# Turn Up the Heat! Board Games, Environmental Sustainability, and Cultural Forms

Michael S. Horn, Amartya Banerjee, Sarah D'Angelo, Pei-Yi Kuo, D. Harmon Pollock, Reed Stevens
Learning Sciences and Computer Science, Northwestern University

**Abstract:** Turn Up the Heat is a cooperative board game that encourages reflection on tradeoffs related to money, comfort, and environmental sustainability. The game playfully confronts power dynamics associated with the use of residential thermostats to control heating and cooling systems. In doing so, it addresses common misconceptions about how thermostats work and how they can be used to save energy and money. Our game incorporates a tablet computer app to simulate a household heating and cooling system. It also gives all players (parents and children alike) the opportunity to adjust a thermostat on their turn. In this paper we provide an overview of our design and a brief summary of results from our playtesting session. Our findings highlight the interplay between, children, adolescents, and adults, and the ways in which families drew parallels between the game and their real-world circumstances.

## Introduction

*Turn Up the Heat* (tidal.northwestern.edu/greenhomegames) is a cooperative family board game that encourages reflection on tradeoffs related to money, comfort, and environmental sustainability (Figure 1). The game playfully confronts power dynamics associated with the use of residential thermostats to control domestic heating and cooling systems. In doing so, it addresses common misconceptions about how thermostats work (Kempton, 1986) and how they can be used to save energy and money (Peffer et al., 2011). Our game incorporates traditional elements such as cards, tokens, and a game board, but it also includes a tablet computer app as a central feature of play. The app simulates heating and cooling system based on factors such as outdoor temperatures, thermostat settings, and home insulation levels. It also gives all players (parents and children alike) the opportunity to adjust a thermostat on their turn.


**Figure 1.** ***Turn Up the Heat*** **is a cooperative board game in which players make tradeoffs related to comfort, energy, money, and environmental sustainability. The game incorporates a tablet computer app as a central aspect of play.**

In designing Turn Up the Heat, we were careful to balance the purely digital aspects of the app with the physical components of the board game. The tablet computer is only one part of the game as a whole, rather than the other way around. Our reason for doing this is to preserve advantageous social aspects of board game play (e.g. Berland & Lee, 2011; Guberman & Saxe, 2000; Nasir, 2005) and to involve entire families in thinking about household energy consumption. Turn Up the Heat is the result of a yearlong iterative process in which numerous prototypes were developed and tested. After seven months internal testing, we brought the game out to nine families for a total of eleven game sessions. In this paper we provide an overview of our design and a brief summary of results from our playtesting session. Our findings highlight the interplay between, children, adolescents, and adults, and the ways in which families drew parallels between the game and their real-world circumstances.

## Background

This project is guided by the idea of building novel interactive systems based on existing *cultural forms* (Horn, 2013; Horn, 2014). The advantage of such an approach is that it provides users with a foundation for engaging in and interpreting an unfamiliar activity. In the case of our game, even though some of the representations are initially confusing, the board game form helps to anchor the experience in a familiar medium. People know that there will be some basic structure that involves taking turns, rolling dice, moving tokens, exchanging play money for in-game resources, and so on. Importantly, they also know how to engage in game play with friends and family. In creating this game, we considered other approaches (such as a more conventional video game), but the board game seemed more appropriate for the types of whole-family engagement we were interested in fostering.

### Board Games and Learning

Board games have been well studied by mathematicians, psychologists, and learning scientists. For example, Berland and Lee (2011) analyzed video of college students playing the cooperative board game, *Pandemic*, and found evidence that players made use of sophisticated computational thinking skills in the course of game play. Nasir (2005) studied children and adults from African American communities playing dominoes. Her analysis focused on the nuanced ways in which players sought and offered help as a way to improve the game experience. These strategies became increasingly sophisticated as she moved from observing children to adults. As a final example, Guberman and Saxe (2000) developed a game called *Treasure Hunt* for use in elementary school mathematics instruction. They found that children created thematic divisions of labor as they took on various roles in the game. These divisions of labor enabled children to accomplish mathematical problems that were beyond their independent ability. In our playtesting sessions we observed similar divisions of labor that seemed to allow families to enact more sophisticated strategies together than they would have on their own.

While not a study of board game play, Stevens, Satwicz, and McCarthy's (2007) study of children playing console video games in homes is notable for what it reveals about the complex and spontaneous *learning arrangements* that children form during play sessions. The study also suggested a mutual interplay between "in-game" and "in-world" experiences of children as they navigate between school, homework, and play. These findings inspire hope that family experiences playing Turn Up the Heat might translate to in-world decisions that families make about heating and cooling their homes. Throughout the game design process, we were guided by the notion of *intrinsic integration* (Habgood & Ainsworth, 2011; Kafai, 1996). Foremost, this means that our game should be fun to play. Additionally, we sought to integrate the core mechanics of game play—namely setting a thermostat in order to stay comfortable, while, at the same time, keeping energy consumption minimal—with our intended learning outcomes. Finally, the representations used in the game parallel the representations that players might encounter in real life.

### Thermostats

Residential thermostats were first developed in the late 19$^{th}$ century but gained widespread use in the 1950s. The first thermostat that players encounter in our game (Figure 2, left) is modeled after a common mechanical thermostat introduced this era. In the 1990s, digital, programmable thermostats started to gain in popularity. These devices allow consumers to program different temperatures for different times of the day so that a house will automatically heat up or cool down at pre-set intervals. According to Energy Star, a joint program of the U.S. Environmental Protection Agency and the Department of Energy, "properly using a programmable thermostat at home is one of the easiest things you can do to lower your energy costs. It's as simple as set and save" (Energy Star, 2010). Despite this optimistic assessment, there are several serious usability problems with these thermostats that fundamentally limit their effectiveness (Karjalainen & Koistinen, 2006; Meier et al., 2011). As a result their programming capacities are widely underutilized (Meier et al., 2011). In response to studies demonstrating a lack of energy savings, the U.S. Environmental Protection Agency announced that it would no longer issue the Energy Star rating for programmable thermostats as of 2009. We now appear to be entering a new era of domestic thermostats that are *smart*, online, and controllable by mobile devices such as smart phones and tablet computers. The Nest thermostat (nest.com) is perhaps the most innovative of these new designs. The Nest incorporates sophisticated interaction techniques, machine learning capabilities, and connectivity to a Web portal. Our game's "Internet thermostat" interface attempts to provide users with an opportunity to directly manipulate temperature zones for their characters (Figure 2, right).

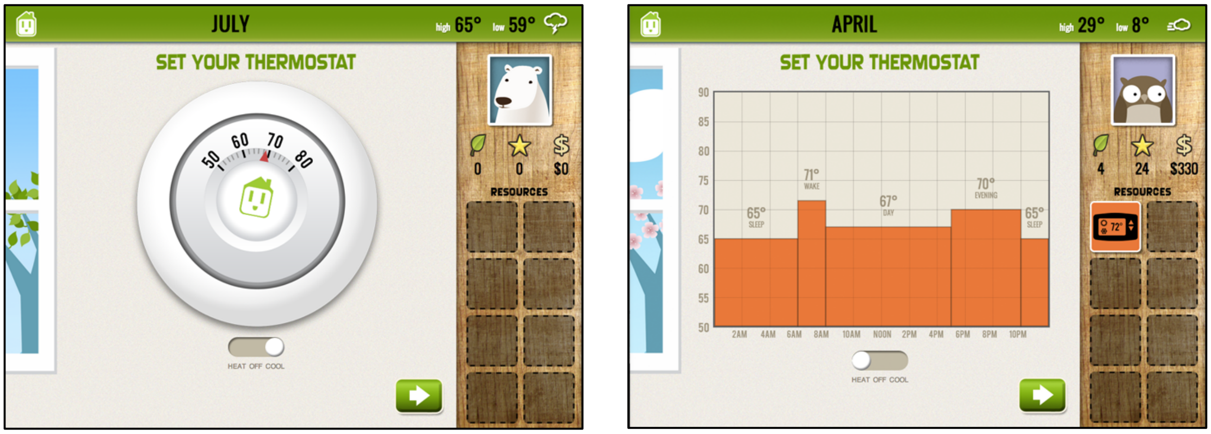


**Figure 2. Players start the game with a manual thermostat (left) and can upgrade to a smart thermostat (right) that allows players to set temperatures for four different time zones.**

However, even though thermostats are perhaps getting "smarter", it does not mean that people will necessarily understand them any better than did in prior decades. The cognitive science research of Kempton (1986) highlights a number of "folk theories" that people hold about how thermostats work. For example, many people think that a thermostat operates like a valve and incorrectly assume that "cranking" the heat up to a higher temperature than necessary will warm up a home faster than setting the thermostat to the desired temperature. In fact, for most heating systems, turning the temperature up higher than necessary does not heat a home any faster and risks wasting energy.

## Background Interviews

Much of the inspiration for Turn Up the Heat comes from a series of 23 interviews that we conducted with families over a period of two years around issues of domestic water and energy consumption. One finding from these interviews is that many youth rarely, if ever, touch the thermostat(s) in their home and that they have a minimal understanding of how thermostats work. Unlike other potentially dangerous (but important) household activities such as cooking and cleaning, there appears to be less of an opportunity for youth to get involved as they get older. Our data suggests three main reasons why this is the case. First, many adults seem uncomfortable with thermostats and use language like "fussy", "tricky", and "afraid I might mess it up" when describing them. Second, parents are often leery of the financial implications of thermostats and tend to believe that children will simply over-adjust for comfort without understanding reasonable temperature ranges, without considering alternative like "putting on a sweater", and without considering broader impact on family finances. Finally, most thermostats are designed to blend in rather than stand out. They are usually beige or white in color with tiny controls that are uniform in appearance (or even concealed by small doors). They also tend to be mounted on the wall at adult height. One of the goals of Turn Up the Heat is to counter these fears and uncertainties and help families explore reasonable and safe ways for children to become involved in consequential household energy management activities. We also hoped to subtly draw attention to power dynamics around the use of residential thermostats by giving all players (children and adults) in the game the chance to set the thermostat for the team on their turn. In this way, we also intended to confront some of the usability issues and misconceptions surrounding thermostat use.

## Design Overview

Turn Up the Heat is a family board game for 2-5 players ages eight and up. The game features a cooperative style of play, meaning that players must work together on the same team to beat the game. A more competitive style of play is possible—in fact, many families suggested that the game could be more fun if family members played against one another—but our play testing made it clear that the cooperative play style resulted in more reasonable game durations (45 minutes to an hour) and more interesting strategy discussions among players. To win the game, players must earn at least 20 Green Points and 20 Comfort Points over the course of one full year while staying out of debt. At the beginning of the game, each player draws a Character Card that determines his or her *comfort profile*. This profile affects how difficult and costly it will be to earn Comfort Points under different weather conditions. To play, team members take turns rolling a die and moving a single token around a game board representing the four seasons of the year. Some spaces on the board indicate special events. For example, when passing Pay Day the team collects $400 to pay energy bills and to purchase resources. Using the tablet computer, players then enter the month of the year shown on the game board and spin for random weather conditions that simulate the climate of the United States Midwest. For example, in January a player might spin a high temperature of 30° F (-1° C) and a low temperature of 12° F (-11° C). Players must then set the thermostat based on their character's comfort profile. The game begins with a manual thermostat that can be upgraded to a smart thermostat in the course of game play (Figure 2). The manual thermostat allows players to set only one temperature for the entire day, while the smart thermostat allows players to set individual temperatures for each of four time periods (sleep, wake, day, and evening).

**Simulator:** After spinning for weather conditions, the tablet computer simulates the home's indoor temperature over the course of the day based on the thermostat settings, the outdoor air temperature, and the home's insulation level. This simulation is shown as a temperature over time graph (Figure 3, left) that animates as the simulation runs. Players earn Comfort Points when the indoor temperature is within their comfort zone (orange area) and lose points when the temperature is outside of the "neutral zone" (light grey area). Of course, running the heating or air conditioning uses energy and costs money. An indicator to the right of the simulator graph animates the energy consumed over the course of the day. Players earn Green Points by using less than 300 kWh for their turn, and, correspondingly, lose points by using more than 400 kWh.

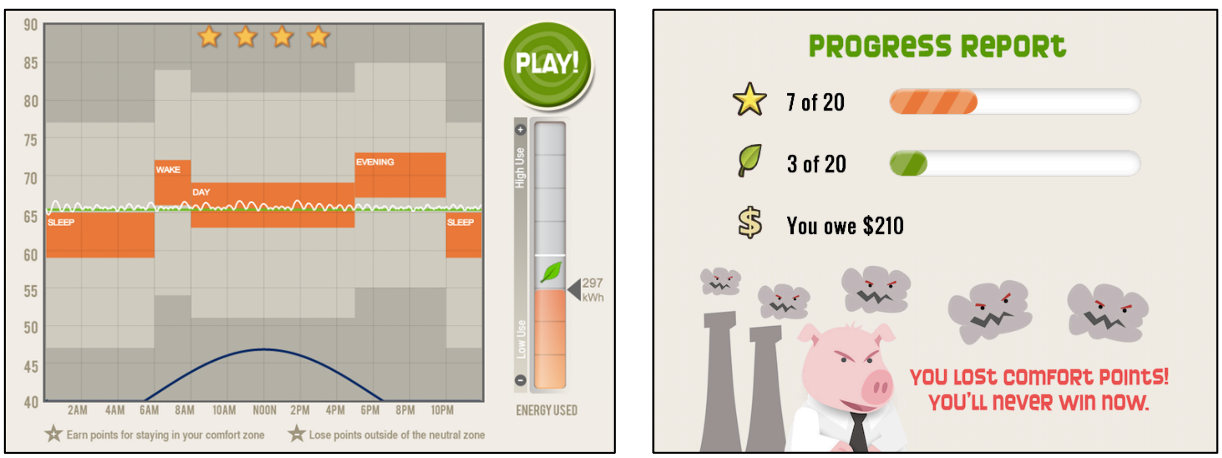


**Figure 3. The app simulates a home's heating and cooling system, showing the indoor temperature on a graph over time. Players earn Comfort Points (stars) when the temperature (shown as a white line) stays within a player's comfort zone (orange). The energy hog (right) serves as the evil nemesis—an embodiment of the opposition posed by the game.**

**Resource Cards:** After setting the thermostat, players have the option of using one of their Resource Cards to make it easier to earn points. Some resources (such as warm clothes, hot chocolate, and ice water) can be used to expand an individual player's comfort zone making it easier to earn Comfort Points while using less energy. Other resources (such as insulation, storm windows, and a smart thermostat) improve the home's infrastructure making the game easier for all players. These infrastructure cards cost money, so team members must decide together if a particular upgrade is worth the investment.

**Paying the Bill:** After running the simulator, all players must make a decision about paying the accrued energy bill, with options to pay nothing (and thus incur a late fee), to pay a minimum amount (computed as a percentage of the total bill), or to pay in full. In extreme weather conditions, the energy bill can be surprisingly high, although not unrealistic for a typical monthly bill.

**The Nemesis:** In many well-crafted collaborative games, there is a sense of impending doom or suspense that makes the players feel as if they are competing against a real opponent manifest by the game itself. As the rules of our game began to solidify, we noticed that while there was some suspense in game play, it felt too amorphous or disembodied. To address this, we added an evil nemesis character, the Energy Hog, who taunts players when they are performing poorly and broods over the success of players when they are doing well. As more energy is consumed during the game, small energy minions (pollution clouds) start to appear and multiply around the progress screen (Figure 3, right).

## Evaluation

To evaluate our game we visited nine diverse families in their homes to conduct playtesting session. Participants included 13 parents (9 mothers, 4 fathers) and 18 children (ages 6 to 16). The families came from a range of social and economic backgrounds including one family who earned less than $25,000 a year, four families who earned between $25,000 and $50,000 a year, and three families who earned more than $90,000 a year. The families all controlled their own heating (and sometimes cooling) systems and lived in a variety of building types, including apartments (2 families), standalone homes (5 families), and condominiums or duplexes (2 families). We began the first session with each family with a brief interview about family practices around board game play, thermostat use, and attitudes towards environmental sustainability. After the interview, we invited the families to play the game. For the first four sessions, substantial intervention was required to explain the rules of play and to work around glitches in the game. These sessions led to important iterative improvements to the design. In the following seven sessions, the researchers did not intervene. We instead gave the families a printed rule sheet and let them conduct the entire session.

## Findings

Here we briefly summarize findings (an in-depth analysis will be shared in a forthcoming publication). Our analysis centers around the ways in which in-game experiences and discussions overlapped with families' real world circumstances, including how the thermostat interfaces in the game related to existing power dynamics around household heating and cooling systems. As we had hoped, the cooperative style of play resulted in family discussions around game strategy and the meaning of the temperature graph and thermostat interfaces. These discussions also led to instances in which family members drew connections between the game and various aspects of their real world circumstances in subtle and not-so-subtle ways. For example, family members often reasoned about the use of Resource cards in the game based on their experience with real-world analogs.

**Family 107**
Dad: How about storm windows...
Mom: Ooh, storm windows.
Dad: It costs you money, though.
Mom: They are well worth it, really, it's like putting plastic on the windows.

Here the mother draws a connection between storm windows and plastic insulation as a way to justify the expense of playing the card in the game. Similar episodes took place with other Resource cards including socks, hot chocolate, and smart thermostats. Other intersections between the game world and the real world came out as a result of the distributed use of the thermostat as the iPad was passed from player to player. For example, in the following excerpt the family is confronted with an unusually high energy bill.

**Family 107: [30:40]**
Boy15: I gained comfort points but I lost … [green points]
Dad: huh. See what your bill is.
Boy13: [looks over boy 15 shoulder] Four hundred dollars.
Boy15: Four hundred dollars, how is that even possible?
Dad: How did you have a $400 bill? What did you do?
Mom: Yeah, what did you do?
Boy15: I put on the heat.
[…]

Dad: Well, you got to put the heat on in the winters.
Boy15: Well, that's all I did.
Dad: Well, it's expensive isn't it?
Boy15: Yeah, it is expensive.

To interpret this episode, it is important to note that we decided to have the game start on Earth Day (April 22) after realizing that late spring and early summer tend to be much easier than winter and late fall. This gives families who have never played the game before a low-risk opportunity to experiment with the thermostat interface and the basic game mechanics. However, it also means that winter comes as something of a shock. As families round the board into December and January they are confronted with more extreme (and expensive) weather conditions, and they realize that they should have been more frugal. In the previous excerpt, the surprise of a high energy bill is an excuse for the father to share aspects of his experience managing the family heating system, presumably something he doesn't do often. It also highlights one of the ways in which traditional thermostat roles were inverted or tweaked through game play. Because the son was the one controlling the thermostat, it gave the father an opportunity to draw a parallel with his real world experience. As we had hoped when we were designing the game, moments like these also led to strategic breakthroughs. For example, in the following excerpts the father interprets strategy decisions of the family as they take progress around the board.

**Family 104**
**Timestamp: 34:50**
Dad: Kid, you got us 4 energy points. Way to go.
Boy10: I used no energy! Because I used my chocolate and I turned off the thermostat. I used NO energy, Mom.

**Timestamp: 36:45**
Dad: I don't need to be that warm. If I go in the mid-60s maybe it'll not be in my total comfort zone, but it'll be in my neutral zone, so I wouldn't spend as much money. [sets thermostat to 66]
Boy10: I'd rather spend less money and use less electricity.

**Timestamp: 1:00:00**
Dad: That was an interesting strategy. You set it as low as you could.
Mom: Like safety ... safety instead of comfort.
Dad: It wasn't super expensive and …

**Timestamp: 1:06:00**
Dad: Now that we know how this works, I'll set the thermostat a lot lower because my goal wouldn't necessarily be to stay within the orange band, but just don't go below the negative. I didn't have that in mind when we started.
Boy10: And don't manage your energy in the game as you do in real life.

This example shows how family strategies could emerge in stages. We see this first in the breakthrough from the son who realizes that it is possible to use no energy on a turn (and thus earn Green Points). This is followed with the father's turn in which he actively interprets the temperature / comfort zone graph (Figure 3, left) and expands on a strategy of giving up on absolute comfort to save energy. Later in the game, the mother pushes this strategy further by using an approach that she calls "safety instead of comfort". Through game play the son comments on his father's real-world energy management ("don't manage your energy in the game as you do in real life"). It's difficult to interpret exactly what the son means by this comment, but he seems to be playfully critiquing some aspect of the family's heating situation, perhaps implying that the home is uncomfortably cold or that the energy bill is too expensive.

Although the father takes a leading role in the development of strategy for family 104, it was not always the case that a parent drove the discussion of strategy. One interesting thing we noticed through our testing sessions was the diverse roles that children and adolescents assumed through play. For example, as the following excerpt illustrates there were several instances in which adolescents took a leading role in both interpreting the game representations and mechanics and coaching other family members.

**Family 106**
Boy16: Oh no, mom.
Mom: What, I'm getting a lot of stars isn't that good?
Boy16: Yeah, but you're not being green!

Mom: I'm not?
Boy16: If you use a lot of energy you're not being green.

Here the mom employs a very common naïve strategy: try to earn comfort points without considering other factors. In many ways, the feedback provided by the tablet computer tends to encourage this approach for inexperienced players. As the temperature simulation runs, animated stars appear with sound effects when the temperature matches a player's comfort zone. The son, in this case, is trying to get his mother to look beyond the gold stars and focus more on the "cost" of comfort by drawing her attention to the energy meter on the right side of the screen (Figure 3, left).

On a related note, we were surprised that despite making many connections between in-game and in-world experiences, families rarely discussed environmental sustainability issues in the course of game play, except for off-hand comments. It could be that the feedback around the comfort vs. financial cost tradeoff (through the bill mechanic) was much more salient than the feedback related to environmental cost. In future versions of the game, we will play up the environmental aspects of the game, perhaps by making the Energy Hog and his pollution minions more aggressive. Other possibilities include imposing a "carbon tax" for high energy use.

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## Acknowledgements


The graphic design for Turn Up the Heat was done by Maisa Morin (maisamorin.com). Laurel Schrementi and Andreas Wadum contributed to the game design. This work was supported by the National Science Foundation under grant IIS-1123574. Any opinions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF. Seed funding was provided by the Institute for Sustainability and Energy at Northwestern.