Gamification impact on tourists’ pro-sustainability intentions: integration of technology acceptance model (TAM) and the theory of planned behaviour (TPB)

Mahmoud Abou Kamar, Azza Maher, Islam Elbayoumi Salem and Ahmed Mohamed Elbaz

Abstract
Purpose – This study used an integrated model that incorporates the Technology Acceptance Model (TAM) and the Theory of Planned Behaviour (TPB) to empirically investigate how eco-gamification stimulates users’ sustainability knowledge and, consequently, their pro-sustainable intentions through the mediating roles of sustainable knowledge and psychological and social norms. Thus, the study aims to examine users’ experiences with the JouleBug app, which is designed to encourage users to complete at least one daily green task.

Design/methodology/approach – After a trial period of two weeks, a total of 360 participants completed the post-game survey during the research process.

Findings – The findings from the structural equation modeling and data analysis indicated a good fit for the model. The findings demonstrate that usefulness, ease of use and enjoyment of eco-gamification enrich users’ sustainability knowledge, which, in turn, strongly influences their pro-sustainable intentions. According to the findings, the three factors of TPB have a significant impact on users’ pro-sustainability intentions. Both sustainable knowledge and social cues play mediating roles in such relationships.

Practical implications – This study advocates that eco-gamification can be used as a platform to modify tourists’ pro-sustainability intentions in emerging tourism and technology destinations such as Egypt. Hence, this study offers significant information to tourism planners and other stakeholders on tourists’ behavioural intentions.

Originality/value – This study examined the effectiveness of an integrated model of TAM and TBP in predicting tourists’ intentions to use eco-gamification to improve the sustainability of tourist destinations.

Keywords Eco-gamification, Technology acceptance model, Theory of planned behaviour

Pro-sustainable intentions, Egypt

Paper type Research paper

Gamification对游客支持可持续发展意愿的影响：技术接受模型（TAM）和计划行为理论（TPB）的整合

摘要：本研究采用结合技术接受模型（TAM）和计划行为理论（TPB）的综合模型，旨在探究生态游戏化如何提升用户对可持续性的认知，从而影响他们支持环保行为的意愿。通过研究可持续性知识以及心理和社会规范在其中的中介作用来实现这一目标。因此，本研究调查了用户使用JouleBug应用程序的体验，该应用程序旨在鼓励用户每天完成至少一个环保任务。

设计/方法/步骤：在为期两周转的试验期后，共有360名参与者在研究过程中完成了后测问卷调查。

研究结果：通过结构方程模型和数据分析，研究结果表明模型拟合良好。研究发现，生态游戏化的实用性、易用性和乐趣能够丰富用户可持续性知识，从而强烈影响他们支持可持续性的意愿。研究结果还显示，计划行为理论（TPB）的三个因素对用户的支持可持续性意愿有显著影响。可持续性知识和社会提示在这些关系中发挥着中介作用。

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Dr Islam Elbayoumi Salem – Corresponding author, Conceptualisation, Methodology, Critical revision of the article. Final approval of the version to be published.
Dr Ahmed Mohamed Elbaz – Conceptualisation, Data analysis and interpretation, Drafting the article, Data curation.

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TOURISM REVIEW
1. Introduction

Sustainability of tourist destinations is a key objective in tourism development (Pulido-Fernández et al., 2019). Experts are working to find solutions for the negative effects of tourism (Becken et al., 2020; Alonso-Muñoz et al., 2022). Using advanced technologies to promote sustainable behaviours can help reduce the negative effects of tourism (Frias-Jamilena et al., 2022). Gamification is a technology that helps users learn through experience instead of relying on data (Lu and Ho, 2020). Gamification uses game elements in non-gaming situations to enhance user experiences and commitment (Huber and Hilty, 2015). Indeed, these games can produce positive psychological and behavioural effects (Koivisto and Hamari, 2019) while also fostering intrinsic motivation and promoting a sense of relatedness, autonomy and competence (Pasca et al., 2021).

Gamification has been applied in different domains, including health care, finance, promotion, training, sports, commerce, education and customer relations (Koivisto and Hamari, 2019; Fernández-Ruano et al., 2022). The advancement and widespread use of technological advancements such as digital platforms and mobile technologies are enhancing the potential to apply gamification in the tourism industry (Buhais et al., 2019). Recent studies reiterate that a gamification is an effective approach to promoting eco-friendly behaviour (Casais and Ferreira, 2023; Xu et al., 2017), as it has been proven to
genuinely produce positive psychological and behavioural effects (Koivisto and Hamari, 2019; Pasca et al., 2021). Specifically, eco-gamification or green gamification provides tourist destinations with an opportunity to motivate tourists to engage in sustainable behaviour (Frias-Jamilena et al., 2022). Eco-gamification is based on the same principles as standard gamification, but with a focus on sustainability to make it an enjoyable, gratifying and meaningful experience (Nor and Azhar, 2017). As a result, green games have been developed to promote environmentally friendly activities and present real-life challenges aimed at reducing the negative impact on the environment’s well-being. These games prioritise the user’s experience and knowledge, encouraging them to participate in sustainability efforts, learn through practical application and receive rewards through incentive programmes (Chelliah et al., 2017).

Tourism research is interested in using intelligent technology, especially eco-gamification. Tung and Law (2017) mainly describe existing applications and speculate on their future effects. Research lacks evidence on whether eco-gamification positively impacts sustainability understanding. The link between sustainability knowledge and pro-sustainable intentions is unclear. Currently, eco-gamification’s impact on sustainability knowledge is still in the early stages (Koivisto and Hamari, 2019). Whittaker et al. (2021) suggest more research is needed on sustainability. It is important to study how eco-gamification can improve sustainability in tourist destinations.

Considering the potential significance of eco-gamification, this study was conducted in response to calls from Pasca et al. (2021) and Dolnicar (2023) to develop studies in various countries to explore the potential of gamified techniques in nudging ethical and sustainable practices in tourist destinations. Therefore, this study investigates the effects of eco-gamification on tourists’ pro-sustainability intentions in emerging markets like Egypt. Egypt’s tech industry is growing rapidly at a rate of 16.3% in 2021–2022, surpassing other sectors (Ministry of Communication and Information Technology, 2022). Tourism is growing quickly. Egypt had 11.7 million tourists in 2022, a 46.2% increase from 2021 (Ministry of Tourism and Antiques, Egypt, 2022).

Tourism growth emphasises the importance of supporting sustainable tourist destinations to achieve the UN SDGs by 2030, especially for sustainable cities and communities (SDG 11) and responsible production and consumption (SDG 12). Egypt is particularly vulnerable to climate change in the Middle East (Hall et al., 2022; Namdar et al., 2022; Viglia and Acuti, 2023). An empirical assessment of eco-gamification’s impact on tourism participation is crucial.

2. Study framework and hypotheses

The study combines theory of planned behaviour (TPB) (Ajzen, 2011) and technology acceptance model (TAM) (Davis, 1989) structures to look at how eco-gamification affects users’ knowledge and intentions about sustainability through the medium of users’ knowledge about sustainability and social cues. TAM consists of perceived usefulness and ease of use. TAM2 and TAM3 expanded the original TAM model to include external factors relevant to specific ICTs. Perceived enjoyment is considered a factor in future technology adoption studies (Huang et al., 2013). Enjoyment is a crucial factor in user intentions, as indicated by ICT analysis and eco-gamification apps (Lee et al., 2021). The model evaluates users’ acceptance of eco-gamification.

2.1 Eco-gamification acceptance and sustainable knowledge

2.1.1 The relationship between perceived usefulness and sustainable knowledge. Perceived usefulness is important in TAM studies. It is about an individual’s belief in the system’s ability to improve their job performance (Davis, 1989). Eco-gamification
encourages user participation in sustainability through interactive gaming features (Koivisto and Hamari, 2019). Prior research suggests that an app’s effectiveness is influenced by its usefulness, which impacts user familiarity and engagement (Aguir-Castillo et al., 2019). We argue that eco-gamification can improve users’ competency and engagement in providing assistive instructions and interactive information, enhancing utilitarian factors and increasing awareness of sustainability issues. The hypothesis is proposed:

\[ H1a. \text{The perceived usefulness of eco-gamification positively influences users’ sustainable knowledge.} \]

2.1.2 The relationship between perceived ease of use and sustainable knowledge.

According to Davis (1989), perceived ease of use is “the extent to which a person expects to incur no effort when using a system”. Previous studies have confirmed that perceived ease of use positively influences users’ acceptance of technology, engagement and loyalty (Calisir and Calisir, 2004). User experience is improved with an easy-to-use app (Rodrigues et al., 2016). We define ease of use as how easily users can adopt eco-gamification, including design elements that make the app user-friendly, educational, and efficient (e.g. 360° view, interactive graphics, assistance avatars, performance metrics and sustainability notifications). These design features reduce user effort, making the app easier to use compared to other simulation games (Rodrigues et al., 2016). Based on the discussion, the following hypothesis is proposed:

\[ H1b. \text{The perceived ease of use of eco-gamification positively influences users’ sustainable knowledge.} \]

2.1.3 The relationship between perceived enjoyment and sustainable knowledge.

Digital activities can impact users’ knowledge (Moon and Kim, 2001). The game’s visuals and user satisfaction are connected (Nguyen, 2015). According to Xu et al. (2017), eco-gamification may include challenges that allow users to engage with sustainability intricacies, leading to so-called “positive stress”. We argue that users are more likely to enjoy gaming if it allows them to share tasks with others who have similar interests. Therefore, the idea that users perceive eco-gamification as “enjoyable” or “fun” can create a sensation of psychological gain, which may be crucial to enabling continual or intense learning (Lee et al., 2021). Accordingly, the study suggests the following hypothesis:

\[ H1c. \text{The perceived enjoyment of using eco-gamification positively influences users’ sustainable knowledge.} \]

2.2 The influence of sustainability knowledge on users’ psychosocial and social cues

\textit{Sustainability knowledge} includes understanding facts, relationships, root causes of tourism challenges, and human accountability for sustainable development (Maichum et al., 2016). Empirical studies confirm the link between knowledge and sustainable behaviour (Chen and Wu, 2015; 2022; Chi et al., 2019). Maichum et al. (2016) found that people act knowledgeable about sustainability when they think others expect them to be sustainable. Kim (2015) showed that people’s choices in voluntary actions, like sustainable behaviours, are not only driven by self-interest. Sustainability knowledge promotes awareness, solutions and action. A positive attitude relies on sustainability knowledge, which encourages pro-sustainability behaviour (Kim et al., 2014). Increased knowledge can enhance individuals’ psychosocial and social drivers. The following hypotheses are made:

\[ H2a. \text{Sustainability knowledge positively influences users’ behavioural belief.} \]

\[ H2b. \text{Sustainability knowledge positively influences users’ normative belief.} \]

\[ H2c. \text{Sustainability knowledge positively influences users’ perceived behavioural control.} \]
2.3 Psychosocial and social cues and pro-sustainability intentions

2.3.1 The relationship between behavioural belief and pro-sustainable intentions. Attitude predicts behaviour, and behavioural beliefs reflect individuals’ views of their behaviour. Studies suggest that attitude influences behavioural intention (Hamid and Bano, 2021). Tsen et al. (2006) found that customers’ beliefs affect their decision to buy eco-friendly products. Other studies (Tasci et al., 2022) related behavioural belief to energy conservation in the workplace. Based on this, by examining the behavioural belief of users towards sustainability, it is possible to predict their pro-sustainability intentions. Therefore, the following hypothesis can be drawn:

\[ H3a. \] Users’ pro-sustainable intentions are positively influenced by their behavioural belief.

2.3.2 The relationship between normative belief and pro-sustainable intentions. Subjective norm is the perception of social pressure on behaviour (Chi et al., 2019). This pressure may come from the community, family or friends (Teng et al., 2015). Previous studies have found that normative belief positively affects green product purchase intention, green hotel selection, organic food consumption and pro-sustainability behaviours (Chen and Tung, 2014; Kim and Han, 2010; Dean et al., 2012). A recent study conducted by Schönherr and Pikkemaat (2023) has revealed that environmental attitudes can be influenced by factors such as social pressure, social media and the COVID-19 pandemic. Thus, we propose that:

\[ H3b. \] Users’ pro-sustainable intentions are influenced by their normative belief.

2.3.3 The relationship between control belief and pro-sustainable intentions. Perceived behavioural control is how easy or hard it is to do a behaviour (Ajzen, 2011). Studies found perceived behavioural control affects behavioural intention (Hsu & Huang, 2012; Kim et al., 2013; Hamid and Bano, 2021). Hsu and Huang (2012) found that tourists’ choices in destinations are influenced by their behavioural control. Control belief influences pro-sustainable intentions and behaviours by promoting low-consumption alternatives like safe waste disposal, recycling and ecological transportation (Huneke, 2005; Druică et al., 2023; Wang et al., 2019). Hence:

\[ H3c. \] Users’ pro-sustainable intentions are positively influenced by their control belief.

2.4 Sustainability knowledge and pro-sustainable intentions

Sustainability knowledge promotes environmental awareness and encourages green product choices (Liu et al., 2020). Research suggests that sustainability knowledge can promote pro-environmental behaviours (Chi et al., 2019). Knowledgeable people tend to choose eco-friendly options (Suki, 2016). Studies show gamification can boost motivation (Fernández-Ruano et al., 2022) and encourage recycling, waste reduction and energy conservation (Aguir-Sl-Castillo et al., 2019). Aguiar-Castillo et al. (2019) used eco-gamification to educate tourists about eco-friendly transportation. Some studies suggest no direct link between sustainability knowledge and pro-environmental intentions. Therefore, the following hypothesis is proposed:

\[ H4. \] Users’ sustainability knowledge positively influences their pro-sustainable intentions.

2.5 The mediating role of sustainability knowledge and psychological and social norms

Cheng et al. (2013) studied the relationship between tourists’ sustainability knowledge, technology responsiveness and eco-friendly practises. Their findings connected knowledge of sustainability and technological responsiveness to sustainable lifestyle choices. The study found that technological responsiveness plays a role in connecting sustainability knowledge and eco-conscious behaviour. Kanchanapibul et al. (2014) found that younger
people’s sustainable understanding and tech skills make them more likely to buy green products. In addition, Ballantyne et al. (2021) argued that a lack of information may decrease understanding of sustainability and preventive activities. Studies on natural and ecotourism destinations highlight the connection between sustainable visitor behaviour, sustainability knowledge and protecting natural areas. Thus, the hypothesis is proposed:

- **H5.** Users’ sustainability knowledge mediates the relationship between acceptance of eco-gamification and their psychological and social norms.
- **H6.** Psychological and social norms mediate the relationship between sustainability knowledge and pro-sustainable intentions.

### 3. Methodology

#### 3.1 Sampling and data collection

Egypt was chosen as the basis of the sample due to various concerns that could potentially jeopardise the long-term sustainability and profitability of the tourism sector. The current study relied on two different phases. In the first phase, permissions were received, from various workplaces, hotels and tourist resorts to research international tourists. Then, a survey was directed to a purposive sample of international tourists in four eco-tourism destinations in Egypt, namely, the Red Sea, Siwa Oasis, Fayoum Oasis and South Sinai, to create a preliminary database. These destinations offer a wide range of natural and recreational attractions that attract a significant number of tourists who are enthusiastic about sustainable initiatives. Additionally, the Egyptian Government has collaborated with local authorities to promote sustainable tourism development in these destinations, aligning with Egypt’s 2030 strategy to improve the environmental footprint of Egypt’s tourism industry (Elgammal, 2022).

Phase 1 involved interacting with tourists. Tourists who agreed to participate in the survey received an English consent letter explaining the study’s objective and including screening questions to confirm their interest in sustainability, smartphone ownership and willingness to participate in the field study. Respondents were informed that communication would be via email and privacy would be protected. Data collection lasted from May 2022 to May 2023, with 360 participants. Phase 2 of the study tested the relationships in our proposed model.

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**Figure 1** The study framework and hypotheses

[Diagram showing the study framework and hypotheses]

**Notes:** H5: Sustainability knowledge (SK) mediates the relationships between PU, PEOU and PE and BB, NB and CB. H6: BB, NB and CB mediate the relationships between SK and PSI

**Source:** Authors’ own creation
integrated model (Figure 1). Participants were instructed to download and use the JouleBug app on their smartphones via an electronic link.

Following Armstrong and Overton (1977), this study concludes that there is no significant difference in the variance/distribution between early and late respondents, indicating that early and late responses are comparable. As per the recommendations of Kock (2021), the function for determining statistical power and sample size requirements in WarpPLS indicated that a minimum sample size of 160 is necessary. The collected data from the survey exceeded the established threshold of 160. A total of 360 responses were obtained and deemed suitable for analysis by tourists. A total of 360 participants completed the online post-game survey on the porsline.com website to further explore the potential of this app in promoting pro-sustainable intentions. The participants’ demographic characteristics are shown in Table 1.

The survey was adopted from previous relevant studies, with certain modifications made to better suit the purpose of the current study. In this regard, the TAM elements (i.e. value or usefulness (five items), convenience or ease of use (five items) and enjoyment (four items) were adapted from Davis (1989), Xu et al. (2017) and Aguiar-Castillo et al. (2019). In line with studies by Chi et al. (2019), sustainability knowledge measures (eight items) were adopted. The diverse constructs of the TPB (i.e. behavioural belief (five items), normative belief (four items) and control belief (four items) were based on Hamid and Bano (2021) and Kucukusta et al. (2015). Pro-sustainable intentions (seven items) were adapted from Kucukusta et al. (2015). All responses were recorded on a five-point Likert scale, with one representing strongly disagreeing and five representing strongly agreeing. The instrument’s validity was evaluated and adjusted by 12 university professors. Before the formal review, a pilot survey was conducted with 40 tourists in the Ras Mohamed and St. Catherine regions of South Sinai to confirm the clarity of the measures. The final survey was then drafted, considering minor modifications based on the pilot survey participants’ feedback, and its link was shared with the intended participants.

3.2 The eco-gamification app

Various apps have been developed to encourage sustainable behaviours. The study evaluated search results from major search engines using keywords like “gamification”, “sustainability” and “game items” to find the appropriate eco-gamification. The analysis included the free apps available on Google and Apple platforms. Five apps were selected based on specific criteria including tasks related to pro-sustainability behaviour, the option

<table>
<thead>
<tr>
<th>Table 1 Demographic information for the sample</th>
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<tbody>
<tr>
<td><strong>Item</strong></td>
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<tr>
<td>Gender</td>
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<td>Age</td>
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<tr>
<td>Educational level</td>
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<td></td>
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<td>Weekly time spent playing online games</td>
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</table>

Source: Authors’ own creation
to use individually or in groups, free access to the app and availability in English. The shortlist of apps included Grow Memo, Green Genie, Eco-Dice, iRecycle and JouleBug. The JouleBug app by Cleanbit Systems was chosen for its use of eco-feedback and game elements to motivate users to conserve energy and modify their sustainability behaviour. The text explains how to make small changes in daily habits to achieve significant energy savings. It can be connected to a home utility account to display energy savings. The platform provides rewards and badges for conservation actions (Figure 2).

The app aims to make conserving energy, water and resources fun, easy and gamified. The app can import information from chosen utility accounts. The app and website have a professional and visually appealing design, with slick and inviting graphics. JouleBug has a straightforward process with 94 distinct milestones or actions that promote sustainability in different categories. Achievements can be sorted by name, location, benefit or frequency. It helps individuals identify the most relevant achievements based on their lifestyle or interests. Users can “buzz” an action by clicking on a corresponding icon after completing it. The icons are called “pins” and some users may think of Girl Scout or Boy Scout badges when they see them. Users need to buzz the required number of times to get these pins. Users can press a pin when using a reusable mug or grocery bag.

4. Data analysis and results

The nonlinear partial least squares structural equation simulation (PLS-SEM) using WarpPLS version 8.0 software was used for the analysis in this study. This technique was selected because it allows for the creation of complex conceptual frameworks for multi-block analysis (Kock, 2021). Tables 1 and 2 describe the quality of the outer and inner models, respectively.

4.1 The measurement model

Before delving into the measurement model, all the constructs’ discriminant and convergent validities, as well as their reliabilities (Cronbach’s alpha) and composite reliabilities (CR) were assessed. As a result, we assessed the factor loadings, CR, $\alpha$, average variance extracted (AVE) and variance inflation factor (VIF). Table 2 shows that all three measures of

![Figure 2](image-url)
reliability and validity (CR, α and AVE) exceeded the 0.7 and 0.5 thresholds, respectively, as recommended by Hair et al. (2017). In addition, multicollinearity and common method bias were analysed with VIF scores and Harman’s single-factor test (Podsakoff et al., 2003). The VIF for all instruments was less than five, suggesting that there was no significant collinearity. Harman’s single factor also gave a good score, which showed that no single factor explained more than 50% of the variation. Following Hair et al. (2017), the heterotrait-monotrait (HTMT) correlation ratio was used to measure discriminant validity as this ratio is increasingly considered a trustworthy technique. All the figures in Table 3 are less than the 0.90 HTMT criteria (Kock, 2021).

### 4.2 The structural model

The p-values and path coefficients (β) of the predicted relationships are displayed in the inner model. As shown in Figure 3, usefulness (β = 0.32; p < 0.01; effect size = 0.208; confidence intervals = 0.217–0.414), ease of use (β = 0.21; p < 0.01; effect size = 0.131; confidence intervals = 0.105–0.306) and enjoyment (β = 0.27; p < 0.01; effect size = 0.172; confidence intervals = 0.169–0.368) all had a positive effect on sustainability knowledge. Therefore, H1a, H1b and H1c are accepted. The findings suggest that sustainability knowledge has a strong positive influence on behavioural belief (β = 0.63; p < 0.01; effect size = 0.396; confidence intervals = 0.535–0.724), normative belief (β = 0.61; p < 0.01; effect size = 0.376; confidence intervals = 0.518–0.708) and control belief (β = 0.63; p < 0.01; effect size = 0.400; confidence intervals = 0.538–0.727), which indicates acceptance of H2a, H2b and H2c. The segment establishes that behavioural belief stimulated pro-sustainable intentions (β = 0.23; p < 0.01; effect size = 0.164; confidence intervals = 0.134–0.334), normative belief (β = 0.20; p < 0.01; effect size = 0.137; confidence intervals = 0.096–0.296) and control belief (β = 0.19; p < 0.01; effect size =

### Table 2 Constructs validity and reliability

<table>
<thead>
<tr>
<th>Variables</th>
<th>CR</th>
<th>α</th>
<th>AVE</th>
<th>VIF</th>
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<tbody>
<tr>
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<td>0.880</td>
<td>0.819</td>
<td>0.648</td>
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<tr>
<td>PEOU</td>
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<td>0.815</td>
<td>0.644</td>
<td>2.994</td>
</tr>
<tr>
<td>PE</td>
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<td>0.820</td>
<td>0.650</td>
<td>3.138</td>
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<tr>
<td>BB</td>
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<td>0.863</td>
<td>0.645</td>
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<td>0.722</td>
<td>0.644</td>
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<td>CB</td>
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<td>0.727</td>
<td>0.647</td>
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<td>0.692</td>
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<td>PSI</td>
<td>0.889</td>
<td>0.833</td>
<td>0.667</td>
<td>4.388</td>
</tr>
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</table>

**Notes:** PU = Usefulness, PEOU = Ease of use, PE = Enjoyment; BB = Behavioural beliefs; NB = Normative beliefs; CB = Control beliefs; SK = Sustainability Knowledge; PSI = Pro-Sustainable Intentions

**Source:** Authors’ own creation

### Table 3 The heterotrait-monotrait (HTMT) correlation ratio

<table>
<thead>
<tr>
<th>HTMT</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<tbody>
<tr>
<td>PU</td>
<td>0.886</td>
<td></td>
<td></td>
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<tr>
<td>PEOU</td>
<td>0.855</td>
<td>0.870</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>PE</td>
<td>0.854</td>
<td>0.872</td>
<td>0.889</td>
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<td>BB</td>
<td>0.810</td>
<td>0.799</td>
<td>0.855</td>
<td>0.883</td>
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<tr>
<td>NB</td>
<td>0.741</td>
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<td>0.834</td>
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<tr>
<td>CB</td>
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<td>0.843</td>
<td>0.895</td>
<td>0.842</td>
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<td>0.814</td>
<td>0.864</td>
<td>0.875</td>
<td>0.885</td>
<td>0.955</td>
</tr>
</tbody>
</table>

**Source:** Authors’ own creation


0.134; confidence intervals = 0.093–0.294); this implies conformity with H3a, H3b and H3c. Notably, a significant relationship between sustainability knowledge and pro-sustainability intentions was established ($\beta = 0.35; \ p < 0.01; \text{effect size} = 0.260; \text{confidence intervals} = 0.248–0.445), lending credence to H4. The coefficients of the instruments were examined to establish the predictive validity of the model.

To quantify, the results indicate that TAM factors (i.e. usefulness, ease of use and enjoyment) account for 51% of sustainability knowledge ($R^2 = 0.51$). In turn, sustainability knowledge explains 40% of behavioural belief, 38% of normative belief and 40% of control belief ($R^2 = 0.40, 0.38$ and 0.40, respectively). Finally, the elements of TPB (i.e. behavioural belief, normative belief, control belief) and sustainability knowledge explain 70% of pro-sustainable intentions ($R^2 = 0.70$).

### 4.3 Mediation analysis

Indirect relationships were investigated to explore the mediating role of sustainability knowledge on the relationship between tourists’ acceptance of eco-gamification apps (i.e. usefulness, ease of use and enjoyment) and their psychological and social norms (i.e. behavioural belief, normative belief and control belief). As shown in Table 4, sustainability knowledge was found to partially mediate the relationship between TAM factors and pro-sustainable intentions.

<table>
<thead>
<tr>
<th>Paths</th>
<th>Direct effect (p-value)</th>
<th>Indirect effect (p-value)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>PU on BB via SK</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>Partial mediator</td>
</tr>
<tr>
<td>PU on NB via SK</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>Partial mediator</td>
</tr>
<tr>
<td>PU on CB via SK</td>
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<td>Partial mediator</td>
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<tr>
<td>PEOU on BB via SK</td>
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<td>Partial mediator</td>
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<td>PEOU on NB via SK</td>
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<td>PEOU on CB via SK</td>
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<td>PE on BB via SK</td>
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<td>PE on NB via SK</td>
<td>&lt;0.01</td>
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<tr>
<td>PE on CB via SK</td>
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</tr>
<tr>
<td>SK on PSI via BB</td>
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<td>SK on PSI via CB</td>
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<td>Partial mediator</td>
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**Source:** Authors’ own creation
knowledge partially mediates the link between usefulness, ease of use, enjoyment, behavioural belief, normative belief and control belief. Similarly, we investigated the mediating role of psychological and social norms in the relationship between sustainability knowledge and pro-sustainable intentions. A partial mediation link is established between sustainability knowledge and pro-sustainable intentions through behavioural, normative and control beliefs. The Variance Accounted For (VAF) verifies the size of the indirect effect linked to the total effect. Ultimately, the VAF estimates the power of mediation, which VAF ranges between 0% and 100%, with values over 80% showing full mediation, within 20% and 80% partial mediation, and under 20% with no mediation force (Hair et al., 2017). Table 4 shows partial mediation has been established as all values are between 20% and 80%. Hence, $H_5$ and $H_6$ are accepted. The cross-validated redundancy ($Q^2$) values, provided for both dependent components, were greater than zero (sustainability knowledge: 0.395; behavioural belief: 0.376; normative belief: 0.398; control belief: 0.510; and pro-sustainable intentions: 0.693), which demonstrates the model’s predictive validity.

### 4.4 Control valuables

To enhance the internal validity of the research and minimise the influence of confounding and extraneous factors, we performed assessments on the control variables of the study, specifically gender, educational level, age and duration of involvement in gaming pursuits, among tourists who endorse sustainability. The results of the study indicated that there was no statistically significant association between the control variables and tourists who express a preference for sustainability. In other words, this implies that the aforementioned factors had no substantial impact on the participants’ inclination towards sustainability.

### 5. Discussion and conclusion

The study findings emphasise the importance of sustainable knowledge in bridging the gap between TAM and TPB. In this vein, the findings indicated that the effects of ease of use and enjoyment are more important in the context of eco-gamification. This may be attributed to the strong influence of gamification elements (e.g. gameplay, features, emotional content, prizes, entertainment and scoreboards). The results emphasised the importance of emotions, specifically intrinsic motivations, in influencing eco-gamification acceptability (Liu et al., 2020). Eco-gamification engages users by performing daily and weekly tasks with the support of enjoyable design features that contribute to the usability and usefulness of the apps. Thus, likable apps can change users’ pro-sustainability behaviours even in the absence of external stimuli, such as penalties, awards, or legal rules (Hamari and Koivisto, 2015). In this vein, eco-gamification can promote sustainability knowledge with the internet and smartphones. The app should include features like 360° programme view, interactive graphical context, assistance avatars, performance metrics and sustainability issue notifications to improve sustainability knowledge. Perceived usefulness may be due to expected environmental benefits from promoting sustainable behaviour.

Based on our findings, it appears that the study model demonstrated greater robustness when sustainable knowledge and psychological and social norms were present. Sustainability knowledge shapes pro-sustainable intentions, reinforced by psychological and social norms. Knowledge affects beliefs and inclinations to respond to situations. Intent and behaviour are influenced (Jacobs and Harms, 2014). Our results support the role of sustainability knowledge in shaping beliefs and controls. This supports previous findings on how knowledge impacts online users (Zhang et al., 2015; Wu et al., 2022). Sustainability knowledge influenced the connection between eco-gamification acceptance elements and norms. If eco-gamification is designed well, sustainability knowledge can influence tourists’ beliefs about sustainability.
Our results show that users’ beliefs affect their intentions. This result supports previous studies on how tourists’ beliefs and perceptions influence their behaviour at eco-tourism destinations (Cheng et al., 2013). Hu et al. (2018) found that tourists with positive attitudes towards local communities and eco-tourism are more likely to participate in eco-friendly activities. This study supports the influence of normative belief on pro-sustainability intentions. Results confirmed that social pressure increases users’ sustainability. This means that users’ pro-sustainable intentions are based on what society expects of them. In this vein, promoting eco-gamification in developing countries can be done through social media, campaigns and local programmes. Measures can promote eco-gamification for sustainable tourism, aiming to increase beliefs. Eco-gamification can help developing countries improve infrastructure, expand wireless networks, develop IT-based industries and enhance environmental appeal.

Contrary to previous studies (Liu et al., 2020), our findings support the connection between perceived behavioural control and pro-sustainable intentions. Perceived control is important for eco-gamification users’ intentions. Factors like skills, time, resources and experience affect people’s willingness to use eco-gamification in tourism. It’s important to improve eco-gamification apps to manage people’s behaviour.

This study suggests three partial mediating impacts:

1. between sustainability knowledge and eco-gamification acceptability;
2. between sustainable knowledge and social cues and sustainability knowledge; and
3. between sustainable knowledge and social cues and pro-sustainable intentions.

We argue that sustainability knowledge and social norms predict pro-sustainable intentions. Two systems work together to create judgements: the rational, evidence-based perceptual analysis system and the emotional system. Rational systems have an impact on sustainable issues (Liu et al., 2020).

5.1 Theoretical contribution

Our study contributes to technology adoption and sustainable tourism by examining the relationships between eco-gamification, tourists’ sustainable knowledge and pro-sustainable intentions using two behavioural theories (TAM and TPB) in one model. Integration was needed due to limitations in TAM theory, including oversimplified constructs, lack of social and cultural factors and no self-efficacy. An integrative model was used to improve our ability to predict tourists’ pro-sustainability intentions. Integrating TAM and TPB into our research model supported predicting users’ intentions to use eco-gamification for sustainable tourism, considering social and psychological factors. TPB explains motivations for sustainability, while TAM guides approach to technological apps for sustainability. The results of the study validate the impact of the TPB model on tourists’ pro-sustainability intentions. It was found that the structural equation model was effectively able to predict the behavioural intention of users in using eco-gamification. The TPB model works better with operationalised sustainability knowledge. Understanding tourist behaviour is important for comprehending their actions in tourist destinations. Our findings suggest that the theory can explain how tourists can promote destination sustainability. The findings support the idea that sustainability knowledge affects pro-sustainable intentions through positive sustainable knowledge and social cues.

5.2 Practical implications

The findings are relevant for destination planners and businesses in tourist destinations. Eco-gamification apps enhance tourists’ travel experience. This insight can help destination planners educate tourists about their ecological impact and encourage them to adopt
sustainable practises aligned with the UNWTO’s SDGs. This study advocates that eco-gamification is a useful tool for increasing tourists’ involvement, particularly in ecologically sensitive destinations. It would be beneficial for destination planners and businesses at the destination to offer gamified experiences for tourists, either before their arrival or during their stay. By providing virtual gamified experiences with incentives, goals and friendly competition, tourists can become more knowledgeable about the destination and develop sustainable behaviours. The use of eco-gamification can be effective in creating a positive attitude and promoting sustainable behaviours among tourists (Xu et al., 2017). Destinations and businesses could consider implementing a reward system that encourages tourists to engage in more sustainable and authentic experiences while supporting local goods and services. This could potentially include incentivizing positive behaviours such as recycling, conserving water and electricity and practicing sustainable consumption through the awarding of badges or points, which could, in turn, lead to tangible benefits such as discounts. Likewise, negative behaviours that impact tourism sustainability could be discouraged by deducting points.

5.3 Limitations and further research

While this study has yielded important insights, it has some limitations. Firstly, our study was restricted to just four destinations. These destinations are widely acknowledged for their eco-friendliness and are likely to attract a specific group of tourists who value sustainable practises. This may have resulted in a greater level of engagement with eco-gamification than is typically expected from other groups. Additionally, the study focused on international tourists. Perhaps if the study is replicated with domestic tourists, it may yield findings. Another shortcoming was the difficulty of choosing the appropriate eco-gamification app for the study, as there is no clear distinction between gamification, simulation, and fun games. The third limitation is that the survey was conducted after the participants’ actual residence in the destinations. Therefore, going forward, it will be crucial to study the impact of using eco-gamification before and during the actual stay at a tourist destination. Finally, given that TPB has some drawbacks, including the exclusion of other variables that influence intention and behavioural motivations, such as environmental or economic factors, emotion or past experiences, other theories, such as flow theory, may provide different outcomes for pro-sustainability intentions. Moreover, future research needs to investigate other factors that could explain pro-sustainable intentions, such as value and emotions. Finally, obtaining a comprehensive nationality classification for international tourists is subject to certain limitations. Therefore, these factors are regarded as limitations of the present investigation.

References


Further reading


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