Last Island: Exploring Transitions to Sustainable Futures through Play

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ABSTRACT

A serious game was designed and developed with the goal of exploring potential sustainable futures and the transitions towards them. This computer-assisted board game, *Last Island*, which incorporates a system dynamics model into a board game's core mechanics, attempts to impart knowledge and understanding on sustainability and how an isolated society may transition to various futures to a non-expert community of players. To this end, this collaborative-competitive game utilizes the *Miniworld* model which simulates three variables important for the sustainability of a society: human population, economic production and the state of the environment. The resulting player interaction offers possibilities to collectively discover and validate potential scenarios for transitioning to a sustainable future, encouraging players to work together to balance the model output while also competing on individual objectives to be the individual winner of the game.

CCS CONCEPTS

• **Human-centered computing** → **User centered design**; • **Computing methodologies** → *Modeling and simulation*; • **Software and its engineering** → *Interactive games*;

KEYWORDS

Sustainability; public engagement; serious games; computer-assisted games; board games; game design

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1 INTRODUCTION

There are various visions of our future, but most policy-makers and scientists agree that life will be substantially different in the post-fossil fuel era [5]. Eroding ecosystems, the end of cheap oil, and climate change all call for new policies to support societal transformations toward low-carbon alternative futures. However, we are still unclear what these futures may look like and how we can transition to them. Sustainability transitions are the processes of change that propel societal systems into a sustainable state of functioning [6]. Within a finite planet, material consumption and the degradation of physical systems cannot grow forever and since economic growth is combined with consumption growth, it is expected that in the future we will witness a crumble or overshoot in the world system [23].

To avoid these severe variations, the concept of sustainability is introduced. Wimberly [27] states that "to be sustainable is to provide for food, fiber, and other natural and social resources needed for the survival of a group", where a group may be on a national or economic sector scale. While there are many other definitions of sustainability, the maintenance, sustenance, stability, continuity of a certain resource, and the goal of avoiding adverse variations are common components in most definitions. Achieving this continuity and controllability can be assisted by raising knowledge and awareness in the general population and, more specifically, in decision makers regarding the impact of their work-life decisions on the socio-environmental system at stake.

To engage individuals such a topic, transfer knowledge, and facilitate dialog, educational science has previously recommended the design of goal-directed activities in the form of *serious games* [11, 21]. Serious games are typically designed for transformative purposes rather than pure entertainment [11] and to create a joyful learning experience by promoting a social form of learning and providing quick feedback [22]. They also offer opportunities for participatory modeling and can be used for crowd-sourcing information about citizen mental models and stakeholder behavior.

The game described within this paper was designed to help identify and explore scenarios of future transitions to promote individuals' awareness about the impact of their decisions. The aim of this educational sustainability game, titled *Last Island*, is to transfer basic knowledge about the complexities of transitioning to sustainable futures while balancing resources along the way to a general audience in a playful way. This game can also support policy and public engagement in shaping a vision on a common future by creating a starting point for conversation surrounding the topic. This is achieved by embedding a simple system dynamics model (Miniworld [3]) into a computer-assisted board game environment, and linking model parameters that control population, production, and environment with actions taken within game. This computer-assisted board game paradigm allows for complex, non-linear outcomes to player interaction, with real-time visualization of the game state to support the players' decision making, while also maintaining the physicality, collocation, and gameplay discussions of a board game.

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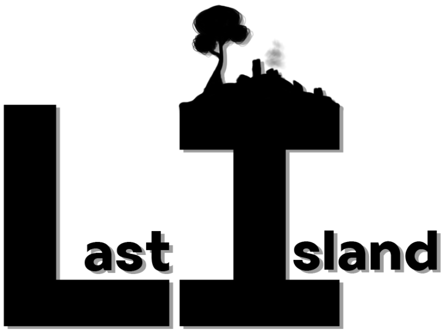


Figure 1: The *Last Island* game logo.

2 RELATED WORK

The positive effects of serious games from learning motivation to learning gains have been demonstrated in several studies [4, 11, 14]. However, these are not achievable unless the fun aspect of the game interacts integrally with the educational aspects [11]. Recently, the interest in serious games for sustainability has grown and a few games have already been created within this field. The leading intention of all these games is to inform players about the environment, society, energy, climate and political challenges related to sustainability. However, some of these have unfortunately not been successful in engaging the players for extended periods of time [15]. By placing too strong of an emphasis on the learning objectives and underestimating the requirement for fundamentally enjoyable game design elements, players are likely to become disengaged quickly when compared to commercial games that focus on entertainment.

Futura is an instance of appealing collaborative game implemented on a multi-touch tabletop with a walk-up-and-play style [1]. The game aims to raise public awareness about sustainability by simulating the impact of population growth on the environment. Although the game achieved engagement and awareness, it did not provide players with the feedback to distinguish between the short-term impact and cumulative temporal effects of their individual and group actions [1]. EnerCities is another example of a serious game, which attracted attention [15] due to its visual aesthetics. The results of the resulting experiment have shown that playing EnerCities leads to positive behavioral changes in school children. However, experienced players believed that the game did not adequately maintain levels of interest [25]. Lack of clues and feedback were also identified as shortcomings of Enercities [17]. The idea of promoting youth knowledge about consumption and production of sustainable products has also been implemented in the SuLi game, which aims at influencing purchasing behavior [13]. All these examples represent a line of research that tries to leverage the enjoyment, engagement and motivation that games provide, to foster the change of behavior in a desired manner.

Some commercial games also embed educational content but are typically not classified as serious games as they heavily focus on entertainment rather than achieving a set of learning objectives. For example, the *Assassin's Creed* series [24] allows players to learn an embellished form of history and architecture, *Kerbal Space Program* [20] can give insight into rocket mechanics and dynamics, and *Papers, Please* [16] promotes critical thought on seemingly unfair social and political constructs. These games are successful in engaging players for long periods of time through their formal and dramatic elements [8] while also imparting real-world knowledge to the player. As a specifically relevant example, Democracy 3 [19] is, at its core, a game about interacting with a system dynamics model. Through an assortment of well-designed visualizations that hide the complexities of the underlying model and an integrated narrative that engages the player, the player is left to make informed decisions and enjoy the game without being overburdened. Following these approaches, we attempted to impart knowledge and understanding on sustainability to a non-expert community of players through the incorporation of a digital system dynamics model into a board game's core mechanics and by balancing educational objectives with engaging gameplay.

3 GAME CONCEPTUALIZATION

The following section sets out the methodology used for conceiving the *Last Island* game and the most relevant aspects that were considered through the design process. For a more complete understanding of the rules and the physical game objects used, readers are referred to the the official Last Island website[1].

3.1 Educational Outcomes

As this game required both educational and entertainment elements, the Cognitive Behavioral Game Design (CBGD) model [21] was adopted as a framework to instigate the design process and expand on the educational objectives. The CBGD model incorporates elements of social cognitive theory [2] and Gardner's theory of Multiple Intelligences [9]. The CBGD model, can be decomposed into three sections. The first section describes five social cognitive elements that help define what the game should convey to the player. These social cognitive elements are often interrelated and have a dual meaning, representing concepts within the game or in the real world.

As part of the design process, the cognitive elements of knowledge and goals could be defined prior to brainstorming gameplay mechanics. Here, knowledge includes understanding three key points:

- The definition of a 'sustainable world' is dependent on an individual's desirable outcome for the world.
- The need for societal change in order to address the decline of finite resources in the real world.
- The relationship between different variables of a system dynamics model of our society and ecosystem.

In designing the Last Island game, we did not wish to directly instruct players on these core knowledge principles but rather to form there own critical understanding by reflect on the game mechanics, the game progression, and the visualization of the systems dynamic model through the digital support system. Certain design choices were taken for this reason, such as minimizing the presence of an authored narrative and allowing the players to form there own

[1] Last Island website: Anonymous for blind peer review

narrative, as well as choosing an existing, well researched, system dynamics model so as to reduce the effect of our own opinions and bias on how the model (and subsequently the gameplay) should progress from round to round. Also, while there are overall gameplay goals to structure win and loss conditions, we seek to allow players to set their own goals by giving flexibility in deciding which societal structures they want to build and whether they will place more emphasis on personal goals or collective goals of the current group of players.

3.2 Overview of Resources Objectives, Rules, and Procedures

With the educational objectives established, the remaining game design process expanded upon the formal and dramatic elements of the game, as defined by Fullerton [8]. The *Last Island* game is computer-assisted board game played with 2 to 5 players. The surrounding premise is that the players are in-charge of the last island on Earth and need to successfully maintain a sustainable society on the island from humble beginnings.

The overall objective of the players is to build a society over the course of 15 rounds by placing tiles, representing buildings that affect three core elements: population, environment, and production. Players are allowed 2 actions per turn which can include drawing a tile from one of three tile decks, placing a tile on the table, or destroying a tile already on the table. Tile pieces can be placed down from a player's hand onto the table in any orientation, as long as they are adjacent to at least one other tile.

The primary resource of the game are the tiles that represent physical structures within the game's world, such as hospitals, factories, and park lands. Each of the three colors of these tiles (red, green, and blue) represents an output variable (population, environment, and production) of the digital system dynamics world model. Each time a tile is added or removed from the table, this information is entered into the digital support system by the players, which updates the parameters of the model of the society and visualizes the effects of the player's choice on the rate of change of population, production, and environment in the current round and the next round. The information written on the tiles indicates which model parameters (such as rate of birth, death, consumption, environmental regeneration, etc.) will be directly adjusted by placing the tile and the color of the tile indicates which output variable is most likely to be affected and to what degree, with darker tiles indicating a greater effect. However, because of the non-linear nature of the system model, placing, for example, a population related tile will also potentially have positive or negative effects on the production and environment in the near or far future of the game.

If the rate of change of any of these is too steep in the current round when the round ends, then the game is lost. If the players last until the end of the 15th round then the group wins and an individual overall winner is determined by who completed the most individual quests. Individual quests are specified by quest cards that relate to the spatial positioning of the main game tiles, requiring players to make patterns such as three in a row or a two-by-two square of the same color. Each player has their own individual quests to complete, with each player drawing two quest cards at the start of the game and immediately drawing another quest card from the deck each time any current quest is completed. The number of quests completed determines that player's individual score at the end of the game. This allows for an overall individual winner to be identified among the players and also promoting risk taking by placing tiles that may result in a higher individual score but may also put negatively affect the system dynamics model and the overall chance of the group finishing the game.

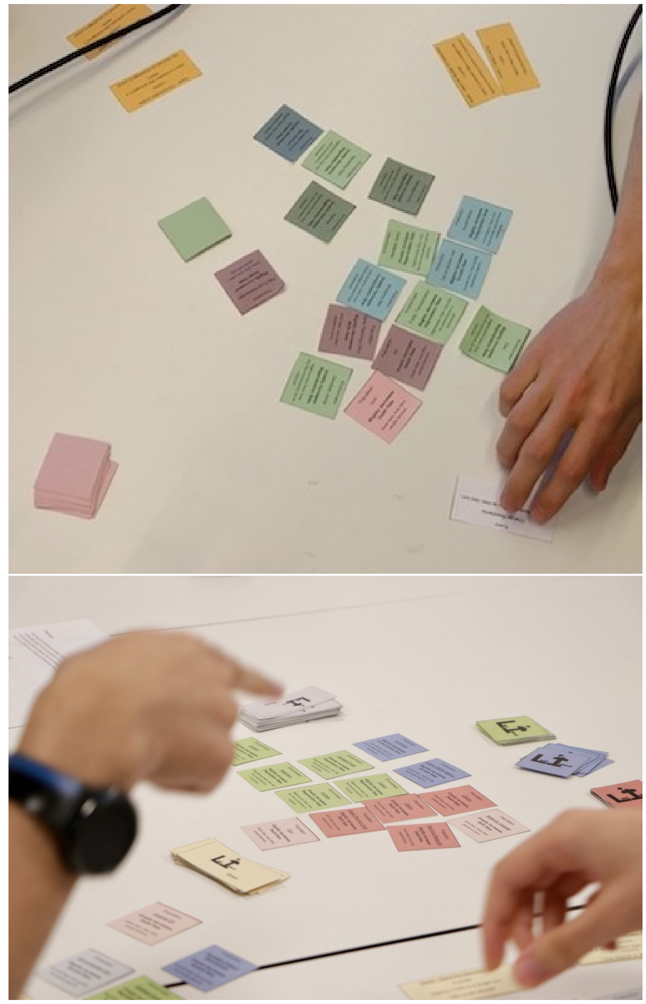
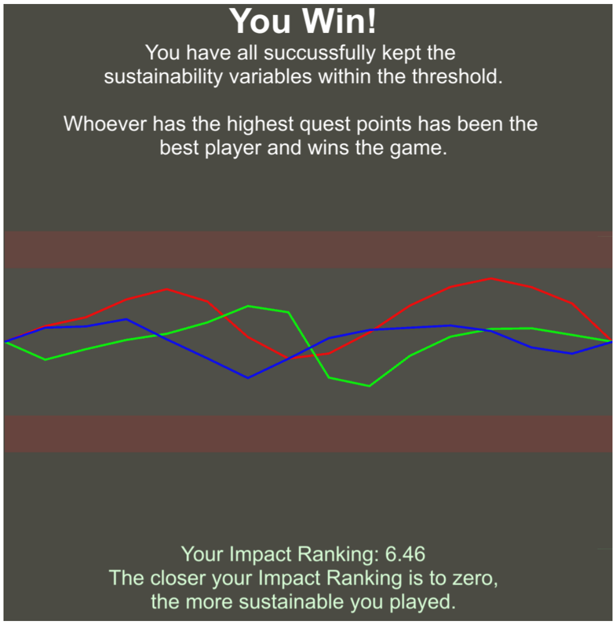


Figure 2: The *Last Island* game being played, showing the main game tiles (red for population, blue for production, and green for environment) in both dark and light shades indicating variable effect, quest cards (yellow) and event cards (white).

Finally, due to the nature of the selected system dynamics model tending towards stability overtime, the difficulty of the game actually decreases as the rounds progress, the opposite to most conventional game design paradigms. To remedy this, event cards were implemented to disrupt the state of the island by removing tiles previously placed by players on the table. The result is a more consistent sense of challenge and suspense engagement throughout the game.



(a)

(b)

Figure 3: The winning (a) and losing (b) screens in the digital support system of the *Last Island* computer-assisted board game.

3.3 Player Interactions

A board game setup was chosen to facilitate face-to-face communication between players to encourage further discourse on topics within the game. For how the players would interact, we decided between cooperative and competitive play. In a cooperative game, players would share resources to help win the game, which gives players a chance to interact with each other in a positive way. This, however, may not reflect the different motives and roles of individuals in the real world, and thus the connection between real-world goals and player goals would be conflicting. Conversely, in a competitive game, players could collect their own individual resources to earn a better score. While this encourages players to find the most optimal way of playing the game, it restricts opportunities for players to interact and reinforces a false real-world mindset that acting greedy is a sustainable behavior, which is a contradiction of the tragedy of the commons paradigm [10].

Therefore, it was decided that the game would incorporate both cooperative and competitive elements in a 'one-wins or all-lose' setup. Here, players need to work together to sustain the society for a certain number of rounds, and if successful, the winner is the player who scored best based on how well they followed their own interests (via quest card completions). If the group of player got to the end of the game (15 rounds) they were given and impact rating, which is shown in Figure 3.a and is calculated from the cumulative deviation of all three curves from the center of the graph across all fifteen rounds. This impact ranking gives an indication of how much fluctuation the society went through over the 15 rounds of play, with a lower number indicating a smoother transition from the initial island society to the final society at the end of the game. This metric also allows the group to play multiple rounds to try to improve their performance.

However, if players were unsuccessful in prolonging the society, all players would lose. Additionally, turns were cycled in each round, such that the first player in round one would be the last player in round two, the second layer in round one would be the first player in round two, and so forth. This gave each player the opportunity to play proactively knowing that other players could correct their mistakes before the end of the round, and for each player to be forced to play reactively and balance the model to adjust for other players' actions and stop the group from losing. This combination of cooperative and competitive interaction patterns facilitate a challenging game dynamic by provoking a dilemma for each player, who must decide whether they should commit resources towards benefiting themselves at the cost of losing the game for everyone and, conversely, helping the group potentially at the cost of not winning personally.

4 SYSTEM DYNAMICS MODEL INTEGRATION

The digital support for the game plays a large role in representing social cognitive elements of the CBGD through visual feedback and keeping track of complex system dynamics of the game that would otherwise be beyond the ability of board game players to calculate [8]. Here, the sustainability of the society is graphically represented in the variables of a system dynamics model. Buttons allow players to keep track of what tiles are present on the board, and feed this information into the socio-environmental model. This simulation provides immediate feedback, which can help explore the effects of each tile, allowing more experienced players to acquire a sense of mastery over their decision making in the game by intuitively identifying input and output patterns.

Investigating probable policies, finding optimal ones and exploring what-if scenarios are three popular applications of these types

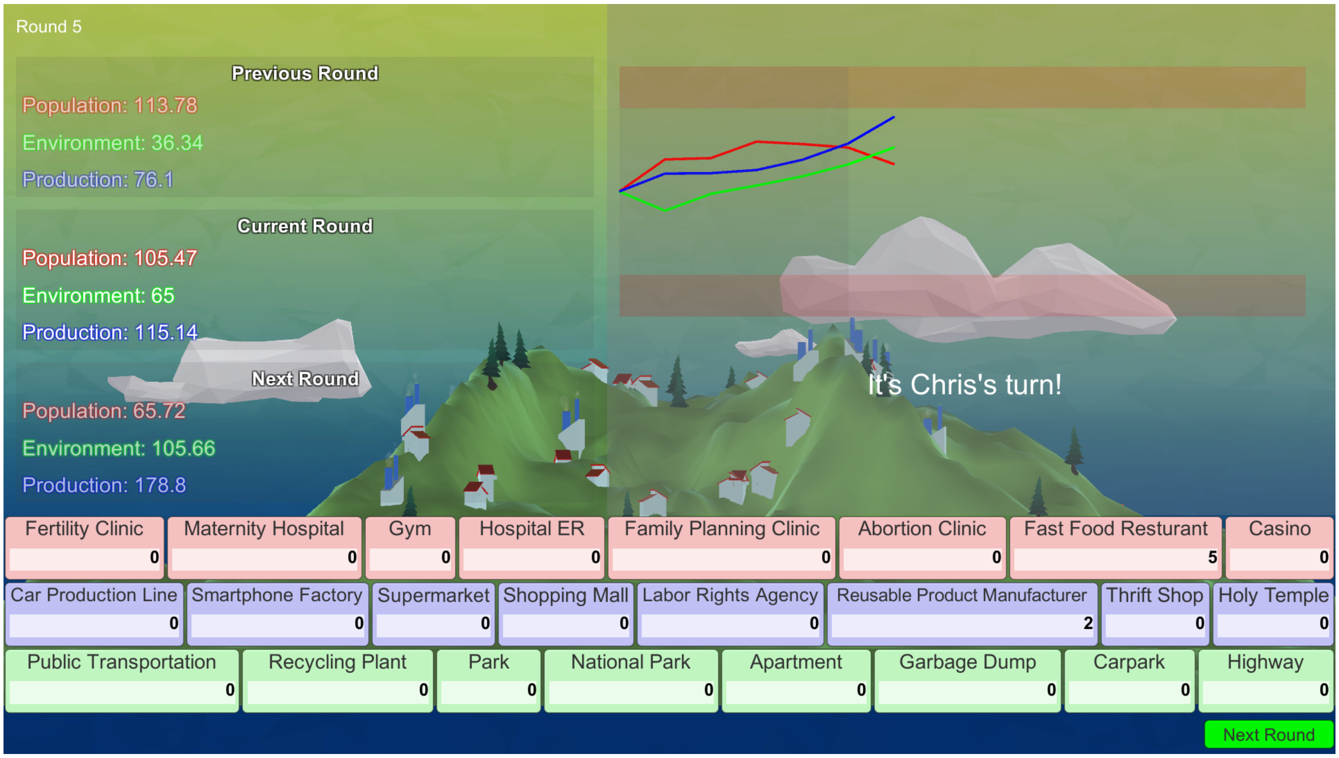


Figure 4: The main game screen in the digital support system for *Last Island*. The past, current, and future rates of change are shown by the values on the left and the graph on the right. Buttons for players to specify which tiles have been added or removed from the table are on the bottom. In the background there is a 3D representation of the current island with the quantity of houses, factories, and trees representing the current state of the three primary variable.

of dynamic simulations. For instance, the results of a climate simulation may show that to reduce climate impact, there needs to be a reduction in economic growth. This may motivate a call for reduction in a fossil fuel consumption from environmentalists, while others try to prevent action from being taken to keep the economic growth and living standards stable. The world model we used included the conflicting input and output variables and highlighted to players that trade-offs are often needed to ensure stability of the environment, the economy, and population simultaneously, while stimulating conversations regarding these.

Two popular world system dynamics models were explored (World3 [7] and Miniworld [3]) as well a bespoke world model [26]. Although Miniworld is a less detailed model, Bossel [3] argues that its results are interestingly consistent with World3, which contains hundreds of state variables, parameters, and equations. Thus, due to the the simplicity, robustness and reliability, the Miniworld model was chosen as the world model to define the system dynamics of the game. The digital support system was developed in the Unity Game Engine[2] with a redeveloped version of the the VENSIM[3] Miniworld implementation.

[2]Unity Game Engine: https://unity3d.com/
[3]VENSIM: http://vensim.com/

4.1 Challenges

An issue that arose in embedding the Miniworld model because many of the input and output variables operate in different scales and without constraints. This is a problem because we want to provide players a way of easily comparing performance between variables through the visual representation of using a unified graph. Also as we were using this game to teach sustainability to players, having arbitrary numbers made communicating the idea of sustainability and measuring the player's success more difficult. To provide clearer information for players to make decisions from, the win condition was constructed such that the players were required to minimise the change of variables between rounds to reflect a stable society. This is done by displaying the derivatives instead of the variable values and graphing a percentage number to represent the rate of change at a single time step. If this percentage is too high or low, then the change is considered too too drastic (possibly leading to an economic crash, environmental catastrophe, unsustainable population boom, etc.) and causes the game to be lost.

5 INITIAL EVALUATION

The current prototype of the *Last Island* game has been used in an experimental workshop to gain feedback from players on both their engagement with the game and their perceptions of sustainability before and after playing the game. The workshop included 24 participants, primarily consisting of undergraduate university students and staff who were invited via general announcements and were not associated with the research project. These participants were divided into seven groups, each with three to five members.

The workshop participants were first given a pre-survey to evaluate their thoughts and knowledge on sustainability and future transitions. They were then provided with an introduction that included the motivation and theory behind the research project and a demonstration of the rules of the Last Island game. Participants were then told that there were gift voucher prizes for each member of the group with the overall lowest impact ranking (as seen in Figure 3.a) as well as a larger gift voucher and a copy of a popular board game for each of the top three players. Individual score was determined by the number of points collected through completed quests in a game where the group successfully lasted all 15 rounds. Participants were then given one and a half hours to play the game as many times as they liked and report their group and individual results from the game with the best impact ranking score. After all games were completed, participants were asked to fill out a custom post-survey on their thoughts on the game and again their thoughts on sustainability, as well as the Flow State Scale [12] and the Play Experience Scale [18].

While a detailed analysis of the data resulting from this workshop is ongoing, initial indications are positive, both in terms of entertainment of the game and having the players reflect on the core knowledge elements of the game. All the groups failed to complete their first play through by allowing the graph to reach the red zone and losing the game. However, all but one group were able to complete their second play through, showing that most groups began to understand patterns within the non-linear system dynamics model and started to identify strategies for maintaining a stable society. The group that failed to complete their second round stated that they had played aggressively, each seeking individual goals over the group goals.

Of additional note is that, while the game was primarily designed to create a conflict between cooperation and competition, the group in the workshop with the overall highest group score also had the two highest performing individual players on quest card completion. This highlights the ability of players to discover the benefits of cooperation even in a setting that seems to dissuade it.

6 CONCLUSION AND FUTURE WORK

In this paper we detailed the design of computer-assisted board game wrapped gameplay mechanics around an existing system dynamics world model (the Miniworld model) in order to stimulate critical reflection and conversation around ideas of sustainability and maintaining stability while transitioning to a sustainable future. The resulting game, Last Island, encourages both cooperative and competitive play and requires players to interact with a complex, non-linear world model in which it can sometimes be hard to predict the short and long-term consequences of individual each player's actions, much in the same way that it can be in the real world. Initial observations of the game being played in a workshop setting indicates that the game was enjoyable and appropriately challenging as well as engaging participants in though and conversation surrounding sustainability.

Future work for this project involves collecting more workshop data and producing insights from this to further the design of *Last Island*. Potential changes may include exploring the use of alternative system dynamics models to provide potentially more complex interactions or, vice-versus, more clear linear patterns for the players to identify and identifying which of these leads to a more satisfying player experience and better reflection on ideas around sustainability. There is also room for improvement in refining the games mechanics to produce a deeper engagement for the players and adding more narrative elements to further stimulate conversations regarding potential futures. Finally, there could be ways of using computer vision to automate the input of information into digital support system and the use of augmented reality to overlay the digital visualization and island representation on top of the physical tiles on the table.

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