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# The Pedagogical Affordances of Game-Based Learning: "Getting To Zero" And Pro-Environmental Action

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## Abstract

In light of concerns over global warming, environmental education has been touted as a means of raising environmental consciousness and effecting transformative change. This paper evaluates the pedagogical affordances of gamification or game based learning in motivating pro-environmental action. In particular, this paper focuses on the role that a physical card game called "Getting to Zero" can play in educating students about the trade-offs that Singapore faces in order to achieving net-zero emissions. It also offers some recommendations on how educators can better incorporate this game in the classroom.

## Introduction

In the recent decade, environmental education has been largely understood in relation to sustainable development. There is a general consensus that environmental education is integral to spurring and sustaining climate change action, among other environmentalist concerns (Yadav et al., 2022). Intergovernmental organisations like UNESCO has asserted that environmental education will become a core curriculum by 2025. Relatedly, countries like Germany and Singapore have announced their plans to mobilise environmental education as an important underlying mechanism supporting sustainable development goals (UNESCO, 2019).

The Singapore Green Plan 2030 signifying a national move towards sustainable development was rolled out in 2021. Consonant to this, the Ministry of Education has launched an Eco Stewardship Programme that supports environmentally sustainable practices in schools (Ministry of Education, n.d.). Accordingly, sustainability as a concept has been integrated into the Humanities, Sciences and Character and Citizenship curriculum (Ministry of Education, 2022). Taking this current emphasis on environmental education as a point of departure, this paper seeks to assess the pedagogical potential of game based learning, specifically that of the "Getting to Zero" card game.

## Gamification in education

Game play or gamification has been identified as a means of augmenting student engagement and galvanising environmental action (Dichev & Dicheva, 2017; Hakulinen & Auvinen, 2014; Hamari et al., 2016). Gamification or "game-based learning" (Kim & Lee, 2013: 8484) refers to the process of deploying game design elements and game mechanics to engage users (sometimes in problem solving,

Zichermann and Cunningham, 2011: 15; Deterding et al., 2011). As compared to more traditional modes of learning, learning through/via games has been deemed as being more appealing due to its novelty, ability to capture the imagination of players and its multi-sensory nature, among other characteristics (Rosa et al., 2003; Clark & Ernst, 2009; Kim and Lee 2013). Meanwhile, the central research question of this study is as follows:

- How does game-based learning impact the way students learn and influence pro-environmental action?
- How can the"Getting to Zero" Game be well incorporated into the geography classroom/curriculum?

A literature review was conducted to examine how game-based learning can influence pro-environmental action in students. The time frame of the review was limited to publications after the year 2000 for currency. A search was run through databases such as Education Source, Education Database, SAGE Journals and Springer using keywords reflected in Table 1. I only went through articles related to physical card or board games.

Table 1: Keyword search for literature review

| **Environmental Education** | **Game-based learning** |
|---|---|
| Sustainability, climate change, sustainable development, environmental consciousness, conservation, preservation | Games, card games, board games, gamification |

A concept matrix developed by Webster and Watson (2002) was used to organise the recurring themes in the literature review. These themes include game elements, the effects of game-based learning in relation to, for example, knowledge acquisition and behavioural changes. Such a matrix provided an effective visual representation of the overlapping aspects of game-based learning in environmental education, thereby guiding the synthesis of ideas (see Figure. 2).

Scholars have reported some advantages in deploying physical games for (environmental) education. Physical games, especially those requiring face-to-face interaction among players have been deemed as better at simulating real-life situations (which may encourage repeated play, Xie et al., 2008). The interaction among players may foster negotiation techniques while enabling them to learn through trial and error, which may energise more critical thinking in the process (Eisenack, 2012; Fjællingsdal & Klöckner, 2020). In Geography education, Mewborne and Mitchell (2019: 58) have identified physical games as an opportunity for students to apply "spatial thinking" to unique (urban) contexts. For instance, Mewborne and Mitchell (2019: 58) emphasised how a table top game "occupies space" and encourages players observe spatial patterns, connections/networks (in a city).

Figure 2: Categorisation matrix to systematically represent different aspects of game-based learning in environmental education

| Author of Research Paper | Domain of Environmental Education | Game Elements | | | | | | | Impacts on Students' Learning | | | | | | Lesson Enhancements | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Game Board | Cards | Points | Role Play | Competition | Visually Attractive | Team Play | Knowledge Acquisition | Enjoyment | Collaboration | Motivation in Learning | Critical Thinking | Positive Behavioural Shifts | Worksheets | Debrief | Digital Learning Resources |
| Martindale & Weiss (2020) | Taphonomy | ✓ | ✓ | | | ✓ | | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | |
| Kirikkaya, Iseri & Vurkaya (2010) | Astronomy | ✓ | ✓ | | | | ✓ | | | ✓ | | ✓ | | | | | |
| Eisenack (2012) | Climate Change | ✓ | | ✓ | | ✓ | ✓ | | | ✓ | ✓ | | | | | ✓ | |
| Chaney & Doukopoulos (2018) | Sustainable Water Resources | | | | | ✓ | | ✓ | ✓ | | | | ✓ | ✓ | | | ✓ |
| Mostowfi, Mamaghani & Khorramar (2016) | Recycling and Waste Separation | ✓ | | ✓ | | ✓ | | | ✓ | ✓ | | | | | | | |

Researchers have reported that game-based learning offers students with an enjoyable learning experience and is thus likely to be attention holding (Kırıkkaya et al., 2010; Martindale & Weiss, 2020; Mostowfi et al., 2016; Callahan et al., 2019). Yet, a student's level of engagement (including their likelihood of repeating the game) may vary based on their profile (e.g. content mastery, motivation levels, Gatti et al., 2019). In order to harness the pedagogical affordances of a game, it will still have to be pitched at an appropriate level for learners. A common pitfall is that some games may be entertaining but too simple (e.g. it reinforces one's understanding of prior knowledge but does not expose one to new information, Eisenack, 2012; Pfirman et al., 2021). Conversely, others may be too simple to be entertaining, which hinders repeated play that can exercise/reinforce memory "retrieval and storage" of important information (Cheng et al., 2019). Moreover, on the one hand, a safe environment for learners to grapple with successes and failures are necessary (Fjællingsdal & Klöckner, 2020). Gatti et al. (2019) have highlighted that students who have persistently failed at winning or succeeding at a game may wind up being frustrated.

Simulation games inspired by real-world (environmental) problems allow for authentic learning. These games are occasionally designed to simplify complex sustainability-related issues for better communication of ideas (Eisenack, 2012; Pfirman et al. 2021). But there is also merit in retaining the complexities (and contradictions) in sustainability politics across multiple scales (i.e. global, regional, national, local). Doing so might improve opportunities for players to cultivate higher order thinking skills (e.g. evaluative/comparative analysis,

perspective-taking in decision making). A collaborative/competitive component is sometimes designed for players to work with/against one another to troubleshoot problems or accomplish an end goal, thereby training players to think strategically and communicate effectively (Cheng et al., 2019; Miller et al., 2019).

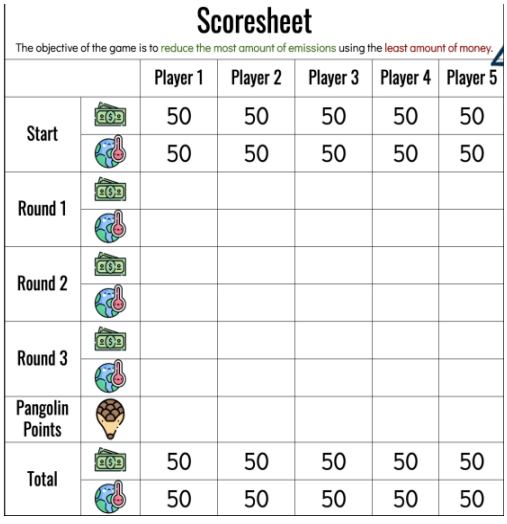
Crucially, game-based learning is premised on an active 'learning by doing' as opposed to a passively receiving information (Gatti et al., 2019; Ouariachi et al., 2020). It has been reported that gamification can augment one's acquisition of knowledge via self-directed or "student-led discovery" instead of "teacher-led information sessions" (Chaney & Doulopoulos, 2018: 174). For instance, some games are apt at teasing out the real-world implications of one's lifestyle choices on the environment, thereby inciting in-depth reflection on how one's actions can generate negative environmental externalities. Consequently, this has the propensity to resonate with learners on a more affective level and by extension, this is more likely to foster a heightened sense of environmental consciousness as well as incite climate action (Cheng et al., 2019; Pfirman et al., 2021; Callahan et al. 2019 e.g. donating money).

Game-based learning can influence students affectively and subsequently, behaviourally. Game-based learning is purportedly more engaging on a personal level, in this case, with respect to environmental concerns. Some educational scholars have insisted that affective intensities that are being stirred up in game-based learning are an effective means of enacting behavioural shifts in players/learners (McGonigal 2012; Fjællingsdal & Klöckner, 2020). Nonetheless, some studies have illustrated that engaging students emotionally may not as significant as stimulating them cognitively (Vázquez-Vílchez et al., 2021), particularly if a game is played only once or twice. Short-term play may not be impactful enough to cause a paradigm shift (Tsai et al., 2021). Further, poorly designed games on climate change can evoke a debilitating sense of hopelessness (Vázquez-Vílchez et al., 2021).

## The pedagogical affordances of the "Getting to Zero" game

"Getting to Zero" is a physical card game that is conceptualised for Secondary school Geography students. The overall objective of the game is to enlighten student players on the kinds of strategies that can be employed and their corresponding trade-offs in striving for net zero emissions. The game consists of elements such as game cards, game currency and a scoring sheet for competitive game play. Student players will presented with a slew of anthropogenic activities with varying carbon footprints (e.g. deforestation, coal mining). The player who has spent the least to ensure the lowest level of emissions wins the game.

Figure 3: Score sheet for keeping track of total greenhouse gas emissions and financial resources



There are two types of cards in the game called power and policy cards. The power cards enable the players to reduce their greenhouse gas emissions while the policy cards, stipulate environmental legislations that contribute to net-zero emissions.

Figure 4: Power cards that can help players to have a better chance at winning the card game

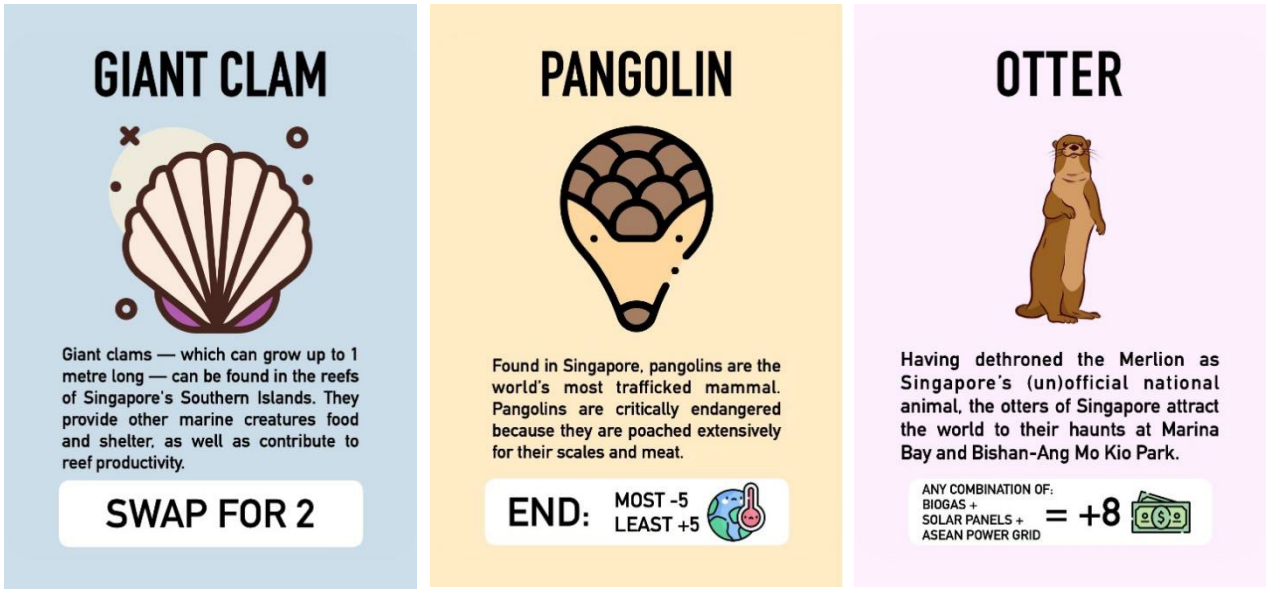
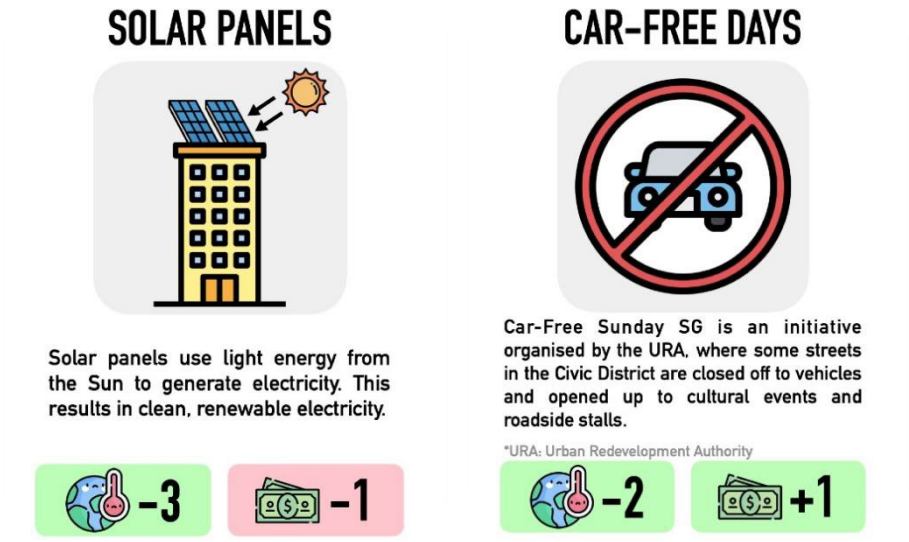



Figure 5: Policy cards on the installation of solar panels and car-free Sundays as means to reduce greenhouse gas emissions



This paper argues that "Getting to Zero" has the potential to engage student learners cognitively, affectively and behaviourally. The interactive policy and game cards are endowed with colourful icons and clear descriptions, which will appeal to visual (and kinaesthetic) learners (who are likely to handle them, see Figure. 4 and Figure. 5). There are also a wide array of policy cards that may encourage game-play repetition, thereby reinforcing an understanding of climate change mitigation policies. The competitive nature of the game (i.e. winning/gaining and losing) will also better illustrate the sacrifices/trade-offs or opportunity costs that are wrought into the decision making process involved in the move towards net-zero emissions.

On a more cognitive level, the authentic examples of climate change policies represented on the game cards (e.g. utilising solar energy as a renewable and cleaner alternative) implies that players may hopefully be able to identify such strategies being implemented around them, on a smaller scale, such as in schools and shopping centers. The transferability of such strategies across scale (i.e. down-scaling, up-scaling, inter-scalar linkages) also presents an opportunity for geography educators to address scale as an important geographical concept.

Beyond developing student players cognitively, Getting to zero could engage them emotionally as well. Since the cards features authentic elements of Singapore's biodiversity (e.g. otters, pangolins) and plans to reduce carbon emissions, their relatability may spur an emotional investment and to participate in the country's conservation and climate change mitigation efforts. Taken together, this game is well-positioned to foster a deeper comprehension of the political economy of carbon emissions which is generally premised on an instrumentalist cost-benefit mode of strategic analysis.

Additionally, this article attempts to plug a gap in the scholarship on game-based learning in climate change education, which tends to be mostly Western-centric in nature. In the same way, Getting to Zero is an important addition to climate change teaching/learning resources that oriented towards the Anglo-American world. Moreover, the card game is helpful in highlighting how geography or the Singaporean context matters in climate change related policies and climate change education. In other words, climate change policies are manifested differently in different places depending on the country's approach.

Nonetheless, Getting to Zero is not without its shortcomings. The point system, along with the depiction of 'carbon neutral' policies in Getting to zero perpetuate a reductionist, rationalist and technocratic approach to a complex and wicked problem. Such an approach also reflects the state's overall stance on climate change action in Singapore, which presumes that the 'negative externalities' of activities such as power generation and consumption can be easily quantified (e.g. financial cost, carbon footprint as trade-offs), with cleaner, greener, and more energy efficient technologies as the panacea. Moreover, Getting to Zero tends to take seemingly 'green' initiatives at face value without problematising them. For instance, a policy card on seemingly sustainable design features such as green roofs (Figure. 6) is silent about how vertical greenery on buildings may be mobilised as a form of 'green sheen' or 'green bling' (i.e. green washing, see Hes and Du Plessis, 2014) for projecting an image of environmental consciousness. Another common example involves buildings touting themselves as 'green' without accounting for the carbon debt that has been incurred to construct

them in the first place. Further, in light of how natural gas will continue to be Singapore's key fuel for electricity while the state is just beginning to explore emerging low carbon 'solutions' (e.g. utilisation and storage technologies, NCCS 2022), compounded by how Singaporeans are unlikely to give up their consumerist lifestyles substantially, Getting to zero might be an idealistic pipe dream.

Figure 6: A policy card on green roofs and their environmental benefits


Even though the policy cards are largely oriented towards top-down, energy efficient climate change solutions on an institutional and national scales, there are opportunities for reflecting on the roles that individuals can play. For instance, a card featuring "car-free sundays" may prompt players to think about how the consequences of each person's lifestyle choices can be multiplied to exert a considerable carbon footprint as a whole. Citing more ways in which individuals can work towards as well as with state agencies and other organisations to achieve net zero emissions might also be more effective at galvanising climate change action among players.

**Recommendations for incorporating "Getting to zero" in the classroom**

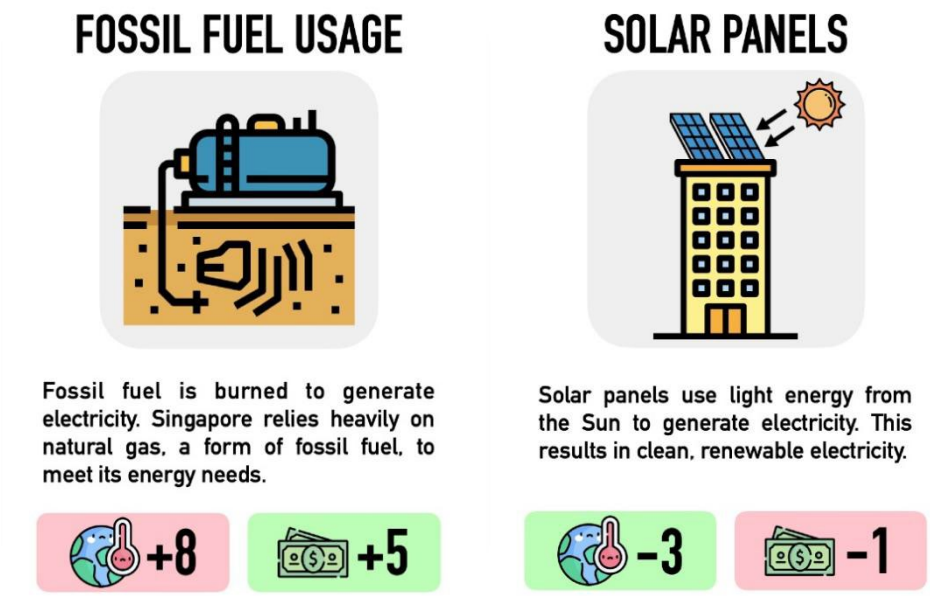
When implementing game-based learning during lessons, it is essential that teachers assume the role of the facilitator during the playing process. Game-based learning may pose a challenge to classroom management, such as when students become overly fixated with winning the game (Kirikkaya et al. 2010). Teachers are therefore indispensable in redirecting the students' attention towards the fundamental big ideas that are woven into Getting to zero, extending these ideas (e.g. with role playing) and asking provocative questions that involve critical thinking. For secondary school teachers covering the Ordinary Level 2236 (Core Geography) and 2272 (Elective Geography) syllabi (SEAB, 2022), these big ideas are learning objectives pertaining to international and national responses to climate change (which are clearly reflected in Getting to zero's policy cards).

Thoughtful teacher facilitation can also make up for the weaknesses of the card game; for instance, in drawing more explicit links between biodiversity (as portrayed in the power cards) and the repercussions of policies (i.e. policies to reduce carbon emissions can slow down the rate of global warming and in turn, how habitable ecosystems are to flora and fauna). Since the policy cards are focused on what institutions, corporations and state agencies can do to reduce carbon emissions, teachers can plug in the gap to illustrate how individuals are equally important in 'getting to zero' by introducing them with tools like a carbon calculator for monitoring their carbon footprint.

Teachers can opt to accentuate the complexity of the game by infusing a more

thorough mode of perspective taking and role playing (see Reckien & Eisenack, 2010; Tsai et al., 2021). The teacher may wish to get students to take on the roles of different stakeholders (e.g. government official, environmentalist, general retailer, green tech company/business, supra-national environmental bodies etc.) Students can conduct some background research on the objectives/interests of their assigned role and can introduce themselves through a one-minute speech so that all players can be clear about the competing interests as well as varying inclinations of these different stakeholders. For instance, a government official and an environmentalist in Singapore may perceive a policy card pertaining to the installation of solar panels differently (see Figure 7). The government official may prioritise the reliability of natural gas while stressing that it is the cleanest of all the fossil fuels, even as the state is looking to diversify its energy source. By contrast, an environmentalist might be partial towards the ubiquitous installation of solar panels across the island, to be funded by the state. An extended game/role play like this could tease out the contradictions and contestations surrounding climate change action while throwing into sharp relief the question of who should bear the costs of such policies or 'solutions'. This inquiry question can also form the basis of a class debate. Additionally, the teacher could direct the class to play this game cooperatively (i.e. groups rather than individually) in order to foster more collaborative learning.

Figure 7: Fossil fuels (non-renewable energy) versus solar power (renewable energy that is cleaner)



A post-game debrief is necessary for teachers to ask difficult critical questions, consolidate important ideas and clarifying (any) misconceptions (Gatti et al., 2019; Reckien & Eisenack, 2010). Teachers can prompt their students to share their rationalisation for the decisions (and trade-offs) that they have made in order to assist them in evaluating the suitability/feasibility and effectiveness of various climate change mitigation strategies using relevant weighing criteria (e.g. scale, cost of or ease of implementation). Relatedly, the teacher could question the extent to which carbon neutrality (i.e. any carbon dioxide released into the atmosphere is balanced by an equivalent amount being removed or absorbed by carbon sinks) or net zero emissions (i.e. any greenhouse gas emissions released into the atmosphere is balanced by an equivalent amount being removed) might be plausible including the recommended time frame that humans have to achieve such a goal (around 29 years, according to the Paris Climate Agreement). Lastly, a debrief is a good avenue for teachers to segue into other extension activities (e.g. written assessments in the form open-ended essay questions, getting students to identify attempts at green washing).

Consonant with the Singapore Green Plan 2030, game-based learning via Getting to zero can be a useful pedagogical tool, alongside skilful facilitation, to raise climate change consciousness. While the card game is skewed towards climate change action on an institutional and national scale, hopefully it can motivate players to consider how they can reduce their carbon footprint on an individual level.

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