Designing a Board Game to Explore and Communicate the Environmental Impact of AI

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As technological developments and financial investments into AI continue, the physical footprint of these systems becomes more pronounced. The environmental impact of AI is complex and sits at the intersection of two major issues: climate change and technological innovation. Because of the scale of each issue, learned helplessness and disempowerment are profound. To address this, drawing on research through design methodologies and board games for sustainability, we developed *SustAIn*. *SustAIn* is a 2-4 player board game that enables players to move throughout a tabletop world, making decisions that affect the game state as an analogy for the environment. The game is designed around the use of narratives that communicate the environmental impact of AI. In this way, it seeks to establish a qualitative point of access to complex environmental considerations that do not always have a robust or comprehensive quantitative context. A print-and-play version of the game is available here: `https://sustain-game.gitlab.io`

Board Game, AI, Sustainability, Empowerment

1. INTRODUCTION

The presence of Artificial Intelligence (AI) on the public, global stage is rapidly evolving. In this paper, AI refers to "the tangible real-world capability of non-human machines or artificial entities to perform, task solve, communicate, interact, and act logically as it occurs with biological humans" (Gil de Zúñiga et al. 2024). This very broad definition includes but is not limited to *generative* AI (GenAI), which refers to "computational techniques that are capable of generating seemingly new, meaningful content such as text, images, or audio from training data" (Feuerriegel et al. 2024). AI, and GenAI in particular, have rapidly become accessible and salient at a global scale (Liu and Wang 2026). AI developments happen quickly (Kok et al. 2025; Yeyati 2026; Tang et al. 2020). These developments, though, come at an environmental and social cost.



Figure 1: *A printed version of SustAIn.*

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The environmental reality of this rapid evolution is becoming clear through "cradle-to-grave" assessments (taking into consideration the water, energy, physical resources, and human labor required for every stage of development) (Ligozat et al. 2022; Falk et al. 2025; Crawford 2021). However, communicating this impact is challenging. One such challenge is the lack of transparent data about the environmental impact of AI models from AI technology developers (Luccioni et al. 2025a). Simultaneously, relying solely on quantitative data to communicate environmental impact, such as litres of water used, does not capture the human (and more-than-human) lived experience of environmental impact.

Researchers at the intersection of data visualization and sustainability are exploring ways to reflect information in an engaging way, from tag clouds to interactive platforms (White 2013; Rist and Masoodian 2019). There are also movements towards real-time data feedback (e.g., (Lavalle et al. 2020)), but these are not necessarily feasible for all contexts. Communicating the environmental impact of AI requires an approach catered to both limitations of available information and the fatigue of the general public. With so much information changing so quickly, it is critical to meet people where they are, especially for such an exhausting intersection as sustainability and technology (Yadav et al. 2026; Van Gaeveren et al. 2024).

To address these challenges, we introduce the design and evaluation of *SustAIn*, a print-and-play board game designed to educate and empower individuals to take actions, have conversations, and build community around concerns related to the environmental impact of AI. The mental fatigue and learned helplessness at the intersection of technology development and environmental sustainability mean that individuals do not exercise the full extent of their agency (Dresp 2022; Landry et al. 2018). We were driven to find ways to mitigate the disempowerment that accompanies learned helplessness, providing players with real-world actions they can take and an overall greater sense of power over the landscape of sustainability and technology.

Rather than centering quantitative data, we embrace a narrative approach to sustainability and computer science education (Veland et al. 2018; Bullock et al. 2021). "Narrative" in this context refers to "historical (past and present), fictional, or real-world story/perspective involving technologies" (Bullock et al. 2021). This puts human experiences at the center of the environmental impact of AI, allowing us to build meaningful connections between raw numbers and human experiences. It also provides a link from digital, amorphous concepts like model training to tangible, real-world actions like using search engines without AI overviews.

Our research was guided by three questions:

1. How might we design an installation that compellingly communicates the environmental impact of AI?
2. How can narratives supplement and support data when discussing the environmental impact of AI?
3. How can the gamification of the environmental impact of AI engage and empower people?

In addressing these questions, we first synthesized the literature on sustainability and AI. Second, we used ideation sessions and our literature as inspiration for a physical installation. Third, we designed this installation to prompt members of the public to reflect on the impact of GenAI in a tangible and engaging way. Finally, we gathered feedback on the installation. In undergoing this design process, we highlight the potential for games and narratives in the communication of cognitively draining material. We also contribute an openly accessible board game, providing people with a tool for engaging with the environmental impact of AI.

2. RELATED WORK

2.1. Environmental Impact of AI

AI's consumption of resources is substantial and wide-ranging (Chauhan et al. 2024). The International Energy Agency (IEA) reports that an average AI-focused data center consumes the energy equivalent of 100,000 households, with future centers potentially consuming 20 times that amount (International Energy Association 2025). While using pre-trained open-source models can mitigate training costs (Ding et al. 2025), the carbon footprint extends to the "embodied carbon" of hardware manufacturing and transportation (Kneese and Young 2024). The prioritization of supply and demand over environmental impact is particularly profound in the GenAI sector (Bashir et al. 2024).

High energy necessitates high water consumption (Režun and Kapusta 2025), particularly as GenAI drives an increase in data center construction (George et al. 2023). While high operational costs provide some incentive to improve efficiency (Mytton 2021), absolute usage remains significant. For example, in 2023 alone, a single major technology company consumed over 23 billion liters of fresh water—80% of which was potable—for onsite cooling (Google 2025).

Beyond utilities, AI infrastructure relies on rare-earth minerals* (Fichter and Hintemann 2014), which are essential for hardware ranging from mobile phones to the Graphical Processing Units (GPUs) used in GenAI training and inference. Rare-earth processing is resource-intensive and environmentally damaging (Zepf 2013; Jha 2014). As data center expansion continues, escalating demand strains global supply chains and exacerbates conflict in mining regions (Rasheed et al. 2025).

Finally, labor is often treated as a fungible resource rather than a human contribution (Snorton 2017). This commodification is evident in the supply chain, ranging from child labor in the Democratic Republic of Congo for mineral extraction (Sawyer and Lantos 2022; International 2023; Currier and Mousseau 2025) to the psychological strain and unfair compensation of data annotators (Abedin 2025; Jensen 2024; Muldoon et al. 2024). These workers are frequently subjected to inhumane conditions to maintain the basic functionality of AI systems, often at the mercy of corrupt militarized government regimes (Kapania et al. 2026). Addressing their treatment as resources rather than people fortifies the connection between social and environmental impact, and highlights the dehumanization to which they are subjected.

2.2. Environmental and Technological Mental Fatigue

The feeling of having no control over technological or environmental outcomes is known as "learned helplessness" (Maier and Seligman 1976). This psychological concept establishes that a systematic loss of agency suppresses the inclination to alter behavior. In technology, the direct relationship to the phrase "learned helplessness" dates back to the 1990s (Henry 1992); the public often feels that innovation proceeds regardless of cost or concern (Chung et al. 2017; Agrahara and Nowreen 2024). This is characterized in practice by an absence of empowerment, wherein individuals are not inclined to take any action (that is, exercise agency they do not believe themselves to possess). AI is no exception. Its integration into daily life makes it feel inevitable. Resistance can feel futile, despite growing anxieties regarding its pervasiveness (Dresp 2022; Kholia 2025).

Learned helplessness also exists in environmental activism (Gunderson 2023; Nagel 2005). It acts as a barrier between worry and "pro-environmental behavior," (Landry et al. 2018) preventing individuals from acting on their anxieties. This lack of agency is most pronounced for those who are closest to the negative effects of environmental disasters (Ramachandran et al. 2021). This is not necessarily without reason; industrialization has put an unsustainable strain on resources across world (Shrivastava and Hart 1995). Efforts going back decades attempt to open discourse between environmental ethicists, corporations, and stakeholders (Shrivastava and Hart 1995). However, we are still struggling to address rising global temperatures (Rounce et al. 2023), water scarcity (Mallareddy et al. 2023), and waste management (Achillas et al. 2013).

This mental fatigue is particularly damaging at the intersection of technology and sustainability. Change is possible, but requires collective, community-based organization. There are stories about public opinion and efforts swaying both environmental initiatives (Bosworth 2022; Freudenberg and Steinsapir 1991) and technology campaigns (Duffy 2021; Perkins 0276). Centering only the stories of when individual actions meant nothing in the face of corporate or political decisions undermine a substantial, powerful force possessed by the general public. Highlighting the variety of outcomes from grassroots, philanthropic, and community-led efforts provide a more robust view of complex situations, beyond the prevalent learned helplessness. However, to the best of our knowledge, there is a paucity of design-oriented work that has included such perspectives in context of the environmental impact of AI. A key aim of our work is therefore to address this gap, by designing an intervention that communicates a diversity of narratives to support individuals in overcoming learned helplessness.

2.3. Board Games as Interventions

After initial exploration of potential design artefacts to communicate narratives (see Section 3.3), we chose to focus on educational board games, which serve as powerful tools to educate, and are not just limited to school settings. Board games that have educational components are common (Treher 2011). They help people think, and are viable for empowering learning and encouraging critical thinking (Squire and Jenkins 2003; Randel et al. 1992; Zhonggen 2019). They also can benefit adults in learning (Boghian et al. 2019) and have been successfully deployed in computer science to introduce complex concepts to young adults (Bezáková et al. 2013; Drake and Sung 2011). There is even a game for tackling introductory quantum mechanics principles (Chiarello and Castellano 2016).

Sustainability education frequently employs board games for learners of all ages. Tsai et al. (2021) argues that games in Education for Sustainable

*The term "rare-earth" is a misnomer; these materials are not geologically scarce but are dispersed across great physical distance and are difficult to extract and refine.

Development improve learning efficiency and reduce cognitive load and learning resistance while fostering collaboration and systems thinking. This reduction in cognitive burden could mitigate the mental fatigue and learned helplessness associated with climate anxiety (Pope 2023). Collaborative gameplay, such as Sandbhor's *Climate Club*, demonstrate the potential benefits of collective action for environmental sustainability (Sandbhor and Hook 2024). Furthermore, games have proven effective in promoting behavioral change and advancing scientific literacy on the environment (Douglas and Brauer 2021). They have also been used to support learning about the UN Sustainable Development Goals (Chen and Ho 2022) and Indonesia's economic development process (Wijoyo et al. 2025).

Beyond just education, games have also been used for empowerment. Digital games engage with empowerment, often targeting self-esteem or necessitating some act of inclusion to achieve the game's objectives (Bleumers et al. 2012; Baccassino and Pinnelli 2025). This is also true of board games. Indeed, empowerment is often one of the learning outcomes from educational board games (Treher 2011). For example, Fernandes et al. (2023) designed a board game that taught older adults about their rights and empowered them to take actions accordingly.

In sum, our work bridges literature on the environmental impact of AI and associated mental fatigue among the public, which highlights a research gap in the design of artefacts in this space that not only educate, but support feelings of empowerment. Given the demonstrable benefits of board games in supporting these aims, we explore the board game as a potentially useful medium for this purpose.

3. RESEARCH THROUGH DESIGN PROCESS

3.1. Research Through Design Methodology

Research through design, to borrow from Zimmermann et al. (2010), "employs methods and processes from design practice as a legitimate method of inquiry" (Zimmerman et al. 2010). Research through design can be used to interrogate a myriad of different materials and objectives, from physical/tangible outcomes such as the design of a game (Coulton and Hook 2017) to higher-level objectives like incorporating added emotional value into products (Desmet et al. 2001). Research through design rejects the rigidity of many research methodologies, and instead embrace exploration and speculative work with the potential to produce novel, interesting artifacts (Gaver 2012). The wide array of applications is especially helpful in multi- and inter-disciplinary research where the creative open-endedness of design-based research provides room for the innovative synthesis of ideas across disciplinary divides (Chou and Wong 2015; Tobi and Kampen 2018; Zimmerman et al. 2007). Our design process addresses RQ1. In keeping with the traditions of Research through Design, we outline a series of problems in Section 3.2. We then ideate responses to these in Section 3.3.

3.2. Developing Our Initial Project Objective

Our original objective was to design a physical installation that communicates the environmental impact of GenAI, and included the additional idea of possibly curating a quantitative dataset of these impacts. Our curiosity about GenAI in particular was due to its prominence in news media (Zewe 2025), government reports (Office 2025), and academic discourse (Hosseini et al. 2025). Our first objective was to further explore literature and evidence to support such an approach, which led us to reflect on four issues.

First, **isolating data specific to GenAI proves challenging**. While information exists regarding individual data centers or mining operations, attributing their resource consumption or extraction solely to GenAI is, like everything else in AI, very complicated and constantly changing. The UK government's report on data centers, for example, mentions that AI is driving the construction of data centers for companies such as Google and Microsoft, but does not go further into whether that is GenAI in particular (if at all) (Government 2026). Although projections indicate a surge in demand for AI-ready infrastructure (Sachs 2025; Srivathsan et al. 2024), deriving specific figures attributable to GenAI is difficult due to the deeply integrated nature of the supply chain, variability in use, and ambiguity in reporting.

Second, **reliable data is scarce**. Most figures regarding AI's environmental impact are estimates, and in fact often underestimates (Gabbott 2024). While proposals exist to reduce resource consumption, they require accurate baselines that are frequently delayed, inaccurate, or protected by law (Ligozat et al. 2022; Carrasco 2025). Although AI's resource consumption may selectively decline with time (De Vries 2023), understanding how this happens requires knowing what is being used now and absent consistent empirical evidence. Very little such evidence exists (Luccioni et al. 2025b; Simpson 2025) despite calls to action. This is just the latest iteration of a long-standing tradition of agnotology in climate research (Porter 2009; Vázquez and Smarandache 2024). Under agnotology, it is profitable to avoid investigation or disclosure of certain

issues, including but not limited to those related to climate change (Pinto 2017).

Third, **the relationship between AI and the environment is not purely negative**. GenAI can facilitate sustainable urban water management (Arslan et al. 2024) and optimize renewable energy systems (Ukoba et al. 2024). Furthermore, models assist in assessing renewable energy life cycles (Bassey et al. 2024) and identifying rare-earth mineral deposits (Nguyen et al. 2025). However, balancing these benefits proportionally against costs is difficult. Positive applications are often theoretical or small-scale, and are contrasted by the presentation of the negative environmental (though still obscured and rapidly outdated) impacts of the very same systems (Kok et al. 2025; Yeyati 2026; Tang et al. 2020).

Fourth, **quantitative comparisons can be reductive and burdensome**. Raw numbers are difficult to parse and come with a substantial mental load (Paschen and Ison 2014). There have been efforts to make data more interesting to consume (Wilde and Karyda 2024; Guyer 2025). For example, popular media often uses equivalencies (e.g., comparing data center emissions to city-wide outputs) to make data digestible (Booth 2025). However, these comparisons can be manipulated to fit an individual's narrative. For example, claims that AI generates less carbon than human artists (Tomlinson et al. 2024) are reductive and damaging. They remove necessary nuance and the social dimensions of environmental impact. Narratives can lessen the burden of raw numbers without those false equivalences (Veland and Lynch 2017).

Thus, we moved away from a quantitative data-driven approach. Instead, we decided to focus on designing an installation that communicates the environmental impact of AI through narrative and interaction, avoiding over-reliance on quantitative data (RQ2). The collection of narratives assembled in the narratives became the "dataset" with which we worked.

3.3. Ideation Sessions

We finalized our design through two ideation sessions, both utilizing the Lotus Blossom technique (Michalko 2006). The first session focused on *what* to communicate. Drawing on our literature review, we mapped the AI lifecycle (Luccioni et al. 2025b), clustering topics around water, energy, extraction, labor, and user awareness. To address the limitations of quantitative data discussed in Section 3.2, we looked at qualitative narratives. This approach allowed us to capture nuance and foster emotional engagement without risking false equivalencies.

The second session focused on *how* to communicate. We balanced logistical constraints, such as production time and accessibility, with the need to mitigate the disempowerment and burnout often associated with the intersection of technology and environmental sustainability (Chung et al. 2017; Landry et al. 2018). We explored various physical installations, ranging from art demonstrations (e.g., melting ice on a running GPU) to collaborative mapping exercises (e.g, connecting places on a map with string). As our conceptualization of what "installation" could mean evolved, we considered what scale of community would be addressed by each idea. We narrowed our ideas more to something that could be replicable at scale or engaged with across multiple physical or digital spaces.

We also noticed a general shift in objective towards creating something fun or absurd to lessen the weight of the material, while still respecting the importance of the issue. To lessen the weight further, we wanted to incorporate community-focused and collaborative elements to the installation, demonstrating that individual actions are never really executed in isolation. Our reflections led to the final idea of a board game, offering a low barrier to entry with scalable impact and active participation. With a board game, we felt we could transform an emotionally heavy topic into an engaging, agency-driven experience.

3.4. Narratives

We returned to the literature to see how narratives are used in educational settings. Narratives are valuable contextual tools in communicating complex or dull information (McQuiggan et al. 2008). Story-telling components keep students engaged and interested when raw data could be dry or disconnected from lived experiences. This can foster a shared understanding among individuals with diverse backgrounds (Korhonen and Vivitsou 2019).

Narratives also help individuals from more homogeneous backgrounds relate to material that lacks a tangible connection to their lives. Beyond making distant historical events feel more relevant (Morris 2009), first-person accounts can ground contemporary issues in a relatable, engaging format (Jensen 2024; Jehangir 2010). Narrative framing is particularly effective in computer science education, where it has been demonstrated to help students conceptualize projects (Artz 1998) and the consequences of their potential careers (Bullock et al. 2021). In sustainability, storytelling enables people of all ages to conceptualize how their actions and the impact of

major actors impact the environment (Veland et al. 2018; D'Amato 2021).

3.5. Board Game Iterations

Our design prioritized narratives, the representation of four key resources (water, energy, manufacturing, and labor), and player engagement and empowerment. The mechanics were inspired by combining the collaborative strategy and geography of Pandemic (Leacock 2015) with the movement mechanics of Candy Land (Abbott and Bradley 1948). Our game evolved through three phases of prototype iterations.

The first iteration of prototypes established the core gameplay loop, centering on a turn-based navigation system driven by dice rolls. Landing on specific spaces triggered card draws categorized as either positive or negative environmental consequences, mystery cards (which concealed either a positive or negative consequence), or an action card that encouraged players to make a real-world decision. These cards shifted a tracking scale toward a "good" or "bad" end. Additionally, branching paths were introduced to allow players to decide the route they wished to take.

The second iteration grounded these mechanics in environmental imagery. We experimented with replacing abstract scales with "thermometers" to mirror global temperature metrics, testing distinct tracks for different dimensions (e.g., people, planet, profit (Böcker and Meelen 2017)). We also prototyped dynamic board states, exploring mechanisms where paths would physically open or close routes, or flip the tiles itself to alter its type (e.g swap negative tile to positive).

The final iteration focused on maximizing player agency and providing a more grounded geographic representation. We consolidated elements from previous prototypes, combining dynamic path modifications with specific tile interactions. We formalized the four resource dimensions (labor, energy, water, and manufacturing) and introduced an "AI Booster," a multiplier simulating how AI investment accelerates the impact of specific actions. To facilitate continuous movement across board edges and de-center Western geographies, we adopted a Peirce Quincuncial map projection (Peirce 1879). This projection naturally divided the board into four quadrants, visually and mechanically aligning with our gameplay requirements.

4. FINAL GAME DESIGN

In this section, we describe the final game design. The game places players in the role of

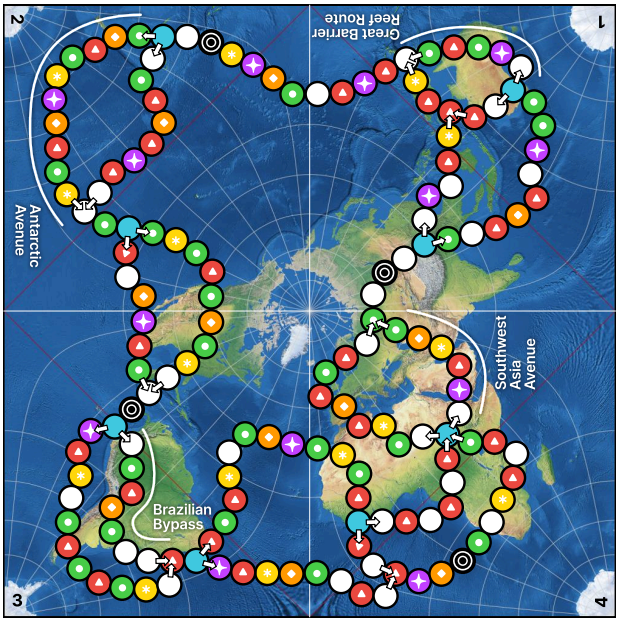


Figure 2: *The final design of the board.*

global citizens navigating a world influenced by Artificial Intelligence. Unlike traditional competitive board games, the objective is not for a single player to win, but for the group to minimize the negative effects of AI on four dimensions of environmental sustainability: Water, Energy, Labor, and Manufacturing. The game concludes with a qualitative narrative based on final metrics (Section 4.5). A time limit is used to simulate the the rapid and time-sensitive issues that accompany fast-paced innovation.

4.1. The Board

The board (pictured in Fig. 2) is divided into four quadrants, with players moving their distinct player token in a counter-clockwise direction. Movement is determined by a single six-sided die. The board features a branching path system. As environmental conditions worsen (represented by the "Thermometers"), specific paths such as "Southwest Asia Avenue" or "Brazilian Bypass" (selected so that there would be one path per quadrant) may become physically blocked by "Lock Pieces," forcing players onto longer, more arduous routes. This mechanic physically simulates environmental loss of infrastructure and mobility. The board can also be changed by a Choose the Change card (see Section 4.2) where players may flip spaces in each quadrant. The number of red, green and neutral spaces are initially the same, but players can change this balance (though the number of red and green spaces always stay proportional to one another). The board spaces are categorized by specific icons, detailing the actions available to the player.

4.2. The Cards

The game utilizes four decks of cards, each serving a distinct mechanical and narrative function:

- **Benefit (Green, 40 Cards)** This will alter the referenced thermometers in the cooler direction. These cards provide examples of how AI is helping the environment.
- **Cost (Red, 40 Cards)** This will alter the referenced thermometers in the warmer direction. These cards provide examples of how AI is hurting the environment.
- **Choose the Change (Yellow, 40 Cards)** Choosing to play the card alters individual spaces in two quadrants per the instruction on the card. Players can choose whether or not they play this card. These cards allow players to exercise agency within the game space.
- **Action (Orange, 8 Cards)** This negates a Cost Card and can be played at any point of the game. These cards allow players to exercise agency within the real world.

Each card features a quote or depiction derived from real-world reporting and qualitative research regarding the impact of AI. Some of examples of these quotes are:

> Example *Benefit* Card:
> Space Intelligence, a company based in Edinburgh, Scotland, says it is working in more than 30 countries and has mapped more than 1 million hectares of land from space using satellite data.
> Cool energy 1 degree. Cool water 1 degree.

> Example *Cost* Card:
> Selah worked in her community, but got paid more as an annotator for an AI company. She quit her job and instead parses through explicit, mentally draining content because it pays better.
> Warm labor 2 degrees

> Example *Choose the Change* Card:
> Your research involves annotation, and there are a lot of technical and ethical advantages to human annotators, but you're worried about their work conditions...
> Flip a green space neutral in Q2 and a red space neutral in Q3.

We incorporated narratives into our game through these cards. We searched for narratives across general search engines (to encounter what the average player would encounter, were they to go searching for this material) in addition to academic databases (Google Scholar and Scopus). We compiled a list of potential sources and noted relevant characteristics, such as source variety and the resources addressed. Some narratives included on our cards were hypothetical, but grounded in reality (e.g the given Cost card example is inspired by (Jensen 2024)). Others were direct quotes taken from journals, news articles, company statements, or reports and reflected the true environmental impact (e.g the given Benefit card example is from (Masterson 2024)).

There were two factors that affected the inclusion of each narrative. First, we wanted the narratives to be diverse. Our sources include news articles, academic journals/conference proceedings, and philanthropic organizations' communications among others. We cover five continents and feature quotes from data workers, activists, technology developers, and government officials. Second, we needed there to be equal weights in the positive and negative directions. There were ±22 degrees for water and labor respectively, ±17 degrees for manufacturing, and ±36 degrees energy, which proportionately represents the prevalence of each resource variety in the literature. We decided to include 40 cards for each deck (aside from the Action cards, of which there are 8) because it allows for several rounds of gameplay without repeating cards. The number of cards being a factor of 8 is helpful to minimize wasted paper for the print-and-play game, as 8 cards fit on each page.

Choose the Change cards introduce nuance by forcing trade-offs; an action benefiting one quadrant costs another. These are optional, and allow a player to decide whether or not they wanted to sacrifice some paths and quadrants in the name of improving other paths and quadrants. This mechanic adds a dimension of player agency, allowing them to physically change the board to reflect their strategy and priorities.

Action cards were action-based, the goal is to foster a sense of collective responsibility. To play the card, participants must preform some real-world task, such as adopting a search engine without an AI overview or messaging a friend about the environmental impact of GenAI. Doing so negates the impact of a Cost card. This action must be performed by the individual who drew the card and can be played at any time to negate any player's Cost card.

4.3. Thermometers

The status of the game is represented through four thermometers (Figure 3): representing Water, Manufacturing, Labor, and Energy, each ranging from -5° to +5°. Thresholds are marked by bold lines; crossing these thresholds triggers the permanent

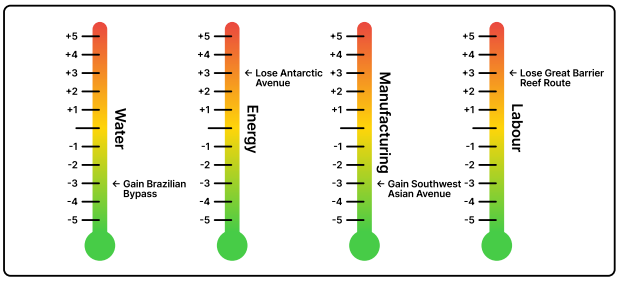


Figure 3: *The four thermometers. At the start of the game, all indicator triangles (printed separately) are set to zero.*



Figure 4: *The AI booster and associated token (cut out separately) for indicating the current booster level.*

closure or opening of specific routes (Section 4.1). If certain thermometers get too hot, "Antarctic Alley" and the "Great Barrier Reef Route" will be permanently closed due to irreversible damage. Conversely, cooling may unlock paths in Brazil or Southwest Asia, reflecting the restorative potential of some innovations.

4.4. AI Booster

The "AI Booster" simulates the volatility and acceleration of technological investment. Upon landing on designated spaces, players can choose to adjust a global modifier that adds to the magnitude of all subsequent Benefit or Cost cards. For example, a +2 Booster increases a standard 1° warming effect to 3°. This mechanic grants players strategic control over the game, and because of the time limit, it allows players to alter speed in their own way. This serves as a metaphor for how capital investment amplifies both the positive and negative potential of AI deployment.

4.5. End State

SustAIn does not feature a win/loss condition. The game ends when a pre-set timer expires. The final scores generate two types of narrative outcomes. In the first, the end state of each thermometer (Water, Energy, Labor, Manufacturing) is associated with narrative outcomes based on its final position (e.g., a Water score of +4 results in a narrative describing severe drought and scarcity). In the second, the values of all four thermometers are summed to determine the global state. These range from "Utopia" (low negative sum) to "Collapse" (high positive sum). This encourages players to discuss what the resulting narrative implies about the real-world trajectory of AI development.

> A relatively 'good' game: Climate levels are steadily dropping due to a worldwide commitment to clean energy, stability and widespread environmental policies. Some ecological damage remains, but humans have successfully adapted with resilient infrastructure that minimizes the impact of further shifts. The world is mostly peaceful and societies prioritize ecological recovery.

> A very bad game: Billions are dead. Continents stand empty, too hot for human habitation. What remains of civilization lies the few zones where water still flows and temperatures drop below deadly thresholds. The computational infrastructure humanity builds lies abandoned. Warlords control the last functioning systems, controlling water, power and food. The survivors inherit a planet fundamentally transformed.

5. PLAYER FEEDBACK

5.1. Pilot Focus Groups

As part of the Research through Design methodology (Zimmerman et al. 2007), we conducted four focus groups of 2-4 individuals for a total of 11 participants (N=11). Participants were recruited via word-of-mouth and a department-wide mailing list. Groups played for between 15 and 25 minutes, depending on the time constraints of participants. The procedure consisted of five stages: a pre-game discussion, instruction review, gameplay, post-game debrief, and a short questionnaire. Two groups consisted of acquaintances, while two were composed of strangers.

Feedback was used to strengthen the narrative framing of the game, clarify instructions, and rebalance the number of tiles on the board. We also decided that, for final interviews, we would recruit groups of friends to provide a more naturalistic boardgame-play environment.

5.2. Group Interviews

After adjustments were made to the game (per the feedback received during the pilot focus groups), we conducted structured play sessions, alongside questionnaires and group interviews to answer RQ3.



Figure 5: *Focus Group 2's gameplay. In this image, P4 is debating with P5 over which space in Q3 to flip following the decision to play a Choose the Change card.*

We conducted 5 sessions, each with 2-4 players for a total of 15 participants. Participants were recruited by word of mouth and posters around the university and surrounding local spaces. Of the participants, 7 were not affiliated with the university. The interview structure was consistent across all groups. The protocol for the group interviews can be found in the Appendix.

Recordings for each of the group interviews were transcribed by Microsoft Teams and then were corrected by the researcher who performed that group interview. Those transcripts were then shared among three researchers (A1-A3), who then developed themes asynchronously, within a shared document (following open coding (Holton 2007)) and subsequently discussed perspectives on these in a meeting to reach agreement. The findings are presented in the subsequent sections.

5.2.1. Questionnaire Responses

In addressing their perspectives on the environmental impact of AI from pre- to post-test, the most common response from the pre-test was "I care about the environmental impact of AI, but I don't know what to do about it" (N=7) whereas, for the post-test, it was "I will take actions to reduce the environmental impact of AI, but I don't think those actions will accomplish anything" (N=6). There was also a difference in the number of participants who indicated "I will take actions to reduce the environmental impact of AI, and I think my actions will have positive consequences" (N=0 in pre-test and N=4 in post-test). The likert items, participants consistently indicated "Somewhat Agree" for most answers (N=9, N=10, N=9) with the exception of "I found this content engaging" for which they indicated Strongly Agree most often (N=13).

5.2.2. Broadening Existing Knowledge on Water Consumption to Include Other Categories of Environmental Impact

Many participants, including those who discussed that they did not use AI often/at all (N=3) focused on water consumption as environmental impact during the pre-game discussion questions (N=8). Most of those participants then discussed having their perspectives broadened by the game, emphasizing the importance of issues with the environment beyond water (N=6). Many of these participants also specifically identified the Labor dimension as being an important perspective to include, and one that they had not previously considered (N=2):

> *"The only thing I really thought about prior was water and I guess subsequently energy. But then thinking about the manufacturing and labor as well, like it runs so much further than I actually initially thought." (Participant 16)*

This participant also noted the connection between water and energy, which is reflected in the cards. Water and Energy had the highest instances of co-occurrence on a singular card (10 Benefit cards and 3 Cost cards, for a total of 13 cards linking water and energy).

5.2.3. Narratives Are Engaging

Participants found the narratives engaging and often indicated that they thought the whole game would only discuss the negative impacts of AI on the environment:

> *"I kind of expected [the narratives] to all be negative. And so the fact that they were like the positive ones were still about AI as well. I was like, oh, that's actually kind of like pleasant. I was like, oh, I can have a positive impact. That's nice to see." (Participant 21)*

Some participants also focused on the narrative elements of the gameplay, such as the narrative at the beginning of the instructions and the end-states (N=4). They also discussed how the Choose the Change cards enabled them to play an active part in the story of the game (N=2). They described feeling pressured to make sacrifices that were uncomfortable:

> *"You can f*** over certain places and make certain places better. Which technically worked fantastically." (Participant 20)*

Together, these findings indicate that the narrative elements of the game, both in the form of the cards and the structure of the game, were means of engaging with the material in unexpected and uncomfortable ways.

5.2.4. Defining Empowerment

Following (Jupp et al. 2010), we asked participants explicitly to describe what "empowerment" means

to them. Some answers were related to the consequences of their actions (N=4):

> *"I mean, I think [about] our ability to actually make a change in something." (Participant 21)*

Other individuals described the process of taking action to be the indication of empowerment, and centered themselves and their experiences in describing empowerment (N=2):

> *"I think for me personally, it's all about education. It's all about knowing that I have access to informational channels of people who are independent and what they do, so they're not biased or financed by a specific side." (Participant 23)*

The variation in definitions signals nuances in appreciation for what empowerment means to them in the context of the environmental impact of AI.

5.2.5. Feeling Empowered, with Caveats

Participants generally felt empowered in the sense that they knew what to do, but did not feel empowered in the sense that it would make a difference in the world (N=6). They expressed that there were small steps they can easily (and planned on actually) taking, but none that would keep up with the toxicity of massive corporations:

> *"I still feel like a lot of it is in much bigger players' hands than mine. Like, I think a small-scale thing we can get. Still, I feel like it's on a much larger scale with the big change happening." (Participant 19)*

Many participants indicated that this reminded them of other issues related to the environment or other global issues (N=4):

> *"It's just made me feel like, well, I don't really want to use it, but me not using it [is] not only going to do anything because it's the companies that need to change. But that's the thing is how I feel pretty much anything environmentally. Like, I try my best to recycle." (Participant 14)*

Participants had difficulty positioning themselves in a meaningful, impactful way. Their sense of empowerment was tethered to their intent to do an act, not that the outcome of that act would be substantial. Still, grassroots movements indicate that these actions (if actually taken) do in fact make a difference at scale (Bosworth 2022; Freudenberg and Steinsapir 1991; Duffy 2021; Perkins 0276).

5.2.6. Wider Conversations about AI

Towards the end of the sessions, participants shared their grievances about AI that went beyond its environmental impact (N=3 groups). This demonstrated that the game supported broader reflection, beyond the subject matter explicitly represented in the cards, with players drawing on their prior knowledge and experiences to make new connections. These conversations included individual participants' stories about being forced to use AI in their work (N=3) or in school work (N=2). They also expressed larger concerns about what this would mean for the intelligence and cognitive function of people (N=2) or larger geopolitical issues (N=2):

> *"I'm also worried about the technology. I think it has great applications... I'm [just] a bit worried about the broader socioeconomic structure the companies are embedded in it all. We optimize for profit at all costs." (Participant 12)*

The conversations that occurred beyond the environmental impact indicated a much larger issue around anxiety and uncertainty consistent with literature on catastrophizing and learned helplessness (Gumus 2025).

6. DISCUSSION

We successfully designed a physical installation to communicate the environmental impact of AI, despite some shifts during the process. We positioned ourselves as a complementary contribution, situated between computer science (Bezáková et al. 2013; Drake and Sung 2011) and environmental sustainability education (Tsai et al. 2021). We incorporated narratives both as framing for the game and as cards to play, to provide a more enriching game experience (Arnaudo 2018).

The most challenging negotiation in the design process (beyond the decision to focus on qualitative data) was balancing the cards. Assigning specific resources and magnitudes to Cost and Benefit cards required subjective judgment calls by the researchers. We view these potential disagreements as opportunities for deeper dialogue between players regarding authority and the nuance of environmental impacts (which did happen in 2 groups, who had some discussion about the weight of their cards). While a researcher or designer may know more than the people engaging with their design, they should also be prepared to sit comfortably with criticism or critique of their decisions.

Our preliminary focus groups provided valuable feedback on mechanics and content, and were coming into the research process with a stronger understanding of the environmental impact of AI (and AI in general) relative to the general public. As such, their feedback was helpful for refining some of the mechanics and receiving feedback on the grounding of the game in real-world narratives and actions.

The group interviews and companion questionnaires provided clarity into how effectively the game engaged and empowered participants. In the likert responses, participants generally found both content

and gameplay engaging and empowering, and indicated a movement towards altering AI use in hopes of better protecting the environment. Comparing likert and narrative responses shows a notable variety and nuance to players' understanding of empowerment and the associated effect of the game.

In the discussion portion, participants generally indicated a lack of empowerment, or a highly nuanced sense of empowerment. Many indicated that empowerment was action-oriented, and thought that the consequences of their actions were critical. Others thought that the motivation and information possessed by the actor was important, with empowerment less determined by outcome. By self-identifying what empowerment means to them, they were able to engage with a more complex conceptualization than cause and effect.

Participants also indicated that they were forced to use AI for work, or that there were far greater forces who had a far bigger role in shaping the environmental impact of AI than they did. Still, in the likert responses, they clearly communicated that they were going to take actions, including actions that would indeed affect the environmental impact of AI. Depending on each definition of empowerment, this intervention was a success for some, but not for others. Participants also took this as an opportunity for catharsis, reflecting on the variety of resources impacted by AI use and their frustration with the overall landscape of technology, politics, and social issues.

Future research should further interrogate the notion of "empowerment" as it pertains to the environmental impact of AI, possibly using a validated measure and more participants. Tracking change in affect and behavior over time would provide a more robust view of how participants changed as a result of this game. There is also a need/desire for more social and community-based spaces to discuss AI and its impacts, including but not limited to forums on the environmental impact of AI.

7. CONCLUSION

Through an iterative design process, we developed a physical board game with components designed to capture the nuance of the AI supply chain (RQ1). We began with a literature review, which revealed that a data-centric approach was impractical due to unavailable or unreliable figures. Consequently, we pivoted to a narrative-focused approach. This allowed us to share qualitative stories without relying on quantitative data (RQ2). Preliminary focus groups validated this approach but highlighted areas for improvement.

Once the game was finalized, group interviews found that participants were generally engaged with and entertained by the game, but had a complicated relationship with the notion of "empowerment" (RQ3). This is consistent with literature on the learned helplessness for both technological developments and environmental sustainability. Still, participants generally indicated that they planned on altering their AI use due to its environmental impact. As researchers, we believe it is vital to bridge the gap between academic work and the general public. *SustAIn* is a step toward empowering individuals who may feel that AI's environmental impact is too big to challenge.

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A. GROUP INTERVIEW PROTOCOL

After signing the consent form, participants were given a single multiple choice question asking "Which best describes how you feel about your relationship to the environmental impact of AI?" (shown in Figure 7. They were then asked two questions: "Do you use AI?" (Follow ups if they don't directly answer: If so, how? If not, why not?); and "What is your general impression of AI's environmental impact?" Players were then given the instructions, and went straight into gameplay of 20-30 minutes (depending on time constraints to keep the total session duration at around one hour). Participants then read the end state of their game, and were presented with the final set of discussion questions:

1. Did you find the narratives engaging? Why or why not?
2. What narratives did you find most interesting? 3) What does "empowerment" mean to you, specifically in the context of AI's environmental impact?
3. Do you feel empowered after playing that game? Why or why not?
4. What is your general impression of AI's environmental impact?
5. Lastly, How do you feel that you fit into the landscape of the environmental impact of AI? Does it feel different than it did before playing SustAIn?

Participants were then presented with a final questionnaire.

B. BOARD GAME ACCESS

The printable elements of the board game can be found at the following url.

`https://sustain-game.gitlab.io`

These include:

- The game board (to be printed across two sheets of A4 or A3 paper);
- The legend and AI booster;
- The thermometers;
- The additional tiles, game pieces, thermometer indicators, and booster token (each to be cut out separately);
- An optional printable dice (glue required);
- A four-page manual to the gameplay;
- A two-page overview of the potential end states and their corresponding scenarios;

- The numbered reference list for the narratives on the corresponding cards;
- The full set of printable benefit, cost, change and action cards (to be cut out separately).

Unless specified otherwise, all items can be printed as-is on A4 paper.

C. IMAGES

Pictures of each iteration of our board design process can be found in Figure 6. The results from the pre- and post-test questionnaire are in Figure 7. The post-test likert scale results are in Figure 8.

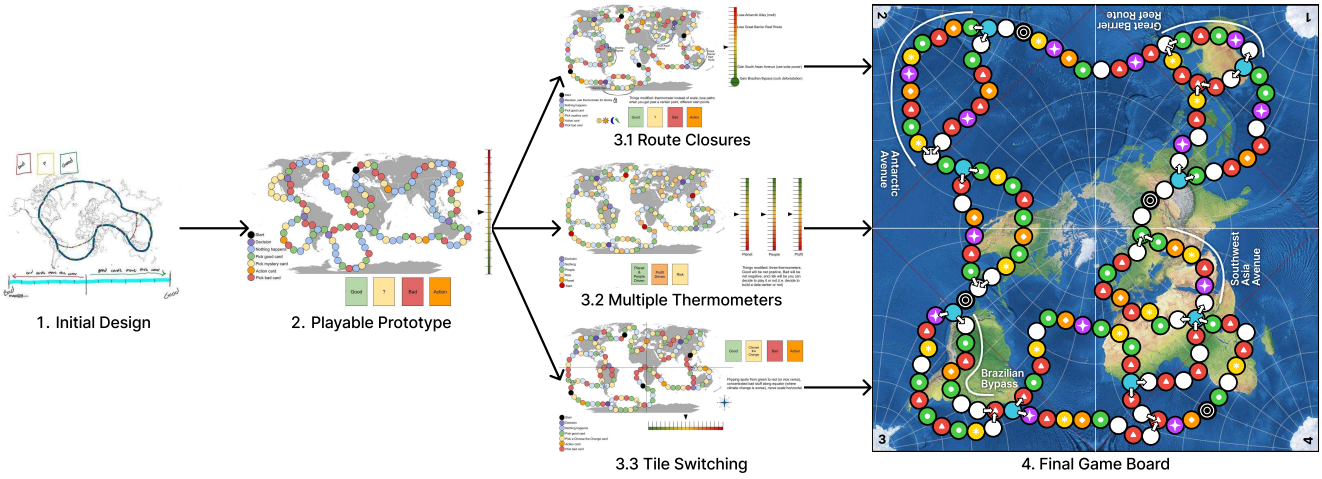


Figure 6: *Evolution of the game board through the design process.*

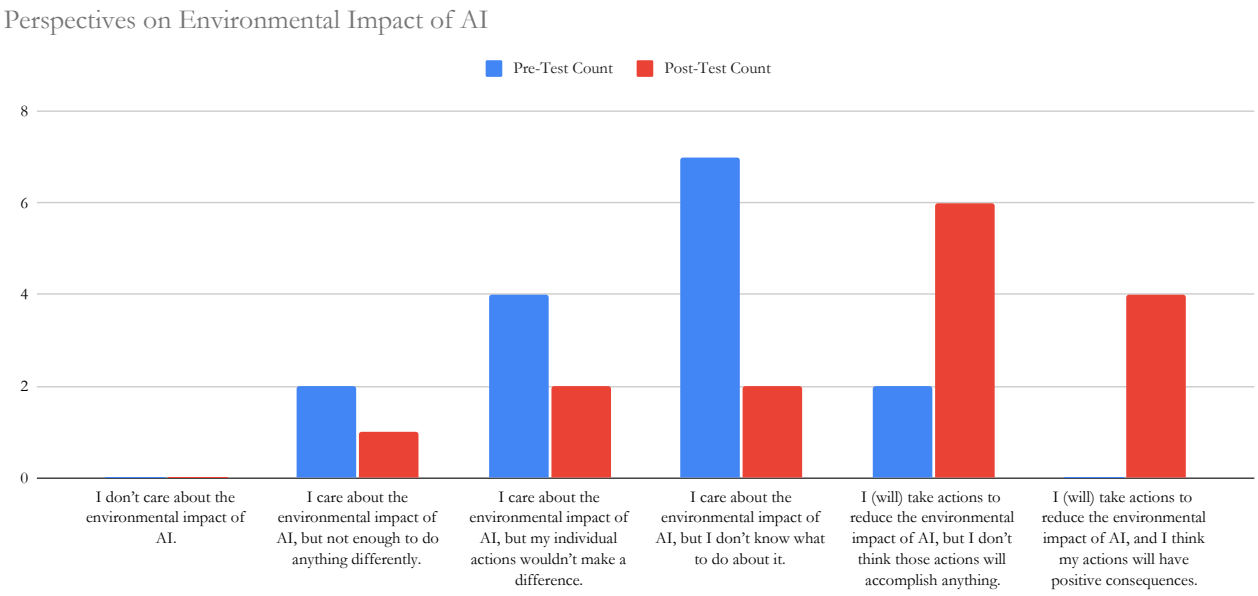


Figure 7: *The responses to asking "Which best describes how you feel about your relationship to the environmental impact of AI?"*

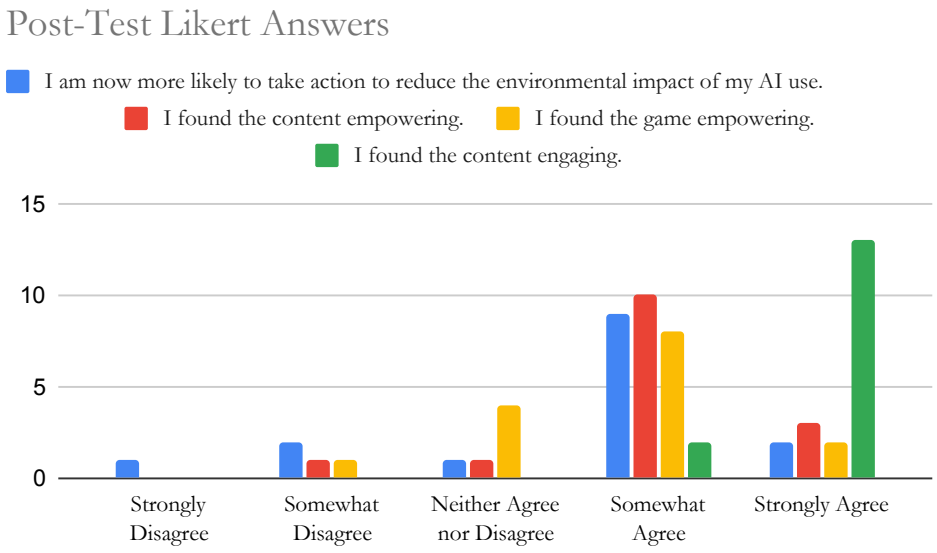


Figure 8: *The results from Likert scale portion of the questionnaire delivered at the end of the Group Interviews.*