International Journal *of* Designs for Learning
2020 | Volume 11, Issue 2 | Pages 96-107

GREEN ECONOMY GAME: A MODULAR APPROACH FOR SUSTAINABLE DEVELOPMENT EDUCATION

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In this paper, we discuss our approach to designing a board game, the Green Economy, that promotes systems thinking. We anchored our game design process on design-by-analogy and rapid prototyping concepts by taking a modular approach to overcome the trade-off between realism and simplicity. The unique feature of the Green Economy enables players to change the rules of the game during the gameplay, which gives them a partial design opportunity. The theme, sustainable development, was chosen to challenge the players' systems thinking in sustainable development. Systems thinking enables us to understand and face the complex challenges in global and networked social structures. Our design experience demonstrates the benefit of designing dynamic game elements that involve both strategic gameplay and game (re)design through systems thinking.

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INTRODUCTION

This case reports on the process of designing a board game that promotes systems thinking within the context of sustainable development education. We chose sustainable development as our theme for the game considering its importance for future generations and its intrinsic relationship with systems thinking.

This game, called Green Economy, incorporated both the gameplay and a game design experience, in one experiential game-based learning activity. We anchored our game design process based on design-by-analogy and rapid prototyping concepts. We also adopted a modular approach for our decision-making to overcome the trade-off between realism and simplicity. By incorporating a unique feature that enables players to change the rules during the gameplay, learners act as both players and game designers.

Throughout the gameplay, learners as players lead a nation that should avoid adverse consequences for the environment while consuming resources for its development. As game designers, learners have to consider the different game elements, rules and assumptions about competitors' plans to promote meaningful design changes that will lead them to win the game. This case demonstrates the process of designing a board game that promotes learners' systems thinking and decision-making while playing both roles.

In the following, we briefly present the context and the composition of the design team and our perspective on design. After describing our game, its elements, rules, and

https://doi.org/10.14434/ijdl.v11i2.25020

mechanics, we discuss our design approach and our use of modular concepts to make various decisions for the game. We conclude the paper with some reflections on our design process.

CONTEXT OF GAME DESIGN

The development of this game was part of a project that encompassed on-going efforts of engaging learners in game design practices. From this research, it was observed that it could be beneficial for the learners to play a game that specifically targeted their learning of how game context and rules would create possibilities and change players' experience. Based on that, a team of graduate students, who attended an advanced seminar in design, was invited to create a board/card or other hands-on (non-digital game) game prototype, as part of their course requirements. This game would provide opportunities for the players to tweak rules, context, characters, and so forth during the play. This game would allow players to understand how possibilities are created and transformed into the game. The team met regularly (weekly-base) after class to discuss the project, built the prototypes, and performed playtesting sessions.

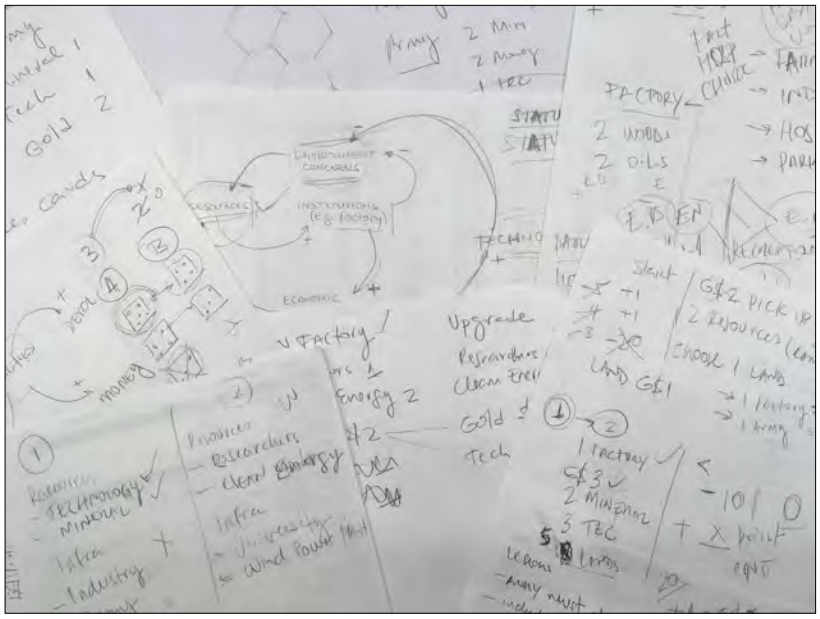

FIGURE 1. Sketches from design process

Design Team

Three graduate students in education constituted our design team. The leader of the team was an experienced board game player and Ph.D. student interested in game-based learning (GBL). The other two members were master's students with little experience with games, but with interest in how games could support language and literacy development.

The diverse background of the group provided a rich environment that supported productive discussions through which different ideas emerged. We held two-hour weekly meetings in the winter of 2017, which helped foster the necessary confidence to share any ideas that might sound 'crazy.'T he team used many sketches (Figure 1) to better communicate ideas as all members of the design team were becoming acquainted with English terms of game mechanics as well as sustainability—none of the members of the design team uses English as the first language.

Our Perspective on Game Design

The current worldwide context is often described as informational, global, complex, dynamic, and networked (e.g., Castells, 2010; Dorst, 2015). The competitiveness and productivity in our economy could be seen as knowledge-based, operating on a global scale in a network of interactions between multiple stakeholders.

The interconnectivity between countries, companies, and people creates a net of relationships that emerged from the technology revolution at the end of the 20th century (Castells, 2010). To tackle many of the new challenges that arose in the current context, new competencies were presented as indispensable for the 21st century, such as creativity, critical thinking, problem-solving, and teamwork (Binkley et al., 2010). Systems thinking, as one of these competencies, enables us to understand the complexity of global and networked structures and their outcomes. Systems thinking also helps us to analyze the complex interrelationship between different domains such as society, environment, and economic agents at different levels (local to global) (Weijs, Bekebrede & Nikolic, 2016).

Games have been presented as a pedagogical possibility to engage players in systems thinking (Kaufman & Flanagan, 2016). Furthermore, games are models of systems (Kim & Bastani, 2017) and systems itself (Fullerton, 2008), which makes gameplay and design of games promising learning tools for complex contexts. As a pedagogical strategy, the design of games supports learning objectives such as coding, design literacy or design thinking, critical thinking, problem-solving, and systems thinking (Kim & Bastani, 2017; Martins & Oliveira, 2018). The design of games nurture plentiful opportunities for students' systems thinking in practice.

The theme of the game, sustainable development, also supported the effectiveness of this game design to enhance systems thinking. Sustainable development is a complex topic that requires a systemic view to be understood and also connects us with the notion of consequential actions.

FIGURE 2. Green Economy.

This feedback process is an essential component within the system and also brings a compelling educational awareness that invites us to disrupt the existing practices to improve the lives of future generations.

GREEN ECONOMY GAME

In the Green Economy game, players are invited to engage in the reasoning of the sustainable development. They lead a nation through two distinctive stages. They gather and manage resources (including land and Gold) in the first stage to build facilities that allow them to evolve as a civilization into the second stage.

The game board is formed with hexagons, and each hexagon represents a land; the cards include resources, chances cards, and rules cards (Figure 2). The game encompasses other elements that represent population, Gold, factories, and army (see Table 1). The first nation that reaches a certain degree of wealth without negative environmental points wins the game.

ELEMENT	FUNCTION
Board	Represents the space where players will build their civilizations
Population	Round chips represent the people from players' civilization who live in a land
Gold	The currency of the game (1 Gold = $10)
Factory	Running a factory (square blocks) results in earning Gold and gaining or losing environmental points (+/-)
Army	Protects players' land, population, factories, etc., and attack other civilization (pawns)
Resource cards	Provides the "raw-material" to build factories or army—Players need mineral, technology, researcher and clean energy to win the game
Chance cards	Provides a player good luck or bad luck (e.g., see Figure 3)

TABLE 1. Green Economy game elements.

To start the game, each player chooses a piece of land (one hexagon in the board) and receives three resources cards and five Golds. In each turn, a player can perform any combination of these actions or perform no action:

1. Buying or conquering one land.
2. Building, closing or upgrading one factory.
3. Placing an army in one land.
4. Moving one existing army to another adjacent land (only one step in turn).
5. Attacking another player's land and/or factory.
6. Upgrading to the second stage of the game.
7. Negotiating to trade resources with other players.

In the first stage, players must have land, Gold, technology, and mineral to build factories and armies. The Factory is the element of the game that provides Gold for payers. Each turn, a player receives for each factory owned 1 Gold and 1 negative environmental point. Yet, the army can move to an any adjacent land. The players may build or use armies to protect their own lands and factories, to conquer an available land and/or to attack other players' land. When players use their army to conquer an empty land, they receive 1 negative environmental point. When they use the army to attack another player, they receive 2 negative environmental points.

Each player starts a turn collecting income and negative environmental points from the factory or factories. The player ends the turn drawing a card from one deck with resource cards (technology or mineral), chance, or rule cards (see Table 1and Figure 4).

A player needs to own at least three pieces of land (identified by the population settled in) and pay 10 Golds, in order to move on to the second stage. In this new stage, the payers gain access to a new deck of cards with new resources (researcher and clean energy), change and rule cards (Figure 4). With these resources, a player can upgrade a stage one factory to a stage two factory that uses clean energy or build a brand new one. Stage two factory provides two Golds in each turn and two positive environmental points.

In this sense, the objective of the game is to "clean" all negative environmental points received. To win the game, a player must present 10 Golds, 1 stage two factory, and 0 (zero) environmental points. It means that some decisions in the first stage (the use of army and building factories) will lead players to deal with a critical burden during the second stage. Thereby, we argue that this gameplay mechanism helps players (as students) reflect on their decisions and the consequences of their actions for the environment.

The negotiation between players is also a significant part of the game mechanics (i.e., trading or buying resources they need to build factories or move to the second stage). Figure 5 summarizes the main elements of the game mentioned earlier.

GAME DESIGN APPROACH

Game Elements

Our design can be best illustrated by the Fullerton (2008)'s structure of games as players, objectives, procedures, rules, resources, conflict, boundaries, and outcomes (Table 2). First, we considered the players, or users, as students with or without previous knowledge related to sustainable development. Players will experience two layers of objectives. First, they will

FIGURE 3. A chance card from stage 1.

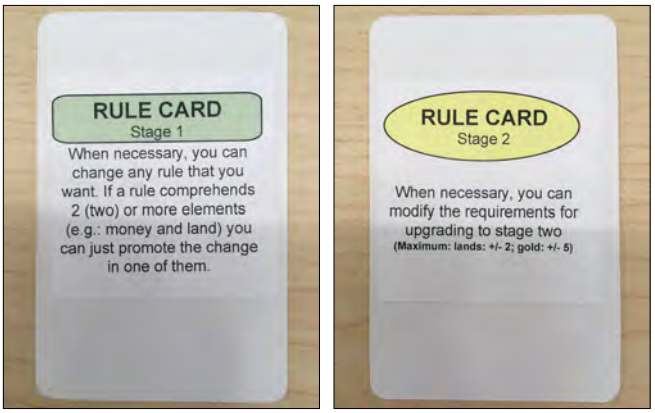

FIGURE 3. Rule cards from stages 1 and 2.

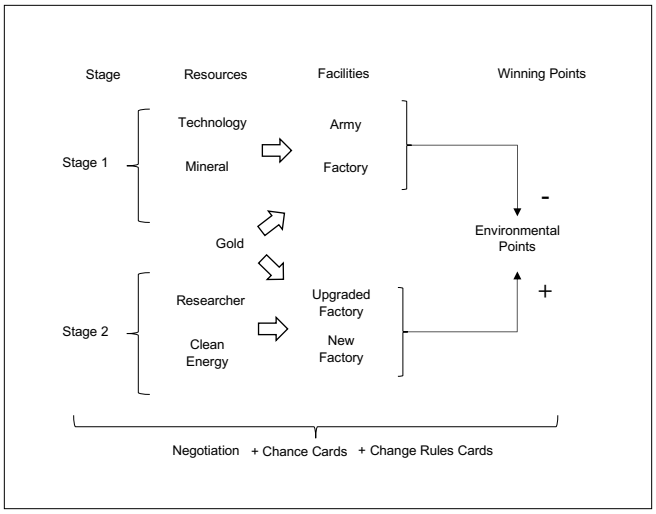

FIGURE 5. Boardgame system elements.

GAME STRUCTURE	DESIGN
Players	No previous knowledge is needed
Objectives	Multiple objectives within two layers (stages) and a final goal
Procedures	Adopted from well-known board games (e.g., battle system)
Rules	Ludus rules (win/lose approach); Flexible
Resources	Different elements to reproduce for the sustainable development
Conflict	Struggles to access resources and to win the game
Boundaries	Board itself and the hexagon that represent player land
Outcomes	Winner, and the lessons learned about sustainable development

TABLE 2. Green Economy game design.

pursue the objective of shifting their "civilization" from stage one to stage two to deal with their environmental issues. Second, at stage two, players will track the final goal to win the game. The players have multiple objectives in these stages, such as collecting appropriate resources.

Procedures (also defined as gameplay) are "the actions or methods of play allowed by the rule" (Fullerton, 2008, p. 29). Our design adopted the procedures presented in many board games to ensure its playability built on the common operation of board games. In turn, each player should think about possible actions, make a decision, make (or not do) a move on the board, and pick a card on the deck to end his or her turn. Our design also intended to preserve the player's agency. In this sense, our rules were designed (or left) to be flexible. For example, in one of our playtesting, we realized

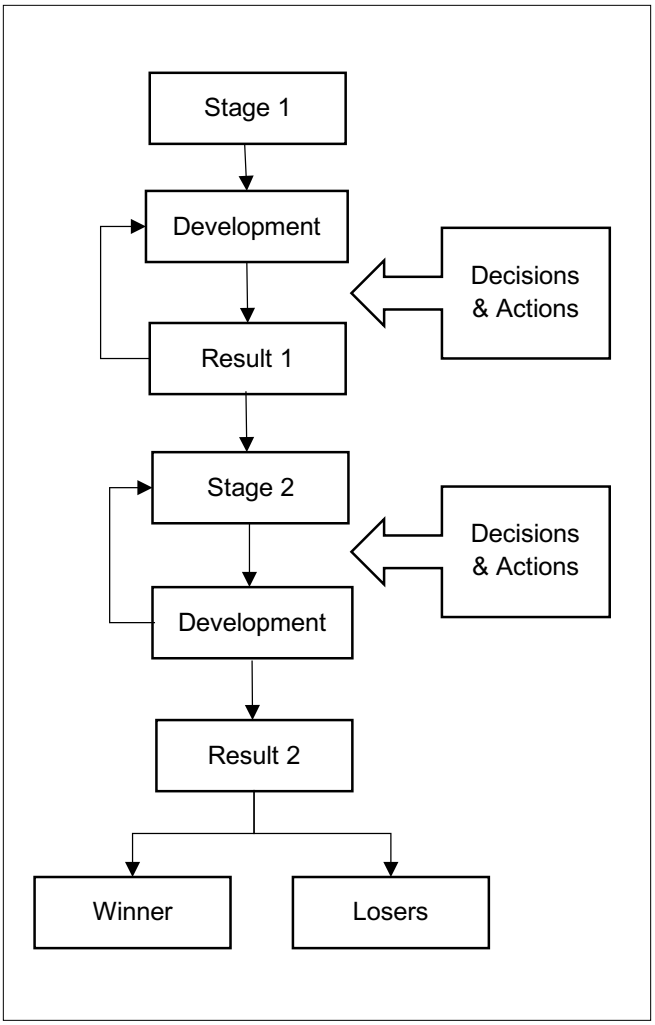

FIGURE 6. Ludus process adapted from Frasca (1999, p. 4).

that the negotiations could be made among players anytime during the game and embody any pretension usually related to resources.

Since the first design team meeting, we wanted to design a competitive game. Competitive games are popular and fun to play, and, seemed easier to design than collaborative games. Oriented by these assumptions, our design approach was based on the concept of ludus rules (Frasca, 1999) that comprises the sense of winner vs. loser in opposition of the concept of paideia rules where a player does not play to defeat others but to promote, for example, the satisfaction for their citizen as in Civilization III® (Briggs & Johnson, 2001; Wu, Hsiao, Wu, Lin, & Huang, 2012). The concept of ludus rules applied in our game is presented in Figure 6.

Fullerton (2008) defined resources as "items made valuable by their scarcity and utility" (p. 31). This idea is similar in our game since the use of resources in our design represents a critical environmental message. We conceptualize that resources, such as space (land) and money (Gold), are essential

but limited elements to build institutions, such as a factory. Hence conflicts among players emerge from the struggles to gain access to resources. Our game assumes every player as part of the game system in which a player may act defensively and offensively in response to other players' actions (Salen & Zimmerman, 2004).

The boundaries of our game can be identified by two layers. First, the board is the primary boundary that limits the action of all players. Second, each hexagon on the board represents a chunk of land where the owner has agency.

Finally, our design preserves the "uncertainty" in the outcomes (Fullerton, 2008) as the key motivator for the players. However, more important than identifying who won the game, our intervention applied to educational context allows educators to promote students' reflection on sustainable development principles and environmental concerns.

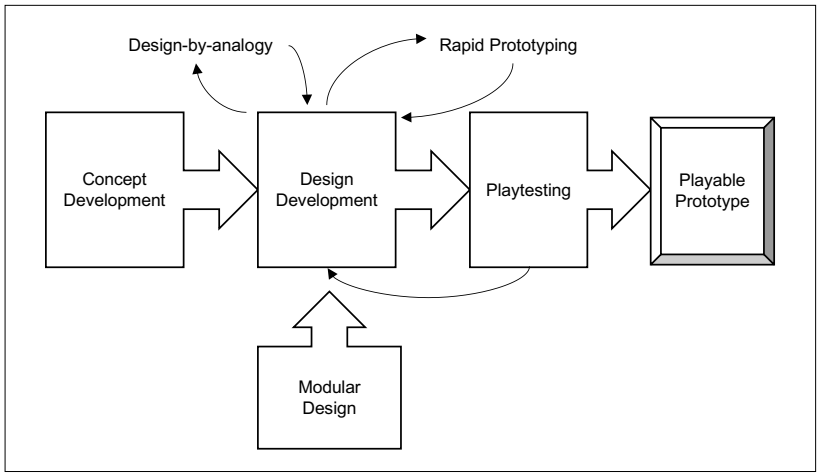

FIGURE 7. Game design process.

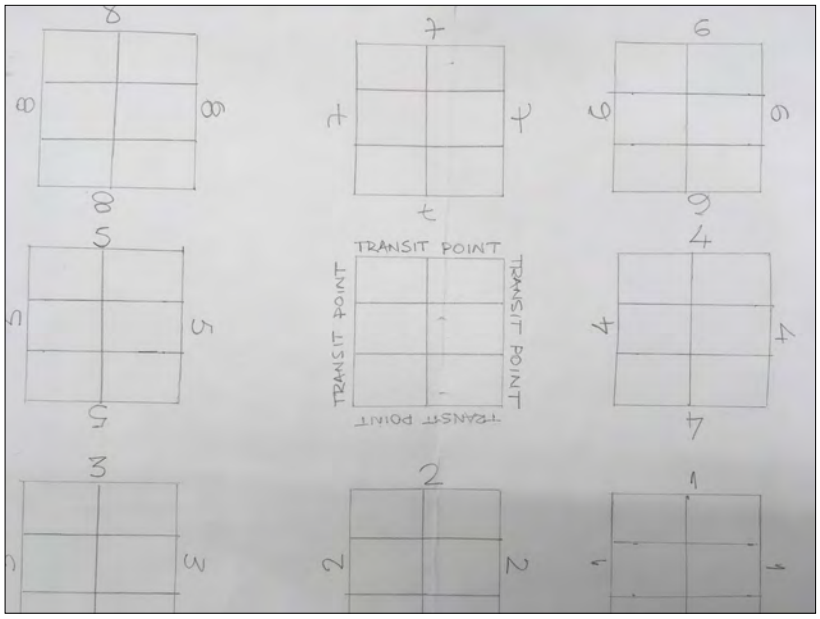

FIGURE 8. First game idea: a quiz game in which each big square (with six divisions) represented a country.

Design Process

Our design process can be considered as an interactive design (Salen and Zimmerman, 2004) – we made decisions to modify any particular element of the game or rule through the experience of playing the game. Therefore, playtesting and prototyping were critical parts of our game design process (Figure 6).

As the first step, we had an intense concept development phase. We have had 13 weeks to present a playable prototype, and only in this first step, we spent four weeks to come up with an idea.

It is a simple design process that was speeded up in the design development phase by two mechanisms. The rapid prototyping strategy (Braghirolli, Ribeiro, Weise, & Pizzolato, 2016; Tripp & Bichelmeyer, 1990) made tangible our thoughts and allowed us to extract lessons from the playtesting and the design-by-analogy approach (Kalogerakis, Lüthje, & Herstatt, 2010; Sio, Kotovsky, & Cagan, 2015), which allowed us to apply well-known game mechanisms to make easy the playability of our game.

Concept Development

In week 5, we had defined the essence of our game. One of the earlier ideas was to produce a quiz game (Figure 8) in which each player would control a territory (country) that other players would pass by (as travelers) and receive a stamp (in a passport) and money for each question answered correctly. This design was not appropriate for the project requirements, which sought for players' learning experience during the gameplay.

Building upon an idea that emerged from our brainstorm in week 1 related to environmental awareness, we elaborated on a sustainable development concept. We also incorporated the idea of territory ownership and wealth borrowed from our first quiz game design.

After we had considered the use of a board game with squares, we developed a concept with a territorial map based on a honeycomb in which each hexagon represented

a territory. Our initial design ideas adopted hexagonal territories from Settlers of Catan® (Teuber, 1995), and included occupying a territory and gathering resources to build different types of institutions.

This initial design had a number of gaps. The complexity of putting a simulated society into a board game was a problem that needed our further consideration that resulted in our "keep it simple" approach adopted in the design development phase.

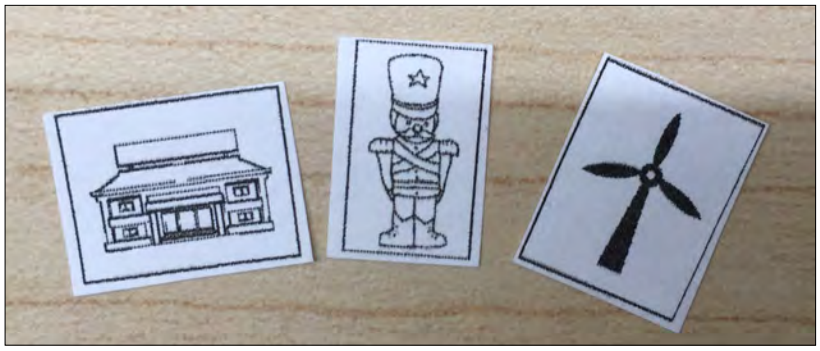

FIGURE 9. One of the prototypes for the factory (first stage), army, and new factory (second stage).

Design Development

In the design development, we needed to focus on the problems that arose in our conceptual phase keeping the design and the game idea as simple as possible. Our first thought was to design the elements of the game (see Table 1) since they are the basis of everything else (rules, mechanics, aesthetics).

After creating the population element to represents the ownership of the land, we created two broad categories of resources in Fullerton's (2008) terms. One represented the institutions (e.g., industries, hospitals, armies, universities, government buildings, churches), places where the population exercised its activities. Another category was the resources gathered/consumed in the game by the population to produce their goods and services. Thus, it was also necessary to express the relationship between resources and institutions and to provide the rationality that resources were limited. Referring to games ,like Rise of Nations® (Big Huge Games, 2003), we defined that the resources were needed to build institutions.

The initial resources proposed were money, minerals, water, oil, wood, technology, and iron, which would be useful to build various institutions. Realizing the complexity of playing (and designing) a board game with too many elements in a web of interactions, we considered the trade-off between realism and simplicity to develop a game that novice players could easily start. Schuurman (2017) described the struggles faced by European wargame designers between 1770 and 1830 in their attempted to design realistic games. The quest for a realistic model that emulated a real war or a battle decreased playability in many of the wargames at that time. To maintain realism while keeping the game simple hence its playability, some wargame designers applied, among other things, an economic approach. This design solution led war game designers at that time to include in their games only the necessary resources.

The design-by-analogy was one of the tools employed to make our game easy to play. As Sio et al. (2015) stated, it is difficult to create something totally original. For them, previous ideas are combined in different ways, adapted or transformed to produce new design solutions. For example, Hargadon and Sutton (1997) described how IDEO designers applied the design-by-analogy concept to transfer ideas from one industry to another to create innovative solutions for their clients.

Although existing solutions are sources of inspiration, they are, at the same time, a form of creative constraints. Sio et al. (2015) presented in their research that people anchored in examples can produce a smaller number of ideas to solving a design task compared to those that do not use examples to solve the same problem. However, when people are based on examples, they can improve the quality and novelty of the solutions. Thus, to develop the concept of our game, we discussed sustainable development involving building and development factories, land exploration, and conflicts inspired by video games, such as Civilization® (Meier, 1991) and Rise of Nations® (Big Huge Games, 2003). Thereby, our fundamental design assumption was anchored in the idea of a player's role-playing as a leader of a nation that evolved through time as in the games cited.

The design-by-analogy was also our approach to tackle our problem with the board design. After having considered a square board game like chess, the hexagonal format was chosen to allow players to have more options for their maneuvers. We defined the board as a representation of the territory divided into pieces of land as cities or even countries where the population will be settled.

The rapid prototyping technique also helped us to speed up the game design. The rapid prototype was crucial in playtesting our ideas, facilitated by the use of paper and pencil to create the elements of the game, and some simple print-outs of game pieces (Figure 9).

Playtesting

Playtesting was a crucial step in the overall design process, as described by Fullerton (2008). In fact, for our interactive design, playtesting sessions were the only way to inform us what had to be kept/improved and what could be forgotten. We refined the design of the game based on an

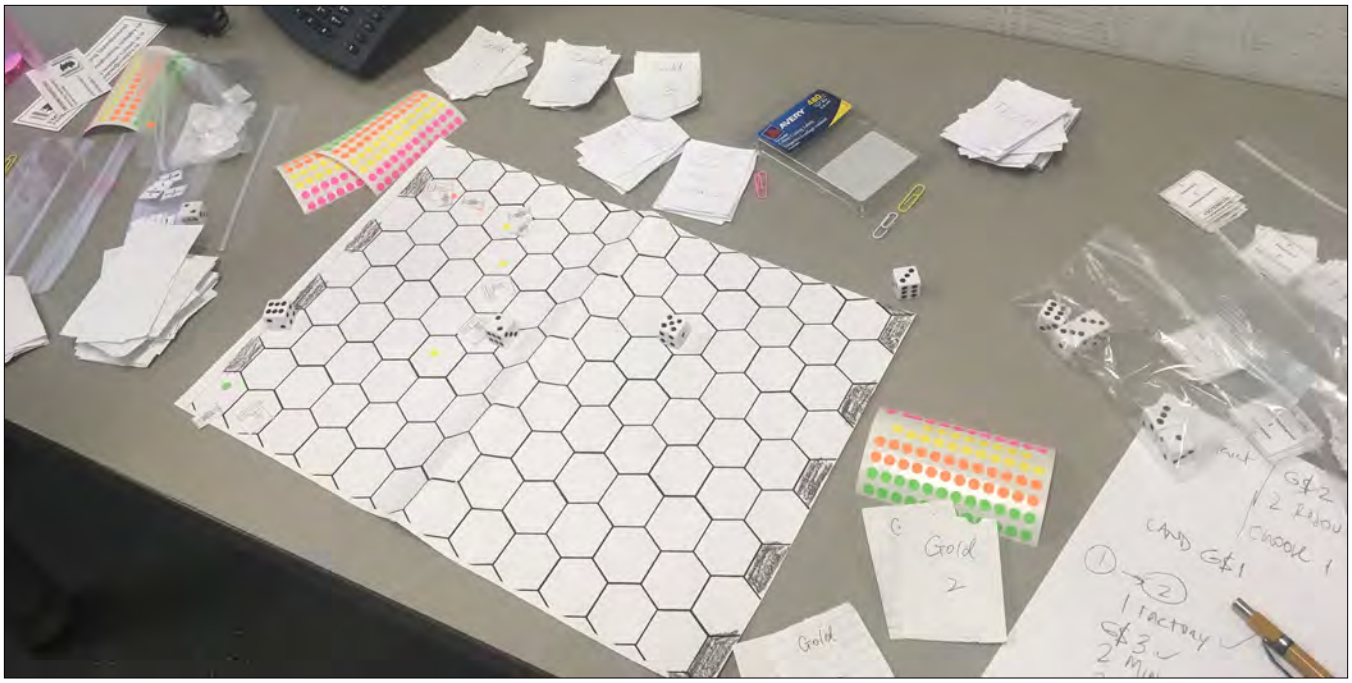

FIGURE 10. First playtesting in which we used a large board that did not promote battles for land.

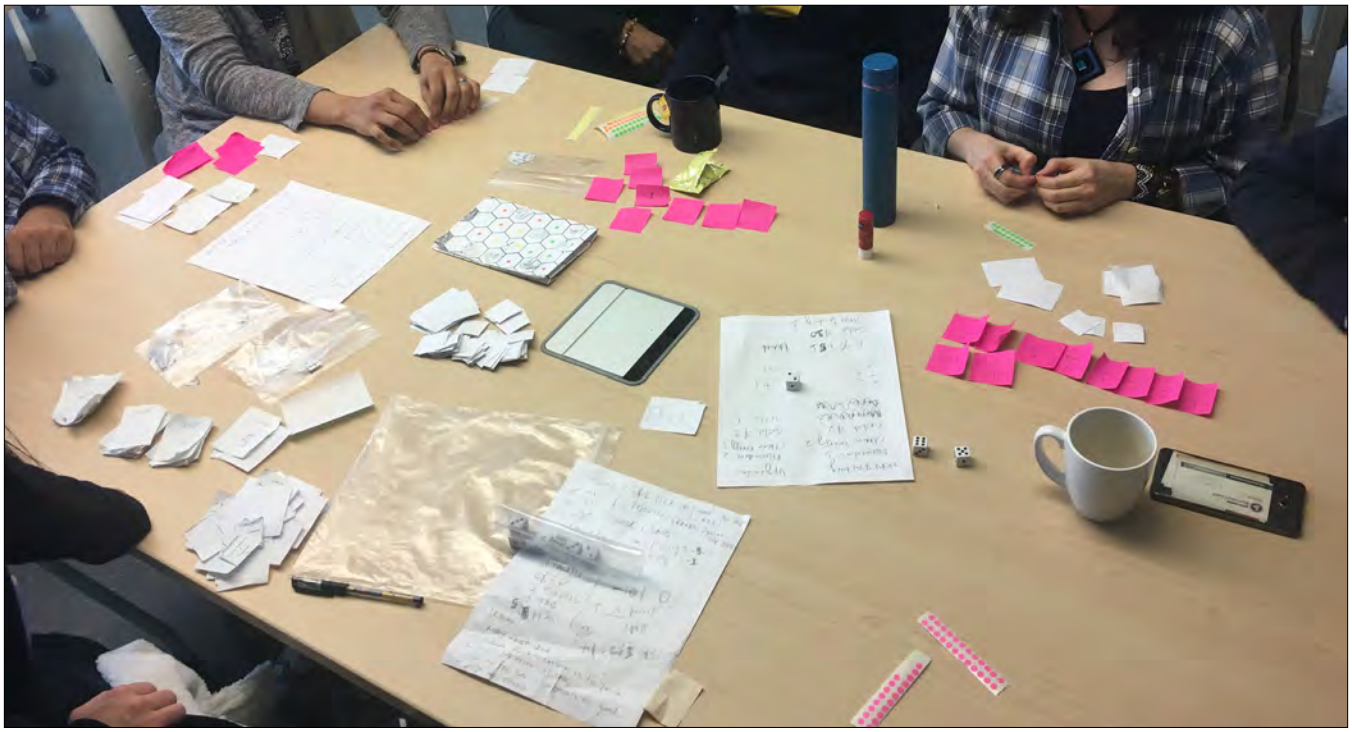

FIGURE 11. Playtesting with our classmates with a smaller board.

iterative process between the prototypes, which embodied our design assumptions, the transfer of game mechanisms (design-by-analogy) that provided inspiration for designing the problem-solving process, and the feedback obtained through playtesting.

We conducted seven playtesting sessions within the design team, which allowed us to see how the game system was working and balanced. For example, our first playtesting helped us determine the size of our board (Figure 10). Initially, it was too large to promote any tension between players, which made the army and the battle system unnecessary.

Playable Prototype

The two-hour playtesting that took place in week 10 with graduate students provided rich feedback for us (Figure 11) and also was our milestone. We could present a playable prototype during the expected design time (thirteen weeks).

In this first playtesting outside the design team become evident that a smaller game board promoted the tensions that we designers wanted to see in nations' borders in their pursuit to gather resources.

During this playtesting, questions related to player interactions also arose. One player was unable to obtain enough resources to build a factory at the first stage and failed to negotiate with other players for resources needed. Therefore, that player remained at the first stage for some time when other players upgraded to the second stage. From this case, we found that it is important for players to have an opportunity to collaborate with others to build institutions (factories, armies), especially when players fail to obtain resources needed from the resource cards and negotiation. We also added chance cards, with which players could collaborate to build factories or negotiate how they trade Golds and environmental points.

The second lesson we learned from this playtesting was to speed up the pace of the game. During the gameplay, we found that if players could only do one action in turn and negotiate in another, the game would take too long. Thus, we decided to allow more than one action and negotiation in the same turn. Also, we increased the value of the positive environmental point for building or upgrading new factories to accelerate the game progression. Furthermore, when players entered into the second stage, they had to play for a long time to clear the negative environmental points received in the first stage. To give players a chance to address this challenge, we added rule change cards to give them the chance to change the positive/negative environmental points received each turn. In this way, players may decide to change the pace of the game.

After playing our prototype with our fellow graduate students, we organized playtesting sessions among the design team to verify our new design (Figure 12). The board was redesigned, and we used counters with different shapes and colors to represent the elements of the game. We recognized that aesthetic is a critical issue to develop an appealing game. In this new board, we designed "bridges" to connect one side with the another to increase the struggles for the space and at the same time to force a strategic reasoning in the use of land.

FIGURE 12. New design with a colored board and new pieces to replace some of the paper made markers.

FIGURE 13. The last playtesting session with master's students.

However, the adoption of an improved design also forced us to promote changes in some rules to accommodate some aesthetic elements. The Gold, for example, our currency in the game, was created in pieces of paper in our first prototypes. To better represent it, we started to use play money, which required creating an exchange rate for Gold to accommodate this new aesthetic feature.

The last two playtesting (Figure 13) took place in an education master's course, three months after the end of our task as a design team. The students, as teachers and educators, provided us in-depth feedback about the application possibilities for our game in learning contexts.

In the first play round in this class, we tested the game without the rule change cards. In the second play session, we observed how the rule change cards provided different dynamics and entertainment and how they changed the players` strategies. The game was played on the second and third day of the course for two groups in two different tables (four players in each table). In addition to checking how the game mechanisms would work, these playtesting sessions also clarified our assumptions about the game purpose, such as the possibility to rethink and change the system during the gameplay (though the rule change cards).

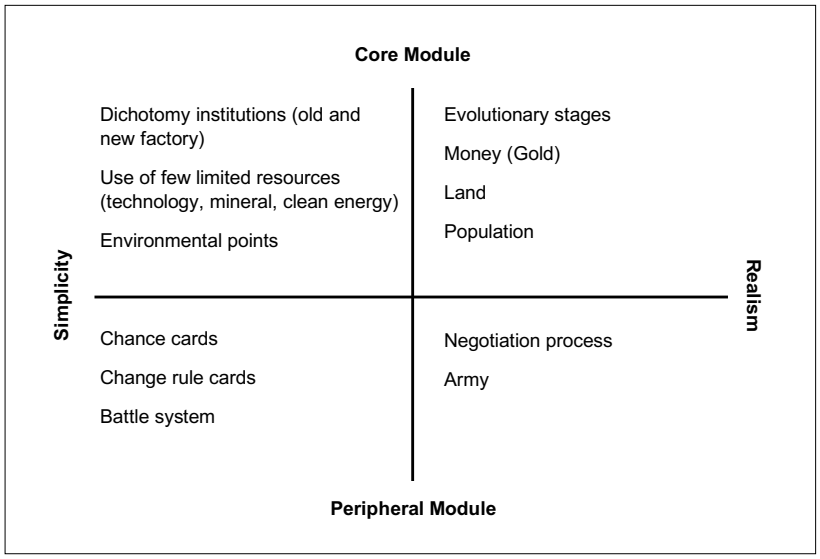

FIGURE 14. Modular design approach

Modular Design

To help us decide what was important to keep in our game, we considered our design as a modular system encompassing core and peripheral modules (Figure 14). We defined a core module as being the combination of game structures such as resources and procedures that directly influence the main educational content, in our case, the sustainable development. This module is at the core of our system. Inside this module, we have, for example, the environmental points system and the evolutionary stages. Our assumption is that elements that constitute the core module cannot be removed without affecting the learning outcome provided by the game system.

The peripheral modules, nevertheless, are built also considering game structures, resources, and game mechanics. However, despite its interrelated connection and the necessary link with the core module, the peripheral modules can be added or removed with a different purpose than learning outcome. Chance cards and negotiation processes are examples of peripheral modules created to design a game dynamic that supports entertainment and strategic moves during the gameplay. These modules promote different gameplay experiences more engaging. For example, players may prefer an Ameritrash® style that encompasses conflicts between players and a certain degree of luck as a resource during the game.

Based on this approach built on the trade-off between realism and simplicity and modular concept ranging from core to peripheral modules, we evaluated our decisions and the feedback received in our playtesting sessions to incorporate (or not) elements in the game. Each decision was classified into these two dimensions to balance our game design developing playability with educational content.

Three design decisions can exemplify the utility of our game design approach. First, to introduce the sensibility of economic growth and development and the consequences of this development to the environment (the core concepts for the learning experience proposed in the game). The decision to have a two-staged game departed us from a more realistic design but allowed us to maintain its balance between simplicity and complexity, using two different types of factories that practically and symbolically distinguish two stages.

The second example concerning the victory point system. In our first attempted to create a realistic game that encompassed the wealth and the sustainable development of a nation, we designed two victory point systems. One represented the economic development and other the environment, both linked to the resources. Thus, when a player-owned certain amount of resources, the points embedded in each of them would help a player wins the game. However, we opted for a simplistic design considering how the environmental points could represent players' decisions/actions to support the learning content grounded on choices and consequences, without linking any points to the resources owned.

The third example illustrates a peripheral module design. After the main elements were established based on the core concepts, the idea for additional dynamics and entertainment in our design appeared during weeks 6 to 8. A battle for resources (e.g., land) introduces an extra competitive feature in the game. Again, our design-by-analogy approach was used to borrow the idea of a battle mechanism from the game Risk® (Lamorisse, 1957). Then, we adopted the idea of an army that consumed resources (bringing the game

near to the reality) and the battle mechanism from Risk® (Lamorisse, 1957). We used the dice rolling of two players as a battle in order to keep the desired simplicity of the game system. This peripheral module was linked with the core module through the environmental points to make the design coherent.

Other peripheral modules were incorporated to offer dynamics affecting the players` strategies. They include the deck of resource cards for players to draw from for each turn, the chance cards, borrowed from Monopoly® (Darrow, 1935) that provide randomly positive or negative outcomes for players, and the rule change cards that give players the power to change (at any moment) a game rule described in the card. Both peripheral modules that shape players' chances and decisions to win the game but do not affect the target learning content.

CONCLUSIONS

This paper seeks to contribute to a discussion of alternatives board game design approaches. A growing wave of game development for educational purposes involves not only the creation of digital games but also card and board games (Kwok, 2017). Board games and card games have the advantage of being built without technology and facilitating face-to-face interactions (Castronova & Knowles, 2015).

In our playtesting sessions, we observed that players with more experience in board games easily recognized some game mechanics borrowed from other games that they played. The game also provided social and entertaining moments for the group of students that played the game, which is expected from a good board game design.

The game was also effective in promoting the awareness that choices bring consequences in our environment and society, which showed us that our design supported the learning outcome considering the game's theme. However, more than this, our design underpinned systems thinking learning through the theme of the game itself and the way that the design was conceived.

Many players emphasized the need to balance the final goal requirements and their decisions (risk-taking), mainly during the first stage of the game. Through the interaction of different game design elements that supported the formulation of emerging strategies, it was possible to see how players develop systems thinking through a gameplay experience. The possibilities that emerge from the game design are not restricted only to the playtime, but also in the debrief sessions conducted by educators after the gameplay.

The rule change cards introduced new learning opportunities in our game and fostered in-depth reflections on systems. Anchored in new design possibilities, the players often had the chance to transform the result of the game completely. Changes like this could be observed in one of the tables in the last playtesting with master's students when the group started playing collaboratively to attack a player who would win the game. For example, in one group, the joint attack was possible when one of the players who had a rule change card allowed players to move their armies more than one land per turn. One of the master's students shared his observation saying, "The rule-changing changed everything!"

The design-by-analogy and the rapid prototyping strategies had a positive impact on our conceptual and design development phases and allowed us to quickly collect valuable feedback through playtesting. Our modular approach was useful to guide our decision process and overcome the tradeoff between realism and simplicity.

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