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Nested Urban Scales: A Pervasive Geogame Model for Collective Energy Efficiency and Action

Malini Srivastava and Mariangel Meza

School of Architecture, University of Minnesota, USA

Correspondence: Malini Srivastava (malini@umn.edu)

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Abstract

As global energy demand continues to rise, energy efficiency remains one of the most cost-effective strategies for managing consumption, and behavioral energy efficiency (BEE) plays a crucial role in reducing energy use in buildings. Energy games designed to address BEE through real-life actions typically focus on a location or a singular building typology such as homes, offices, or schools. While these games provide location-appropriate energy-reducing actions, they rarely focus on the simultaneous and multiple identities players hold in location-based games. For example, players may be part of a household in a residential game while simultaneously being a neighbor at the block scale, and part of the larger community at the city scale. In this article, we begin by defining serious pervasive energy geogames (GeoSPEGs) at the intersection of serious games, pervasive games, energy games, and geogames. Then, we present a case study analysis of efargo, a residential GeoSPEG, where the players (homeowners or renters) hold simultaneous identities and allegiances related to their household, their neighborhood block, and their city. The game structure allows for aligned individual and collective game incentives, creating potential for cooperative and competitive play. Next, we compare and synthesize the pervasive game design models utilized for the efargo case study with the "unified geogame design patterns." We conclude our analysis with a proposal for a GeoSPEG design model that intersects and combines existing design frameworks for pervasive and geogames utilized during the design of the efargo game, and we introduce "nested urban scales" as a fundamental geogame design pattern.

Keywords

behavioral energy efficiency; game design model; geogame; pervasive game; serious energy game

1. Introduction

Global warming and climate change form the critical context for evaluating existing buildings' energy efficiency. Data suggest that the building and construction sectors collectively account for 34% of final energy use and 37% of energy-related CO_2 emissions, while energy used for building operations accounted for 32% of global demand in 2023, and between two-thirds and three-fourths of building-related emissions are associated with operations (United Nations Environment Programme, 2024). Reducing operational energy use and increasing building energy efficiency could result in significant reductions in global warming (Granade et al., 2009). Building energy efficiency may be achieved through investing in building improvements and encouraging energy-use behavior by building occupants to prevent energy waste. Altering household members' behavior can rapidly reduce carbon emissions, making behavioral energy efficiency (BEE) programs promising for reducing operating costs and leading to persistent behavioral change (Allcott & Mullainathan, 2010; Allcott & Rogers, 2014; Andor & Fels, 2018; Aydin et al., 2018; Dietz et al., 2009; Kamal et al., 2019; Nolan et al., 2008). Tools that encourage energy-saving behavior are found to be more effective when offered in synergistic combinations (Composto & Weber, 2022; Khanna et al., 2021). Frequency, medium, duration, and achievability, combined with the challenge of interventions, also have an impact on BEE effectiveness (Boncu et al., 2022; Karlin et al., 2015). Behavioral interventions can be most effective when they are offered in combination with social influence and relationship-building (Abrahamse, 2019; Staddon et al., 2016). Social groups such as family, friends, neighbors, and community members can be influential through influence mechanisms (Abrahamse & Steg, 2013; Grilli & Curtis, 2021; Rau et al., 2022).

Serious energy games designed to address BEE through real life energy-saving actions typically focus on a singular building typology such as homes, as in games like HomeRUN (Agusdinata et al., 2024), Apolis Planeta (Csoknyai et al., 2019), PowerSaver (Fijnheer & van Oostendorp, 2015; Fijnheer et al., 2021), PowerAgent (Gustafsson et al., 2010), Power Explorer (Gustafsson et al., 2009), and Energy Battle (Geelen et al., 2012); or offices, as in games like Energy Chickens (Orland et al., 2014) and GResBAS (Barbosa et al., 2017); or schools and universities, as in Gamified HMI (Méndez et al., 2021), Battle of the Buildings (Inman, 2011), and the K-12 Energy Challenge (Srivastava, 2019). While these spatially-aware games successfully provide location-appropriate energy-reducing actions and engagement, they typically focus on action items in immediate surroundings (Laato et al., 2020). In serious energy games, competitive play is typically between individuals and their homes or households (in residential games), and cooperative play opportunities typically present within individual households (Nasrollahi et al., 2023) or individual building types such as offices or schools. These games typically do not take advantage of inter-household or multiplayer cooperative play.

Geogames, a game typology that involves real-world locations, can engage players in meaningful play that helps them learn about their local environments, and have cooperative in-person interactions with the local community members and game participants (Laato et al., 2020; Schlieder et al., 2006). Geogames have the potential to expand to local contexts and communities. In games like Pokémon Go, where real-world locations are utilized, players have the potential to make a positive contribution by engaging in environmentally friendly behaviors, adopting eco-friendly habits, supporting environmental initiatives, and advocating for environmental-protection policies (Kordyaka et al., 2024). The simultaneous, multiple identities players hold in geogames are typically not the focus of serious energy game structures.

For example, residential serious energy game players simultaneously hold identities as neighbors at the neighborhood scale and members of the larger community at the city scale, but games do not typically focus on all these identities and usually limit their focus on one of the identities. These simultaneously held multiple identities by players across urban scales (neighborhoods, blocks, districts, and cities) have the potential to prompt multiple identity-based, location-based interventions, maximizing potential for social influence.

In this article, we propose a design model for games at the intersection of serious games, pervasive games, energy games, and geogames that aims to address BEE while taking advantage of nested urban scales, that we define as simultaneous identities that players may hold in geogames, based on their location and the context referenced at various spatial scales. For example, the player may identify as a homeowner or renter at the scale of their residence but may identify as a neighbor at the scale of the block within which their residence is located or as a community member at the scale of the neighborhood or city. Geogames designed around the concept of nested urban scales recognize that players simultaneously hold multiple identities, shaped by the geographic scale associated with their location.

2. Methodology

We begin by defining serious pervasive energy geogames (GeoSPEGs) as a special category of games that exist at the intersection of serious games (games with goals beyond entertainment), pervasive games (games that blur ordinary life and game actions), energy games (games that reduce energy use), and geogames (location-based play in which a player's real-world geographic position is intrinsic to the game experience). Then, we present a case-study analysis of efargo, a GeoSPEG that allowed for aligned individual and collective game incentives, thus creating the potential for simultaneous cooperative and competitive play due to multiple player identities aligned with nested location scales and areas. Designed and implemented by a team led by this article's corresponding author, the efargo game included structures that allowed for aligned individual and collective game incentives, where the players (homeowners or renters) held simultaneous identities related to nested urban scales. Next, we discuss the design frameworks utilized for the efargo case study: Poplin's game elements (Poplin, 2011, 2012), Srivastava's extensions of Poplin's game elements (Srivastava, 2016), Harteveld's triadic game design (TGD) model (Harteveld, 2011), and unified geogame design patterns (UGDPs) which are based on the work by Ahlqvist and Schlieder (2018). Ahlqvist and Schlieder (2018) proposed a "unified vocabulary that cuts across the realms of Geo and Game" by studying the alignments and differences between unified core and extended geographic concepts (Janelle & Goodchild, 2011; Kuhn, 2012; Kuhn & Ballatore, 2015) with game components identified by Holopainen (2011) and key game elements proposed by Järvinen (2008). We adapt and utilize the unified vocabulary proposed by Ahlqvist and Schlieder as UGDPs. We follow a similar synthesis methodology to compare the UGDPs with the frameworks that informed the efargo design. On this basis, we propose an expanded game design model for GeoSPEGs, building on Harteveld's three fundamental principles of Reality, Meaning, and Play, and adding three design elements, namely, Representations (Interfaces), Resources, and Networks.

3. Game Types and Overlaps

The efargo case study has overlapping characteristics of pervasive games, serious pervasive energy games (SPEGs), and geogames (Srivastava, 2020). Here we position the efargo case study as a GeoSPEG. We first define the overlapping game typologies to define GeoSPEGs and propose the GeoSPEG game model.

3.1. Pervasive Games

Pervasive games blur the boundaries between everyday life and gameplay, creating experiences that unfold within real-world settings. Often, these games extend gameplay into the real world with the use of hybrid interfaces and technologies such as mobile devices, wireless networking, and positioning systems (Kasapakis & Gavalas, 2015). Huizinga (1949) proposes the "magic circle," i.e., the boundary created by games where their rules apply. Pervasive games extend a game's boundaries beyond the magic circle into ordinary life (Montola et al., 2009; Nieuwdorp, 2005). Gameplay is therefore enmeshed with the real world (Benford et al., 2005). Pervasive games may be location-specific, such as Pac Manhattan (Poplin, 2012), location-aware, such as Your Way Your Missions (Chen et al., 2013), or trans-locational, such as Barbarossa (Kasapakis & Gavalas, 2017a, 2017b). These games allow players to contribute to game objectives through real-life actions; in this way, they have the potential to facilitate the transfer of game knowledge to the real world, thus giving players the potential to achieve serious goals. By including hands-on tasks in real-world applications that require player engagement, pervasive games may induce behavior change (McGonigal, 2006), further narrowing the gap between the game world and reality (Gustafsson et al., 2010), due to the quality of existing simultaneously in-game space and ordinary life and space.

3.2. SPEGs

Serious games serve purposes beyond entertainment (Michael & Chen, 2006). Deterding et al. (2011) identify "serious pervasive games" at the intersection of serious games (i.e., games used in non-game contexts for serious purposes) and games that are extended beyond entertainment. These games have demonstrated enhanced user engagement, comprehension of complex concepts, and application of knowledge through practical interventions (Ahmadov et al., 2025; Lamb et al., 2018). SPEGs, then, are games serving the serious purpose of aiming to reduce energy use and enhance energy efficiency in the real world (Srivastava, 2020). In these games, players can work to reduce impacts by applying their game knowledge. However, knowledge gained through gameplay only becomes impactful when it informs real-life situations: for example, when game players take real-world actions as part of their gameplay to conserve energy. SPEGs utilize physical space as the gaming platform, often blending digital and physical elements. SPEGs began in 2007 with Power Agent, implemented by Gustafsson, Katzeff, and Bång, to encourage teenagers and their families to reduce energy consumption in Sweden (Gustafsson et al., 2010). Serious energy games designed for BEE in households positively influence player motivation and engagement in energy conservation (Agusdinata et al., 2024; Boncu et al., 2022; Csoknyai et al., 2019; Fijnheer, 2022; Geelen et al., 2012; Gustafsson et al., 2010).

3.3. Geogames

Geogames are a form of location-based play in which a player's real-world geographic position is central to the game experience. Supported by geographic information technologies which make the physical environment an active part of gameplay (Ahlqvist et al., 2019), geogames require players to navigate real-world settings—such as neighborhoods or cities—while engaging with game elements that are triggered or shaped by localization technologies like GPS (Heinz & Schlieder, 2019; Schlieder et al., 2006). Geogames can strengthen players' connections to nature and deepen understanding of environmental issues (Schneider & Schaal, 2018; Schneider et al., 2017). Several mobile geogames, such as Origami, Ingress, Geo TicTacToe, and others, are multiplayer games that develop spatial competencies (Bartoschek et al., 2017). The use of advanced technologies in geogames can dynamically alter game environments, generate new content, and adapt experiences based on player behavior or feedback, thereby expanding the possibilities for personalized and context-sensitive gameplay (Poplin, 2024). Extending the genre of geogames to a technology-independent concept (Järvinen, 2008), Ahlqvist and Schlieder (2018) define geogames as games that emphasize spatial relationships and patterns.

3.4. The Case Study, efargo, a GeoSPEG

The efargo case study is a residential GeoSPEG (Figure 1, #15) at the intersection of serious energy games (Figure 1, #6), pervasive games (Figure 1, #1), and geogames (Figure 1, #4), designed and implemented with the goal of reducing energy use in all homes in Fargo, North Dakota. Working from the assertion that games in general and pervasive games in particular have the potential to create community, action, and participation, the efargo residential game, implemented in 2016, was a part of the larger eponymous efargo effort for the City of Fargo's participation in the Georgetown University Energy Prize (GUEP).

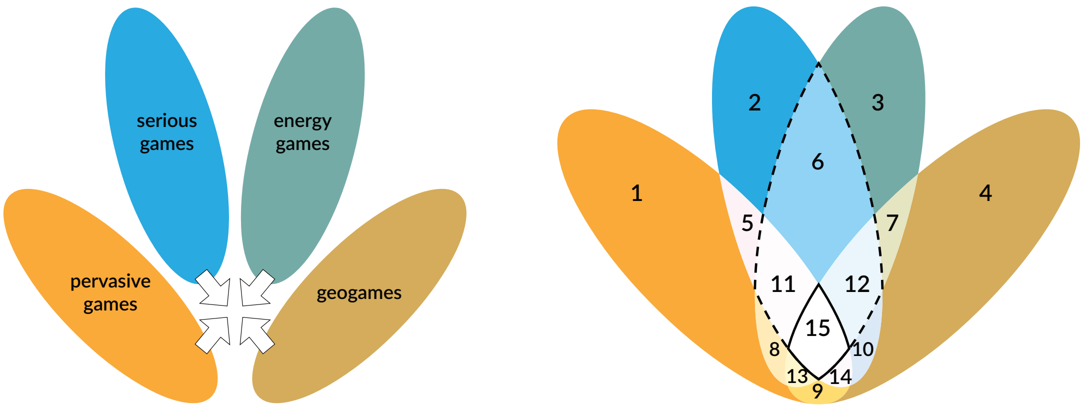

Figure 1. efargo game at the intersection of serious, pervasive, energy, and geogames (#15 on the right). Notes: (1) pervasive games; (2) serious games; (3) energy games; (4) geogames; (5) pervasive serious games; (6) serious energy games; (7) energy geogames; (8) pervasive energy games; (9) pervasive geogames; (10) serious geogames; (11) SPEGs; (12) serious energy geogames; (13) pervasive energy geogames; (14) serious pervasive geogames; (15) GeoSPEGs.

The nationwide GUEP competition, announced in 2014, was aimed at improving energy efficiency and reducing energy use in cities with populations ranging from 5,000 to 250,000 people (Srivastava & Nelson, 2017). This competition presented an opportunity to examine whether playing games can reduce energy use through BEE efforts ("$5 million Georgetown Energy Prize," 2014; Brandes et al., 2018; GUEP, 2018). The competition lasted from January 2015 to December 2016. Energy use data collection in 2015 and 2016 was compared against baseline energy use for 2013–2014. Fifty cities in the United States participated in the GUEP. A competition team was established at North Dakota State University under the identity and trademark of "efargo" (Srivastava, 2019; Srivastava & Nelson, 2017). In partnership with municipal government and utility providers, the team researched, designed, and implemented several serious energy games incorporating building-improvement- and behavior-based approaches, playful interactions, and other awareness-building opportunities. This article's corresponding author led the team and its research, design, and implementation efforts. In the GUEP energy-use data, efargo's work resulted in Fargo being ranked as the fourth-highest energy saver (achieving an aggregated city-wide 6.84% energy-use reduction over the two-year competition period, normalized and compared to baseline energy use for the competition-preceding two-year period). Fargo was declared the overall winner of the GUEP based on a multi-criteria evaluation (Brandes et al., 2018; Srivastava & Nelson, 2017).

The efargo residential GeoSPEG had the serious goal of enabling participants to overcome the informational and behavioral challenges of the energy-efficiency gap (Hirst & Brown, 1990) and thereby adopt environmentally beneficial behavior with proven outcomes (Head & Hunt, 2014) to reduce their energy use. As a pervasive game, efargo fostered direct engagement with place (players' homes, blocks, and neighborhoods), structuring real-time behaviors and actions that blurred the boundary between everyday behaviors and gameplay. As a GeoSPEG, efargo made players' geographic location intrinsic to their roles or identities (homeowner or renter, neighbor, or community member), and the players' cooperative and competitive real-time actions were related to incentives at different scales or areas (player's household or residence, player's block, and player's neighborhood). Players' geographic locations and their identities—both as Fargo community members and as part of the GUEP, competing against 50 other cities in the semi-finals and 10 other cities in the finals stage—played an important role, making nested urban scales instrumental as a design concept in spurring engagement during the efargo game.

4. The efargo Game

The efargo game was released to the City of Fargo community over nine weeks (Srivastava, 2016), from February 2016 until April 2016. Three hundred and one players signed up for the game and were part of the initial nine-week game implementation for which data were collected. The game remained accessible through the efargo website (http://efargo.org/game) after the nine-week implementation and was utilized by the community, although data were collected only during the initial nine-week period. Of the 301 initial players, 299 players progressed beyond the initial sign-up.

The efargo game interface was a web- and mobile-based game board consisting of two equal areas. The left side was the efargo game board and leaderboard (Figure 2a). The right side was the informational section, which educated and instructed players in the game, and provided information about energy use and energy actions, community dialogue, and social media links (Figures 2b, 2c, 2d, 2e, 2f, and 2g). The right side changed frequently based on the players' actions and position.

The primary game mechanism was for players to advance game activity tokens (blue circles in Figures 2a and 2b) to the highest levels of the game board by completing real-life energy-saving actions and responding to surveys and quizzes about energy efficiency. Nine tokens were released at the rate of one token per week (Figure 2b). The players' goal was to capture Waste-a-Watt, a character developed in co-design efforts with the community. Waste-a-Watt personified energy waste and was embedded throughout the upper levels of the game board (Figures 2a, 2c, and 2d). Each horizontal row of cubes was a level: Yellow and orange levels were lower (easier challenges and fewer points), and red levels were higher (more difficult challenges and greater points; Figure 2a). There were seven levels in total, and each week's blue token could be advanced to a higher level every week. Game activities were embedded in the cubes, revealed when players moved the weekly tokens to the colorful cube surface. The weekly tokens, when placed and advanced on the game board, unlocked information about energy waste and quizzes about energy efficiency and provided energy-saving actions for player completion (Figures 2e, 2f, and 2g).

Figure 2. efargo game board examples. Sources: Srivastava (2019, 2020).

Each week's token focused on a particular area of residential energy efficiency (Figure 2b). For example, the Week 1 Lighting token involved quizzes and information about lighting and lighting-related energy-saving activities (replacing inefficient light bulbs with LED bulbs, etc.) that were embedded in the cubes, revealed when tokens were advanced by the player. Of all the tokens or topic areas, Lighting (Week 1) had the most engagement (as measured by the number of players who earned points), followed by Space Heating (Week 2), Water Heating (Week 3), Devices (Week 4), Controls (Week 5), Cooling & Ventilation (Week 6), and Player's Choice (Week 7). In the Civic token (Week 8), players were asked to leave the game portal and enter an app called mySidewalk to suggest ways in which the city could address energy waste, energy savings, and climate change (mySidewalk, n.d.). In the last token (Week 9), efargo organized a celebratory in-person event where players could earn points by visiting interactive booths and engage directly with each other and stakeholders. The attendance at the event was approximately 275 people over the course of four hours.

The efargo game objectives included engaging homeowners and renters in (a) learning about energy waste in their homes (learning and awareness); (b) acting to reduce energy use (behavior); (c) investing time and financial resources to reduce energy use (investment); and (d) completing energy-saving actions (engagement and action).

4.1. Geography-Based Structures, Incentives, and Interfaces in the efargo Game

There were five ways in which player location and geography played important roles in the efargo game design. First, the efargo effort's co-design process incorporated the community and was dispersed around various locations (public library, zoo, and schools) to welcome participation and engagement. The team conducted biweekly community meetings at the Fargo Public Library in an ongoing design process, garnering community input for events and engagement. The efargo narrative was developed with public participation. Early sketches of stories and characters were presented to the community; children and adults responded to initial sketches with feedback and their own versions of the characters. Members of the efargo team combined and developed these sketches into the final character version. Waste-a-Watt, the monster that personified energy waste and inefficiency that emerged from these efforts, provided an easily communicable and visual theme for efargo (Srivastava, 2019, 2020; see Figure 3).

Figure 3. Waste-a-Watt character and narrative development for efargo with community participation in multiple public locations. Sources: Srivastava (2019, 2020).

Second, the efargo game structure expanded player agency as the game progressed. Weeks 1–6 incorporated actions and engagement at the household and neighborhood scale. During the later weeks of the game (Weeks 7–9), the weekly tokens (civic and public) had activities that encouraged community dialogue during community events, and engagement with the municipality, utilities, and other organizations, expanding player social identities from individual players or household members to community members at the city scale (Figure 4).

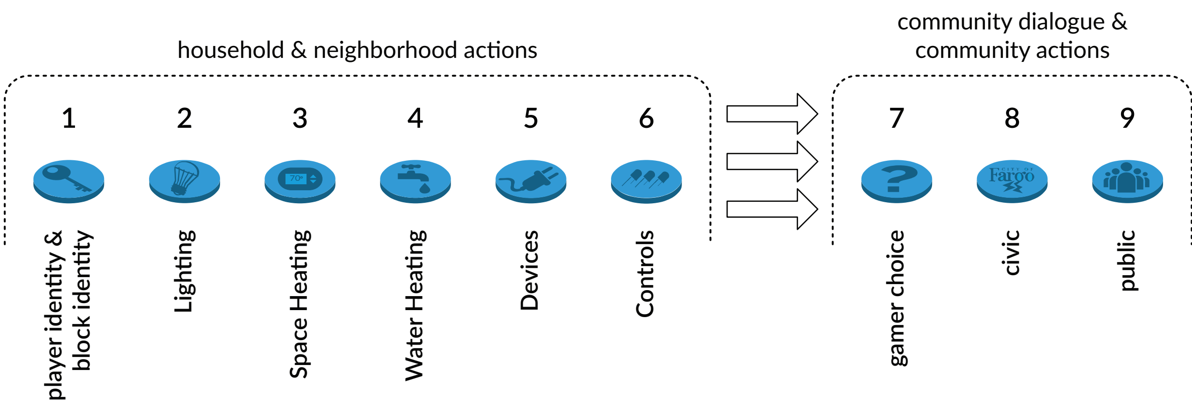

Figure 4. efargo weekly tokens that expanded players' nested social and spatial identities (from household and block to community and city) during the progression of the weekly gameplay.

Third, the design of the game incentives allowed players to cooperate and compete for winning the game as individuals or household players, as neighborhood members, and as community members of the City of Fargo. The game incentivized players with weekly prizes randomly selected from the highest-scoring winning blocks. The overall 10 highest-scoring players received smart thermostats as grand prizes. There were three ways of winning the efargo game that related to players' multiple and nested identities. The first two ways related to each player's block-based identity. Points earned through advancing the game tokens through challenge levels determined weekly game scores for each player or household. To determine the weekly champion player, the scores of all neighborhood-block players were aggregated. The block with the highest score was declared that week's winner. A weekly individual champion was identified by randomly selecting a player from the week's winning block. To increase their chances of being selected as the weekly champion, each player needed to contribute as many points as possible to the block score while helping their neighbors achieve high scores through cooperative play (outreach and networking). The third method of winning the game was based on the highest individual or household game score, awarded competitively to the highest-scoring 10 players in the city at the end of nine weeks. This allowed the game designers to selectively verify game actions within a small subset of finalists while also requiring them to submit individual household energy-use information.

Fourth, the efargo game results interface included a leaderboard and a frequently updated city map (Figure 5). The leaderboard included each player's individual scores and rank and their neighborhood block's scores and ranks. The city map showed each block's score, i.e., the aggregated scores of individual household players. The map also showed the past week's winner, i.e., the block with the highest aggregate score.

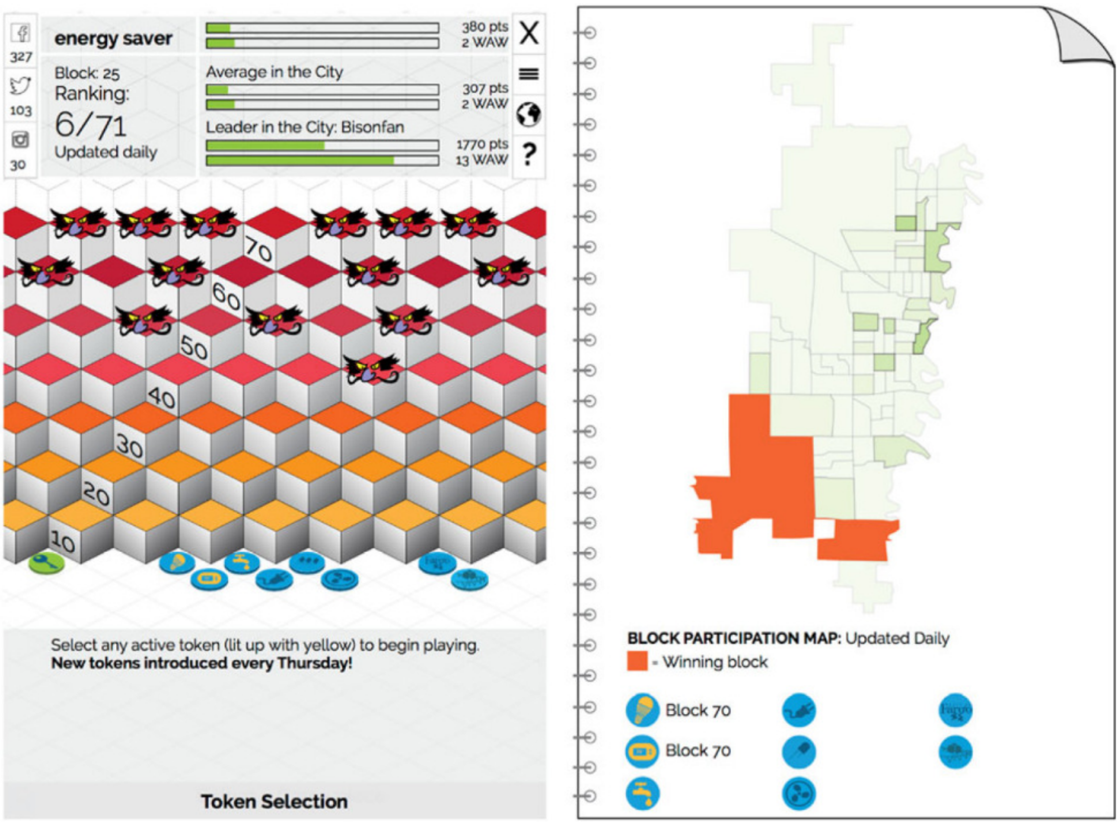

Figure 5. efargo game board and block score map which was updated daily during the nine-week gameplay. Source: Srivastava (2020).

Lastly, to achieve city-wide energy use reductions for the GUEP competition, the city as a whole needed to lower overall energy use as much as possible. Therefore, while individual wins created competitive incentives, ultimately the incentive structures that allowed for cooperatively achieving maximum reductions and highest engagements were considered essential. Each individual player's identity was also associated with, and nested within, the City of Fargo community as a whole, which provided a unifying motivation and meaning for the community.

4.2. Summarized efargo Game Results

The following results from the implementation of the nine-week game are summaries of game results reported by Srivastava (2020), who led the efargo research, design, and implementation. Data collection methods for the nine-week game period included in-game quizzes and documentation of player participation and completion metrics. Additionally, the efargo team conducted pre- and post-game surveys and energy use data collection.

Of the 301 people who joined the efargo game during the nine-week implementation, 56 people completed the pre-game survey and 64 people completed a post-game survey (Srivastava, 2020). Through an analysis of survey responses, efargo players reported learning about energy savings ($N = 56$, $p < 0.01$), willingness to engage in energy-saving behavior ($N = 56$, $p < 0.01$), and willingness to invest in energy savings ($N = 56$, $p < 0.05$; Srivastava, 2020). Twenty-six people gave permission to access the energy use data through their utility. Utilities were able to locate and provide complete energy-use data sets for 13 players. Data revealed energy-use reductions that began during the game and increased in the eight-month period after the game implementation. A monthly total savings of 1,273 kWh, or 12%, was observed ($N = 13$, $p = 0.25$; Srivastava, 2020).

It was possible for any player to earn a maximum of 3,600 points. Of the players, 5% achieved the maximum number of points, 10% had a high range of points, 27% had a medium range of points, 31% had a low level of points, and 27% did not progress to earning points. Four hundred and twenty-eight information summaries and related quiz responses were completed throughout the game for various weekly tokens. Of all the tokens, Lighting (339) earned the greatest number of completed energy-saving actions, followed by Heating (288). Most other tokens had similar levels of activity such as 239 actions for the Water token or 197 actions for the Controls token. The Civic token had the least number of actions (180) reported as completed. Overall, the players reported completing a total of 2,375 energy-saving actions through the game interface.

The relationship of players' willingness to invest in energy savings with specific behaviors, actions, or investments was assessed by means of specific action-related questions from the efargo post-game survey. Respondents were asked to indicate whether they had completed several different behaviors or home improvement tasks because of playing the efargo game. For each of these items, participants could select the following response options: "Implemented during or after [the game]," "Planning to complete," "Had already completed [before the game]," "Willing to consider," or "Not willing to consider."

The action item with the greatest percentage of respondents was "low-medium cost investments for replacing old incandescent bulbs with LED bulbs": 42.9% of respondents ($N = 56$) completed this action item during or after the game, and 21.4% indicated that they planned to implement the item during or after the game. The two action items with the next best results were respondents' willingness to turn down their thermostat 2 degrees

Fahrenheit in the winter, and their willingness to use the "air dry" selection on their dishwasher. The former had 41% respondents who had either completed or were planning to complete the action item, and the latter had 39.3% respondents who had either completed or were planning to complete the action item. The next action item, replacing old holiday lights with LED light strings, was reported as completed (21.4%) or as something that players were willing to complete (14.3%), for a total of 35.7% of the respondents.

The next 10 action items, ranging from 28.6%–21.4% of respondents who had either implemented or were willing to implement the action items, were a mix of no-cost behavior change efforts and low-cost investment efforts such as washing clothes in cold water, turning up the thermostat 5 degrees Fahrenheit in the summer, putting on an extra sweater and slippers instead of turning up the heat, switching off power strips, unplugging a second or third refrigerator, and hanging clothes inside to dry in the winter.

Finally, the no-cost behavior-changing action items that garnered affirmative responses from 14.3%–19.7% respondents ($N = 56$) who had either completed implementation or expressed willingness to implement during or after the game included switching off lights (19.7% of respondents) and hanging clothes outside to dry in the summer (17.9%). Players also invested in low-medium cost action items related to energy efficiency controls, such as installing timers on exhaust fans (19.6%), installing solar-powered outdoor lighting (landscaping or holiday; 14.3%), installing occupancy/motion sensors or timers on outdoor lighting (14.3%), and installing dimmers on the most-used lighting (14.3%). For the no-cost and low-cost measures, the percentage of respondents who had either implemented the action item during or after the game, as well as the percentage of players who were planning to implement the action item during or after the game, were more substantive than for the high-cost action items.

5. Game Design Model, Elements, and UGDPs

5.1. efargo Design Model and Elements

efargo's game structure was based on the TGD model (Harteveld, 2011), which proposes balancing the attributes of Meaning (player motivation), Reality (contextual agency), and Play (immersion, entertainment, and fun) during pervasive game design (Figure 6a). Per Harteveld, the consideration of reality within a pervasive game design allows the game to connect to something familiar in the player's real world. Additionally, per Harteveld, if the pervasive game is a serious game, then it must contribute some meaningful value. The notion of meaning and generated value in Harteveld's model is often represented as feedback to the community for achievement in the game or value from the game. In efargo's case, the value and achievements for players and their communities were aligned and focused on the overall reduction of energy use in Fargo. Harteveld's model further sets apart games from other environmental cultural expressions or awareness efforts by including game structures that allow engagement, fun, competition, storytelling, role-play, and rules that create the game's magic circle, and which together form the third TGD attribute, Play. Play allows the game to incorporate qualities of immersion and fun, distinct from other cultural media. Immersion is a particularly important aspect in a pervasive game with a serious purpose, because gameplay that spans between the game environment and the real world requires players to move between one and the other, which can otherwise be disruptive to the game's immersive quality.

Poplin's game elements, extended by Srivastava's game tools and narratives (Srivastava, 2016), served as primary guiding elements for efargo's design. These include Environment, Objects, Goals, Rules, and Players (Poplin, 2011, 2012). The game Environment, which for Poplin (2012) means a geographical location, was the City of Fargo for the efargo game. Game Objects for Poplin (2012) are physical objects such as buildings, and stakeholders (their moods, satisfaction) and the events they participate in as part of gameplay. Srivastava (2016) proposed Tools as a way of extending Poplin's game Objects to any activity that has a representation (physical or digital) in the game, or on which there is a material impact of the game. Poplin's game Rules define how the games are played and how activity is rewarded (Poplin, 2012), and Players are the game participants (Poplin, 2012). Needing the Fargo community to align around the goal of winning the GUEP competition, Srivastava (2016) proposed Narrative as an addition to Poplin's game elements, to include storytelling or other narrative representations as an intrinsic part of a location-based, identity-building concept in pervasive geogames (Poplin, 2024).

5.2. UGDPs

Ahlqvist and Schlieder (2018) emphasize geogame patterns—recurring design structures that support the transfer of ideas across contexts, with the understanding that the interaction between geographic and game design concepts could improve the design of future spatial games and geogames. They examine two influential frameworks from geography: first, Kuhn (2012) and Kuhn and Ballatore (2015), which focus on spatial information through 10 core concepts, and second, Janelle and Goodchild (2011), which emphasizes spatial thinking and reasoning. Ahlqvist and Schlieder (2018) further draw on two complementary game design frameworks, Holopainen's game components (2011) and Järvinen's game elements (2008). They conclude that the two approaches differ in perspective, with the former representing a game design perspective, and the latter representing a user-oriented perspective. Collectively, their synthesis forms the basis for proposing a unified vocabulary for geogames. We utilize this proposed vocabulary as UGDPs (Tables 1 and 2). In their analysis, the authors note several key correspondences. For example, Location in geography aligns with game components like Environment and Objects. They suggest that Rules from game design mirror spatial simulation models and processes in geography, while Agents in games relate to entities that carry out actions or goals, like players or agents in GIS simulations. Interface, representing how players interact with games, also has a clear parallel to the role of technological interfaces used in GIS to manipulate and view spatial data. However, the authors also recognize areas where further exploration is needed, particularly with concepts like Game mechanics and Contexts, which do not directly correlate with existing geographic terms. By identifying overlaps and gaps between game components and geographic concepts, they propose new terms—Rules, Agents, Interface, and Simulation—as additions to the traditional geographic lexicon. Thus, Ahlqvist and Schlieder (2018) offer a unified vocabulary, which we present as UGDPs, that bridges the fields of geography and game design.

6. Comparative Synthesis of Geogame Patterns, Game Elements, and Game Model

Utilizing synthesis methodology like Ahlqvist and Schlieder (2018), we compare the UGDPs with the frameworks that informed the efargo design (Poplin's game elements and Harteveld's TGD model). We first identify and discuss the overlapping patterns and elements and bring them into correspondence with the Reality, Meaning, and Play principles of Harteveld's TGD model (Figure 6a). We then identify the UGDPs that do not correspond to Poplin's elements and Harteveld's TGD model. We continue to include the two game design frameworks, Holopainen (2011) and Järvinen (2008), to illustrate the game design perspective and the user-oriented perspective. Based on the comparative analysis illustrated by the efargo case study implementation, we propose expansions of the TGD model (Figure 6b), for community-focused serious pervasive geogame design. This model integrates the following additions: Representation (at the intersection of Reality and Meaning), Resources (at the intersection of Reality and Play), and Networks (at the intersection of Meaning and Play). These proposed expansions bridge pervasive games that focus on the individual player to pervasive geogames that address aligned player and contextual community goals.

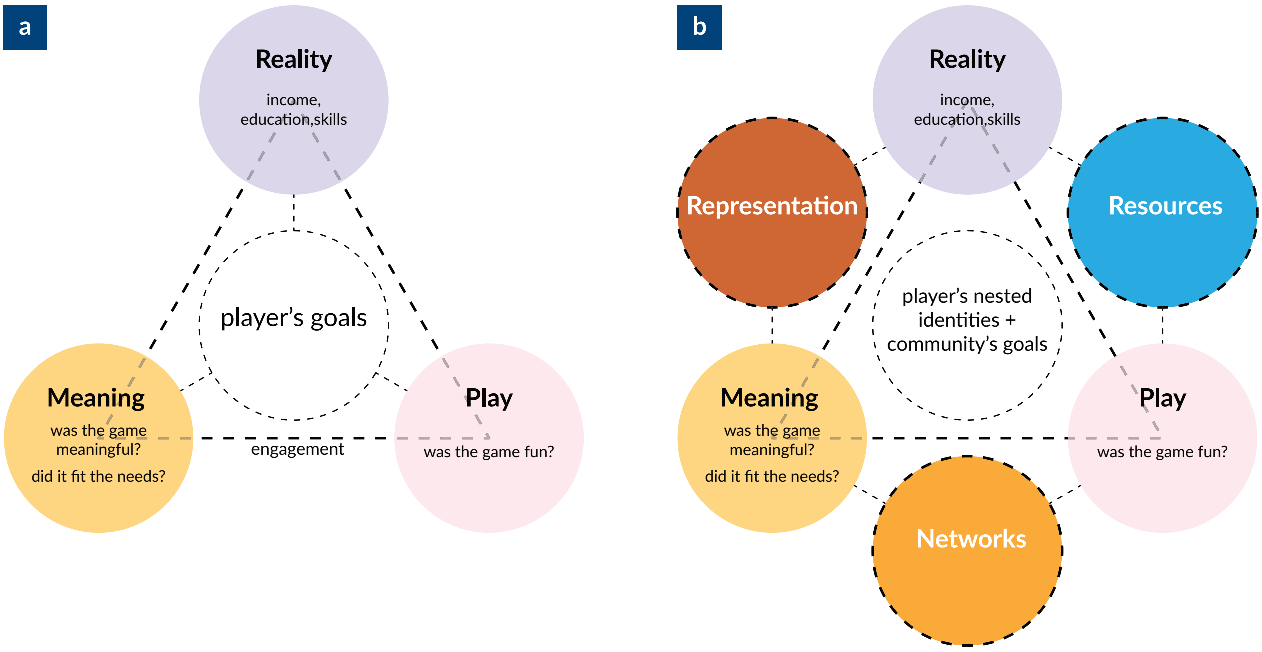

Figure 6. Extending Harteveld's model for pervasive game design for GeoSPEGs: (a) Harteveld's TGD model for pervasive games; (b) proposed expansions of the TGD for GeoSPEGs.

6.1. Synthesizing UGDPs With the Reality Component From the TGD Model

Reality (Harteveld) or Environment (Poplin) elements and attributes allow the game to connect to the real world. We propose that Ahlqvist and Schlieder's (2018) UGDPs Location, Distance, Neighborhood, and Field describe real-world geography as game space with the potential for play (Table 1). In this case, Location is understood as the method of specifying "where," Distance allows an understanding of the relationships between locations, Field is the understanding of continuous attributes or phenomena, and Neighborhood identifies areas or regions that have common attributes of Distance, Location, and Field. The game Environment, which for Poplin (2012) means a geographical location, was the City of Fargo for the efargo game. The efargo game Locations included all home typologies (single-family homes, duplexes, townhomes, and apartments) and reflected the reality of the City of Fargo's housing stock, which was 57% rental at the time of the efargo game. Including the Distance, Neighborhood, and Field patterns in the Reality principle of the game model allowed us to expand the game environment beyond a single player's reality, acknowledging the complex context of the city to which players could respond.

Table 1. Correspondence between Ahlqvist and Schleicher's UGDPs, Poplin's game elements, and Harteveld's TGD model.

UGDPs (based on Ahlqvist & Schlieder, 2018)	Components (Holopainen, 2011)	Key Game Elements (Järvinen, 2008)	Game Elements (Poplin, 2011, 2012; Srivastava, 2016)	TGD Model (Harteveld, 2011)
Location		Information	Environment	Reality
Distance		Information	Environment	
Neighborhood		Information	Environment	
Field	Game elements	Environment (Information)	Environment	
Meaning		Theme	Narrative	Meaning
Value		Contexts		
	Goals and sub-goals		Goals	
Event	Action (Events)	Game mechanics (Information)	Event	Play
New Rules	Rules (Modes of play, Evaluation functions, Closures, End conditions)	Rule set	Rules	
New Simulation	(Game session, Play session, Set-up and set-down, Game instance, Extra activities, Game time)	Information	Rules	

6.2. Synthesizing UGDPs With the Meaning Component From the TGD Model

Within serious games, the TGD model allows Meaning to be understood from the players' point of view and gleaned from the game's suitability to players' circumstances. We propose that Ahlqvist and Schlieder's (2018) UGDPs, Meaning and Value, correspond to Holopainen's and Poplin's Goals and sub-goals, allowing us to connect player context and community to the development of meaning and value (Table 1). In Poplin's framework, game Goals include finding satisfactory real-life solutions and educating players (Poplin, 2012) and thus can be understood to refer to the purposes behind creating games as well as to players' objectives. Meaning in a serious game comes from the achievement of value in the game at the individual scale (such as knowledge acquisition, skills development, and attitude or behavior shifts), and at the community scale (such as building social relationships, exerting social influence, and benefiting the community). In pervasive play, it becomes essential to derive value for individual players as well as for the community to maximize and achieve aligned rewards. For Ahlqvist and Schlieder's (2018) UGDPs, Value derived from the role played by spatial information is understood as Context in Järvinen's (2008) game elements. Meaning, therefore, may be understood as an emergent property of interaction, context, and alignment within a community. In the efargo game, creating value and achieving the goal of energy savings created alignment at the various scales (home, neighborhood, and city). For efargo, actions and mechanisms of winning the game were aligned towards the goal of energy savings as contextualized by the GUEP, thus creating shared goals, values, and meaningfulness. Further, we align Ahlqvist and Schneider's Meaning to Järvinen's game Theme (Järvinen, 2008), and extend it to the game Narrative (Srivastava, 2016), allowing players to interpret and draw meaning from representational storytelling. The Waste-a-Watt character provided a representation, narrative, and theme linking the Environment, Objects, Goals, Rules, and Players across multiple games and events for Fargo's participation in the GUEP competition.

6.3. Synthesizing UGDPs With the Play Component From the TGD Model

Games are defined by game structures that simultaneously allow engagement, fun, and competition, governed by rules that create an immersive magic circle (Montola et al., 2009; Nieuwdorp, 2005). These form the Play component in Harteveld's model. Play is an important aspect in a pervasive game with a serious purpose: Where play is placed in ordinary reality, it spans between the game board and the real world, requiring players to move between them, which can be disruptive to the game's immersive qualities. Similarly, Play is a crucial aspect of distinguishing geogames from GIS-based artifacts that are not games, such as interactive maps. We include the following components, elements, and concepts into Harteveld's world of Play (Table 1). Ahlqvist and Schlieder (2018) incorporated Holopainen's (2011) modes of Play, Goals and sub-goals, Events, Evaluation functions, Closures, and End conditions in the category of New Rules. Rules or rulesets are procedures governing gameplay and are ubiquitous to the frameworks under consideration. Similarly, Poplin's game Rules define how games are played and how activity is rewarded, to meet the game Goals (Poplin, 2012). Further, Ahlqvist and Schlieder (2018) describe Simulation as a dynamic enactment drawing parallels between Game sessions, Play sessions, Set-up and set-down, Game instance, and Activities in Game time as the Objects, Agents, and Rules as in a GIS. An individual portion of the process bound in time is characterized as an Event and is related to Holopainen's Action and Järvinen's Game mechanics. All these elements come together to create a game's magic circle, i.e., the boundary separating the game from ordinary life (Montola et al., 2009). In the case of efargo, creating the magic circle started with engaging the community in a co-design process that developed the narratives and game characters. This aimed for the development of a community identity for the national competition, positioning ordinary life actions of energy-efficiency behaviors to be perceived as playful activity, defeating the hidden energy waste monster, Waste-a-Watt. Rulesets that establish weekly game session rhythms, cycles of cooperative and competitive actions and events, and weekly community and individual rewards are described above in Section 4 of this article. The Evaluation functions of the efargo game were based on two key aspects: engagement and energy use reduction. The engagement activities (how many efficiency activities, learning quizzes, and community events and dialogues were completed by players) determined the weekly engagement points and the resultant weekly block and individual winners. The energy function was tracked by the utilities, who were partners in the efargo effort, and provided energy use data to the design team at the city-wide scale and individual players' energy use. Players who reduced the greatest amount of energy were declared winners at the end of the nine-week efargo game implementation. The city-wide residential energy use was reported to the efargo community on a quarterly basis during the entire two-year duration of the GUEP competition, thus continuing to incentivize the use of the efargo game beyond the initial nine-week city-wide synchronous play period. This informed the community about their performance as a whole in reducing energy use across the city for the GUEP competition.

6.4. Representation: Proposed Addition to TGD at the Intersection of Reality and Meaning

In pervasive games, where life's ordinary spaces, time, and resources are cast into the magic circle (Montola et al., 2009), the idea of reality and its representation take on new meaning. Representations are filters or lenses that cause a shift in perception, which allows reality to be perceived as a game, and through which immersion can be instantiated, even through ordinary life actions (Montola et al., 2009). Harteveld (2011) frames games as selective models of reality where representations are not neutral; they shape the player's perception and influence what is interpreted as relevant and meaningful. We propose Representation as depicting reality selectively to communicate meaning in the game (Table 2). From the UGDPs, we include Interface, Accuracy, Granularity/Scale within Representation. New interfaces (Ahlqvist & Schlieder, 2018), Interfaces (Holopainen, 2011; Järvinen, 2008), or Game tools (Srivastava, 2016) are representations by which players access the game (Figures 2 and 5). The interfaces determine how reality is selectively depicted and how the game is played, while also becoming the mechanism of creating immersive flow. The interface plays a crucial role in the dynamic of players making meaning. Accuracy (Ahlqvist & Schlieder, 2018) allows the spatial layering of information, and Granularity/Scale (Ahlqvist & Schlieder, 2018), i.e., the amount of information and the scale of representation, are important considerations aligning with meaning formulation in geogames.

The efargo game provided various game board components that represented meaningful aspects of the aligned individual, household, and community game incentives. In efargo's case, the city map (with blocks delineated based on census block boundaries) was the meaningful Granularity or Scale of aligned performance between the individual or household player and the neighbors identified with census blocks. A map of the city that showed each block's comparative performance through a color scale (Figure 5) was updated daily on the game board. The color-coding allowed players to compare their block's performance with others. The lightest green blocks were the lowest-performing, and the darkest green blocks were the highest-performing. The "greening" of the entire map based on higher community engagement and performance could lead to (and indeed, *did* lead to) energy savings that resulted in carbon savings for all Fargoans. Thus, the city map with neighborhood blocks was the daily and weekly representation of game goals (energy saving actions) and resulting performance, providing incentive and eco-feedback to game players.

Table 2. Comparing Ahlqvist and Schleicher's UGDPs to Harteveld's TGD model to include Representation, Resources, Community, and Networks.

UGDPs (Ahlqvist & Schlieder, 2018)	Components (Holopainen, 2011)	Key Game Elements (Järvinen, 2008)	Game Elements (Poplin, 2011, 2012; Srivastava, 2016)	Proposed Expansions of the TGD Model
Granularity /Scale		Information	Implied in Environment	Representation
Accuracy		Information	Implied in Environment	
New interface	Interface	Interface	Tools	
Spatial heterogeneity		Information		Resources
Overlays		Information	Implied in Environment	Networks
Spatial dependence		Information		
	Game elements	Environment (Information)	Implied in Environment	
New Agents	Players, Game facilitators	Players (Information, Components, Environment)	Player	Community
Object	Game elements	Components (Information)	Object	

We propose that Ahlqvist and Schlieder’s (2018) UGDPs New interface, Tools (Srivastava, 2016), Information, and Interfaces (Järvinen, 2008), correspond to representations such as visuals and eco-feedback systems, and that they allow players to infer the meaning of geographic and spatial structures as representing the player context. These visual and interactive layers are where meaning is negotiated, based on how players perceive and respond to cues presented by the game environment.

6.5. Resources: Proposed Addition to TGD at the Intersection of Reality and Play

Real-world differences in how players perceive the game are based on the reality of their physical, social, and economic circumstances, reflecting Spatial heterogeneity (Ahlqvist & Schlieder, 2018). In a GeoSPEG like efargo, the spatial component of pervasive games introduces a layer of complexity, as gameplay occurs within real-world settings where access and agency can vary significantly across players. For instance, renters may face structural or contractual barriers that limit the available energy-saving actions, whereas homeowners often have more autonomy to implement changes. Resources at the intersection of Reality and Play can address variability in player agency. These resources may take on the form of scaffolds (Reigeluth & Myers, 2013) such as in-game informational resources, game mechanics’ flexibility and customization to suit player needs, and lastly, coaching that provides players with social, physical, and knowledge support. In the case of efargo, these scaffolds were made available through multiple instructional resources (for example, Figures 2e, 2f, and 2g), and players were able to select from a range of energy-saving actions (tokens, levels, and action cubes all provided multiple potential actions to choose from)—or to propose their own (Token 7, the Player’s Choice token)—based on their individual circumstances. In addition to these scaffolds, providing resources that understand and recognize the resource gaps within the player community is crucial. For example, to address the lack of electronic devices in some households, an efargo station was set up for public use in the local library. Additionally, efargo gameplay was incentivized to have the block score inform the weekly champion (winner), thus encouraging assistance in the gameplay from neighbors and others.

6.6. Networks: Proposed Addition to TGD at the Intersection of Meaning and Play

Per the TGD model, players bring their own identities, contexts, networks, and expectations into the gameplay space. However, Spatial Dependency can manifest as individuals or groups in proximity, such as individuals living in the same neighborhood, who might be more likely to interact or share similar characteristics and form social connections and therefore exhibit similar behaviors or attitudes (Weijs-Perrée et al., 2017). In geogames, social cohesion develops through Spatial dependencies, and Networks of relationships between game Objects (individuals that have shared identity, or spatial, temporal, and thematic properties) can be realized through Overlays that can infer spatial associations by comparing mapped variables by locations (Ahlqvist & Schlieder, 2018). The efargo game used census block boundaries as game neighborhood blocks where such overlays and spatial associations occur, given that census blocks are bounded by visible features (e.g., roads), and nonvisible boundaries (e.g., property lines), and may share population characteristics such as economic status and living conditions. Additionally, in efargo, Spatial Dependency was conceptualized through the nested urban scales concept that intersected players’ social and spatial identities held simultaneously across urban scales: the home, the neighborhood block, and the city (Figure 7). As the game progressed, the game structure allowed players to participate in game actions at increasingly large scales. Allegiances related to the multiple identities were further reinforced through aligned incentive structures. Methods of winning the game were based on completing energy-saving actions and adopting energy-saving behaviors. For example, players cooperated within the household to earn points and with neighbors for the block-scale incentives. While the neighborhood blocks competed against each other for weekly incentives, they were simultaneously in a cooperative relationship as Fargoans for the national GUEP competition incentives.

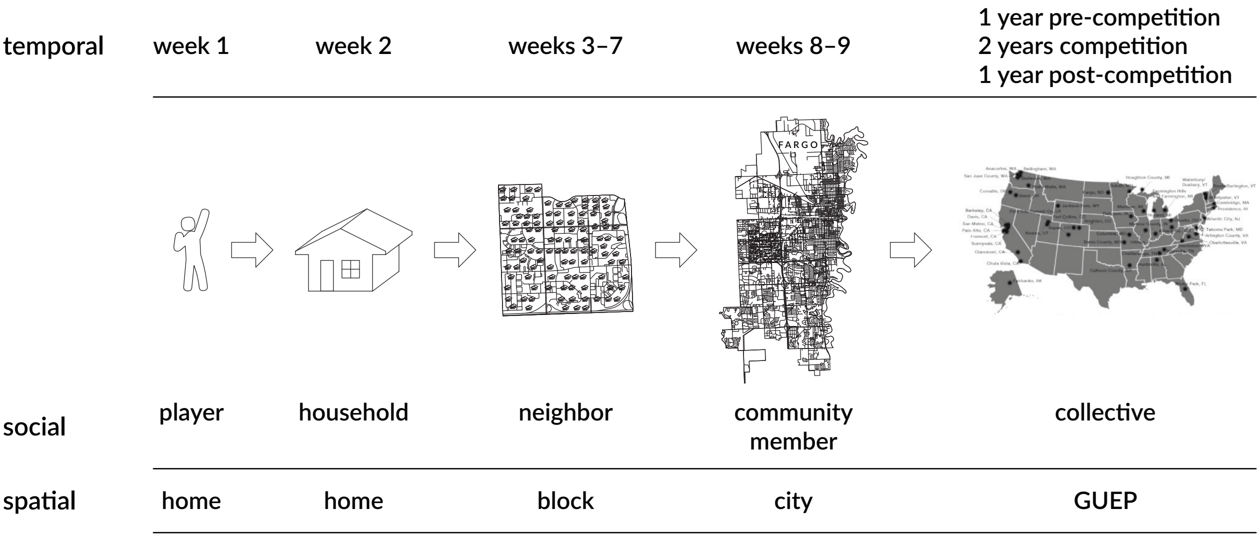

Figure 7. efargo social, spatial, and temporal expansions across nested urban scales.

7. Conclusion

In Harteveld's TGD model, the individual player is implicitly at the center of the Reality, Meaning, and Play attributes. In our expanded model (Figure 8), we continue to center players, but also explicitly add players' simultaneously-held identities across nested geographic urban scales. Intended for GeoSPEGs, the community is positioned as the audience and participant, in addition to the individual players. Thus, this expansion centralizes Ahlqvist and Schlieder's (2018) Agents (entities that act towards the goals) and Objects (individuals that have identities and spatial, temporal, and thematic properties; Figure 7) by expanding the focus from Player to Community goals. The community here includes other players, facilitators, cheerleaders, bystanders/onlookers, designers, stakeholders, and implementers, all related through shared geographic context.

While continuing to consider the balance between Harteveld's original attributes (Reality, Meaning, and Play), the expanded model addresses the potential for shared understandings. Thus, it situates Networks at the intersection of shared meaning and play, Representations at the intersection of emergent meaning shared between players and community, and Resources addressing diverse needs at the intersection of heterogeneous reality of the players and immersive gameplay. This aims to maximize player participation, shared community benefits, and aligned goals.

Ahlqvist and Schlieder (2018) identify three spatially-driven patterns in geogame design: (a) fundamental spatial patterns (locality, proximity); (b) spatial activity patterns (navigation, race-to-finish, collection); and (c) spatial interaction patterns (gaining ownership). They emphasize the incompleteness of these patterns and the need for more pattern identification. In recognition of the fundamental nature of nested urban scales, we propose this concept as a fundamental spatial pattern for geogames (Figure 7). This concept

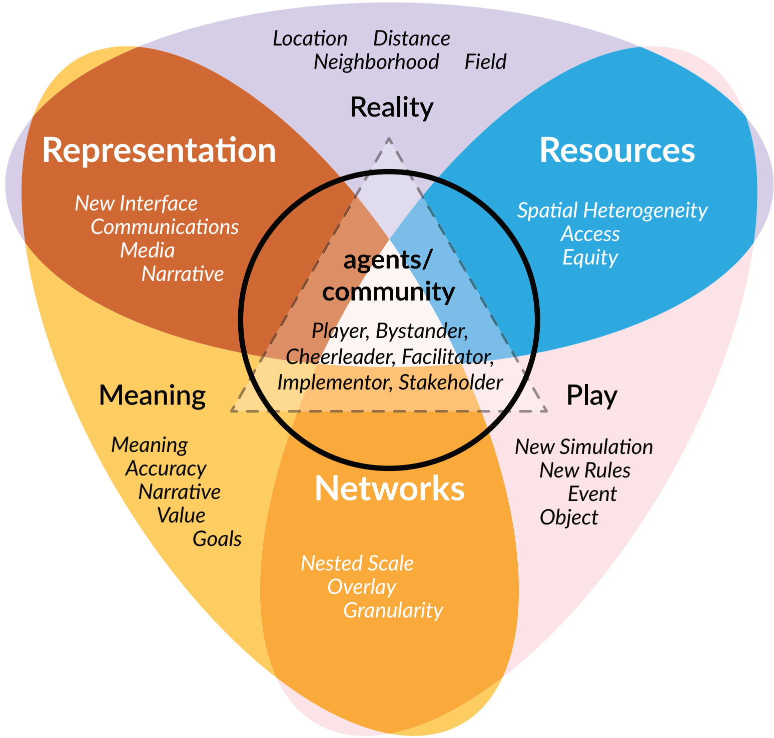

Figure 8. Proposed expanded model for the design of GeoSPEGs.

allows players to hold multiple simultaneous identities and makes available goal-aligned actions based on their geographic location and across multiple scales of agency.

While the proposed GeoSPEG design model builds on previous work (Ahlqvist & Schlieder 2018; Harteveld, 2011; Poplin, 2011, 2012; Srivastava, 2016, 2020) with the addition of a fundamental spatial pattern, both the expanded model and the spatial pattern need to be validated through application, data collection, and controlled analysis of other serious pervasive geogames. Additionally, the efargo game implementation existed within a national competition that provided the opportunity for shared identity, meaning, and goals for all Fargoans, which would be difficult to replicate in future studies.

Nevertheless, careful selection of games that incorporate aligned player and community goals, multiple locations (desks, parks, buildings, neighborhoods, and cities) with geographic interfaces, could be utilized to test the proposed concepts. For example, Greenmate, a single-player web-based game, incorporates typology-based mini-games across locations (home, school, and farm) to perform tasks leading to awareness of carbon footprint and energy consumption in daily tasks (Bhattacharya et al., 2025). The authors of the current article are designing a serious pervasive energy game that expands gameplay from competing schools to student homes and neighborhoods, which may provide data to test this model.

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Conflict of Interests

The authors declare no conflict of interests.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Google Gemini was used to format the reference list according to the APA citation style. The authors subsequently proofread the formatting.

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About the Authors

Malini Srivastava (AIA) is the associate dean for research at the College of Design, University of Minnesota. She is a licensed architect, associate professor, director of the Consortium of Research Practices, and MS in architecture (applied research in practice). She was inducted into the UMN Academy of Distinguished Professors in 2023.

Mariangel Meza is a graduate student in the PhD program at the College of Design, University of Minnesota. She is a Fulbright scholar (2023–2025) and a licensed architect from Paraguay. She holds specializations in sustainable construction, inclusive design-accessibility, and university teaching.