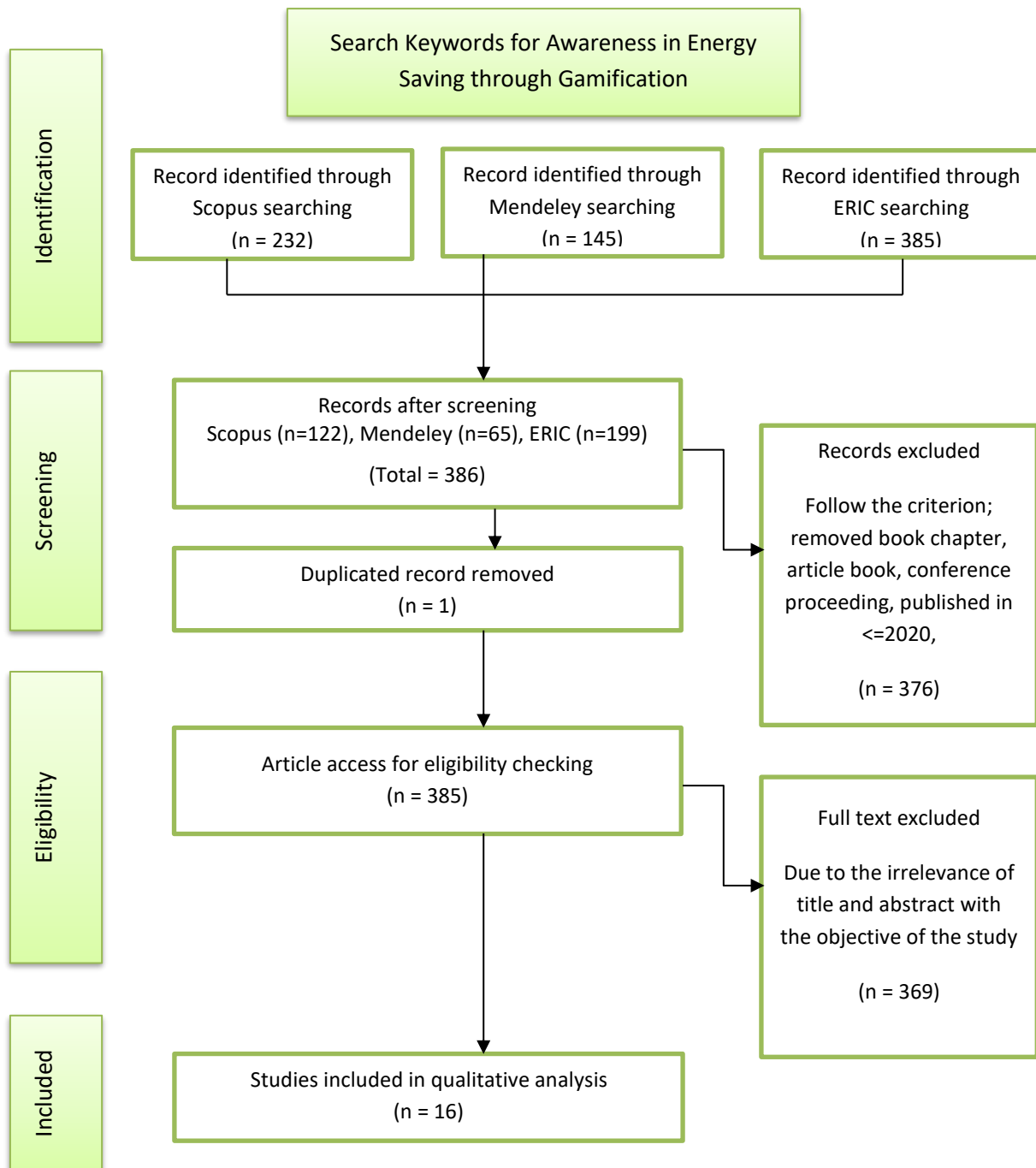
Fig. 1. Flow diagram of the proposed searching study [21]

3. Results

Based on the searching technique, 16 articles were extracted and analysed using Microsoft Excel, which can be seen in detail in Table 3. Based on the thematic analysis, three themes were developed: awareness of energy saving, the effectiveness of gamification towards energy and behaviour among tertiary students towards the energy saving application. The results can serve as an inspiration for initiating sustainable energy projects in underdeveloped nations. The intervention raised tenants' awareness and participation in specific energy-saving behaviours.

All articles were classified based on three core themes, which are: (1) awareness of energy saving (8 articles), the effectiveness of gamification application towards energy saving (13 articles), and behaviour among undergraduate students towards energy saving (13 articles).

Table 3
Summary of energy saving awareness, the effectiveness of gamification towards energy saving and behaviour among undergraduate students

Authors	Title	Year	Source Title	Themes
Safarzadeh *et al.,* [22]	Energy supply chain empowerment through tradable green and white certificates: A pathway to sustainable energy generation	2022	Applied Energy	Awareness Behaviour
Mattsson and Laike [23]	Young children's learning about lighting and turn-off behaviour in preschool environments	2022	Energy and Buildings	Effectiveness Behaviour
Wang *et al.,* [24]	Green Retrofitting Simulation for Sustainable Commercial Buildings in China Using a Proposed Multi-Agent Evolutionary Game	2022	Sustainability (Switzerland)	Awareness Behaviour
Thormann *et al.,* [25]	Stadium Travel and Subjective Well-Being of Football Spectators	2022	Sustainability (Switzerland)	Behaviour
Huang and Lin [26]	Evolutionary Game Analysis of Energy-Saving Renovations of Existing Rural Residential Buildings from the Perspective of Stakeholders	2022	Sustainability (Switzerland)	Effectiveness Behaviour
Chen *et al.,* [27]	Evolutionary game analysis on supply side of the implement shore-to-ship electricity	2021	Ocean and Coastal Management	Awareness Behaviour
Fijnheer *et al.,* [28]	Competition in a household energy conservation game	2021	Sustainability (Switzerland)	Effectiveness
Pietrapertosa *et al.,* [29]	An educational awareness program to reduce energy consumption in schools	2021	Journal of Cleaner Production	Awareness Effectiveness Behaviour
Casals *et al.,* [3]	Assessing the effectiveness of gamification in reducing domestic energy consumption: Lessons learned from the EnerGAware project	2020	Energy and Buildings	Awareness Effectiveness Behaviour
Hafner *et al.,* [4]	Results and insight gained from applying the energycat energy-saving serious game in UK social housing	2020	International Journal of Serious Games	Awareness Behaviour
Mulcahy *et al.,* [9]	Designing gamified apps for sustainable consumption: A field study	2020	Journal of Business Research	Effectiveness
Böckle *et al.,* [11]	Exploring gamified persuasive system design for energy saving	2020	Journal of Enterprise Information Management	Effectiveness Behaviour

Kaselofsky *et al.,* [30]	Top Energy Saver of the Year: Results of an Energy Saving Competition in Public Buildings	2020	Environmental and Climate Technologies	Awareness
Chen *et al.,* [31]	Energy-saving and pricing decisions in a sustainable supply chain considering behavioural concerns	2020	PLoS ONE	Behaviour
Kotsopoulos *et al.,* [32]	User-centered gamification: The case of IoT-enabled energy conservation at work	2020	International Journal of E-Services and Mobile Applications	Effectiveness Behaviour
Hafner *et al.,* [33]	Energy use in social housing residents in the UK and recommendations for developing energy behaviour change interventions	2020	Journal of Cleaner Production	Awareness Behaviour

Following the interview sessions conducted with seven (7) respondents, all the transcribed data were categorised based on the three main themes: (1) awareness of energy saving (8 articles), secondly, (2) the effectiveness of gamification application towards energy saving (13 articles), and (3) the behaviour among undergraduates' students towards the energy saving (13 articles). The three themes were selected based on respondents' agreement frequency during the interview sessions and their repetition of terms.

3.1 Awareness of the Energy-Saving Application

The study has revealed that students' perception of managing energy requirements in hostels or other premises is influenced by their trust in renewable energy providers. The trust will also impact their energy awareness and willingness to enhance their knowledge in this field. The current generation is always in rivalry with ecological development in the energy sector. The competition among schools to decrease energy consumption (referred to as the School Race) based on a shared Energy Charter can employ gamification as an alternative approach to promote education in energy-saving (Play4energy) [13,19]. In science and its practical applications, paying greater attention to the upcoming expansion in the energy division is vital. The findings are doubtful, suggesting a lack of understanding, insufficient knowledge, and limited awareness of environmental issues. Providing subsidies can encourage rural residents to participate proactively in energy-saving renovations of their homes [19,34]. The boiler's operating efficiency can be enhanced by minimising waste heat resources [35]. Moreover, psychological barriers (such as a lack of awareness of the issue) also dampened the motivation of some residents to engage in energy-conserving activities [33,36]. Nurturing a strong sense of environmental consciousness and a desire for energy-saving knowledge is essential among individuals responsible for household management. The Internet of Things facilitates a deeper understanding and greater engagement of users in managing domestic energy, resulting in heightened awareness and education among senior clients.

3.2 Effectiveness of Gamification Application Towards Energy Saving

Adopting existing monitoring techniques and tools as the basis for novel educational approaches is appropriate to be applied in universities and businesses. Gamification has recently been used to enhance individual clients' engagement with specific energy systems. The effectiveness of

gamification relies on both the users' feedback and non-game contextual features [37]. Designing persuasive energy conservation applications can derive benefits from using HEXAD gamification user types [11,15,38]. Employees' demand for rewards and connection is the primary motivation for engaging in gamification in the workplace [17,39]. An application that generates individualised messages, probably coupled with gamified interference, is recommended in the games. The guidelines for further adopting gamification in practical applications in universities and organisations shall be scrutinised before implementation. In general, the study can guide future researchers and practitioners who wish to outline successful user-oriented gamified interventions [29,40,41]. Figol *et al.*, [42] reported that gamification could also be applied to inspect the behaviour of specific crowds of people. The effectiveness of the application of game design can be substantiated via social housing involving a longitudinal, "two-stage experimental design, employing both pre-post and control group approaches" [43]. Gamification is applied wherever a game or valuable element is commenced. Gamification technologies are a great method to interact with university students. Students who utilise these resources will experience genuine satisfaction upon accomplishing competitive tasks grounded in the principles they learned from these games. The game-like apps encourage energy-saving behaviours, which saves much money [39,44].

3.3 Behaviour among Tertiary Students towards the Energy Saving and Gamification Application

Behavioural transformation in energy-saving involvements is gaining recognition as a vital process for supporting environmental campaigns in campus residences. It is potentially more important to focus on behavioural changes rather than imparting technical knowledge, especially at higher education institutions, to ensure the success of sustainability campaigns. Since gamification aims to change audience behaviour thoroughly, it is widely used to increase the effectiveness of audience involvement in various practices. Gamification is a powerful means of affecting human behaviour [1,8,10,43,45,46]. The study by Trotta [10] precisely connects the level of involvement in environmental campaigns with the residents' behaviour, and, notably, when the involvement is visualised graphically, it inspires active participation from students and residents. Three distinct outcomes, including traditional electricity generation, the energy efficiency programme (EEP), and renewable portfolio regulations, are used to evaluate the providers' behaviour (RPSs). Although some can claim their support for sustainability, they do not necessarily putting the proclamation into action. However, it was discovered that the games could encourage learning about lighting and lighting use, even if the games had no significant impact on behaviour [10,41]. An energy-saving behaviour showed no significant effect [10,47]. In a nutshell, fostering volunteered commitments, establishing collective goals, and undertaking all necessary actions are critical for realising the aspiration of preserving the environment.

4. Conclusions

This study used multiple databases, namely Scopus, Mendeley, and ERIC database, which produced 16 articles that conform to research questions adapted to the Boolean search. The results indicated three themes: awareness of energy saving, the effectiveness of gamification application towards energy and behaviour among undergraduate students towards energy saving. The findings reported that an average electricity saving of 3.46% and an average gas saving of 7.48% were achieved due to the intervention, which also boosted tenants' awareness of and engagement in key energy-saving behaviours. In conclusion, it can be anticipated that gamifying energy-saving initiatives can increase green awareness among tertiary-level learners in the future. Moreover, life-cycle

aspects must be considered in the product designs to encourage energy saving and promote green renovation. For further research, data from the other research databases can be referred to apart from the existing database used in the current study and the development of the application or games will be developed for the good impact among tertiary students since this group of students are practicing with the situation and to create awareness of energy saving in Malaysia.

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Conflicts of Interest: The authors declare no conflicts of interest to report regarding the present study.

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