

Serious Games as an Inclusive Disaster Risk Communication Tool: A Literature Review

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Introduction: Disaster Risk

The world is experiencing a notable rise in global disasters. In 1996, a total of 39 incidents were recorded compared to 396 in 2019 (Institute for Peace and Economics, 2020). Such incidents persist with 141 countries around the world exposed to at least one ecological threat between 2019 and 2050 (Institute for Peace and Economics, 2020). Furthermore, a population of a billion people are located in countries that do not have the resilience to deal with such threats (Institute for Peace and Economics, 2020). Therefore, governments and organizations over the world are shifting their focus to risk reduction and preparedness efforts in order to prepare for the risks people are facing and will continue to face worldwide.

According to the United Nations International Strategy for Disaster Risk Reduction, preparedness refers to “knowledge and capacities developed by governments, response and recovery organizations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters” (Paton, 2019, Page 328). With the increase in the number of unprecedented disasters, the outcomes can be very difficult to endure for the people, community, and environment. Therefore, there are several ways to help build resilient communities and mitigate the severe consequences of disasters through education and skill-building.

In this literature review, serious games will be studied as a learning modality for disaster preparedness. Serious games are those with an educational purpose, rather than games meant for entertainment. The increase in popularity of using non-traditional methods such as games for learning has made it an appealing and effective tool in various fields like training and development in corporate settings, education, and health. With respect to risk management in particular, many serious games on disaster risk preparedness and management have been developed and evaluated for efficacy. For example, The FLAIM Trainer has been found as an effective simulator for trainings on firefighting not only because of the virtual reality technology which immerses the user into a realistic context while maintaining his/her safety, but also because it is the first game of such nature to combine VR with haptic technologies (Ning, 2020).

Although serious games have the potential to promote an engaging learning environment and improve education outcomes, there are some limitations to inclusive design in game-mechanics and simulation components that need to be addressed. For example, serious games are often limited in their range of potential disasters by not representing diverse populations, including but not limited to minority communities in terms of identities, races, ethnicities, backgrounds, abilities, cultures and beliefs (Executive Order No. 14035, 2021). Moreover, the design of games can neglect considerations of individuals with language barriers and other marginalized groups. Given that the population of potential trainees is diverse with each person having unique characteristics and skills, ensuring an inclusive game design that is accessible and tailored to the needs of the target population is important to consider. This is also especially important seeing that populations of color and marginalized communities are often the most impacted by disasters.

In the coming sections, we briefly showcase the nature of current community outreach programs on disaster risk management. Subsequently, we present serious games as a viable alternative to more traditional programs, with both limitations and potential advantages for

promoting inclusion when properly designed. Examples of such games are then presented. Our goal is to be able to present potential areas of improvement for serious games to be used as a viable, more representative, and more inclusive alternative to disaster risk reduction programs while providing readers with guidance on selecting or designing inclusive serious games for disaster risk preparedness and management.

Current Approaches to Disaster Risk Management

Current community outreach programs related to disaster risk and recovery aim to increase community resilience and reduce vulnerability to disasters (Federal Emergency Management Agency [FEMA], n.d.; Red Cross, n.d.). These programs typically involve educational initiatives, training workshops, and capacity-building activities to improve disaster preparedness and response. For example, the Red Cross offers disaster preparedness workshops, while FEMA provides online training resources for disaster response volunteers (FEMA, n.d.; Red Cross, n.d.). Other programs, such as the Disaster Recovery Partnership (DRP), focus on providing long-term recovery support to communities affected by disasters (U.S. Department of Housing and Urban Development [HUD], n.d.). These outreach programs play a critical role in enhancing community preparedness and recovery from disasters. However, despite such programs, marginalized and diverse groups still remain as the most vulnerable to and impacted by disaster impacts. Most of the current programs do not meet the additional barriers faced by such groups like lack of resources, cultural and lingual barriers, and limited mobility. Additionally, some of the currently present outreach programs do not fully incorporate the perspectives and experiences of diverse communities in the design and implementation of disaster preparedness and recovery initiatives, leading to mistrust and lack of engagement from these communities (Guadagno et. al., 2017; Pike et. al, 2020).

Serious Games

Serious Games Definitions and Usage

Serious games (SG) have been defined as “Games designed for educational, training or modification of behavior” (Hammady & Arnab, 2022, Page 2). In the past decades, games have evolved beyond the traditional entertainment industry as they became adopted in different fields like education, technology, and even healthcare (Hammady & Arnab, 2022). The engaging and interactive characteristics and elements present in games have made them a compelling modality used to target and encourage strategic thinking, learning, raising awareness and the increase of certain behaviors. Different terminologies are used to describe game designs such as gamification, persuasive games, and serious games (Hammady & Arnab, 2022). While much research has used these terms interchangeably, there are slight differences in their definitions depending on the context. Kapp (2012, Page 29) defined gamification as “the idea of adding game elements, game thinking and game mechanics to learning content” while SG is defined to be created to achieve a specific goal and present specific content (Kapp, 2012).

Serious Games in Education

Over the past decade, there has been an increase in the application of technology-assisted education. SGs are designed for educational purposes to help cultivate players' knowledge and skills as well as track performances within the gaming process (Zhonggen, 2019). Zhonggen (2019) study, found that with their ability to influence learners' moods, serious games help to form a positive mood and environment to encourage and intrigue the interest of learners. Thus, SG can provide an entertaining and active learning environment that can be accessed on various digital platforms. SG can not only trigger a positive emotional response, but also has the potential to improve knowledge retention and memory (Solinska-Nowak et al., 2018). This can further improve engagement and education outcomes (Maheu-Cadotte et al., 2018).

Videogames have been found to not only support but adjust certain behaviors as they tend to have a "persuasive power" (Bogost, 2010). Bogost calls this a "procedural rhetoric" which combines the basic mode of rule-based representations and interactions with the rhetoric of computer powers which includes running processes and executing rule-based symbolic manipulation. Consequently, videogame persuasion has potential in the fields of politics, advertising, and learning (Bogost, 2010). According to the article (2010), Bogost finds that video games are an effective tool to persuade players to adopt, or even change, certain behaviors or beliefs due to their interactive nature which provides players with the decision-making experience and facing consequences. Gameplay mechanics, such as rewards and punishments, can also persuade players to behave in certain ways. The article also discusses how video games can use persuasive techniques, such as propaganda or advertising, to convey a message or promote a particular viewpoint.

Serious Games in Disaster Research

Disaster preparedness usually occurs before or after the disaster recovery to mitigate the consequences of the disaster (Ning et al., 2022). Thus, many serious games have been developed to understand disaster preparedness by training stakeholders to predict, plan and manage disasters before they occur. As such, serious games have been designed to enhance disaster knowledge, awareness, and evacuation skills by informing the stakeholders on what to do and where to go in a potential disaster (Ning et al., 2022). Serious games have great potential when combined with other features such as crowd behavior and Building Information Modeling (BIM) to provide closely related scenarios and experiences to the real world (Ning et al., 2022). The preliminary results of games aimed to improve communities' disaster awareness, preparedness and evacuation skills have shown some great potential in training players' judgment as they have to navigate and choose their path to safety exits (Ning et al., 2022).

Disaster researchers have reviewed studies of serious games in different regions which emphasized the importance of designing games for the different stakeholders and customizing the data collection process. According to Choudhury et al. (2022) who reviewed studies in serious games for landslides in data-poor regions such as India, multiple computer games are recommended to be designed for different stakeholders in the disaster risk management process. As such, designing a game to establish the roles and responsibilities of stakeholders; a game on data collection of information such as demographics, preparedness measures taken, impacts of

disasters, and awareness; a game to identify landslide-related variables, and a game to identify landslide risk and future actions is beneficial in disaster preparedness (Choudhury et al., 2022).

Based on the reviewed disaster research, it is apparent that serious games have the potential to not only be used as a training tool in disaster risk reduction; but also, as strong persuasive tool to reach communities or groups that are otherwise hard to reach in various fields. Examples of how serious games can be used in disaster risk reduction are shown below.

The American Red Cross (n.d.) designed a youth preparedness education program for the K-2 age group called 'Prepare with Pedro' Launched in 2021. This 30-to-45-minute bilingual (English and Spanish) program aims to teach students how to be prepared and take action for home fires or local hazards. The game is delivered using different educational tools such as storytelling, animated videos, and a game application that provide learners with various learning opportunities. The fun and engaging interactive game has a friendly penguin who guides children through a set of challenging activities. Throughout the game, children are taught coping skills for handling home fire emergencies and other stressful situations. When completing this game, children are awarded a badge which creates a sense of achievement and satisfaction.

Build a Kit Game produced by U.S. Department of Homeland Security (DHS) (n.d.) targets young individuals aged between 7-12 that is used to teach people how and what to assemble in their emergency supply kit. Using a leveled game scenario (meaning that the player must complete certain prompts before moving to the next stage/ mission), the main character Gayle and her friends have to pick the correct items to put in their emergency kit. At the end of the game, participants can print their emergency kit checklist. Notably, there are multiple characters in the game that represent different races and cultures, yet such representation is limited to the physical appearance alone rather than being included in the game narrative which could have added a more substantive input for diversity. Research has shown that having characters of different races and from diverse populations in serious games increases inclusivity by promoting diversity, representation, and fostering a sense of belonging and an ability to relate among players, especially if they deem themselves as similar to the characters represented in a game. Furthermore, research has shown that such representation can enhance players' engagement and enjoyment, and help reduce prejudice and stereotyping (Hussain & Griffiths, 2008; Williams et al., 2009). Moreover, including characters of different races can help address systemic barriers to participation in gaming and improve access to gaming opportunities for marginalized communities (Consalvo, 2012; Gray et al., 2016).

Disaster Master Game, another game created by DHS targeting individuals aged between 6-12, is a comic-style game that has eight levels of disaster scenarios from wildfires to tornadoes to hurricanes. Throughout the different levels of the game, players will help the characters face these hazards by selecting different choices of response and recovery measures. With every correct answer, players receive a reward, and you are advanced to the next level. The creation of this user-friendly game used the elements of serious games to promote engagement and educate players on emergency preparedness. The depiction of the scenarios along with the simple language used makes it easily comprehensible for children and youth. Additionally, the diversity of characters in the game from different ethnicities and races as well as a character in a wheelchair creates an inclusive environment to present the scenarios. Notably, this game does a good job at introducing the characters as a part of the narratives including their interest, where

they are from, etc. which adds substantive characteristics to them beyond physical appearance alone.

Ready 2 Help is a card game designed for children older than 8 years to teach them skills on how to respond to emergencies. The card game is available in six languages and includes kid-friendly content and language. Families and children receive the card game free of charge from FEMA Warehouse which helps eliminate financial barriers. It also provides a fun opportunity for children and families to play together and learn from one another. The video tutorial on the website includes culturally diverse children playing the game and closed captioning for accessibility, which demonstrate an additional attention to detail given to inclusivity beyond character phenotype (U.S. Department of Homeland Security, 2021).

Overall, it is worth noting that the games in existence are often targeting younger populations, with fewer examples of games that are targeting adults and marginalized communities like black, indigenous and people of color. Some of the games designed have factors that are inclusive of different populations i.e., representation of characters of color, free provision of the game, etc. Yet, there is still a lack of explicit references to inclusive design in the game materials.

Limitations of Serious Games

Research on disaster-related community outreach has demonstrated the importance of addressing inclusivity and racial disparities in disaster preparedness and response (Ablah et al., 2019; Peek et al., 2013; Quarantelli, 2005). Studies have highlighted the disproportionate impact of disasters on communities of color and the need for inclusive outreach efforts that account for the unique needs and challenges faced by these populations (Ablah et al., 2019; Peek et al., 2013; Quarantelli, 2005). Despite the potential to promote an engaging learning environment and improve education outcomes, there are some limitations to inclusive design in game-mechanics and simulation components that need to be addressed. This section will look into what these limitations are, how they can be overcome to ensure that disaster risk reduction serious games, when designed with inclusivity in mind, can be an effective tool to address such need.

One of the limitations of SGs is the capacity to reach a diverse audience covering a range of age groups, gender identities, racial and ethnic groups, or global cultures. Only a scarce number of games declare their objectives to bridge the gap of cultural and linguistic backgrounds and fight gender inequities in vulnerable communities (Solinska-Nowak et al., 2018). The absence and insensitivity of these objectives in the design and development of SGs not only impact the effectiveness of the games but also makes it difficult to promote sustainability and build resilience among vulnerable communities (Solinska-Nowak et al., 2018).

The content in SGs tends to be focused on the most common and deadliest disasters and there has been a small niche of SGs focused on localized disasters such as floods, extreme weather conditions, and tsunamis (Ning et al., 2022; Solinska-Nowak et al., 2018). Therefore, limited content that does not include a broad range of disasters impacting diverse populations can be a disadvantage, due to the lack of diversity in the content of games present that can be utilized by diverse communities.

Every individual has a unique background, skills, preferences, and motivations. SGs are often designed with a fixed progression of tasks which makes dynamic tailoring of difficulty and content per individual a challenge (Hooshyar et al., 2018). Therefore, adapting to the dynamic difficulties of various individual's skills and knowledge is a limitation of SGs (Hooshyar et al., 2018).

Serious Game Design

Effective Design Principles

According to Bellotti et. al. (2010), designing effective serious games requires adherence to several principles that help to ensure that the game is both engaging and effective at achieving its educational goals. First, identifying the learning objectives and aligning them with the gameplay mechanics. This requires the designers to consider the specific skills, knowledge, or behaviors that the game aims to teach the players. For instance, a serious game designed to teach emergency management skills should feature scenarios that require the players to apply the skills they have learned in a simulated environment. Second, ensuring that the game is inclusive, accessible, and usable for all types of players. This involves considering the diverse needs and abilities of the players, including cultural backgrounds, physical abilities, and cognitive capabilities. The game should be designed to cater to all these different players and their needs. Third, ensuring that your game design is engaging and immersive to your specific target group. This required the game to have engaging story-lines, visuals and audio elements, and gameplay mechanisms. Fourth, ensuring that the game is effective in achieving the learning objectives. This requires designers to incorporate appropriate assessment and evaluation mechanisms into the game.

Designing Serious Games for Inclusivity

There are several ways to design serious games that are inclusive and consider diversity and equity. Designing serious games based on the social model of disability by considering the players' capabilities which include vision, hearing, motor skills and cognition is an important step toward inclusivity (Cezarotto et al., 2022). Including closed captioning and language translation can help target a broader audience (Cezarotto et al., 2022). In addition, the content, storylines, and characters in SGs also need to resonate with a diverse audience (Cezarotto et al., 2022).

Representation in Game Design

Having a multidisciplinary and interdisciplinary team in the development and designing of SGs ensures the diverse voices are heard and the inclusive needs are met (Cezarotto et al., 2022). Cezarotto et al. (2022) demonstrates that when the individuals designing and creating the games are themselves members of various marginalized groups, the outcome more effectively and authentically represents a wider range of the target audience. Additionally, inviting inclusion specialists to meet with the team and to review the design throughout the whole process helps teams learn about possible barriers and modify/add features of inclusivity (Cezarotto et al., 2022). This is done through the presentation of two frameworks to guide teams to review issues involved in accessibility, equity, diversity, inclusion, and representation. The first one being the 'Framework

for designing games for accessibility' states that all players fall somewhere in a spectrum of need that ranges between permanent, temporary and situational need. Therefore, the framework suggests that games should be designed while discussing and thinking about these needs in categories (visual, hearing, motor and cognitive). Thinking about those needs in categories allows us to have a comprehensive approach and to avoid a lack of identification that is otherwise very likely to rise. The second framework introduced is the 'Framework for designing games for diversity,' which offers a perspective on enhancing accessibility to strengthen inclusion practices in gaming and game design through the use of team building, intent & inspiration, world building, and access & support elements (Cezarotto et al., 2022).

Research also supports that developing games that are not informed by players who are representative of marginalized communities makes it less appealing for them to participate and engage in traditional game designs (Consalvo, 2012). Therefore, developing SGs through co-creation and partnerships with the stakeholders including the target audience makes SGs inclusive and effective. The need for partnerships is not only limited to the design phase but in every stage including the decision-making process, establishments of objectives, and content creation. (Blackett et al., 2022). Additionally, using critical frameworks and engaging marginalized populations in Computer Supported Cooperative Work (CSCW), the study of how people utilize technology collaboratively, often towards a shared goal, leverages lived intersectional experience in game design.

Rankin and Irish (2020) studied Black Feminist Thought in Inclusive Game Design and found that Black Women appreciate games that provide "authentic cultural experience; feature intersectional game characters that reflect real-life experiences; accurately portray the diversity of Black women's bodies and provide opportunities for players to customize game assets" (Rankin & Irish, 2020, Page 117). Their research shows that incorporating authentic cultural experiences, intersectional game characters, diverse representations of Black women's bodies, and player customization options can not only make games more inclusive for Black women, but also enhance their overall gaming experience by providing a platform that reflects their identities and empowers their engagement.

Cognitive behavioral game design is a new framework that incorporates Social Cognitive Theory and Multiple Intelligence that teach designers to create engaging and immersive learning experiences (Starks, 2014). SGs can be designed using the five elements of knowledge and self-efficacy, goals, outcome expectations, facilitators, and impediments which are needed to elicit behavioral change (Starks, 2014).

A procedural content generation that generates content automatically through algorithms can alter game content to adapt to the needs or skill level of individual users more effectively (Hooshyar et al., 2018). This empowers players to take an active role in developing the content to meet the learning objectives that are relevant to them. This method of design involves both the player and the designer as they co-create content in an iterative and interactive procedure (Hooshyar et al., 2018).

Serious Disaster Game Design for Disaster Risk Reduction

Overall, designing a serious disaster game for disaster risk reduction requires various methodologies to consider and is often a complex process that involves multiple stakeholders. Firstly, stakeholder engagement in the co-creation and development process is necessary to ensure the objectives of the SGs apply to the target population. Through co-creation methods, the content developed has to be reflective of the racially and culturally marginalized diverse populations. Disaster risk reduction varies per location and lived experience as each community and person is unique. For example, in some communities cultural and religious restrictions may be a barrier for women's participation in in-person awareness sessions or activities. With such knowledge in mind, designing a virtual serious game may help to reach such populations. Such cultural awareness and knowledge is only possible if stakeholders from the relevant communities are involved as active partners and decision-makers. Therefore, developing these partnerships and including stakeholders in decision-making processes is important to capture how knowledge is shared and used in disaster prevention and mitigation.

Second, ensuring that the SGs are accessible to the people and can be customized to meet the needs and resonate with the audience is very important. These features can include closed captioning, language translation and speech transcription. When raising awareness on disaster prevention the narration of the games needs to be tailored to those of marginalized communities. For example, those with visual and hearing impairments need a different contextualization of a disaster scenario and may need different learning modalities to engage with the game.

Third, SGs have to include diverse characters to represent and resonate with the population. Disasters can result in different impacts depending on many elements which include gender, race, neighborhood, and environment one lives in. In addition, there can be cultural differences that need to be accounted for in the game design process because they have a bearing on the acceptance of the presented game by the audience and the experience of a hazard event by different groups. This ensures that the three components of Larson Billing's (1995) Culturally Relevant Pedagogy (learning, cultural competency and critical consciousness) are met. Ensuring that the characters and scenarios in the games are based on real-life scenarios enhances engagement and knowledge retention. This helps build resilience and sustain the skills needed to prevent and prepare for a disaster.

Conclusion

Disaster risk has been increasing worldwide, leading to the increase of its costs and impact. Marginalized communities are often the most impacted by such disasters; yet, remain as the hardest to reach by disaster risk management traditional efforts. Serious games, meant for educational and behavior change purposes, have been demonstrated as an effective way to persuade and influence people's behavior, including in the field of disaster preparedness. The research has found that serious disaster games have gained popularity in the past decades and are being utilized as an effective learning modality to raise awareness and teach skills to various stakeholders. With strong potential in the use of serious games as an effective tool to

communicate with and reach diverse populations, it is important to consider the limitations and best practices of designing serious games for inclusion purposes presented in this review.

The voices of diverse stakeholders are central to advancing and improving inclusive game design. Co-designing games with the population increases their efficacy as it informs on the relevant skills and knowledge needed. This also provides opportunities for the audience to engage and empowers them to take ownership of the games designed to meet the needs of their community. In addition, the content of the games has to reflect the needs of the communities and address the local disasters and barriers such as accessibility, language, and culture that exist.

Although many studies have found serious games to be effective in teaching and memory retention, there still are some limitations in the design process in regard to inclusivity (Bogost, 2010; Blackett et al., 2022; Hammady & Arnab, 2022). Providing accessible features such as closed captioning, narrator-speaking, and language translation as well as including characters from diverse backgrounds that resonate with the players are initial steps to promote inclusivity. Finally, future research has the potential to expand more on specific design mechanisms for serious games targeting marginalized populations in regard to common disasters like floods, landslides, earthquakes, impacts of climate change, etc. Further work is also needed on reviewing relevant games in such fields and the need for more games that are intentionally designed for the inclusion of marginalized and hard to reach populations. There is also a need to consider the present game design practices and digital divide. For instance, there are various problematic practices in the gaming industry i.e., adults are less likely to be included in game design compared to youth which leave out a great basket of knowledge and expertise (Lachney, Babbitt, & Englash, 2016). Additionally, practices like lack of racial and ethnic awareness and gender harassment often show up in youth-based content creation and game-oriented learning communities such as Scratch (Richard & Kafai, 2016).

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