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Edcraft: Gamified Handicrafts as an Inspiration for Teenagers to Practice Upcycling

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Abstract

This qualitative research study investigates the effectiveness of gamified handicrafts as an inspiration for teenagers to practice recycling and upcycling. The study utilises focus group interviews and thematic analysis to explore the perceptions and experiences of 15 teenagers who participated in an educational programme called Edcraft, which combines gamification and handicrafts to promote sustainable practices among youth. The findings reveal that Edcraft successfully motivates teenagers to engage in recycling and upcycling activities through its gamified approach, which includes challenges, rewards and social interaction. Themes such as ‘social connections are vital’, ‘convenience and rewards are significant motivators’, ‘gamified activities help attract and engage teens’ and ‘environmental knowledge is crucial to prolonging recycling’ emerged from the thematic analysis. The results also highlight the positive impact of Edcraft on teenagers’ attitudes towards the environment and their willingness to adopt sustainable behaviours beyond the programme. The implications of these findings for promoting environmental education and sustainability among teenagers are discussed, and recommendations for future research and practice are provided.

Keywords: Environmental education; gamification; handicrafts; recycling; sustainability; teenagers; upcycling

Introduction

The urgency of mitigating environmental degradation through sustainable practices like recycling and upcycling is more palpable than ever. While the significance of these behaviours is well acknowledged, galvanising teenagers — tomorrow’s decision-makers — remains a formidable task. Even in our rapidly evolving digital age, where information is at one’s fingertips, mere awareness is insufficient to inspire tangible behavioural change (Liu & Zhang, 2024). The current global scenario accentuates the need to foster pro-environmental behaviours, not just as periodic activities but as ingrained habits, especially among the younger generation who stand at the frontline of witnessing and combating climatic ramifications (Tyson & Kennedy, 2021).

One potent avenue emerging from the intersection of pedagogy and technology is gamification. By infusing traditionally non-game contexts with elements of game design, gamification promises a rejuvenated approach to environmental education (Deterding *et al.*, 2011). Contemporary studies affirm its prowess in catalysing intrinsic motivation, fostering engagement and anchoring positive behavioural modifications (García-Fernández *et al.*, 2022). Furthermore, with teenagers

being intrinsically attuned to gaming ecosystems, leveraging gamification could bridge the chasm between environmental awareness and tangible actions.

In this milieu, the Edcraft event, instituted in the vibrant Klang Valley of Malaysia in 2020, stands as a beacon. Embracing gamification's essence, the initiative aimed to kindle secondary school students' passion towards environmental issues, chiefly emphasising recycling and upcycling. This qualitative inquiry delves deep, exploring gamification's efficacy in fortifying pro-environmental behaviours among teenagers, drawing insights from a careful post-event evaluation coupled with exhaustive focus group discussions.

At its core, our endeavour seeks to elucidate gamification's promise in the environmental education realm, aspiring to shed light on strategies that resonate with teenagers' psyche. In extrapolating our findings, we aspire to chart blueprints for tailored interventions that can inspire and instil lasting pro-environmental behaviours among the youth.

Literature review

Recycling and upcycling are crucial components of sustainability, contributing to waste reduction and the conservation of natural resources. However, effectively engaging individuals, particularly teenagers, in these behaviours presents a challenge. Traditional approaches, such as information provision or education, have shown limited success in promoting recycling and upcycling behaviours. Therefore, exploring new approaches that effectively promote pro-environmental behaviours is imperative.

One innovative approach to fostering pro-environmental behaviours is gamification, the integration of game design elements in non-game contexts to motivate and engage individuals (Deterding *et al.*, 2011). Gamification has been successfully applied in diverse fields, including health, education and marketing, to drive behaviour change. Studies have consistently shown that gamification enhances intrinsic motivation, engagement and enjoyment, resulting in positive behaviour change (Mekler *et al.*, 2017; Seaborn & Fels, 2015). The investigation into the use of gamified learning among adolescents corresponds with the wider examination of pro-environmental conduct and its theoretical foundations as outlined in the aforementioned scholarly articles. Similar to the works of Steg *et al.* (2014), Khan *et al.* (2019), Nguyen *et al.* (2015) and Donmez-Turan and Kiliclar (2021), this study explores the theoretical foundations that underpin pro-environmental behaviour. Likewise, the investigation of gamified learning among adolescents is similarly grounded in a theoretical framework. This theoretical framework is grounded in the ideas of gamification, psychology and education. Its objective is to comprehensively examine the impact of several elements, including motivation, engagement and intrinsic rewards, on the recycling behaviours of adolescents. The investigation of gamified learning in relation to pro-environmental behaviour enhances our overall comprehension of the subject by examining how gamification might incentivise and educate adolescents about environmental concerns. This aligns with the theoretical frameworks presented in the aforementioned scholarly articles.

Several studies have investigated the use of gamification specifically in the context of promoting recycling and upcycling behaviours. For instance, Oh *et al.* (2016) conducted a study in a university setting, examining the effect of gamification on recycling behaviour. The researchers found that the gamification intervention significantly increased recycling behaviour among the participants. Similarly, Kim *et al.* (2019) explored the effectiveness of a gamified waste management system in a workplace, demonstrating its efficacy in promoting recycling behaviour.

Gamification has emerged as a dynamic pedagogical tool in education, employing game design elements in non-game contexts to heighten engagement and motivation (Castillo-Parra *et al.*, 2022). Research has increasingly underscored gamification's potential in cultivating interactive learning environments, catering to the digital-native generation (Alonso-Fernandez *et al.*, 2021).

While the benefits of gamification in fostering motivation are recognised, some critiques suggest potential pitfalls. Specifically, there are concerns that overly focusing on external rewards, such as badges or points, may undermine intrinsic learning motivations (Wouters *et al.*, 2019). However, as posited by Dah *et al.* (2023), when gamification is integrated thoughtfully, aligning rewards with educational outcomes, it can strike a balance between intrinsic and extrinsic motivators.

Pro-environmental behaviour refers to conscious measures done by individuals to reduce the negative impacts of their activities on both the natural and built environment and it simply refers to deliberate efforts aimed at reducing the negative ecological impacts of human activities. The study conducted by Sharma (2014) explores the barriers that hinder pro-environmental behaviour and argues that societal reform is crucial in order to strengthen and maintain such behaviour. Kaiser *et al.* (2017) highlights the division in categorising pro-environmental conduct, whether based on its ecological consequences or the environmentally conscious motivations of the individual. Srinivasan *et al.* (2021) emphasises the crucial significance of pro-environmental conduct in the context of addressing environmental issues, highlighting the complex relationship between individuals' environmental concerns and their active participation in such action.

Promoting pro-environmental behaviours among the younger generation has taken centre stage given the intensifying environmental challenges (Kaiser *et al.*, 2020). Such behaviours encompass actions that consciously seek to minimise harm to the environment, ranging from energy conservation to sustainable consumption (Chen & Tung, 2020).

The 'pro-environmental behaviour' model provides a structured framework for analysing environmental acts, although it has been criticised for potentially oversimplifying intricate matters. Contemporary viewpoints stress the importance of taking into account various sociocultural elements that influence environmental behaviours (Zheng *et al.*, 2019). However, in the context of this study, this framework continues to be important, offering a structured perspective to examine environmental behaviours among adolescents, especially when combined with complementary theoretical insights. In addition, a recent study conducted by Zhang *et al.* (2022) highlights the adolescents who possess a development mindset not only demonstrate greater academic success but also enjoy improved mental well-being as time progresses. This emphasises the essential interaction between mentality and psychological well-being in adolescents. By integrating these observations with the impact of game design on adolescent conduct, as demonstrated in the research carried out by Lee *et al.* (2020), we can gain a deeper comprehension of how teenagers are socialised into gaming systems and how these systems can be utilised to encourage environmentally friendly behaviours and attitudes among young people.

The incorporation of gamification, which refers to the application of game design elements in non-game settings to increase engagement and motivation (Deterding *et al.*, 2011), not only influences recycling behaviour but also acts as a catalyst for enhancing individuals' comprehension and awareness of environmental issues. The study conducted by Lee *et al.* (2020) investigated the impact of a gamified mobile application on the environmental knowledge and pro-environmental behaviours of high school students. The results clearly indicated that the programme, which incorporated gamification concepts, effectively enhanced participants' environmental awareness and encouraged them to actively engage in ecologically responsible actions.

These studies collectively indicate that gamification holds great promise as an effective tool for promoting pro-environmental behaviours, including recycling and upcycling. However, further research is necessary to explore the effectiveness of gamification in different contexts and among various populations, particularly teenagers.

In recent years, additional studies have emerged that focus on gamification in the context of recycling and upcycling. For example, Smith *et al.* (2021) conducted a study among teenagers, utilising a gamified educational programme to promote recycling and upcycling behaviours. The

findings demonstrated positive effects in terms of increased recycling rates and improved environmental awareness among the participants.

Methodology

This study employed a qualitative research design, specifically a focus group study, to explore the motivations and experiences of teenagers regarding recycling and upcycling. A qualitative approach was chosen as it allows for an in-depth exploration of participants' perspectives, emotions and values surrounding pro-environmental behaviours (Kitzinger, 1995). The research took place in the Klang Valley area of Malaysia and focused on secondary school students who participated in the Edcraft event in 2020. The event aimed to promote recycling and upcycling through gamified learning activities.

The participants were selected using purposive sampling, specifically targeting students who had attended the Edcraft event. A total of 15 students aged between 13 and 17 years participated in the study. The focus group discussions were conducted in a classroom setting, with each session lasting approximately 60 minutes.

The focus group discussions were facilitated by a researcher using a semi-structured interview guide consisting of open-ended questions. The interview guide was carefully designed to elicit rich and diverse responses from the participants, exploring their understanding of recycling and upcycling, experiences during the Edcraft event, perceptions of the effectiveness of gamified learning activities and motivations for engaging in recycling and upcycling. Prior to the study, the interview guide underwent a pilot testing phase to ensure its quality and effectiveness in capturing the desired information.

To maintain rigour and minimise researcher bias, the researcher established rapport with the participants through clear communication, creating a safe and supportive environment for open discussion. Ethical considerations were addressed by obtaining informed consent from participants and ensuring their confidentiality. The study also took measures to mitigate potential risks or discomfort associated with participating in the focus group discussions. Ethical approval was obtained from the relevant ethics committees or review boards.

The focus group discussions were audio-recorded and transcribed verbatim. Thematic analysis, following the steps outlined by Braun and Clarke (2006), was employed to identify patterns and themes within the data. This involved carefully reading and coding the transcripts, categorising the codes into broader themes, and iteratively refining and organising the themes. Rigour and trustworthiness were ensured through techniques such as intercoder reliability checks, where independent researchers reviewed a subset of the data and compared their coding decisions, as well as member checking, where participants were given the opportunity to review and validate the findings.

It is important to note the limitations of qualitative research in terms of generalisability and transferability of the findings. However, steps were taken to enhance the credibility and transferability of the study, such as the use of direct quotes from participants to support the themes, detailed descriptions of the research context and methods, and a clear explanation of participant selection criteria.

Findings

The present study employed a focus group methodology to examine the motivations and experiences of secondary school students in relation to recycling and upcycling. More specifically, the study explored the use of gamified learning activities in an environmental protection context. The data was subjected to thematic analysis, resulting in the identification of four overarching

themes: social connections, convenience and rewards, gamified activities and environmental awareness.

The utilisation of gamified learning activities not only affords students the chance to acquire knowledge pertaining to environmental concerns, but also does so in a pleasurable and engrossing manner. Concurrently, they facilitate the cultivation of interpersonal skills and provide concrete incentives for active participation. This statement is consistent with the Theory of Planned Behavior (TPB), a theoretical framework developed by Ajzen (1991). The TPB highlights the significance of attitudes, subjective standards and perceived behavioural control in shaping individuals' intentions to engage in specific behaviours. Within this particular framework, the favourable attitudes and perceived benefits linked to gamified learning activities can be seen as influential elements that motivate individuals to participate in pro-environmental actions such as recycling.

The feedback received from the participants unambiguously suggests that the integration of gamified learning activities possesses the capacity to considerably augment motivation and engagement among secondary school students, specifically in the domain of recycling and upcycling. Furthermore, the findings underscore the significance of customising gamified tasks to correspond with the specific interests of students, while also offering avenues for both collaborative and competitive engagements. This is consistent with the tenets of the Elementary Rational Choice Theory, which posits that individuals are driven by their rational assessment of the advantages and disadvantages involved (Cornish & Clarke, 1986). Within this particular framework, the advantages linked to gamified activities, namely in terms of pleasure and incentives, can be perceived as an integral component of the logical evaluation that motivates students to engage in recycling and upcycling endeavours.

The study participants demonstrated a deep sense of gratitude for the social connections they established with their peers while participating in gamified learning sessions. Furthermore, the participants expressed significant levels of pleasure with respect to the simplicity and advantages associated with these activities, such as the ability to earn points and badges that can be redeemed for incentives. Moreover, the participants exhibited a favourable response to the gamified components integrated into the activities, which encompassed their competitive characteristics and the inclusion of obstacles. Participating in these activities not only assisted their learning of knowledge pertaining to recycling and upcycling, but also fostered an appreciation for the importance of environmental conservation. This aligns with the theoretical framework of social network theory (SNT), which suggests that individuals are influenced by the social connections and networks they are a part of (Valente, 2010). The theory is in alignment with the beneficial social interactions and support that are obtained through gamified activities.

The ramifications of the study's findings extend to both the realm of environmental education research and its practical applications. The study presents empirical evidence supporting the notion that the implementation of gamified learning activities can serve as a viable strategy for fostering active participation and interest among secondary school students in the domain of environmental education. Furthermore, the research emphasises the significance of creating gamified educational tasks that align with the interests of students and offer them chances to engage in collaborative and competitive interactions with their fellow classmates. Furthermore, the research indicates that the implementation of gamified learning activities has the potential to facilitate students' comprehension of environmental concerns and foster the acquisition of the necessary competencies and expertise required for them to assume the role of conscientious environmental guardians.

Theme 1: Social interactions are vital

The focus group discussions revealed a prominent theme highlighting the significant influence of social connections on the motivation of teenagers to actively adopt pro-environmental habits,

specifically in relation to recycling. Participants unequivocally underscored the sway of their peers and the profound sense of belonging that emanates from collectively engaging in recycling initiatives. For instance, Participant L shed light on the considerable impact of social influence, acknowledging its pivotal role in their decision to partake in environmentally responsible activities. This aligns with the TPB, which posits that attitudes, subjective norms and perceived behavioural control significantly influence an individual's intention to perform a behaviour, such as recycling (Ajzen, 1991).

Conversely, Participant I conveyed a sense of individuality, suggesting that external opinions regarding their pro-environmental conduct held minimal sway over their choices. This perspective resonates with elements of the Elementary Rational Choice Theory, which suggests that individuals make choices based on their rational evaluation of costs and benefits (Cornish & Clarke, 1986). In this context, Participant I's stance highlights their individualistic approach to pro-environmental behaviour, where the perceived personal benefits of such actions may outweigh external social pressures.

Furthermore, Participant C articulated a profound commitment to the greater good, emphasising their indifference to others' opinions because of their acute awareness of the Earth's preservation. This altruistic perspective accentuates the potential to harness intrinsic motivations for pro-environmental behaviours among teenagers, aligning with the concept of altruism in environmental psychology (Wang *et al.*, 2021).

Importantly, the influence of friends and family members surfaced prominently, as Participant M highlighted the influential role of social connections in shaping their recycling behaviour. This aligns with the social network theory, which posits that individuals are influenced by their social ties and networks (Valente, 2010).

In a similar vein, Participant O underscored the significance of peer influence, particularly among teenagers, as a driving force behind pro-environmental actions. This resonates with the social identity theory, which suggests that individuals derive their self-concept and behaviours from the social groups they belong to (Wang *et al.*, 2021).

These compelling insights substantiate the assertion that social connections wield substantial influence over teenagers' decisions to engage in recycling behaviours. They are consistent with prior research highlighting the pivotal role of social connections and the concept of social change in motivating youth to actively participate in pro-environmental behaviours. (Balundé *et al.* (2020); Zelenski and Desrochers (2021)). These scholarly foundations bolster the logical underpinning of the argument, affirming the indispensable role of social interactions in shaping pro-environmental behaviours among teenagers while drawing connections to established psychological theories.

Theme 2: Convenience and rewards are significant motivators

The second emergent theme pertains to the significant influence of convenience and rewards on the recycling practices of teenagers, which is supported by well-established psychological and behavioural theories.

The participants emphasised the considerable obstacles they faced while trying to access recycling facilities in their local communities, which served as substantial barriers to their recycling endeavours. This statement is consistent with the theoretical framework known as the TPB. According to TPB, an individual's intention to engage in a certain activity is greatly influenced by their perception of behavioural control, which encompasses both internal elements and external factors such as accessibility (Ajzen, 1991). Significantly, Participant G and Participant I highlighted the crucial significance of easily accessible recycling facilities, indicating that the lack of such facilities posed a significant obstacle to their recycling practices. This discovery aligns with previous scholarly investigations, exemplified by Strydom's (2018) research, which highlighted 'lack of time' and 'inconvenient access to recycling facilities' as significant obstacles to the practice

of recycling. Hence, our findings provide support for the existing literature, confirming the significant role of ease in determining recycling behaviours.

In contrast, Participant A presented a unique viewpoint by emphasising the ease of recycling within their condominium. They noted the presence of easily accessible recycle containers that assisted their recycling efforts. This observation highlights the significant influence of environmental signals in encouraging pro-environmental behaviour, in accordance with principles derived from behavioural economics and nudging theory (Staddon & Cerutti, 2003). The implementation of easily accessible recycling bins functions as a strong environmental stimulus that streamlines the process of recycling, hence decreasing cognitive exertion and rewarding the practice of recycling.

Moreover, the discourse explored the motivational efficacy of rewards in stimulating recycling practices. Participant H and Participant G articulated their conviction that monetary incentives have the potential to function as influential motivators for individuals to participate in recycling activities. This viewpoint is consistent with the principles of operant conditioning, in which incentives serve as positive reinforcements that enhance the probability of behaviour recurrence (Staddon & Cerutti, 2003). The acknowledgement of incentives as drivers emphasises the intricate relationship between external rewards and recycling habits among adolescents.

The results of this study highlight the complex interplay between convenience, rewards and recycling practices in the adolescent population. Recycling habits have been significantly facilitated by the emergence of easily accessible recycling facilities, which can be attributed to the effect of the TPB. Concurrently, the influence of environmental cues on promoting convenience is consistent with principles derived from behavioural economics. Furthermore, the acknowledgement of financial incentives as drivers of motivation aligns with operant conditioning theories, underscoring the complex array of variables that impact recycling practices in teenagers populations.

Theme 3: Gamified activities are effective in attracting and engaging teens

The efficacy of gamified activities in both grabbing and maintaining the attention and engagement of adolescents in recycling habits is further supported by the third thematic thread that emerged from the focus group talks. The aforementioned observation is consistent with well-established behavioural and motivational theories, providing theoretical support for our findings.

The participants provided detailed descriptions of how gamified learning activities, which incorporated game features and competitive aspects, effectively captured their attention and sparked their interest in recycling. The statement aligns with the TPB, a theoretical framework that emphasises the impact of attitudes and perceived behavioural control on individuals' intentions and subsequent behaviours (Ajzen, 1991). The testimony of Participant K highlights the impact of positive attitudes and perceived control on recycling intentions, as seen by their engagement and learning in gamified experiences centred around recycling. Furthermore, the testimonial provided by Participant J emphasised the enduring sense of fulfilment and continued fascination that arose from their involvement in these gamified activities. This statement is consistent with the notion of intrinsic motivation, which refers to the phenomenon wherein individuals participate in an activity for the inherent gratification and pleasure it provides (Ryan & Deci, 2000). The continuous interest exhibited by Participant J serves as evidence for the appeal and efficacy of gamified activities in cultivating intrinsic drive among adolescent individuals.

Our study focuses on investigating the impact of gamified learning on the engagement of teens in recycling activities. The results of our research strongly emphasise the significant contribution of gamified features in both capturing attention and motivating individuals to take action. The involvement observed in this study is consistent with other research, including Garg's (2022) investigation, which emphasises the crucial function of motivation in fostering the engagement of adolescents in an entertainment-focused setting. The affirmation of Participant C regarding their

happiness and satisfaction with the gamified activity serves to further strengthen this notion. Significantly, the act of investing one's efforts into recycling and creating practical objects from recyclable materials is in accordance with the concepts of self-determination theory (SDT), which highlights autonomy, competence and relatedness as key factors that generate intrinsic motivation (Ryan & Deci, 2000). The results emphasise that the implementation of gamified activities not only enhances motivation but also strengthens the sense of achievement among adolescents, hence strengthening their dedication to engaging in pro-environmental behaviours.

The examination of the thematic investigation of gamified learning activities reveals their remarkable efficacy in captivating and engaging adolescents in recycling behaviours. Our findings are supported by the theoretical foundations of the TPB, intrinsic motivation theory and SDT. These theories provide a comprehensive understanding of how attitudes, perceived control, intrinsic motivation and a sense of accomplishment are interconnected to promote long-term involvement in pro-environmental actions facilitated by gamified activities. The research conducted by Luarn in 2023 provides support for the positive impact of gamification on the enhancement of intrinsic motivation in the context of learning.

Furthermore, a study conducted by Cheng *et al.* (2022) offers empirical support for the notion that the attitudes and social norms of young individuals towards recycling can be enhanced through the utilisation of gamified learning interventions. The study emphasises that attitude has a significant role in shaping recycling intentions within a gamified learning environment. This study highlights the efficacy of gamified learning activities in promoting the recycling intentions of young individuals.

Theme 4: Environmental knowledge is crucial to prolonging recycling

The final theme that emerged from the analysis highlighted the importance of environmental awareness and knowledge in sustaining environmentally friendly habits, such as recycling. Participants recognised the lack of ecological awareness among teenagers, with participant E specifically mentioning the poor understanding of recycling and the tendency of residents to dispose of recyclable items as regular waste. Participants I and G emphasised the need for campaigns to educate the public and raise environmental awareness, which would subsequently lead to green behaviours like recycling. Participant D highlighted the lack of consideration for the consequences of improper waste disposal, contrasting it with the growing awareness among young people who recognise the impact of their actions on the Earth. Moreover, participant O mentioned the need for intrinsic motivation and understanding of the purpose behind recycling to develop a sustainable habit.

The findings emphasise the crucial role of knowledge and awareness in cultivating positive attitudes and motivations towards recycling. A study done by Ahmad *et al.* (2016) stated that The likelihood of individuals engaging in persistent recycling behaviour is positively influenced by their comprehension of the negative outcomes associated with inadequate waste management, as well as their possession of a favourable attitude and established recycling habit. Environmental knowledge serves as a driving force behind pro-environmental behaviours, working in conjunction with awareness to generate positive motivations and attitudes towards recycling (Afroz *et al.*, 2017). Participants acknowledged that individuals are more likely to recycle consistently when they understand the consequences of poor waste management and possess a positive attitude and habit towards recycling.

Discussions

The findings of this study carry significant implications for the advancement of environmental education and the promotion of sustainability among teenagers. These implications extend to both theory and practice in the fields of environmental education and gamification in education.

Implications for practice

Enhancing engagement through gamification: The integration of gamified elements into educational programmes has the potential to captivate teenagers, fostering their motivation and interest in recycling and upcycling. Designing interactive, challenging and rewarding gamified activities can lead to sustained engagement and commitment to pro-environmental behaviours.

Harnessing social connections: Our findings emphasise the pivotal role of social connections and social influence in motivating teenagers to embrace recycling and upcycling. Creating opportunities for social interactions, cultivating a sense of belonging and promoting positive peer influence can further stimulate teenagers' participation in pro-environmental behaviours. Collaborative initiatives and peer-led activities offer effective strategies for leveraging social connections and influence among teenagers.

Convenience and rewards as motivators: Convenience and tangible rewards were identified as significant motivators for teenagers in adopting recycling and upcycling behaviours. Ensuring accessible recycling facilities in schools, homes and public spaces can eliminate barriers and facilitate the adoption of recycling behaviours. Additionally, incorporating tangible rewards, such as incentives or recognition, can boost teenagers' sense of achievement and reinforce their commitment to sustainable practices.

Importance of environmental knowledge: Comprehensive and relevant environmental education is instrumental in sustaining recycling and upcycling behaviours among teenagers. Integrating environmental education into educational programmes equips teenagers with essential knowledge and understanding of the environmental impacts of their actions. Emphasising the benefits of recycling and upcycling, as well as raising awareness of global environmental challenges, strengthens teenagers' commitment to sustainable behaviours.

Implications for future research

Long-term effects of gamification: Future research should delve into longitudinal studies to explore the enduring effects of gamified interventions on teenagers' recycling and upcycling behaviours. These studies can provide insights into the sustainability of behaviour change and identify factors contributing to the maintenance of pro-environmental practices.

Diverse rewards and incentives: Further investigation is warranted to discern the effectiveness of different types of rewards and incentives in promoting recycling and upcycling behaviours among teenagers. Research can pinpoint the most effective rewards with lasting impacts on behaviour change.

Cross-cultural effectiveness: It is essential to examine the effectiveness of gamified interventions across various cultural and socio-economic contexts. Understanding how cultural and contextual factors influence teenagers' motivations and experiences can inform the design of tailored interventions sensitive to diverse populations.

Technology-enhanced interventions: Exploring the role of technology, such as mobile applications or online platforms, in gamified recycling and upcycling interventions for teenagers is a promising avenue. Research in this domain can uncover the potential of digital platforms to engage and educate teenagers about sustainability, opening up innovative pathways for promoting pro-environmental behaviours.

Stakeholder collaboration: Collaboration between schools, communities and policymakers is indispensable for the successful implementation of recycling and upcycling initiatives for teenagers. Establishing partnerships and engaging multiple stakeholders can foster the adoption of sustainable practices, creating supportive environments conducive to pro-environmental behaviours among teenagers.

In summation, this study showcases the efficacy of gamified approaches in motivating teenagers to embrace recycling and upcycling. Our findings underscore the significance of social

connections, convenience, rewards and environmental knowledge in influencing teenagers' motivations and experiences. By incorporating these insights into environmental education programmes and initiatives, we can empower teenagers to embrace sustainable behaviours, thereby contributing to a more environmentally conscious and responsible future.

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Ah-Choo Koo is a Professor at Faculty of Creative Multimedia (FCM), Multimedia University (MMU). She received her B.Sc. (Hons) from the Universiti Teknologi Malaysia (UTM) and her PhD from MMU. Her research, publications and creative works are mainly on imparting knowledge and skills in the field of design and creative multimedia technology. Recent years, she has been involved in numerous projects of web-based interactive technology, animation, and video technology to create some design artefacts together with her co-researchers. She is currently the Chairperson for the 4th International Conference on Creative Multimedia 2024, a co-located conference of the Digital Futures International Congress.

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