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CO-DESIGNING EDUCATIONAL GAMES FOR CLASSROOMS

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Over the past 15 years, various government agencies in Singapore have supported educational game development and research, producing multiple digital games (e.g., *Legends of Alkhemia, Statecraft X)*, and non-digital games (e.g., *Green City Blues, Money Matters*). Although these games had been successful as research tools used to investigate game-based learning, their impact in schools has been limited by contextual factors including the school environment and culture (Chee et al., 2014). Further, little is documented regarding the details of designing educational games for these contexts. This paper describes the challenges I faced as a new researcher in Singapore tasked with designing new educational games that could simultaneously be used as research tools while also serving as effective, sustainable learning experiences in classrooms in Singapore. Although research-based educational games in Singapore and around the world have been created to instantiate and test theories of learning, these games have often been created without much attention given to classroom practicality and longer-term sustainability. This paper recounts this process and describes the constraints that were faced. By describing the conditions and constraints from the development process, the author hopes to inform and improve the design of future research/educational games that can have lasting and significant impact on Singapore student learning.

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BACKGROUND

In 2014, I was awarded a grant by the Office of Education Research in Singapore to create and study non-digital educational games for use in classrooms. Previously, expensive digital educational games had been developed for research, but were no longer being used. Studies associated with these games suggested that games were difficult to use due to the education system's tendency to gravitate toward maintaining the status quo. Rather than creating games that could test game-based learning theories at the expense of sustainable and practical use, I sought at the outset of the project to design games that would both test theory while fitting into local classroom ecosystems. As I was a new resident in Singapore with no prior experience in the education system, this meant finding out more about what local classrooms were like in order to understand and design for what teachers and students wanted. This paper describes some of that process.

EDUCATION INNOVATION IN SINGAPORE

In order to stay atop an increasingly competitive global market and address students' changing education needs, Singapore's Ministry of Education has regularly enacted nation-wide education initiatives. These initiatives, such as "Thinking Schools, Learning Nation" and "Teach Less, Learn More" have been often framed in ways that encourage educators, researchers, and policy makers to stay abreast of contemporary solutions to challenging education issues, such as how we can promote life-long learning, how to develop "one's moral, cognitive, physical, and social abilities", and how to foster student creativity and innovation (Saravanan, 2005). These initiatives, being nationwide, are also widely impactful, including curriculum review and reform across all schools in the country. Such large-scale, ministry-driven initiatives are made possible in part because of the way that Singapore's education system is organized. Specifically, there is a tight coupling between the Ministry of Education (MOE) and the nation's only teacher education program (the National Institute of Education), supporting the implementation of government policies and curriculum whole cloth across the country (Dimmock & Tan, 2013). Further, the social compact held between school leaders (e.g., principals) and teachers

in Singapore includes a culture that values traditionally Confucian-based paternalistic leadership, in which school administrators are expected to be have "moral courage", to be "honest, considerate, trusting, inspiring, and understanding", as well as "domineering and strong-willed" (Ibid p. 13). Teachers, in turn, are expected to defer to and follow the authority and guidance of the leadership (Ibid). This centralized structure and school culture can create scenarios where teachers find themselves encouraged and supported to enact government initiatives but must figure out on their own how such initiatives will be adapted to and implemented in their classrooms.

One area where this has played out is with the design and use of educational games. In the early 2000s, Singapore's Ministry of Education, National Research Foundation, and the National Institute of Education began supporting game-based learning research and development projects. Game development was supported across a variety of topics and media such as Ideal Force (Chee et al., 2006), a digital game-based experience to teach physics, Statecraft X (Chee, 2013), a digital role-playing game designed to teach citizenship, and Mind your Money, a board game to teach financial literacy. Some of these games were able to show significant gains in student learning in limited contexts (e.g., Chee & Tan, 2012), and the games' researchers suggested that further game-based learning work would need to overcome key social tensions in order to be successful in Singapore. Specifically, they highlighted the ways that learning approaches that are embedded in educational games' designs differ from the largely pragmatic approaches to education often adopted by local teachers who tend to defer to actions that maintain the status quo. A game, on its own, is insufficient for disrupting this system, the authors argue, as there is also a need to spur innovative teaching practices (Chee et al., 2014). Practical, structural, and cultural shifts must accompany games if we are to avoid using them as new tools that achieve the exact same ends as before.

These studies into educational games research in Singapore (e.g. Chee, Mehrotra, & Ong's, 2014) have thus far echoed prior work highlighting the importance of situating education interventions in local classroom cultures (Squire et al., 2003). More recent research has pointed to teacher-reported barriers to adopting games in classrooms as less about theory and more about issues of logistics and practice, such as finding the time to use games, finding the right games to fit their needs, ascertaining technical or financial support, and figuring out how to use the games well (Koh et al., 2012; Takeuchi & Vaala, 2014). Education research into game-based learning cannot be strictly about how games work in theory but must also address how they work practically and design-based approaches can be applied here to balance these needs (Barab & Squire, 2004; Brown & Campione, 1996). In particular, such approaches guide games projects to address 1) persistent problems of teaching practice and 2) use iterative and collaborative design for both developing educational theory and simultaneously enacting sustainable, systemic change (Penuel et al., 2011). To date, such an approach has not been documented in Singapore but was thought to be an approach that could address the previously documented needs of designing for local contexts and effective learning.

This paper describes the design and development of one non-digital game, *Sovereign City*. The game was created using a co-design approach in which teachers were considered stakeholders, central to the design, use, and effectiveness of the final product (Roschelle & Penuel, 2006). The game's development team, consisting of one researcher/game designer and one visual artist, regularly consulted with the teacher-clients in order to understand their needs and integrate their ideas into the games' designs. The game prototype developed through this approach took approximately six months starting from the first meeting and ending with playtests with students in authentic classroom settings (i.e., as a part of the teachers' curriculum).

The remainder of this paper is structured as follows. It first describes the constraints that were perceived throughout the project, characterizing the initial rationale used to create the game. It positions the development research and design as a process that can help solve a problem held by the stakeholders, the game as a product and potential solution, and the teachers and students as stakeholders and users. It describes the context, game, and development process, organized in terms of the initial constraints, including the beliefs and goals that were held by the designer *a priori*, the game's development and how it plays, and a reflection on one full implementation of the game and future work.

INITIAL CONSTRAINTS

Prior to the start of the game's development, three major constraints were considered essential to meet. These constraints were derived from the designer's prior work on developing digital games for classrooms and underscoring the importance of creating coherent classroom game experiences (Gaydos, 2013). First, for games to be adopted in schools and used effectively in ways that met local needs, a bottom-up co-design approach was chosen over a top-down approach, where a bottom-up approach meant acknowledging and designing from the primacy of classroom culture (Squire et al., 2003). That is, the games developed were intended to first address the needs of the teachers and students in everyday classrooms, an approach that resonated with prior recommendations in Singaporean education reform (Luke et al., 2005).

The second constraint that the games also needed to incorporate was the needs of researchers, but not at the expense of usability. At the onset of the project, the needs

of the researchers were largely in terms of grant fulfillment, including creating games that were low cost, research-generating, educational, and useful for teachers. Students' and teachers' needs were approximated (prior to meeting) as "games that were playful and educational."

Finally, constraints were derived from assumptions about working in public Singapore schools, established broadly through discussions with local teachers, researchers, and administrators: the game should be educational at face value, visibly integrating content that the school or teachers find valuable, and the games shouldn't be offensive or lewd, avoiding topics deemed politically sensitive (e.g., marriage, sexuality, or providing opportunities to critique Singapore), as these topics might be inappropriate for classrooms, unfavorable for future political support, or even illegal under local law.

With these constraints in mind, the project began with a series of meetings between the author and local educators interested in using games in their classrooms, connecting through shared personal contacts as well as through specifically designed speaking engagements organized through a government-supported initiative. These organized talks were intended to bring researchers and educators together to create communities of practice and as a research project to better understand how such communities of practice could be developed and supported. I was invited as a speaker to one of the talks, as I was seeking collaboration with local teachers to co-develop educational games.

Because of these talks, I was introduced to teachers who expressed interest in using games in their classrooms. Future meetings were arranged with these teachers to better understand their specific game interests and needs and Sovereign City, a geography game, was developed as a result of this collaboration.

SOVEREIGN CITY

Sovereign City was co-developed with three teachers at an academically strong school in Singapore. Of the three participating teachers, two had less than two years' experience teaching, and one had more than 10 years of teaching experience. The teachers conveyed interest in including games in their classrooms to better address typically boring content in a new and engaging fashion. They reported that they didn't regularly play games of any sort, but they had poor experiences with a digital game that was implemented in their school previously, as the game had significant technical hurdles that disrupted student experiences and thus learning. Despite their prior negative experiences with digital games, the teachers were generally positive about the potential for non-digital games. Over the first three months, I sought to 1) help the teachers understand what sort of game was possible, 2) to understand the teachers' particular needs in order to develop a game that best fit their intended use and 3) to begin soliciting ideas about what sort of game they would like to use.

In the first meeting with teachers, we played a previously created physics game that I had developed with a local artist. The goal of this first play session was to show concretely the type of product that would be created as a result of collaboration, to reassure the teachers that a viable product was possible, and to show teachers what new contemporary games were like. In subsequent meetings, we played commercial games that exhibited mechanics that were new for the teachers (e.g., games in the deck-building genre) so as to expose the teachers to a broader variety of contemporary commercial card games. Prior discussions with other teachers had suggested that games like Monopoly were commonly understood as the canonical board game that was thus most appropriate for educational redesign, for example by replacing properties or community chest spaces with quiz questions. I felt that showing teachers new games with new mechanics would help them to think of new ways to use games beyond embedded quizzes.

Playing games together to begin the researcher-teacher collaboration had other purposes as well, including trust-building, whetting teachers' appetites for game-design, providing the teachers and researchers with shared game playing experience that could be referenced later in the design process, and for improving my own understanding of the work of the teachers in Singapore and the school system in general.

From these meetings, I came to understand that the teachers had no single preferred pedagogy to apply to the games, pre-defined designs that they wanted to see created, or institutional constraints that defined specific goals (e.g., specific content to be covered by the game). They hoped that a game would be developed that could improve how well students learned the content from the textbook and later, ideally, produce quantifiable learning gains. They were supported by their school as they explored new pedagogical tools and were not pressured to show results immediately. The geography content that they wanted the game to address was not mandatory for all students, rather was an optional extension that the teachers chose to cover, time permitting.

Additionally, through these meetings with teachers, the following needs were explicitly identified: 1) the game needed to cover a particular chapter in their geography curriculum that discussed issues of energy sources and use, a section of their curriculum that they felt was especially boring for students and difficult to teach, 2) the game needed to be non-digital because prior work with digital games were met with significant technical complications and classroom disruptions, 3) the game needed to fit within a 50-minute

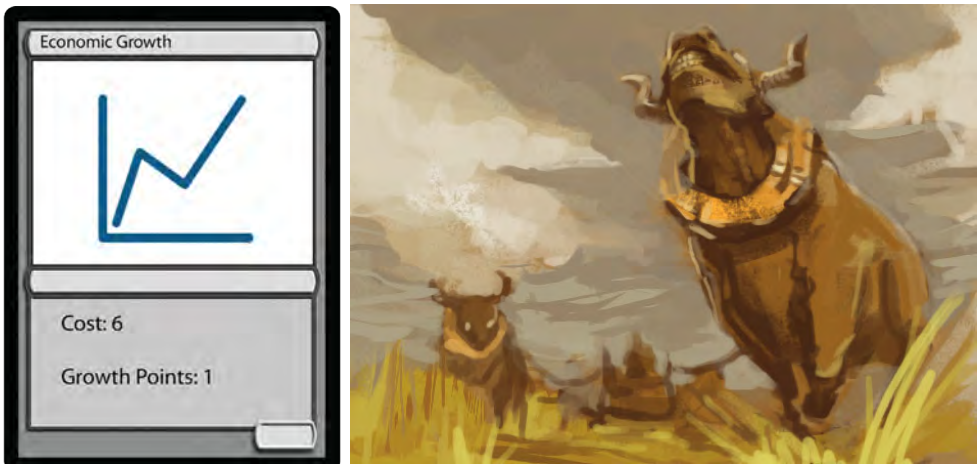

FIGURE 1. a (left) Iconographic art used to test the mechanics. The teachers preferred this aesthetic. b (right) Sovereign City Prototype Card Art representing energy produced through animal domestication. Art by Shirin Rafie.

long classroom session or multiple sessions. Additionally, the teachers had no budget for development, and so the game had to be low cost, provided by the research budget. To support the development process, the teachers could provide curriculum materials (e.g., books), content advice, regular hour-long meetings to review game development and provide feedback and could recruit students for playtesting. A tentative timeline was established, allocating about four class periods for game play during spring of the following year.

Together with the teachers, three topics were brainstormed as potential content areas that could be appropriate for a game based on the book that teachers were using: 1) Policy, values, and argumentation, 2) conceptually understanding energy production 3) the emergent energy crisis associated with balancing a country's development and the negative outcomes of development (e.g., pollution), and 4) a data collection activity associated with understanding energy consumption in their lives. A variety of game ideas were introduced and discussed, including already-existing genres (e.g., bidding games such as Modern Art; deck-building games such as Dominion), and the possibility of making a new game without starting from an already existing game (e.g., something about argumentation).

Design and Development

After about three meetings, the teachers and I agreed that a next useful step would be for me to create a game prototype that they could play and provide feedback about. The teachers could only dedicate about one hour per week to the project, and so rather than spend the next few months designing a game an hour at a time from scratch together, we decided that the teachers' expertise would be best applied through feedback at weekly playtests.

The first prototype of the game was based on the deck-building genre, with the aim of introducing students to different types of energy resources that could be used to develop further energy-based infrastructures and to introduce the notion of an energy crisis that could occur if consumption outpaced production (option 3).

The game was designed to be *conceptually integrated* (Clark et al., 2011) or similarly, an *endogenous* game wherein core mechanics were mapped on to the to-be-learned principle and content knowledge was tied to game knowledge as well as strategies for success (Squire, 2006). Prototype cards were created to test game rules and mechanics in a laboratory setting with other researchers and staff to check for playability and alignment between the game content and the game's mechanics (Figure 1a).

Initially, the game was going to explore many different types of ways to produce energy, such as windmills, domestic animals, piezo-electric materials, and coal. As commercial board games often provide fictional rich worlds in which the game takes place, the original idea was to follow the same idea for this educational game. We imagined the game taking place within fantastical steampunk setting, introducing both book-based content as well as more arbitrary but still true-to-life methods for creating energy. Thus, at the same time that the deck building mechanics were being play tested, sample art styles were being created for the teachers to evaluate (Figure 1b).

Early feedback from the teachers showed skepticism about the steampunk aesthetic and the deck-builder gameplay mechanics. The teachers' suggested that the game needed to be kept simple, both in look and in feel, and encouraged me to prioritize easy play with relatively few cards and rules. The core of the game's mechanics and its idea were seen as generally good though needing some refinement (i.e., simplification and balance) and rules clarifications. Teachers preferred the use of icons over the steampunk aesthetic and raised concern regarding the art appealing to all students.

After this first round of feedback and for the next five weeks, simpler, brightly colored art (2a) and easy to understand rules were the focus of the design. One of the primary concerns that teachers raised repeatedly during this time was how to help the students learn how to play the game

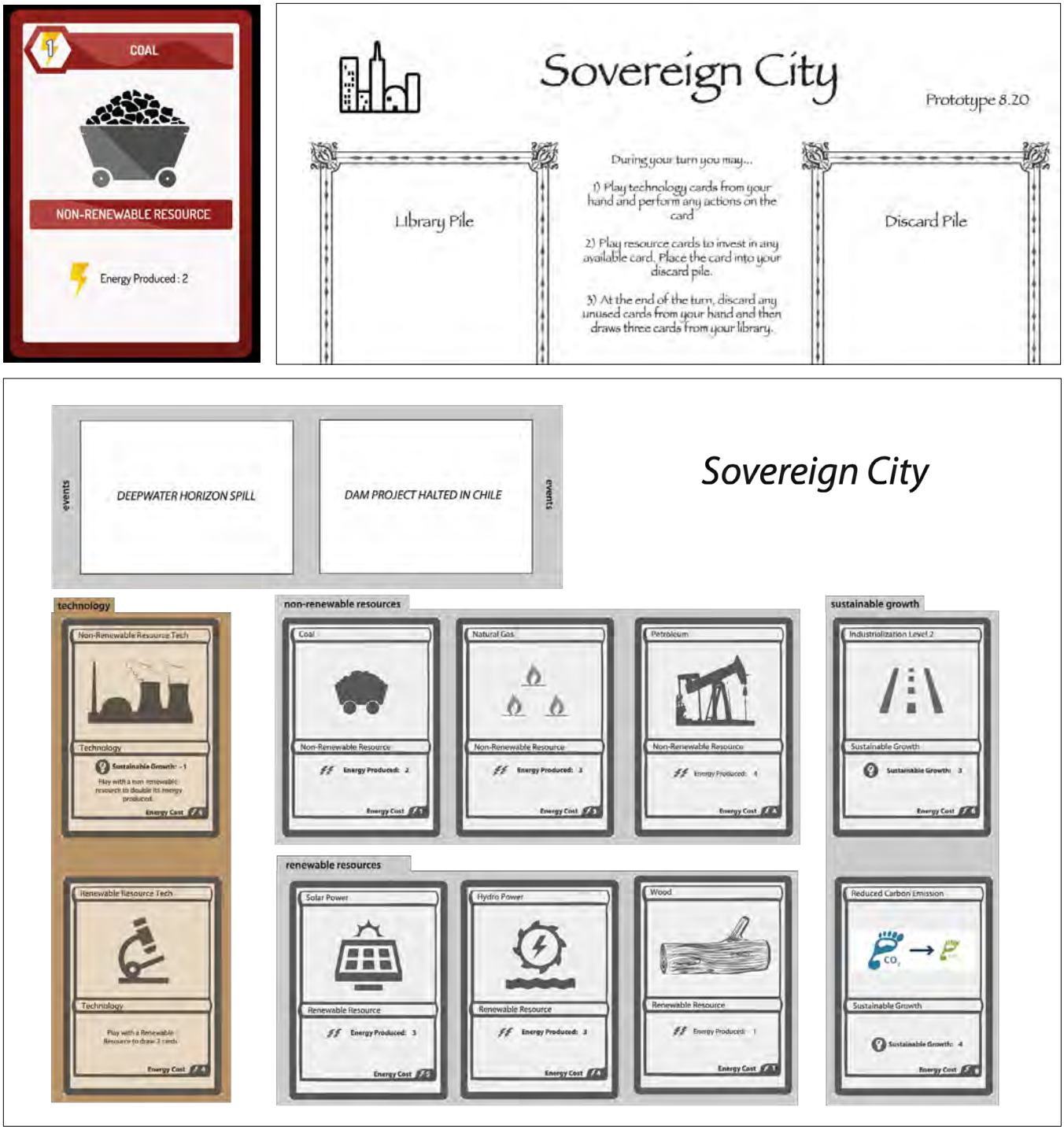

FIGURE 2. a (top left) Cards were redesigned to have simple, brightly colored graphics. b (top right) An A5-sized play-mat for each student showed how each player's cards should be arranged and included a simple review of the game rules. c (bottom) An A3-sized play-mat showed students how to set the game up. Art by Shirin Rafie.

correctly and quickly. They were concerned that students would not read the rules on their own, would not do as they were instructed, and would be confused and off-task during game play. To address the concern, the teachers assembled a slide presentation to explain how the game is played that they intended to present to students at the start of the lesson. With regards to simplifying the design, novel energy sources that were not mentioned in the book (e.g., piezoelectric materials) were removed from the game; only book-based content remained.

The temporary art began to be replaced with a brightly colored, icon-based design (Figure 2a). Supplementary materials were created to help the students play the game, including small, A5-sized play-mat for each student to place in front of them to use (Figure 2b). These small mats also included a summary of the rules that were explained by the teachers in the presentation. Additionally, large, A3-sized "play mat" that could be placed on a table and used to help students set up the game (Figure 2c). The game is named for Singapore, a *Sovereign City*.

During these weeks of development, teachers also invited students to stay after class or after school to play the game together, gathering feedback on confusing points or clarifications needed. At the end of the five weeks, now approximately two months since the start of the development process, two copies of the playable prototype were complete.

Sovereign City **Game Play**

In the complete version of the game, *Sovereign City* can be played by three to four players, where each player starts with the same six cards stacked face down (their "deck"). Initially, their deck is composed of four "wood" and two "sustainable growth" cards. To play, players take turns drawing a hand of three cards from their deck and using these drawn cards as a form of currency with which they can selectively purchase a single new card from a central library. The central library is composed of a group of cards that count toward currency, sustainable growth, or have an effect. These cards are placed face up so all players can see them. Newly purchased cards and the spent currency are discarded at the end of each round. At the start of a new round, if a player cannot draw any cards from their deck, they may shuffle their discard pile and draw new cards from it. The game is over when three stacks of cards from the library are depleted. At the end of the game, players count the points on their sustainable growth cards and the player with the most points wins.

Playing *Sovereign City* feels a lot like playing a simplified version of the commercial game *Dominion*, as it shares many features. For example, both games include the same core actions of drawing cards, playing any action cards, buying cards, and then cleaning up all cards that were played. Both games involve central tradeoffs between economic development and victory points. Both games include cards that produce more currency and that allow special actions. At the outset of the project, the choice to use a commercial game as the basis for design was deliberate, as I thought a commercially successful game would be most likely to support students in feeling like they're *playing*, a phenomenon that I felt was essential to game-based learning. The choice to use *Dominion* in particular as the model game was my own, however, and was based on prior experience with deck-building games. I was already familiar with 1) variations in rules across games in the genre and 2) successful strategies that emerged within games like *Dominion*. Based on this experience, I could roughly imagine that such a game might be able to be adapted for classroom use.

In deciding on the particular rules that would distinguish *Sovereign City* from *Dominion*, I drew on two sources. First, the teachers' feedback was immensely helpful for shaping the particulars of the adaptation. For example, *Dominion*, is complex, intended to be a re-playable commercial entertainment game, and is recommended for players over the age of 13. With four experienced players, one game can take around 40 minutes to complete. As teachers pointed out, the game would need to be simplified for it to be used in classrooms with middle school students, most of whom would be unfamiliar with such a game. Additionally, *Dominion's* theme being generally European and including cards such as "Market" and "Bureaucrat," had no geography content either in its mechanics or in its theme. *Sovereign City* needed cards and rules that incorporated appropriate geography concepts.

Teacher feedback, however, could not be used exclusively to drive all of the design decisions. In such cases, I developed designs based on *Dominion* or other games in the deck-building genre. For example, I also considered the two-player deck-building game *StarRealms*, where players directly work against one another as they build a fleet of starships and battle stations that can use to attack their opponent and reduce their life to zero. Contrast this with some versions of *Dominion*, where the rules are such that players mostly play alongside one another, rarely interacting while they work to build the most efficient deck economy relative to other players. When creating the rules of *Sovereign City*, I needed to actively develop rules—drawing on my knowledge of Dominion or StarRealms or any other relevant deck-building game—that would fit the project constraints.

Another way that genre was used was to help explore how such academic content would be integrated into the game (e.g., rules or otherwise). For example, in addition to integrating content into card text (e.g., coal is a non-renewable resource) and game rules (e.g., energy resources do not directly produce sustainable growth) I explored the use of strategies as a way to embed content. In commercial deck-building games, cards can be designed so that when used together. However, for players to take advantage of this synergy they must pursue it strategically, that is, they must construct their deck in a way that results in the pairings happening with more frequency. Such strategies are often abstract, but once uncovered can help to keep the game interesting, as they can make a player feel powerful when they are successful. In *Sovereign City,* strategy was used as a means for embedding content. For example, to make the

SUPPORTING GAME MATERIALS	DESCRIPTION
Game Mats	Two game mats were created to support play, including 1) A group mat that described how to set up the cards for each group of students 2) an individual mat (per student) that included rule reminders.
Thinking Journal Prompts	Teachers asked students to reflect on their game play and answer questions in their "thinking journals." These journals were typically used in class to write reflections and turn in homework.
Slide Decks	Teachers used slide presentations to introduce the game to students, to organize the class experience (e.g., with a projected timer) and to modify game play (e.g., introducing new rules). Separate from the game, slides were used to introduce students to relevant content through lecture.
Curriculum Guidelines	Teachers created their own planning documents that outlined what material would be covered during the class, when it would be covered, and how it aligned to their curricular goals.
Teacher Handbook	A document was created for distribution amongst other teachers that included an outline of the game, described how it related to relevant content, and that included the game components to print and play.

TABLE 1. Supplementary material created to support game play in the curriculum.

renewable resource cards more appealing in the long run, I created a technology card that, when played with a renewable resource, could lead to a chain reaction, allowing for more cards to be drawn and used during that player's turn. This engine-building strategy can also be found in *Dominion* and allowed me to align the content-based notion that renewable energy resources are better than non-renewable energy resources long-term.

First Play Test

Creating a game that can be played in a classroom context means thinking about not only the game, but also the teachers and other artifacts that accompany the game. For this project, the teachers and I collaborated on these materials, which ranged from curriculum guides that outlined content coverage per lesson (Table 1) to slide decks that could be used to explain game play to students. As a pilot, to test the game in a class-like setting, two of the teachers agreed to dedicate two classes each to the project, including one lecture on the game content and one class period to play the game.

During the pilot game play session, two groups of approximately thirty students participated in one approximately fifty-minute-long class. The teachers began class with a slide presentation explaining how to play the game. Specifically, the teacher showed students how to set the game up on the table, what each of the cards could do, and posed hypothetical questions simulating game play. For example, they presented students with a hypothetical hand of cards they could draw, showed them a corresponding game state, and asked students what actions were allowed in the given scenario. They allowed few minutes after the presentation for questions and answers before letting students free to play the game. The total set up and explanation took approximately 12 minutes. The teacher allowed the students to play for the next ten minutes. While students played the game, a research assistant, the teacher, and I walked around the classroom to help students with rules questions.

After ten minutes had passed, approximately 22 minutes into class, the teacher asked for students' attention, and proceeded with a series of questions about their game experiences, including observations about what happened in the game and why. For example, the teacher asked, "Did you notice whether renewable resources or non-renewable resources were depleted first? Why do you think that is?" After a brief discussion, the teacher provided the students with three questions to answer for homework.

During the accompanying lecture, the teachers covered content from the book chapter. To do this, they used slides to present lecture material and actively questioned the students. For example, one of the teachers showed students a picture of a coal mine, asked students to recall what they had learned previously about the formation of coal, and to make guesses about where such coal formations might be prevalent.

This pilot game play session was felt to be a success, as it showed that students were able to successfully play the game and seem to have fun while doing so, and that teachers were able to successfully use the game in their classrooms without significant disruption to their teaching agenda. The pilot also helped us to see that the game would need to be played longer to be effective and that the game would likely thus need to cover more content. Playing the game once for ten minutes did not seem to provide students with a sufficiently substantial experience that could be leveraged in other aspects of their geography class for improved learning. Additionally, because the accompanying lecture

needed to rapidly cover material that was in the chapter but not present in the game, there was little opportunity for synergy between students' in-game activity and course work.

Increasing the game content would mean also justify giving up so much class time for game play, which they felt could be resolved in a number of different ways. For example, they could show improved learning as a result of play, show that they are able to cover more content, that they could cover the same content more deeply, and/or they could show that students were more engaged and excited about learning. than they usually cover without the game. the game content needed to be better tied to the book. These issues were addressed in a subsequent iteration.

Teacher-led Design

Once core game mechanics and art settled, changing less from week to week, teachers were able to imagine more concretely, how the game could be used or modified for use in their lessons. With this imagining, the design of the game was able to shift, moving away from major changes to mechanics, and toward how the game could cover more content. Though the game had integrated and used the required textbook content for its core mechanics, it did not cover *all* of the book material, and there was more content that the teachers felt would be necessary to cover in order to justify so much time spent on game play. Together, the teachers and I created three game variants to include this needed content.

First, the teachers noted that acquiring cards that represented non-renewable resources had no negative effect on the player and felt that the message ("It's okay to invest in non-renewables") ran against the ideas found in the textbook. Together we created a way to address the negative environmental potential of energy resources into the game, creating new rules themed after the Deepwater Horizon spill and protests to the Patagonia Dam. Originally, these two topics were designed into the game rules only. However, to ensure that the students understood the content and how game play was affected, the teachers designed the content to be introduced to the class through an interruption to typical game play, triggered with a siren to gather all students' attention. The events were summarized and projected onto a screen, with the teacher explaining what had happened and how it changed the game. After the explanation, students could resume play using the new rules.

Second, students' geography textbooks introduced the idea that differences between countries', including different resources, different energy needs, would thus lead to different solutions for developing energy resources in a sustainable fashion. To cover this topic, "country cards" were created to enable comparisons across countries, as each player drew one of four country cards, each providing a purchasing modifier for different card purchases based on characteristics of the country. Each country - China, the United States, Norway, and Singapore—had a modifier based loosely on real-world characteristics. Norway, for example, had a penalty for purchasing solar power and a bonus for purchasing hydroelectric, modeled after its geographic and infrastructure characteristics, respectively.

Finally, the teachers felt that the game's winning objective—to be the player with the most sustainable growth points in your deck at the end of the game—did not convey the coordination necessary amongst countries if they wanted to tackle topics such as climate change. A different, cooperative goal was proposed—to have players work together to achieve the best score amongst them, comparing the results at the end of the game across each group of four players.

To introduce these different game rules, we began by teaching students how to play the "base" set of the game, in which students would focus on buying cards and maximizing their sustainability points. During the second week of play, students were given "country" cards to randomly choose from, affecting the materials they purchased based on their country card's different characteristics. During the third week of game play, students played as different countries again, and teachers also interrupted student game play to introduce the Deepwater Horizon event events. Finally, during the fourth week, students played cooperatively rather than competitively, trying to maximize their group scores rather than individual scores. Rather than embed all of the content into the game in the first week, we guessed that the layering of game rules would be beneficial for at least three reasons. First, by learning the basics of game play, we hoped to not burden students with rule complexity. Second, we hoped that the changes would keep the game interesting for students over the course of the four play sessions. Lastly, by purposefully changing important aspects of the game rules, we hoped students would learn better, as drawing comparisons across different models can be helpful for conceptual understanding (Marton & Pang, 2013; Rittle-Johnson & Star, 2009).

***Sovereign City*—Full Implementation and Postmortem**

A second full implementation of the game was played and researched before the project ended. Steps were taken to ensure that the teachers who were using the game could continue to do so, and that any teachers who would want copies of the game could obtain them. The digital materials for the game were packaged into PDFs for easy distribution, the physical prints of the cards were left with the teachers, and all design files were made available so that teachers could modify cards digitally if need be.

The project produced generally positive results. At the time of the project's closure, the game had been played by approximately 150 students and been used to produce qualitative research on how game-based learning could be

better supported with considerations for student identity (Gaydos & Devane, 2019). Though quantifiable learning was not investigated, the game was useful enough to be used annually for approximately four years, until social distancing measures stopped students from attending school in person. Additionally, the teachers involved in the project were recognized with national awards for innovation in co-designing the game.

FUTURE WORK

Reflecting on the development process and the final outcome suggests a fundamental misunderstanding of the nature of the games that we were trying to make in the first place. That is, initially, I had envisioned designing a game for teachers to use, where "use of the game" was limited to asking students to play the game. Instead, over the course of this project, the teachers needed to be able to use the game as they would any other pedagogical tool, adjusting it to fit their classroom and curricular needs.

The process of co-developing with the teachers was illuminating for future collaborations by providing at least one concrete heuristic to look out for in the development process. For the game *Sovereign City,* teachers proposed and created a slide deck that they could present to the class during game play that modified the rules of the game in order to cover content associated with the Deepwater Horizon Oil Spill, a topic found in their textbooks. This moment of transition can be interpreted from Wenger's (1999) description of *practice* as a response to design, and his appeal to creating *minimalist* designs that support and provide room for users' practices. Given that teaching is itself a design practice (Laurillard, 2012), it makes sense that games designed for classroom use must be designed to be regularly *redesigned by teachers.* The case here allows us to provide rich description of what this looks like in context: teachers themselves needed to be able to re-design the game through proposing new rules or introducing new components (slides) that they could see as means to achieving their own classroom goals.

Related to this design heuristic, it's worth noting also that the teachers' roles and design experiences greatly affected their view of game redesign. For example, the teachers' needed to meet particular textbook requirements in order for the games to fit within their curriculum goals and needed to redesign or supplement the game to fit meet these goals. They also had little time to dedicate to directly design the game themselves and little experience with game design. In addition to creating re-designable games, it may also be important to address the roles teachers perceive themselves to be in, the learning goals they are pursuing, and to support teachers' re-design practices and expertise.

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