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PLAYFUL PHI: USING COGNITIVE BEHAVIORAL GAME DESIGN (CBGD) TO CREATE A COVID-19 PREVENTION GAME, VACCINE NATION

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Abstract

During the Covid-19 pandemic, scientists and public health organizations such as the CDC and the WHO promoted health guidelines to the public. However, social media misinformation, social stigma, and a drastic change in lifestyle lead to reduced compliance or non-compliance with these measures. As a result, playful public health messaging emerged as an attempt to increase health literacy around Covid-19 preventative practices, one of which was the tower defense game, Vaccine Nation. This article outlines the design principles of Cognitive Behavioral Game Design (CBGD) and how they were used to design the tower-defense game Vaccine Nation, incorporating recommended health interventions including isolating, hand hygiene, social distancing, wearing masks, and eventually getting vaccinated.

Keywords: *games, public health, Covid-19, disease prevention, health literacy, play, health promotion, Vaccine Nation*

Introduction

The Covid-19 pandemic created the necessity for the rapid deployment of public health information (PHI) in a way that the average person could understand and implement. While the official responsibility for conveying this information fell to organizations like the World Health Organization (WHO) and the Center for Disease Control (CDC), average citizens used social media and playful ways to spread information as well. This article conveys a timeline of events, focusing on public announcements regarding the pandemic, followed by examples of PHI produced by the public and a brief discussion of its accuracy and effectiveness. Finally, it presents a design brief of the game Vaccine Nation, and how the design was informed by the serious game framework, Cognitive Behavioral Game Design.

The Center for Disease Control and Prevention (CDC, 2023) presents a detailed timeline of the discovery and spread of Covid-19: In December of 2019, a virus quietly appeared in the populace. Symptoms were similar to pneumonia, with patients reporting high fevers and trouble breathing. The pneumonia-like disease didn't respond to typical treatments and seemed comparable to stronger viral strains such as SARS and MERS. By early January of 2020, both the CDC and the world Health Organization (WHO) were actively investigating the disease. On January 10, 2020, the new disease had a name: the 2019 Novel Coronavirus, coined by the WHO. Ten days later, the virus had spread to 5 countries. On February 10, 2020, the virus was confirmed as one of the world's most lethal, with over 1,000 worldwide deaths in less than 60 days. On February 11, the WHO announced the new official moniker for the disease: Covid-19. One month later, the same organization declared it a pandemic (CDC, 2023).

The next 2 years would see worldwide quarantines that restricted travel by air and sea, as well as local lockdowns that restricted everyday travel. Schools and businesses turned to online operations as the physical buildings were closed. In the midst of this, public health officials scrambled to provide health information to the masses (CDC, 2023) (Center for Disease Control, 2023).

In 2007, the CDC created guidelines for dealing with a viral pandemic – specifically, influenza. The guidelines emphasized several goals, including lessening impact on community health centers by flattening the peak of illness and reducing the number of cases long-term. However, the overall goal was to reduce deaths from disease. Because it takes 4-6 months to develop a new vaccine, the CDC presented a strategy involving several non-medicinal methods that the public could combine in order to thwart the spread of the virus. These strategies included hand-washing and covering coughs as well as self-isolation for sick members of the public, and voluntary quarantine for people who were exposed. Surgical masks and respirators were mentioned as possible interventions as well. The CDC also had social distancing recommendations for children and adults, with school closures for children and behavioral measures for adults. Adults were encouraged to practice social distancing, avoiding crowded places and limiting necessary trips, like shopping, to essential excursions with reduced frequency. Employers would also need to contribute to community health during a pandemic, with the CDC recommending tactics such as allowing employees expanded freedom to use company leave, encouraging telework rather than in-person gatherings, and using spacing strategies for those in the office (CDC, 2007).

During the pandemic of 2020, the CDC guidelines became a lifestyle for the world. Infection and death rates were continuously reported over the news and social media. Schools and workplaces shut down, stores reduced their hours, and air and sea travel was indefinitely suspended. Amidst the corporate and travel changes, the community was asked to make everyday lifestyle changes as well: be vigilant about hand-washing, wear masks everywhere, keep their children home, and stay indoors.

During the Covid-19 pandemic, there were individuals and groups who were resistant to or simply did not comply with preventative procedures suggested by the CDC, NHS, etc. (Barceló & Sheen, 2020; Malecki & Keating, 2021; Keller, Honea, & Ollivant, 2021). For instance, resistance to mask-wearing involved social stigma and perception of disease risk, however the normalizing of mask-wearing helped improve attitudes and compliance (Barceló & Sheen, 2020). Others may have been confused by the magnitude of ever-changing information and unable to determine which sources to trust – often looking to social media alongside established news outlets (Malecki & Keating, 2021). Some initially complied, but dropped interventions too soon, believing the worst of the disease to be over (Keller & Honea, et. al., 2021). In sparsely populated areas, the disease spread slowly, leading to confusion about the outcome expectations of preventative behaviors and disbelief about how their personal actions would have an effect on their own susceptibility or the health of their communities (Keller & Honea, et. al., 2021). Health literacy is the ability for individuals to find credible sources and evaluate health messages for the purpose of making optimal health decisions (Bin Naeem & Boulos, 2021). Increasing health literacy includes helping people understand where to find health information, how to understand health information, and how to apply that information to their own lives (Bin Naeem & Boulos, 2021). Covid-19 presented a double goal; reduce the prevalence of the virus, and increase health literacy in the public.

Scientists and journalists did their best to spread accurate information to the public, however, social media influencers can post unvetted information that is seen and absorbed globally by millions – and that information is often misleading. Bin Naeem and Boulos (2021) found that, in some cases, as many as 40% of social media posts about Covid-19 came from unreliable sources, containing false information about how Covid-19 spreads as well as how it is treated. They noted that the WHO coined this flood of misinformation an "infodemic".

Playful Public Health Information (PHI)

While the infodemic involved the public posting misleading health information, another public-driven movement emerged where the private sector provided PHI with more accuracy, and more fun. Playful PHI was primarily comprised of musical interventions and games.

Music

One of the first major health messages was the promotion of handwashing, and education about the proper techniques. In 2009, the WHO released a report titled "WHO Guidelines on Hand hygiene in Healthcare," which included an infographic featuring their recommended handwashing technique (p. 156). In 2010, the CDC released a podcast with a song to the tune of "Happy Birthday" that was supposed to be sung along with

handwashing (Center for Disease Control, 2023). This song, along with the infographic (World Health Organization, 2009), became popular during the beginning of the pandemic and were widely circulated on social media. However, a then 17-year old William Gibson (BBC News, 2020) introduced playfulness by building a website, Wash Your Lyrics (Gibson, 2020), which allowed people to input the title of a popular song, or even their own custom lyrics, and have the WHO handwashing infographic printed with the customization, thus combining music, handwashing techniques, and user creativity.

Celebrities joined in on the playful spreading of health information through music. Liz Giuffre (2021) chronicled musician-led interventions by Gloria Gaynor, Neil Diamond and Dolly Parton. Gloria Gaynor made a 20-second video that she posted on popular social media sites YouTube and Tik Tok in which she washed her hands for 20 seconds while singing her hit song, I Will Survive. To further this playful PHI, she turned the video into a challenge, using the #IWillSurvive hashtag to inspire others to wash their hands as well. Diamond and Parton changed the lyrics to their popular songs to coincide with the message of handwashing and social distancing. Diamond changed his song, Sweet Caroline, to refer to washing hands and not touching each other. Parton's song, Jolene, originally contained sassy no-touch lyrics as an anthem against romantic cheating, but Parton playfully added the admonishment to wash your hands.

Games

According to educational game researcher Kurt Squire (2006), games are a medium that provides simplified worlds, in which the game design focuses players on what is important within the world. As games primarily involve doing, they present a "functional epistemology" (Squire, 2006) in which players actively facilitate their own learning. During the pandemic, designers created playful experiences to pass on public health messages while embedding interactivity and the opportunity to identify themselves as heroes.

The Vaccination Game

The Vaccination Game (mrcwimm, n.d.) is a single-player, turn-based game that focuses on containing a pandemic by vaccinating countries. The game presents the player with a virus name, an infection threshold, lethality, recovery time, and weekly spread. The player has 13 weeks to distribute vaccines, with just over 4 million vaccines per week. During gameplay, the player sees countries on a map. Countries are covered with circles that start blue (not infected) and turn red based on the prevalence of infection in the country. Once the pandemic has run its course, the bubbles turn pink. Green slivers within the bubbles represent the vaccinated. Red lines between countries indicate the viral spread. In-game tips encourage players to focus on large travel hubs and pay attention to places where the virus has not spread. When the 13 weeks are over, the game supplies statistics for infected people and fatalities both without vaccines and with vaccines. Finally, the game displays how many people were saved via your vaccination strategy. The Vaccination Game was funded by the UK organization IMPRINT, which focuses on maternal vaccination (IMPRINT, n.d.).

Pandemic, The Board Game

The original Pandemic game was released in 2008 (Andersen, 2016), well before Covid. According to developer, the game has been used in educational settings to teach about disease spread (Borrelli, 2020)**.** Other sources indicate the game has been used to teach teamwork (Anania, Keebler, Anglin, & Kring, 2016), management principles (vanEsch & Wiggen, 2020), and language (Masuda & deHaan, 2015). This multiplayer board game takes place across the globe, with 2-4 players in specific roles like scientist, researcher, and medic (Andersen, 2016; Anania, Keebler, Anglin, & Kring, 2016). Players work together to eradicate up to 4 diseases at a time by building and maintaining research stations, treating illness, and preventing outbreaks. Eventually, players win by researching and finding cures for every disease on the board (Z-Man Games, 2018). While the original game does not feature an explicit narrative, a later version, Pandemic legacy, adds a 12-month timeline in which player characters can get scarred during their world-saving experiences, and even die (Andersen, 2016).

Designing Vaccine Nation

The handwashing website focused on a single intervention in a playful way, and the games used a global approach to teaching about disease spread. One focus was extremely narrow, while the other is quite wide. Therefore, the author desired a way to create a game with specific intervention goals that focused on individual experience that would create a worldwide impact. The goals for creating the game included encouragement for individuals to participate in several health interventions simultaneously, as this is most effective at disease prevention, and individuals need to have self-efficacy for creating an impact. However, individual actions are also beneficial and necessary for the health of a community. The lens of community allows for individuals to see the impact of their actions on a scale that may be more easily identified with than a global perspective. One effective way to show that individual actions can create wider outcomes is to use the lens of community. While the average person cannot create policies, control travel routes, etc. in order to affect global outcomes, individuals can use grassroots efforts to spread information and then watch as their community of influence is transformed around them. To create a game that would show how individual participation in health interventions can create positive outcomes for their communities, Cognitive Behavioral Game Design was chosen to structure the design of the game.

Cognitive Behavioral Game Design

Cognitive Behavioral Game Design (CBGD) is a serious games framework that incorporates behavioral theory, learning theory, and the player enjoyment process (Starks, 2014). The behavioral elements are derived from Social Cognitive Theory (Bandura A. , 2004; Bandura A. , 2001), where the process for behavioral change involves knowledge (why change?), goals (what to change), outcome expectations (realistic change), encouragement (keep on changing!), and barriers (how to handle resistance to change). The framework has been used to create a game that successfully increased knowledge about alcohol abuse and reduced intent to use alcohol recreationally (Yap, et al., 2020), and to inform the design of a pressure-sensitive pen to assist disabled children with handwriting (Rettinger, et al., 2022).

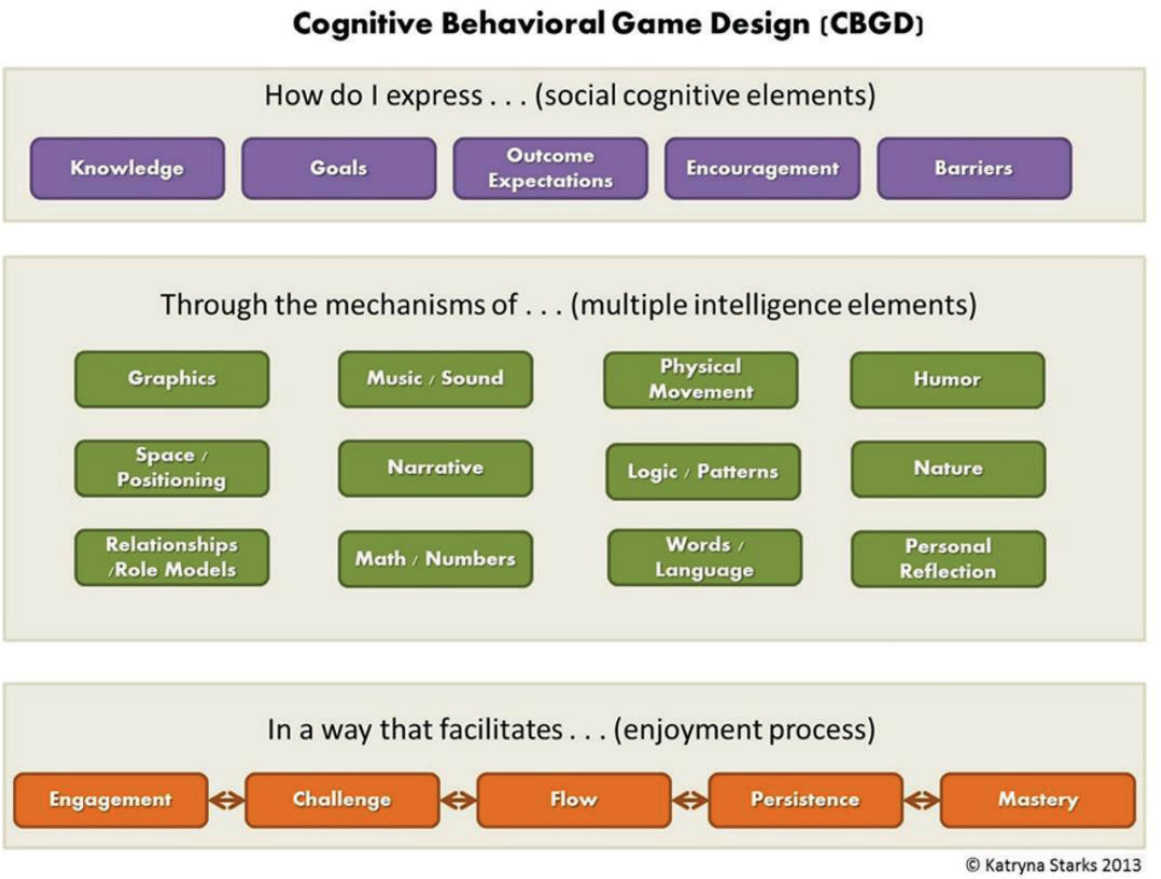

Figure 1
the CBGD model

The learning theory includes elements from Multiple Intelligence theory (Gardner, 1999), but converted to components of games. Therefore, visual/spatial intelligence becomes two components: graphics and space/positioning; body/kinesthetic intelligence becomes physical movement; mathematical/logical splits into math/numbers and logic/patterns; musical extends into music and sound (indicating sound effects and atmospheric ambience); interpersonal becomes relationships

and role models (indicating other players as well as game NPCs); and intrapersonal becomes personal reflection as the player analyzes their choices and the aftermath thereof. Verbal/linguistic intelligence includes words/language as a standalone, such as in word games, but also narrative (words and language combined into a story); CBGD also incorporates humor as an intelligence, though that was not in Gardner's original theory. Humor has been shown to increase learning in it's own right (Hovelynck & Peeters, 2003; Ziv, 1988).

The player enjoyment process is a bilateral flow of emotional states which includes engagement (the initial garnering of attention sufficient to make the player participate in the game), challenge (designed difficulties), flow theory (Csikszentmihalyi & LeFevre, 1989), persistence (the desire to continue play through or despite challenges), and mastery (the satisfaction of triumph).

Using CBGD to design games involves choosing the social cognitive elements to express, and the multiple intelligence elements used to convert those elements into gameplay in a way that facilitates the enjoyment process (Starks, 2014). One notable aspect of CBGD is the dual nature of goals. Social Cognitive Theory focuses on the goals of behavior change (Bandura A. , 2004), which is what the designer wants players to do in their real lives as a result of their experience playing the game. However, games have diegetic goals that occur within the magic circle (Linser, Lindstad, & Vold, 2008) of the game itself. Designers must align the diegetic goals inside the game with the social cognitive "life goals" they want the player to perform. Similarly, the multiple intelligence factors have been translated from internal ways of seeing or learning into tangible mechanics that incorporate external experiences, however still within the game.

Designers may choose to focus on one or several social cognitive elements and use one or several multiple intelligence mechanics, however the entire enjoyment process should be considered in the design. The enjoyment process includes forward and backward movement, so that designers have room for flow to drop back into challenge, perhaps; or to use level changes as stopping points, which necessitates re-engaging players upon their return. Similarly, mastery does not mean that gameplay is over, mastery can be achieved per level, chapter, boss, etc., with the player needing to rely on persistence to continue forward.

Vaccine Nation (Starks K. , 2022) was designed to use CBGD to address the latter. The designer considered that adults may make conscious decisions to not comply due to strongly held beliefs, but younger players may respond to game-based educational initiatives. Another consideration was that the preventative measures promoted during the Covid-19 era were initially recommended for influenza (CDC, 2007), which means they are also affective in spreading other common viruses, meaning the game could be beneficial even after the pandemic was more controlled. For those reasons, the target age for the game was 14 and older.

The Social Cognitive Elements in Vaccine Nation

Vaccine Nation was designed to convey *knowledge* of the preventative measures suggested by health agencies, as well as their proportional impact on community and personal health.

Figure 2
Street Scene with Interventions and outbreaks

In the game, the preventative measures were hand-washing, hand sanitizing, social distancing, mask wearing, and vaccination (Center for Disease Control, 2023; World Health Organization, 2009; Sharma, 2020). The characters in the game participated in individual interventions, but the player created health-promotion programs that "broadcast" their messages to several individuals in the game town. Thus, the player used public relations programs to influence individual behaviors, which had a corresponding effect on public health: the more individuals participated in the preventative measures, the healthier the community became.

The *diegetic goal* in the game was to increase the survival rate of the town to 85%. This was conveyed in a small narrative that appeared next to the survival and perish rates for the town. This not only gave players a goal, but a sense of difficulty through timing, challenge, and progression. However, CBGD also includes *life outcome goals* outside of the game. For Vaccine Nation, these goals included awareness and self-efficacy. The game was designed to increase awareness of how individual activities contributed to community survival, but also to present the realism that people cannot avoid disease – it must be managed. Finally, the self-efficacy goal was

for players to understand that they can impact the health of their communities through their own personal behavior, with the hope of *behavioral outcomes* that included practicing the interventions and possibly even encouraging their practice to others within the players' spheres of influence.

Progression toward a visual and persistent goal is a sort of player encouragement, but other *encouraging elements* were included as well. When characters were reached by a player's public broadcast, the character displayed an icon indicating the message they received. Characters who received multiple types of messages displayed multiple icons. Game achievements were included to reward the player for using a variety of broadcasts in sufficient manner to increase community health.

Multiple Intelligence Mechanics in Vaccine Nation

The multiple intelligences mechanics used in the game were: graphics, space/positioning, narrative, relationships/role models, logic/patterns, words/language, personal reflection, and humor. Vaccine Nation is a tower defense game in which people emerge from an apartment building on the top left and move through a city, encountering virus outbreaks as they go. Players must place towers that broadcast health messages to the characters. If a character receives a broadcasted message and acts on it, there will be a visual indicator of compliance, such as a character wearing a mask or displaying a social distancing shield. A percent survived and a percent perished score appears at the top of the screen. The percentages indicate survival rates for the entire community.

Graphics

According to Squire (2006), in educational games, graphics double as signposts, giving players insight into the world and how to learn within it. While metaphors can work in games, Vaccine Nation is designed to help the player see their real-world behavior as way to effect people in their own neighborhoods and communities. Hence, the game is set in the real world, and graphics include normal buildings that one would see in a city, such as shops, a gym, a bank, a school, office buildings, and most importantly, a hospital. To add to the real-world setting, buildings are arranged in streets, complete with crosswalks. The game is 2D, and the streets are arranged from top to bottom. All characters move on their own, and use the crosswalks to cross from one street to another. Areas where "towers" are placed are styled as grass or sky as to not depart from the street scene.

Similarly, the characters are people rather than animals or other metaphors. The game consists of cartoonish graphics that were sourced from the public domain. The characters are meant to serve as role models in their influence on players (Bandura A. , 2001). Furthering the distance from reality by making them non-human may have impacted player ability to relate to them as such.

The graphics depicting preventative behavior mimic their real-world counterparts, with the exception of social distancing. The soap dispenser is pink, while hand sanitizer seems blue, but also in a clear bottle. As these are used, bubbles appear on the characters, with white bubbles representing soap and blue bubbles representing hand sanitizer. Social distancing is

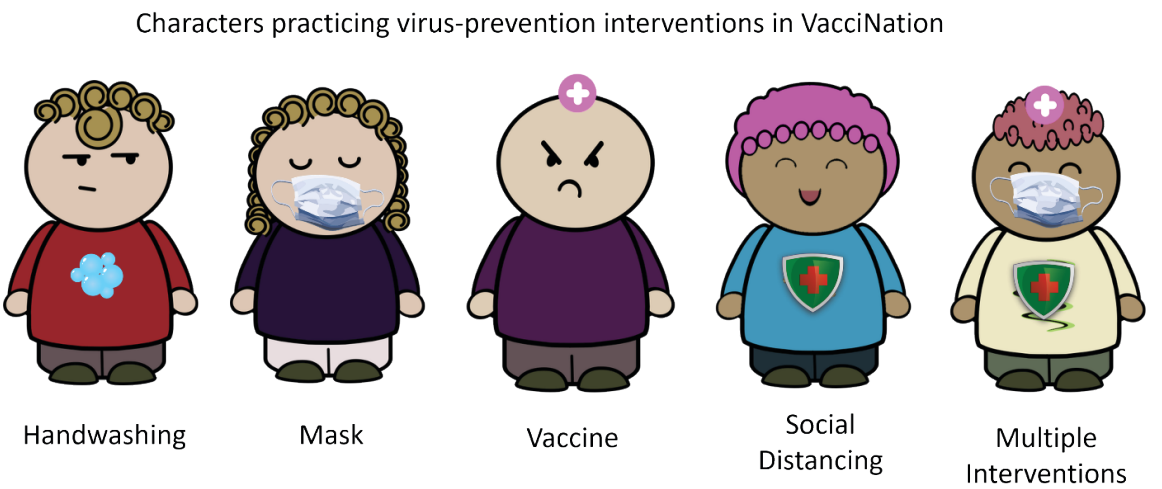

Figure 3
Characters Practicing Interventions

represented by a shield that appears on each character who practices that method of prevention. Masks and vaccines are similar to the real-world, however each is represented by a different symbol. The masks in the menu appear blue and resemble the blue surgical masks worn largely during the initial phase of the pandemic, while N95 respirators, which provide more protection, are shown on the faces of the characters. Both types of masks were recommended by the CDC (2007). The use of the blue masks in the game UI is thought to be a less confusing visual, while the pop-out effect of the masks on the characters makes it clear that they are N95s.

Vaccines are also depicted with two different graphics. The vaccines in the player menu are represented by a green test tube with a red cap, which is the same test tube that represents the "i" in the title graphic. However, test tubes on characters would appear awkward. Instead, when the characters are vaccinated, a pink circle with a white cross appears over their heads. This is meant to relay the proper idea of vaccinated individuals while avoiding official symbols, such as the red cross, which is only to be used in specific circumstances (International Committee of the Red Cross, n.d.).

Viruses are graphically represented as a bunch of sharp star-like objects, rotating around to indicate activity. Outbreaks appear in front of buildings, and they exist in 3 varieties, represented by the colors orange, blue, and green. All characters begin healthy and their skin reflects their diverse ethnicities, however, upon getting sick, the characters turn a light shade of green. If they recover, their skin turns back to normal. If they

Figure 4
A Viral Outbreak with 2 Strains

get sicker, they turn a dark shade of green. This allows players to quickly ascertain the location of virus outbreaks and the health of their communities.

Narrative

The narrative in the game is short and, as written, consists entirely in the top right corner. It explains that you (the player) is responsible for saving the citizens of your town from a virus using research and public programs. This short narrative is about one sentence long, and is quickly followed by game instructions. This narrative is reinforced with the graphics and mechanics, which involve citizens going about the town in everyday activities, and encountering virus outbreaks as they go. While players would need to move quickly to post their towers, there is room to create their own narratives about the characters and where they going. For instance, during time the player waits for research points to accumulate, they may notice that each character has a pre-programmed destination.

The narrative of the player using research and public programs to influence the populace is designed to create a sense of responsibility for the player. The use of "Research" to buy programs is used instead of money. Players may feel powerless to earn enough money to create a program in real life, and may not know where to start. However, research, even through reading news articles or valid social media sources, is something that everyone can do. Therefore, everyone can earn "research" points in real life, using that information to influence those around them.

Relationships/Role Models

The focus of the game is increasing community health, which has higher stakes than attempting to influence a single individual, however, relationships are formed between individuals, which adds more depth. For that reason, the game includes not only community health percentages to track, but individual characters who adopt disease prevention behaviors. Players can follow individuals from the initial apartment and to their destination, watching as they adopt interventions, avoid prevention behaviors, get sick, recover, or get extremely sick and possibly perish. Characters on their way to a destination are programmed to retreat back to their home at a certain level of sickness. If they get even sicker, they will change their destination to the hospital on the bottom right of the screen.

Further, players can view characters as role models for adopting specific interventions such as masking, social distancing, and vaccinating. Viral outbreaks are visible on character destinations, so players can watch as the characters are exposed to the virus, the number of times they are exposed, whether they get exposed to double-outbreaks (more than one variant of the virus), and how they respond. This can contribute to knowledge and encouragement regarding the effectiveness of the interventions. For instance, near the beginning of the game, a player may watch a character with no interventions get sick immediately after being exposed to a virus, turn a light shade of green, and then have to retreat home shortly after. Later in the game, a character who is masked and practicing social distancing may survive an exposure and get to

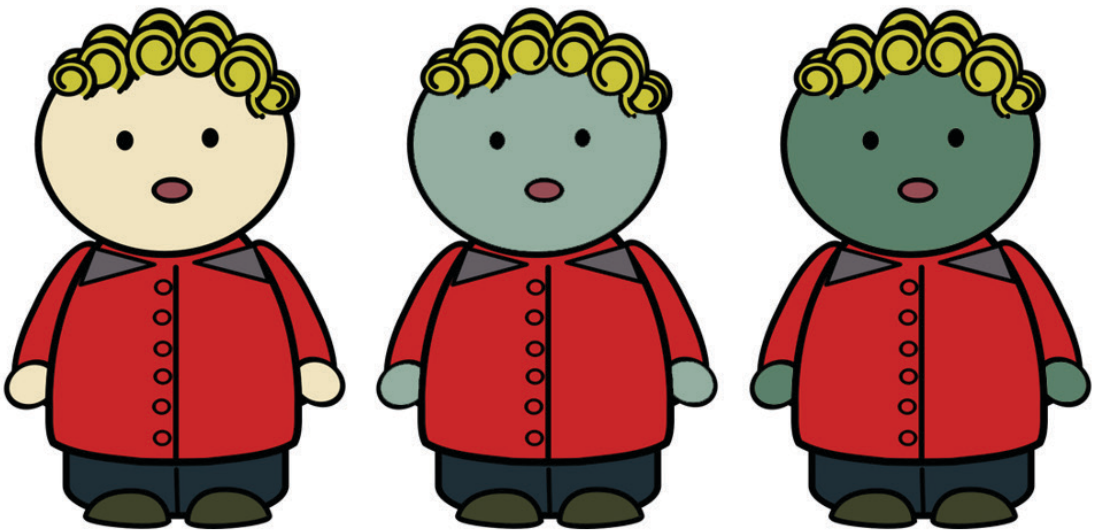

Figure 5
Illness Progression

their destination. In the late game, players can watch characters who are masked, social distancing, and vaccinated survive double or triple exposures. In essence, the individual characters and their states of health vs sickness adds a more personal aspect to community health. These are not 'numbers', they're 'people'.

Numbers and Patterns

Multiple Intelligences Theory (Gardner, 1999) has two math-related intelligences, Math/Numbers and Logic/Patterns. Vaccine Nation uses both of these to convey the strengths of the interventions and their corresponding effects on the population. The player can see the number or people in the population, which is counted every time a new character leaves the apartment. The population consists of every character that has been on the board, for the duration of play, and therefore represents the number of characters that the player could have a direct influence on. Days in the game complete about every 10 seconds, with the population building randomly. The perished and survival rates are displayed in percentages. This offers the player a narrow view of actual characters affected along with a percent-of-population view that is often presented in media. This allows them to compare the impact of live percentages with game percentages. Intervention "prices" are also presented in numbers, but the cost of the interventions are not in money. Every time a campaign reaches a character, or a character gets to their destination without perishing, they gain research points. These points are spent on interventions. The emphasis on research points rather than money helps allay anxieties about the cost of interventions. Most players will understand intervention costs individually, for instance, a box of masks bought in a store, or a single bottle of hand sanitizer, however costs for these items in a public health context may be difficult to grasp. There are also interventions that cost time, but not money. Social distancing and isolating at home do not have direct monetary costs, but they are affective interventions.

The game contains patterns that are mathematically influenced, but not presented in number form. Each intervention contributes differently to character health, with soap being the weakest intervention and vaccination being the strongest. These interventions contribute to research at their corresponding strength. Players will note that the game gets "easier" once they implement stronger interventions, and the survival rate increases.

Another numeric pattern that mimics the real world is that the "cost" of the interventions increases or decreases according to the intervention. Smaller interventions, such as soap, hand sanitizer and social distancing increase in cost as they are used due to the effort involved in getting those messages out to the public, and to signify that they are helpful, but not enough to completely prevent illness, thereby pushing the player to strive for later interventions. The cost of masks goes down because the intervention is quite visible, so there are research points to spend on getting health messages to people, but there is a social effect of normalizing mask use as people see others with masks on. The combination of peer influence and official health campaigns results in lower mask costs in the game. Finally, the costs of vaccination decrease as a representation of research goals. Once a vaccine is approved and released to the public, the cost of distribution would rapidly decrease as efforts shift to getting enough of the population vaccinated.

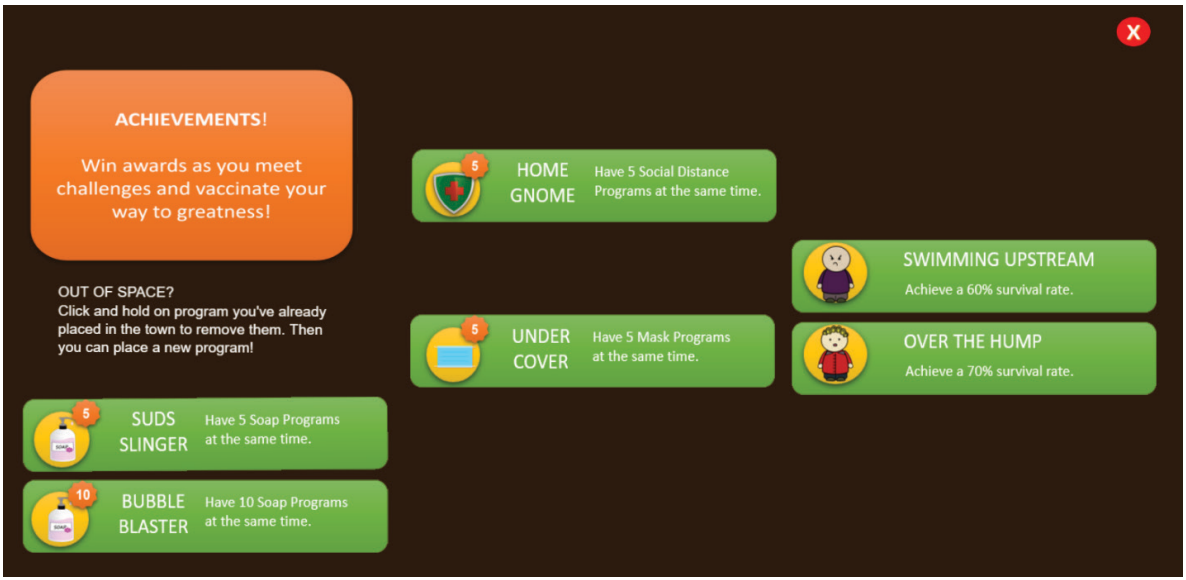

Figure 6
In-game Achievements

Humor

While not a specific intelligence proposed by Gardner at the time of CBGD's release, the researcher added humor as a separate form of presentation. Humor aids in learning (Hovelynck & Peeters, 2003) and is often used in narrative contexts, but humor can also be presented visually, through movement, and several other mechanisms. For that reason, the researcher chose to isolate humor based on the effect of mirth and surprise rather than specific presentation. In Vaccine Nation, the main game screen contains serious information that respects the topic. The achievements, however, use humor as a tool for encouragement. Achievements give players mini-goals on the way to winning the game, guide players to understand if they are progressing, and help them discover actions and items they can use in the game. Achievements in Vaccination include "Suds Slinger", "Bubble Blaster", "Sani-Sparkle", and "Home- Gnome". The player attains achievements by placing a certain number of programs on the game screen, and by attaining various levels of survival.

The Enjoyment Process

The enjoyment process is the final part of CBGD, and is meant to lead the player through the process of gameplay, while increasing self-efficacy for playing the game. The nature of serious games is such that there is a message or lesson to be

learned within the game, and that message or lesson is often received via narrative or gameplay completion. The enjoyment process, therefore, consists of design goals that keep the player engaged until the full game lesson can be reached at the end of the game.

The CBGD Enjoyment process consists of Engagement, Challenge, Flow, Persistence, and Mastery. Engagement catches the player's attention and motivates them to initiate gameplay. In Vaccine Nation, engagement was designed via the colorful logo and the vaccine test tube replacing the "I" in the title. The letter case is also engaging, as the title is Vaccine Nation. This is meant to make players envision an advocacy group or a health movement rather than simply the concept of getting a vaccine, therefore taking an abstract concept that seems too large to accomplish and, instead, centering the player in a responsible role within a grassroots organization.

Once engaged, the player is challenged with an explicit responsibility: "Save your citizens …" The 'vaccine nation' is led by the player, who has full responsibility to get the word out. The game begins immediately, with citizens wandering into viral outbreaks even as the player is reading the narrative and learning the interface. Though the population and perished rates start from zero, by the time the player understands the game and starts playing, they are faced with sick citizens and a high perished rate. That gives players a sense of immediacy to start public health interventions. Fortunately, the player starts with 100 research points so they can afford a few handwashing campaigns at the beginning, and a few citizens will have arrived at their destinations unscathed, allowing the player a few more research points soon after.

Part of the challenge in Vaccination is not just choosing and placing public health programs, but in choosing where to place them. Campaigns messages rotate, reaching players on both sides of a street. Players can watch to see where several citizens are already walking, or they can use a strategy of anticipation, allowing the citizens in the town to fend for themselves while fortifying the area near the apartment building so that new citizens will immediately receive messages.

Once the player understands the primary game loop (place a public campaign, watch it reach citizens, observe the effect on the survival rate, use the number of research points to determine the next intervention), the player will be in a state of flow. Flow is a state in which challenge and skill are constantly rebalancing, allowing the participant to feel intrinsically rewarded by tasks that feel effortless (Csikszentmihalyi & LeFevre, 1989). In the state of flow, participants fully concentrate on the task at hand, and often lose track of time. The design elements in Vaccination that promote flow are the game loop itself, as well as the constant stream of small goals that present themselves during play. Players can focus on placing interventions, following individual citizens, watching for new outbreaks, managing research points, planning future interventions, and monitoring the survival/perish rates. They can also view the achievements board and create new goals, using that information to plan their intervention strategy. Soon after beginning play, the game goals seem easily attainable.

However, players are not ready for mastery just yet. Before mastery, there is the stage of persistence. Like real-life viruses, the game contains various outbreaks of the virus, each stronger than the next. These new outbreaks are introduced between

80 and 100 days after the last, with 3 outbreaks in total. The older versions of the virus do not disappear, and outbreaks can simultaneously appear in the same location. The new outbreaks tend to drop the survival rate of the citizens, presenting the player with a new challenge and an increased sense of urgency as they realize the threat is far from over. These new outbreaks not only mimic life, but allow the player to move beyond complacency within the game. The player cannot stop placing interventions, and may need to change strategies altogether. For instance, a player may need to place several social distancing campaigns as they await the research points to place vaccinations, or they may need to remove handwashing messages and replace them with masking programs.

Once the player persists through the three stages of outbreak, they will achieve mastery when the survival rate reaches 85%, however there are several others opportunities for players to feel that they have reached mastery. The achievement system rewards players at earlier survival percentages, such as 60% and 70%. While not reaching the ultimate goal, players can see their achievements and make personal decisions that they have reached a satisfying reward. Further, players that reach an 85% survival rate can continue with the game and reach a survival rate up to 89%.

Conclusion

During the Covid-19 pandemic of 2020, the CDC and WHO promoted guidelines on prevention as researchers worked to develop a vaccine. The public was instructed to isolate, quarantine, wash hands, and wear masks. In the midst of this, misinformation spread. People became confused about how the virus spread, and social media proliferated with unreliable answers – so much so that the WHO coined the phrase "infodemic". The infodemic led people to reduce compliance with public health guidelines, or refuse compliance at all. However, others actively promoted health literacy by playful means, like music and games.

This paper explored the design of a playful PHI game, Vaccine Nation (Starks K. , 2022), which uses the principles of Cognitive Behavioral Game Design (Starks K. , 2014) to encourage compliance with public health measures. Cognitive Behavioral Game Design has three main components: Social Cognitive factors that promote behavior change, Multiple Intelligence factors that influence game mechanics in a way that facilitates learning, and the Enjoyment Process which keeps players engaged with the game long enough to absorb the information. In Vaccine Nation, the player is responsible for broadcasting message encouraging citizens to adopt prevention measures to avoid catching a virus. As the messages are received, the citizens show visible signs of compliance: using soap and hand sanitizer, practicing social distancing, and wearing masks. In the late game, once vaccinations are researched, they show their vaccinated status. If the player looks closely, they can follow citizens, seeing that they go home to isolate when symptoms appear, and to the hospital if the illness worsens. Over time, the town transforms as less citizens become ill and the survival rate rises. Achievements encourage the player along the way, awarding badges for the number of promoted programs in each category, and reaching survival milestones.

Future Work

As of this writing, the Covid-19 Public Health Emergency is ending (CDC, 2023) and Vaccine Nation has not been tested for change in attitudes or behavior, however, interventions such as social distancing and mask-wearing are effective against viruses even outside of a pandemic, therefore research can be performed to test attitudes toward these interventions and to discover if people can be persuaded to re-adopt these behaviors during times like "flu season" which occurs annually, or during other times of highly active viral spread from colds.

Another consideration is that Vaccine Nation takes place in what appears to be a middle-class city center, with buildings representing shops, a gym, a bank, a school, and office buildings. The architecture is modern but generic. Future game levels can be designed in which neighborhoods are more specific, indicating cultural centers and other places where distinct architecture may define the city. For instance, generic grocery stores can become fruit stands or bodegas, and the game background can include famous landmarks such as the Statue of Liberty, the Golden Gate Bridge, the Taj Mahal, Eiffel Tower, etc. These levels can help players feel as if the game is taking place in their own neighborhood, helping them to remember to take care of their neighbors by taking care of themselves, while also emphasizing that public health is worldwide, and they may need to adopt these measures once again if they travel.

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