Gamification to Prevent Climate Change:

A Review of Games and Apps for Sustainability

Running head: GAMES AND APPS FOR SUSTAINABILITY

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Abstract

Gamification, the application of game design principles to a non-gaming context, has been used to promote pro-environmental behaviors. Such principles have been implemented in boardgames, team competitions, electronic games, smartphone apps, and in apps that researchers developed primarily to collect data. We review the games and apps that have been evaluated in empirical research in the last 5 years and provide a list of apps and games that have yet to be tested. Gamification has been used for sustainability education, energy reduction, transportation, air quality, waste management, and water conservation. Although we do not know yet why certain games and apps are more effective than others, gamification appears to be a promising avenue for preventing climate change.

Keywords: Gamification, Games, Apps, Climate Change, Sustainability

Climate change poses an existential threat to human life. Although it is caused by human activities, changing environmentally harmful behaviors has proven a difficult task. Games and smartphone applications (i.e., apps) present an opportunity to increase sustainable behaviors. We provide a brief review of games and gamification in the context of sustainability. Included in this review are studies examining the effectiveness of boardgames, electronic games, and apps (both gamified apps and apps used for data collection). The relevant studies can be broadly categorized into four topics: sustainability education, energy reduction, transportation/air quality, and waste management/water conservation. We will discuss each of these topics below.

Gamification consists of applying game design principles to a non-gaming context such as changing energy consumption habits [1]. The principles of gamification include clear progression paths with achievable goals, levels and rewards, giving players agency over their actions, making use of strategy and novelty to engage players, providing feedback, making use of social comparison or competition, encouraging cooperation between players, or various combinations of these principles [2,3,4,5]. Gamification helps create an environment in which individuals are intrinsically motivated to engage with material related to the area where behavior changed is desirable [6]. In the context of boardgames, researchers have emphasized specific principles for effective gaming including offering a multitude of roles an individual could take on to address the problem under consideration, mimicking the interactions of society, and having goals that cause players to reflect on their behavior [7]. While there are several reviews of gamification in the context of sustainability, most are purely theoretical and discuss only a small sample of games which usually have not been evaluated in controlled trials [8,9,10,11,12,13]. Our review takes a different approach by focusing on games and gamified interventions, including gamified apps, that have been empirically tested in either a lab or an applied setting.

1.1 Sustainability Education

Gamification, particularly through boardgames, can be an effective way to educate people about sustainability in general. For example, playing the "Oil Springs" expansion of the popular boardgame "Settlers of Catan" led to increased pro-sustainability attitudes and self-reported sustainable behaviors [14]. Graduate students who played "Factory Heroes," a game designed to improve sustainability leadership in the context of manufacturing, reported increased knowledge of sustainable manufacturing practices [15]. However, this finding is from a pilot test and need to be replicated before the game can be used as an intervention in an applied context. Boardgames have also shown to be an effective platform for education about biodiversity [16]. For example, the "Keep Cool" boardgame was found to increase youths' feelings of personal responsibility for sustainability and the belief in international cooperation for finding solutions to climate change [17]. Researchers have theorized that boardgames may be particularly effective for visualizing the effect that an individual has on other players and consequently the environment [18]. Additionally, boardgames may be an effective tool for researchers measuring environmental attitudes when working with children [19]. While these results are promising, none of the reviewed studies tested behavioral outcomes resulting from playing sustainability-themed boardgames. Additionally, interventions designed to increase knowledge about a topic rarely lead to behavior change unless a lack of knowledge was preventing individuals from adopting a certain behavior, such as recycling [20]. Future studies examining the effects of educational interventions should consider what barriers to behavior change are removed by providing information to participants.

1.2 Energy Reduction

Decreasing home energy usage is one area where games and gamified apps have the potential to encourage sustainable behavior. "Cool Choices" is a game in which players compete as a team to reduce energy usage over a multi-week period. Players claim points in the game for engaging in either one-time or recurring sustainable behaviors. These pro-environmental actions are made visible to other players on the game's online leaderboard. An evaluation study revealed that playing "Cool Choices" led to long-term reductions in electricity consumption, especially among individuals who initially consumed high amounts of energy [21]. Other researchers found that playing "Energy Cat," a game designed for touch-tablets in which participants attempt to make a virtual home energy efficient, led to neither significant long-term reductions in electricity and gas usage [22] nor to better knowledge about energy consumption [23]. These results may be explained by participant reports that the game needed clearer instructions, appeared juvenile, and was not fun. Such a conclusion would be consistent with the frequently made claim that games are more effective when they are entertaining [2].

Evaluation studies of gamified apps yield promising results. For example, use of "Powersaver Game" or "Reduce Your Juice" led players to reduce their energy consumption upon completion of a four-month trial [24, 26], whereas "enCOMPASS" or "Apolis Planeta" led to long-term reductions in household energy usage [25, 1]. Common characteristics of these gamified apps include a mechanism to report goals for sustainability, a dashboard to track progress, and some form of social comparison with other app users. "Ringorang"—a smartphone app with customizable trivia questions—was found to increase intentions to install solar panels and accelerate the timeline with which participants planned to install them [27]. Nevertheless, it is unclear exactly how long the effects of gamified apps last. Wemyss et al. [28] evaluated the long-term effects of "Social Power," an app that connects to the household's smart meter and

provides weekly energy saving challenges. One year after the participants used the app, researchers observed no difference in electricity usage between households in the treatment group, which had been encouraged to use the app at least once per week, and households in the control group.

To reduce energy consumption in the workplace, researchers developed the gamified app "My Backyard Garden," which led to reduced electricity consumption specific to computer-related energy usage [29]. Another app, "GReSBAS" (Grid Responsive Society through Building Automation Systems), effectively encouraged a variety of energy saving behaviors in an office setting such as turning off lights when not in use [30]. In an educational context, the use of the apps "Abouit" and "Labels for your Planet," in conjunction with traditional teaching methods, improved undergraduate business students' energy consumption habits as well as their knowledge about sustainability [31].

1.3 Transportation and Air Quality

Several studies have examined how apps and games can be used to deliver messages, track data, and reduce carbon emissions related to transportation as well as promote alternative forms of transportation [32,33,34,35,36]. The "Mordor Sharper" game, which simulates the experience of carpooling, was used to examine how gamification can encourage carpooling in Warsaw, Poland [37,38]. Estimates based on the study's results revealed that if the gamified app could decrease the number of cars on the road by 20,000 cars per day, emissions from fossil fuels in Warsaw would reduce by over 30,000 metric tons per year. Likewise, the "Kids-Go-Green" app improved students' knowledge about sustainable methods for travel [39].

It is unknown which specific features of gamification are most effective for increasing user engagement with sustainable-transportation themed apps [40]. When researchers reviewed

apps relevant to both transportation and diet, they discovered that there was not a single app that gave players feedback on carbon emissions from these two domains simultaneously [41]. Furthermore, they found no app emphasizing the shared benefits to an individual's health and the environment from transportation methods such as biking. When air pollution was framed as a health concern, participants diagnosed with respiratory problems were more likely to engage with an app called "AirForU" that reported the air quality in their local area [42]. While some behavior changes did occur (such as exercising inside instead of outside on days with poor air quality) the authors did not report whether these changes were statistically or substantively significant. The authors did report however that engagement with the app declined for 90% of participants within 12 weeks.

Behavioral data collection has been identified as one of the key contributions that psychologists can make for the mitigation of climate change [43]. Apps may provide a useful tool for researchers to collect data about transportation. For example, "IPET" (Individual Persuasive Eco-Travel Technology) collects data about participants' travel, automatically processes this information to provide sustainable travel alternatives through pop-up messages in the app, and offers users points to further encourage sustainable travel [44]. However, successful implementation of "IPET" requires a significant time commitment from participants in order to obtain accurate travel data. In another study, the app "GoEco!" was used to successfully track travel patterns and provided feedback to participants about how to reduce the carbon impact of their travel [34,45]. As scientists continue to study apps as a tool for data collection, it is important to balance the desire to unobtrusively collect detailed personal information (such as travel patterns) with participant privacy [46], particularly as perceived risk of data leakage is one reason individuals may opt out of engaging with these apps [47].

1.4 Waste Management and Water Conservation

In an intervention designed to increase recycling behavior, tourists were encouraged to use an app called "WasteApp" to locate recycling bins in several cities [48]. "WasteApp" was effective at increasing recycling for users who perceived the app as useful. However, participants' expectation of a reward (rewards being one of the central gamification elements tested in the study) was negatively correlated with user satisfaction, and no correlation was found between expectation of a reward and recycling behavior. Other studies of "WasteApp" found that the intention to use "WasteApp" was lower for participants who considered it risky to provide personal information (despite no personal information actually being collected by the app) [47].

Water conservation is another context where researchers have tested whether sustainability can be promoted through games and gamified apps. In a study examining how to increase engagement with a community dashboard for water-related event preparedness (e.g., planning to conserve water during a drought), researchers compared how different gamification elements affected the frequency with which participants connected to the platform [49]. Participants, particularly those who were interested in helping others and supporting their community, reported being motivated to prepare for water-related events in response to the use of gamification elements such as getting points for reading articles provided on the dashboard. Similarly, adding a visualized component to water meters via an app which simultaneously set water conservation goals, provided incentives for water conversation, and allowed for social comparison with other users resulted in reduced water consumption [50]. Boardgames such as "Water Ark" have been found to increase knowledge about and perceived personal responsibility for water resources [51,7]. Likewise, adolescents who played "Ocean Limited," another

boardgame, demonstrated increased cooperative problem solving related to marine sustainability (e.g., planning a response to or preventing future oil spills) [52].

1.5 Psychological Mechanisms

Several psychological theories can explain why certain aspects of gamification are effective. Gifford [53] suggests 29 barriers (or "dragons") to pro-environmental behaviors some of which can be addressed by gamification. For example, games can educate individuals about which pro-environmental behaviors they should adopt or instruct them on how to undertake sustainable behaviors they were not aware of. Thus, games and apps could reduce the ignorance barrier for individuals who do not know what behaviors they should adopt. Engaging in pro-environmental behaviors in the context of a game or app can also reduce the perceived risks of those behaviors. For example, if an individual anticipates risks from biking to work—either from the time commitment, physical risk to safety, or a belief that they will not be able to maintain the habit—an app could help plan an efficient, safe route, and prove an incentive structure to help maintain the habit.

White et al. [54] propose the SHIFT model for adopting pro-environmental behaviors. Games can be useful in overcoming the social influence, habit formation, and tangibility components to behavior change described in the SHIFT model. Leader boards and team-based activities, common features of games, are based in social influence. One component of social influence, social norms, are beliefs about how people currently behave or how people should behave. If a game or app compares the behavior of players and rewards those who engage in certain behaviors it is possible for games to establish pro-environmental behaviors as socially normative. Another component of the SHIFT model is habit formation. By practicing pro-environmental behaviors in the context of a game, an individual might repeat that behavior after

the game ends, thus turning the behavior into a habit. The SHIFT model argues that because the effects of climate change are not immediately palpable, individuals may not feel compelled to change their behavior. Games and apps may alleviate this barrier by giving tangible pro-environmental goals with immediate rewards for completing the desired behaviors.

The theoretical frameworks proposed by Gifford [53] and White et al. [54] were supported in a recent meta-analysis examining the psychological mechanisms that lead to pro-environmental behaviors [55]. Specifically, social norms, self-efficacy, and the belief that climate change is happening were among the strongest predictors of adaptive behaviors. Each of these mechanisms can be influenced by games and apps. While researchers have not yet determined which specific aspect of games and gamification best promote pro-environmental behavior, many aspects of gamification align with psychological mechanisms for behavior change.

Conclusion

Games and gamified apps show promise as a tool to promote sustainable behaviors, particularly in comparison with other methods for behavior change [56]. Apps that use elements of gamification, such as providing feedback or earning points for a behavior, are generally rated more positively by users than apps that attempt to change behavior by providing information alone [57]. Gamification can lead to longer-term psychological engagement than other behavior change methods such as nudging [56]. In order to assist future researchers investigating the effects of gamification in the domain of sustainability we have compiled a list of available games and apps.[1] For each game and app we provide a brief description and state whether or not it has already been empirically evaluated.

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[1] The list is available at: https://osf.io/qbx2u/?view_only=7a94cd2344614e78855a43cd5cf55392

There is much about gamification that we do not know. It is still unclear why certain attempts at gamification are more effective at promoting behavior change than others. Likewise, we know little about the balance between fun, engaging games and games that are primarily informative. It is also the case that while there are many studies on topics such as transportation and energy saving, other areas such as sustainable diets have yet to receive the same attention in relation with gamification [9]. As technology continues to develop and our ability to collect behavioral data improves, researchers should continue to investigate the use of apps as a tool for data collection. In sum, the recent extant literature presents a promising picture for the use of gamification and apps in the fight against climate change.

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