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Evaluating the use of community co-creation approaches to develop the Disaster Ready! boardgame for disaster risk reduction education in Nepal

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Abstract: Communication and public education are vital to increasing community resilience to natural hazards. Recent disaster risk education initiatives have challenged top-down hierarchical models of outreach by embracing community-led, participatory and co-creation approaches. Here, we evaluate the process of developing the Disaster Ready! boardgame through community co-creation and co-design methods with students and local educational stakeholders. Discussions with communities directly informed the content and play style of the game, and input from student participants shaped the artistic evolution of the game board to include important cultural, social and environmental symbols. The final version of the game is therefore more locally representative and rooted in the lived experiences of communities in rural Nepal. The process of co-creation also facilitated the collaborative development of knowledge on natural hazards through participant-led discussions and dialogues. We highlight that stakeholder and community participation throughout the development phase of serious games, and in other disaster risk reduction (DRR) resources, is vital to producing bespoke and contextually relevant resources for DRR education. Central to the longer-term success and continued use of the game in Nepali schools was also the transfer of agency over the game to local educational facilitators. Through reflexive discussion on our co-creation approach we highlight the limitations in our method and the challenges in creating a fully co-produced resource. This includes the influence of power dynamics and hierarchies of perceived knowledge, where an imbalance in authority over the co-creation process may limit the creative input of the community. We suggest that overcoming these challenges to achieve higher levels of community participation in the co-production process will require greater planning on the part of researchers, as well as funding pathways that support longer term development of trusting, reciprocal and creative relationships with communities and local stakeholders.

Keywords: disaster risk reduction; education; serious games; multi-hazard; community resilience

Supplementary material: An overview of the game and how it is played is available at https://doi.org/10.6084/m9.figshare.c.8246463

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Central to building increased community resilience to natural hazards, such as earthquakes, floods, wildfires and landslides, are sustained public education initiatives (Johnston *et al.* 1999; Ronan and Johnston 2001; Shaw *et al.* 2004). For many developing countries, however, the educational and technological infrastructure required to support sustained and widespread disaster risk reduction (DRR) education is still emerging (Aghaei *et al.* 2018). International aid, non-governmental organization (NGO)-led programmes and academic outreach initiatives, primarily from institutions following Western science methods, have often attempted to fill this gap through resource creation and communication campaigns in schools and across communities. However, such campaigns can lack long-term sustainability by failing to work within existing educational and social structures and operating with a 'helicopter' outreach approach (Hagelsteen and Becker 2019; Barclay *et al.* 2022; Nkombi and Wentink 2022). Historically many of these outreach initiatives have relied on externally developed resources, such as leaflets, maps, posters, presentations, as well as TV and radio broadcasts. While such methods can be effective in certain contexts, they often embody a 'knowledge transmission' pedagogy in which recipients are 'empty cups' to be filled with externally given knowledge, often projected from a westernized understanding of social and natural phenomena (Freire 1970; Haynes *et al.* 2007; Schumann *et al.* 2018; Nakano and Yamori 2021). Both the *Comprehensive School Safety Framework* (GADRRRES 2017) and the *UN Disaster Risk Reduction in School Curricula* (Selby and Kagawa 2012) instead affirm the need for a modern disaster pedagogy that: 'Brings knowledge to life' [and] 'is active, interactive, experiential and participatory' (Selby and Kagawa 2012, p. 29).

Locally based NGOs and community-led organizations are therefore often more effective in delivering DRR outreach given their ability to maintain projects over the long term, and to work directly with communities to create locally relevant and representative resources. Being already embedded within their own local context, they are often more able to build the trusting, reciprocal relationships required for meaningful knowledge exchange and collective co-creation (Sou *et al.* 2021). Some externally initiated communication and education projects have, more recently, also

aimed to move away from traditional top-down approaches, instead embracing a paradigmatic shift to community-based DRR along the principles of co-creation and reciprocal knowledge sharing, and with the aim of building people's own capacity to cope with natural hazards (Gaillard and Mercer 2012; Childs *et al.* 2017; Nkombi and Wentink 2022). Co-creation is defined as 'a collaborative generation of knowledge' (Pollock *et al.* 2022) and '[an] act of collective creativity' (Sanders and Stappers 2008; Avila-Garzon and Bacca-Acosta 2024), commonly employed through participatory approaches (e.g Le De *et al.* 2015). Co-creation typically draws on alternative pedagogical frameworks, such as experiential, affective, imaginal and dialogic learning, which facilitate learning and engagement through experience, emotions, imagination and discussion, respectively (Kolb 1984; Selby and Kagawa 2012; Aubrey and Riley 2019; Parham *et al.* 2020). Arts-based participatory methods, such as drawing, poetry, filmmaking, as well as surrogate experiential learning through playing serious board games and videogames, have been particularly effective in previous DRR education initiatives (Gaillard and Mercer 2012; Miller and Brockie 2015; Schumann *et al.* 2018; Parham *et al.* 2020; Sou *et al.* 2021; Valli 2021; Nalla and Ranjit 2022; Barclay *et al.* 2023; Naismith 2025). These resources can act as boundary objects (Star and Griesemer 1989; Jean *et al.* 2018), which facilitate the development of cross-boundary knowledge, and, if co-created, the process of co-creation itself can lead to further collaborative development of knowledge (e.g. Delima *et al.* 2021). As discussed by Le De *et al.* (2015), the visual and interactive nature of participatory co-creation methods can also widen the scope for participation by including people with low levels of formal education, or those who may be illiterate or innumerate. When used appropriately, co-creation therefore offers an effective challenge to traditional pedagogies and knowledge hierarchies by valuing and drawing upon scientific, community-held and Indigenous traditional knowledge systems and involving a range of actors in the process. Co-creation is also a valuable approach for creating locally relevant and contextually representative resources, where context-relevant practical exercises have been identified as one of the most effective approaches to DRR education (Parham *et al.* 2020).

This paper focuses on the process of developing the Disaster Ready! board game, as a serious game for DRR education in Nepal following the principles of co-creation and iterative design. The Disaster Ready! game forms part of a growing field of serious games for DRR education (Michael and Chen 2011; Pereira *et al.* 2014; Mani *et al.* 2016; Mossoux *et al.* 2016; Solinska-Nowak *et al.* 2018; Schrader 2022; Villagra *et al.* 2023), where serious games are those that have an explicit educational purpose and replicate a real-world social, physical or environmental situation to give players the opportunity to practise surrogate experiential and imaginative learning (Dieleman and Huisingh 2006; Selby and Kagawa 2012; Solinska-Nowak *et al.* 2018; Parham *et al.* 2020). Game-based learning also provides an interactive sensory experience, where an aesthetic design and the right balance of opportunity for success and overcoming challenge may elicit positive emotions in players. This helps to consolidate affective learning through emotion (DeKanter 2005; Dieleman and Huisingh 2006). The novelty and action-based nature of serious games also makes them especially effective tools in environments where rote-learning styles of education are more common, such as in Nepal. Games that encourage collaborative play may also draw on the impact of sociocultural experience and dialogic learning through collective discussion, debate and collaboration (Dieleman and Huisingh 2006; Solinska-Nowak *et al.* 2018).

Of the serious games that have been developed previously, such as the Hazagora board game, which was developed to teach students about volcanic risk in Goma (Mossoux *et al.* 2016), and Breaking the Silos (de Ruiter *et al.* 2021), most are developed externally to the recipient communities and thus arrive as a 'finished product' with limited scope for subsequent iteration and community input. The completeness of resources and the perceived hierarchies over the control of resource development, which are generally held by the project initiators and funders, can discourage people from deeply contributing to and engaging with these resources (Sou *et al.* 2021; Naismith 2025). Some serious games have, however, begun to embrace a co-creation approach. For example, the game DisCoord, which examines landslide and flood risk in Uganda (Delima *et al.* 2021), used community feedback to modify the game style and content, co-creating knowledge in the process through discussion and negotiation between different project actors. St Vincent's Volcano (Mani *et al.* 2016), which is a video game exploring volcanic risk on St Vincent, utilized co-creation approaches from the outset by using community focus groups to define the scope of the game from first principles. In this paper, we share our own perspectives on the process of co-creating the Disaster Ready! board game, with the aim of contributing towards a more generalized framework for the use of co-creation approaches to develop serious games in DRR contexts. We highlight the successes and strengths of our approach to produce a bespoke, locally relevant and contextualized resource, while also identifying the limitations in our own practice and offering considerations for future projects.

The Disaster Ready! game is open source, shared under a CC BY-NC-SA licence, and can be accessed upon request from the first author for educational and outreach purposes.

Study location: Nepal

Nepal is a multi-ethnic, multi-lingual, multi-religious and multi-cultural state, with over 125 different ethnic groups and languages (Government of Nepal, National Statistics Office 2021). Nepal is a predominantly rural society with only 9% of the population living in urban areas. It is a tectonically active country and has a history of destructive earthquakes. In this century alone over 20 000 people have lost their lives as the result of an earthquake in Nepal (NSET 2024). The most recent major (Gorkha) earthquake occurred in April 2015 and had an M_W of 7.8 (Lizundia *et al.* 2017). Nearly 9000 people were killed and another 23 000 injured, with the earthquake destroying thousands of homes and leaving 3.5 million people homeless (Lizundia *et al.* 2017; Varum *et al.* 2018). Earthquakes in Nepal can also trigger secondary hazards such as landslides, avalanches and fires, which cause further destruction (Kargel *et al.* 2015). Alongside tectonic hazards, Nepal also experiences extreme weather and is ranked as highly vulnerable to the effects of climate change (The World Bank Group 2021). In recent years, the frequency and severity of wildfires have increased, particularly during the summer with extreme hot and dry weather (Pokharel *et al.* 2023). In the wet season, rainfall has also increased leading to a greater occurrence of flooding, landslides and debris flows (Baniya *et al.* 2024).

The government of Nepal has committed to the UN Sendai Framework (2015–30) for DRR (United Nations 2015) and established the National Disaster Risk Reduction and Management Authority in 2017, with the aim of shifting to a 'proactive' rather than reactive approach to managing disasters (NDRRMA 2017). There is a particular focus on adapting to meet the challenges of climate change and the complexities of the multi-hazard context in Nepal. In a statement in October 2024, the government recognized that 'socio-cultural and economic disparities heighten the vulnerability of women, children, persons with disabilities and marginalized communities to the impacts of disasters' and have committed to more inclusive DRR approaches (Government of Nepal 2024). Alongside the government, there are also many NGOs in Nepal that are engaged in DRR activities. For example, the National Society for Earthquake Technology (NSET)

Fig. 1. School buildings and a classroom in Okhaldhunga, Nepal. Upper panel shows external wall of a school building that is crumbling and has a large hole under the window. Classrooms were often not watertight, with holes in the roof and walls. Gaps in the walls also meant sound travelled between classrooms and disrupted classes and student concentration. The lower panel shows the inside of a classroom. Wooden benches and a whiteboard were commonly the only materials available for students and teachers with very limited access to textbooks or other resources.

have carried out many DRR projects focused on training, retrofitting buildings and improving urban resilience to disasters. Another example of effective internationally led resource creation was the development of the 'The Red Panda: DRR Mascot' YouTube videos in Nepali by the United States Agency for International Development aimed at educating school-aged children on earthquake response and safety.

Nepal still faces many challenges with DRR and public education. Only 27% of the population have completed senior secondary education, dropping to 10% in the poorest rural communities (UNICEF Nepal 2022). In part, this is because reaching local schools often requires walking long distances on dangerous roads and as students get older there is added pressure to stay at home to help with agricultural and household work. For many young girls, access to education also ends upon being married, sometimes as young as 15–16 years old. Within rural public schools some teachers lack access to formal training and predominantly use traditional rote-learning methods. In one school that we visited the headteacher explained that they had been unable to teach content on earthquakes this year as they 'could not afford the textbooks' (school and classroom photographed in Fig. 1). Beyond the core-curriculum textbooks, which are provided by the government in publicly funded schools, teachers or students often have to use their own money to buy additional textbooks, including on geoscience-specific or DRR content.

Game development

A central principle from the beginning of this project was to create a resource that could be used independently by local educational stakeholders, such as teachers and local facilitators, and therefore would remain of value beyond the limited timeframe covered by the funding of this project. Different artistic participatory methods were considered, such as drawing workshops to create a comic book (e.g. Sharpe and Izadkhah 2014) or using photography and filmography. However, it was decided that a serious game would be the easiest to integrate into the existing school curriculum. Developing a serious game through a co-creation approach also has the dual benefit of co-producing knowledge through the creation process, as well as being an educational tool for continued teaching after its initial development.

Initial development of the game prototype

In this section we discuss the initial process of developing the game prototype. Ideally, to adhere to the principles of co-creation most closely, the project would have been developed with community input from first principles (Van Niekerk and Annandale 2013; Knight 2025). For example, a game may not have been the first choice of resource for the communities with which we were working, or they may have favoured a different style of game. The choice to develop an initial prototype was, however, driven largely by funding requirements to produce a complete proposal for the project in the application stage and also due to the limited timeframe and resources for the project. We therefore decided that it would be most effective to arrive with a prototype that could then be iteratively developed with community input. In the section 'Evaluating the process of game development through co-creation approaches' we discuss this approach within a more general framework for co-creation and highlight the limitations and areas for future improvement in our approach.

The first prototypes of the Disaster Ready! game took the form of a simple card game. We initially thought that creating a game that used only a single deck of cards had the benefit of being small, easy to transport and more readily explained. However, upon play-testing with university students, it became clear that this style of game also lacked the nuance required to simulate the complex physical phenomena that lead to earthquakes or the social systems that create vulnerability. For example, as the original version of the game focused solely on earthquakes, it was important to capture their random timing and inverse magnitude–frequency distribution in the game. From a pedagogical perspective, to encourage action-based and experiential learning there also needed to be an element of choice and subsequent consequence depending on the players' actions in the game for them to learn effectively. The requirement for both randomness and player choice therefore meant that a full board game set-up was the most appropriate. We chose to set the game in a rural Nepali village to ensure the game was contextually relevant to a Nepali-specific audience, most of whom subsist based on rural agricultural livelihoods. As discussed above, the initial focus of the game was on earthquake hazards and preparedness. This focus reflects both the significance of earthquakes as a major hazard in Nepal and our own predisposition to geological hazards given the backgrounds of the development team in Earth Sciences. In the section 'Evaluating the process of game development through co-creation approaches' we discuss the decision to include other hazards, based on community input, to better reflect the multi-hazard context of communities in Nepal.

The preparedness and resilience actions on the game cards (e.g. what to pack in an emergency bag and sheltering under strong furniture such as a table) were based on advice from the NSET website and their 'Prepare Yourself' page (NSET 2024). Our intention behind basing our cards on their advice was to ensure that the actions on the game cards were consistent with national advice, which is more specific and relevant to the Nepali context than general earthquake preparedness advice. The wording of the action

cards was checked by experts in earthquake science, although the Nepali translations were done through Google Translate to avoid adding additional unpaid work onto local Nepali staff. Dual Nepali–English instructions and translations on the cards were integrated into the game to ensure maximum accessibility for students and teachers. Supplementary Material A gives a more expansive overview of the game and how it is played.

We also aimed to represent the current work of, and ongoing DRR projects being run by, NGOs in Nepal. For example, NSET have been working with UNICEF since 2023 on the 'Safer Schools' initiative to develop emergency evacuation plans, conduct earthquake drills and retrofit buildings. Volunteers Initiative Nepal, who facilitated the schools' workshops in this project, are also encouraging the development of community disaster preparedness committees in the Okhaldhunga region for autonomous, community-led resilience building. These community-wide projects formed the inspiration for the community centre component of the Disaster Ready! game. This requires that all players enter the community centre on the game board together and only then can they unlock a community project (such as forming a committee or making an evacuation plan) in which all players gain a higher number of points than the individual in game actions. This component of the game was designed to require coordination and collaboration, potentially creating frustration when not all players agree to enter the community centre at the same time or on which project should be unlocked. Nonetheless, it is the fastest way to gain a significant number of points in the game and therefore aims to encourage learning through social discussion and collaboration and also highlights the benefits of preparedness occurring on a collective and community scale. It was not possible to represent all the DRR activities being carried out in Nepal by the many different NGOs and institutions in the DRR space. Nonetheless, the actions and projects that we chose to include in the game were based both on robust nationally specific advice and on the work of Nepali-run NGOs, which have an established history of working on DRR projects in similar communities.

The original illustrative style of the Disaster Ready! prototype was produced by Leeds-based artist Michael Geary using vibrant coloured pencils. The aim was to give the game board a loose and fun style that would be aesthetically engaging for children, drawing on materials and media the students might be familiar with and may use themselves in lessons. The initial drawings of buildings on the game prototype were based on our preconceived imaginings and internet images of rural Nepali villages. As these drawings were done by a UK-based artist, they were therefore a projection of a westernized perception of Nepal rather than Nepal as perceived by the communities and students who live there. In the future, hiring a Nepal-based artist would allow for more authentic cultural input, but due to funding and timeframe limitations this was not possible for this project. Being aware of some of the limitations of our approach, we therefore chose to keep the illustrations on the initial prototype game board relatively simple. This was a trade-off between an emptier gameboard being less engaging, but one full of incorrect details being equally as jarring and off-putting for Nepali players. We deliberately left room for the illustrations to be adapted based on student input in the co-creation process (artistic workshops are discussed below in the section 'Iterative development with community input') by leaving the prototype of the game board relatively unfinished. An image of the initial prototype of the Disaster Ready! game is shown in Figure 2.

Iterative development with community input

Co-creation of the game content

Between October and November 2024 we carried out a 4-week fieldwork campaign in Okhaldhunga, Nepal, to develop the Disaster Ready! game through community co-creation approaches. We delivered teaching sessions in four schools, with a total of 155 students (Fig. 3) where students ranged in age from 7 to 15 years old. On some occasions, classes of different age groups were mixed to cover a shortage of teachers within the school. All sessions were facilitated by local staff from Volunteers Initiative Nepal who acted as translators and liaised with community members and teachers. Within these workshops the game prototype was used both as a DRR teaching resource and as a starting point to iteratively develop the game. Methods of iteration and co-creation varied between stakeholder groups. With adult teachers this was often through direct discussion of the game, its contents, and how that related to their lived experiences and concerns, whereas when working with students in schools, the iterative development process occurred instead through play-testing and informal observation. Both methods were effective approaches for co-creation and for incorporating community input into the development of the game, although they offered different insights and opportunities for collaboration, as discussed below.

Discussions with teachers and other adult members of the community were particularly useful in revising the content and focus of the game. For example, conversations about the hesitancy of some people to prioritize earthquake preparedness given that there were other hazards that they faced more regularly (such as floods and wildfires) highlighted the importance of reflecting a multi-hazard context in the game. Additional hazards (floods, landslides and wildfires) were therefore added to the game whilst in Nepal by drawing them on blank game cards that we had taken out with us for that purpose. The final version of the game will be expanded further to include cascading or secondary hazards. For example, some of the large-magnitude earthquake hazard cards will include an instruction to draw a card from a second hazard deck, containing possible secondary hazard events that could be triggered by an earthquake (such as a glacial outburst flood or landslide). In the village of Langtang, Nepal, following the 2015 Gorka earthquake over 350 people, including locals, guides and foreign tourists, were killed by an avalanche triggered by the earthquake. Including secondary and cascading hazards is therefore vital to DRR education efforts and producing a comprehensive and locally relevant resource.

Discussions with community members also highlighted the impact of global warming and changing weather patterns on the hazards faced by communities in Nepal. Several people highlighted that they had observed that floods and wildfires were occurring more frequently and had become more severe over the past few years. While most people did not directly attribute this to anthropogenically caused global warming, it does highlight the importance of including and educating communities on climate risk in order to maximize opportunities for pre-emptive climate mitigation and adaptation. The production of a 'climate change expansion pack' is currently being tested for the revised version of the Disaster Ready! game, which would add more details about climate-related hazards, including specific adaptation measures, and would increase the frequency and severity of climate hazards such as wildfires and floods within the game. This advanced version would be targeted at the upper age group of students to provide an extension exercise for further learning. Future versions of the game may also contain 'character cards' that are representative of a cross-section of Nepali society (e.g. school student, farmer, city worker, grandmother). Characters would each have a 'power' to use during the game, and a specific vulnerability. This could be a valuable way to emphasize current inequalities in disaster outcomes and potentially encourage students to discuss the social influences on disaster vulnerability.

Co-creation of the game content with student participants, by contrast, was focused primarily on developing the pedagogical value of the game. By observing play styles and student interactions

Fig. 2. Initial prototype of the Disaster Ready! game. Buildings are grouped into categories: Learning/Schools (blue), Individual Actions/Homes (orange), Recovery/Health Clinic and Farm (green) and Community action/Community Hub (yellow). At each building students gain a corresponding card with a real-life action that gains them points (to then move their counters up the point scale on the left of the board). Example actions include 'Drop, Cover, and Hold' as well as advice on how to pack an emergency bag. Red squares trigger an earthquake once landed on and points are deducted from all players corresponding to the magnitude of the earthquake. All cards and game instructions are written in English and Nepali (see Supplementary Material A for full game instructions of the initial prototype).

it was possible to perceive where the game was already engaging and promoted learning, and where it could be improved. For example, the competitive nature of the game meant that many students, whilst engaged with the gaming aspect, were not taking the time to read and comprehend the action cards, which is important for DRR learning. Over the course of the sessions, we tried to iterate the rules to encourage slower reading and greater comprehension, first by requiring the students to read the card to the group and then requiring the group to discuss the card together. Whilst this did improve comprehension somewhat, the most effective approach was found to be making the cards multiple choice, building in a greater element of (1) challenge (of getting the right answer) and (2) consequence (getting or not getting the points) and thus increasing the capacity for decision-orientated learning.

It was also notable that students tended to adapt the rules of the game as they played, and thus it was played with different rules depending on each group of students. We encouraged this approach, both somewhat as a consequence of the language barrier meaning our explanations of the rules had to be simplified, and on the assumption that the students would use the components of the game to play in the way that they felt was most enjoyable. For example, the game had originally been designed so that players move only in a clockwise direction around the board, but the students often chose to move freely between buildings on the game board. We decided to adopt this aspect of the rules, feeling it gave students a greater element of choice about their actions and thus better reflected their realities. It also became clear that some rules were overly complicated – for example, that recovery cards had to be kept in the hand and played at the point of an earthquake often meant students chose not to collect those cards, potentially as a result of not understanding their value in the game, and thus missed out on the information presented by those cards.

Co-creation of game illustrations and artistic style

Whilst delivering workshops in Nepal, alongside iterating the content of the game, we also ran several artistic workshops to get student input into the artistic style and illustrations of the game. In groups of three to five, students were given blank copies of the game board and packs of crayons and colouring pens to mirror the original media of game illustration. We encouraged students to draw on the board in whatever way they chose, with many choosing to draw representations of their homes, as well as the nature around them. Trees, animals, insects and flowers were common features of their drawings (Fig. 4) and these have been directly incorporated into the final artwork of the game board. The revised illustrations on the board were also based on our own photographs and observations while in Nepal (Fig. 4). Being predominantly collected by L. Wainman, these photographs were an additional method through which to specifically capture the differences between our original westernized perception of Nepal and the lived reality of Nepali communities, where some of those details may even have been too 'ordinary' to be intentionally captured by the student's drawings. For example, the school in the initial prototype was blue, but almost all schools in this district of Nepal are yellow, and thus changing the colour scheme was a clear way of signifying to

Fig. 3. Workshops using the Disaster Ready! game. Upper left: adult and student participants playing the game as part of a community-level workshop. Upper right: students practising 'Drop, Cover, and Hold' upon drawing that card from the game deck. Lower left: students drawing on a blank version of the gameboard as part of a co-creation drawing workshop in their school. Lower right: Nirmala Karki explaining the concept and rules of the board game as part of independently delivering a workshop to a local community.

students the identity of the building. Figure 4 shows examples of the artistic evolution of the game board and Figure 5 shows the final version of the Disaster Ready! game board.

Evaluating the process of game development through co-creation approaches

Benefits of the co-creation approach to game development

One of the benefits of using the Disaster Ready! game, both as an educational tool and as a resource to collectively co-create with students, was the excitement and engagement that it generated (benefits and challenges of game co-creation approaches summarised in Table 1). Unstructured observations from our interactions with students illustrated different levels of engagement and participation before, during and after the sessions. During the initial introduction to the sessions, we observed that students were sometimes subdued or distracted, but upon mention of the opportunity to 'play a game' immediately became more enthusiastic and engaged. This was often clear in a change in the student's body language – from withdrawn and looking around, to many leaning forward over their desks to view the game and listen to the explanation of how to play and how they could contribute to its development. The aesthetics of the game in particular provoked curiosity, with students commenting both on the identity of the buildings and relating the features on the board back to locations in the local landscape (such as a nearby river). Students also showed notable emotional investment in the game – celebrating upon earning points, laughter and animated discussion between players, and frustration, collective and individual, when an earthquake occurred. Emotional connection, aesthetic engagement, the drive to succeed and sociocultural experience have all been identified as important factors in retaining learning from serious games through affective, imaginal and dialogic learning (DeKanter 2005; Dieleman and Huisingh 2006; Solinska-Nowak *et al.* 2018). The game also offered an alternative to the usual rote-learning approach common in most of the schools we visited. We feel that centring the student experience rather than being teacher-focused provided an opportunity for action-orientated learning and was therefore particularly effective in gaining student engagement. Following the sessions, many students were also keen to take home leaflets to their families on how to pack an emergency bag back and several commented at the end of the lessons that they were excited to tell their parents what they had learned through the game workshop. This highlights that DRR outreach focused on schools may still permeate and add value to the wider community through dissemination of knowledge from the students to their family members (Ronan and Johnston 2003; Carlino *et al.* 2008; Sharpe and Izadkhah 2014).

The process of developing the game content and rules with students also served as a pathway to have more theoretical

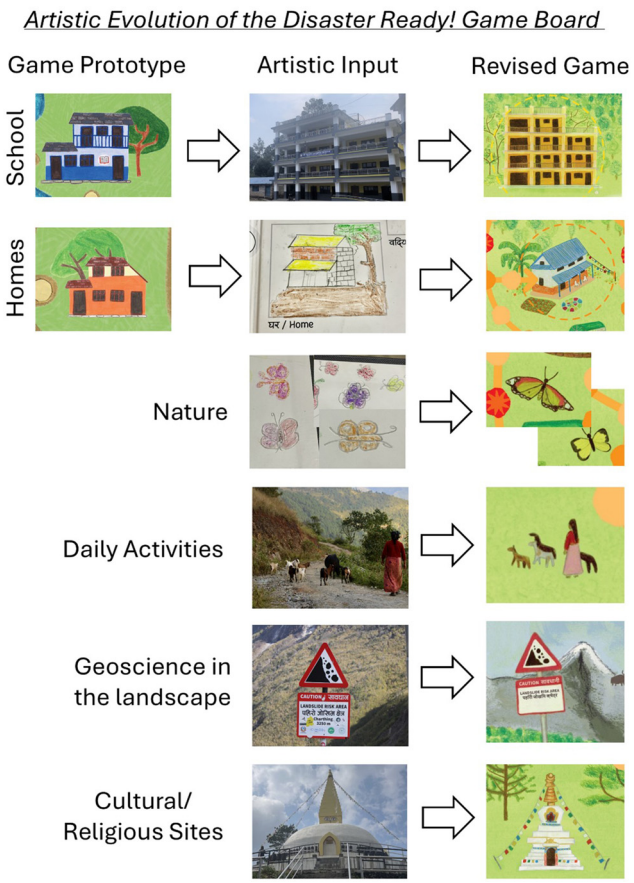

Fig. 4. Artistic evolution of the Disaster Ready! Game Board. The left-most column shows the original drawings of the game prototype, where applicable. The right-hand column shows the finalized illustrations of the game board based on input both from students' drawings and photographs from the campaign (as shown in the central column). Some aspects of the illustration were revised from the prototype (such as key buildings like schools and houses) whilst other concepts were only introduced after the co-creation illustration workshops (such as butterflies, which appeared repeatedly in the students' drawings).

discussions about the hazards the game was representing. For example, during some school sessions students suggested that only the person who had landed on the red earthquake square should receive negative points. However, this opened up discussions on why this was not realistic, given that earthquakes impact whole communities and countries. Many students were also curious about the theory behind the occurrence of natural hazards but had not previously had the chance to learn about subjects such as tectonic plates, fault motion or climate change. As such, following the workshops using the board game, several impromptu 'Geoscience 101' lessons were delivered covering these topics. It was notable that on several occasions teachers also sat in on these lessons as they were also curious to learn more about these topics that are not commonly taught. The iterative process was therefore valuable in itself, as a way to spark discussions and generate the creation of collective knowledge, as well as being an approach to produce a bespoke and locally relevant educational resource. The Disaster Ready! game can therefore be understood as a dynamic boundary object (Star and Griesemer 1989), where the process of co-creation facilitates knowledge development, and where the object itself (the Disaster Ready! game) can be iterated based on the knowledge developed through its co-creation.

An example of this is how discussions with community participants and educational stakeholders highlighted that some aspects of the game did not reflect their own local realities. For example, by focusing on earthquakes, they highlighted that the initial game prototype failed to capture the multi-hazard realities that many people in Nepal face. Some actions on the cards, such as suggested items to pack in an emergency bag like a radio, were also highlighted as being unrealistic for most local families, many of whom were living below the poverty line. This highlights that even whilst adhering to nationally specific advice, some actions may still need to be tailored to community-specific circumstances. Nonetheless, our discussions about the shortcomings of the initial prototype of the game, such as some actions being unrealistic, still led to collective knowledge creation and resilience building. For example, we discussed that if a radio was unrealistic for them, then what other objects that they already possessed would most want to have with them in an evacuation scenario. We were thus able to collectively brainstorm the most important actions for individuals in the community to pack in an emergency bag. Such discussions helped to facilitate a more relational pedagogy with fewer asymmetries in power between 'teachers' and 'recipients' (Knight 2025). Community participants were keen to explain to us their own experiences and the importance of alternative items they would pack in an emergency bag (such as nappies and children's toys), which we had not originally considered.

Alongside student participants, teachers are one of the key stakeholders in the development of serious games and educational resources. Reception to the Disaster Ready! game by Nepali teachers was generally positive, with several asking to keep copies of the game for future use in their schools and being actively involved in the game workshops. Some teachers were, however,

Table 1. Summary of the benefits and challenges to using co-creation to develop DRR serious games

Benefits of game co-creation	Challenges of game co-creation
Student excitement (increased engagement and affective learning potential)	Securing funding for multiple project phases – e.g. pre-engagement, co-creation stages and follow-up
Student-centred input is an alternative to traditional 'knowledge transmission' rote-learning styles	Long timeframes required to build trusting and creative relationships with communities
Pathway for theoretical DRR discussions and knowledge building (dialogic learning)	Can still be driven be external/Western knowledge systems
Game acts as a dynamic boundary object	Perceived hierarchies of knowledge and resource completeness or ownership can limit community creative input
End resource is more locally relevant and bespoke to community-specific contexts	Communities and researchers may have different visions/priorities
Encourages relational pedagogies and challenges traditional hierarchies of knowledge	
Opportunity to 'train the trainers' and transfer agency to local stakeholders	

Fig. 5. Revised version of the Disaster Ready! game board. Drawn by M. Geary using coloured pencils and gouache. Building illustrations have been updated from the original prototype based on students' drawings and photographs. The space between buildings has also been infilled with depictions both of the surrounding environment (trees, butterflies, birds, etc.) as well as daily activities in Nepal (e.g. playing volleyball at school, farming activities, and Hindu and Buddhist cultural sites). The numbers on the left-hand ladder appear in both the Hindu–Arabic numeral system as well as the Devanagari system used in Nepali.

more hesitant given the unfamiliar style of teaching embodied by the game-based method and on one occasion described their concern that it took time away from core subjects. Several teachers did comment on the usefulness of the game in providing an opportunity for students to focus on a task for an extended period. Others told us that, in their view, having dual English–Nepali translations added value to the game as it also provided an opportunity for students to practise and test their English language skills. The English–Nepali translations were, however, another slight shortcoming of the initial version of the game. Certain key words such as 'fault' have no immediate Nepali translation, and thus presented additional complexity in explaining the concept to students. Often translations were also unnecessarily complex or used overly formal language which was not familiar to most students. This was due to the translations being done via Google Translate initially to avoid placing a sizeable amount of unpaid work on Nepali collaborators, although it highlights the importance of pitching language appropriately. The revised version of the Disaster Ready! game is being retranslated by N. Karki, a native Nepali speaker, to maximize the accessibility of the game. Students younger than around 7–8 years old particularly struggled to read the cards (in English or Nepali) and thus represent the youngest age limit on students for whom the game is a valuable resource.

The final element of co-creation occurred organically and focused not on the game itself but on how the workshops using the game were delivered. Early versions of the workshops were led by L. Wainman from the University of Leeds, and thus were delivered in English with Nepali translation by N. Karki. As the sessions developed, however, they shifted towards being led increasingly by N. Karki, as well as other local Nepali facilitators, and thus were delivered in Nepali with L. Wainman providing additional support. Local educational facilitators also began to suggest alterations to the sessions, such as new explanations, or warm-up games to play with the students. By the end of the 4 weeks all workshops were being delivered independently by Nepali facilitators involved in the project. We observed that the transition towards sessions being led by a Nepali person in the Nepali language led to a noticeable increase in session engagement. The flow of the sessions improved, and the participants were more confident in asking questions and telling their own stories of their experiences. This principle of 'training the trainers' and transferring agency to local facilitators is crucial to the long-term use of resources and effective risk communication (Mercer *et al.* 2008). Use of the board game has continued in a local library school club since the end of the initial 4-week campaign. A questionnaire to assess the capacity of the game for building student knowledge was tested with classes at the library school and preliminary results showed an increase in student knowledge around earthquake resilience and response after playing the game (see Supplementary Material B).

Limitations and challenges in our approach to co-creation

In this section, we evaluate our approach to co-creation against the co-creation framework outlined by Knight (2025) and the framework for citizen participation in disaster research developed by Van Niekerk and Annandale (2013). Within the Niekerk and Annandale framework our approach to the co-creation of the Disaster Ready! game covered several of their defined 'intensities' of participation. At the lowest level this included *Information Sharing* through the content on hazards shared with communities as they played the game. We also utilized community *Consultation* both on *Topics and Issues* to define the scope and content of the

game and through *Interim Findings and Direction* as part of the iterative development process. Nonetheless, communities were not involved in decision-making throughout all stages of the project, such as in the outset phase where it was decided to develop a serious game, or in the design stage of the original prototype. This means that higher intensities of community participation, such as *Collaboration*, were not fully realized. The Disaster Ready! project was also externally driven rather than being the result of community self-mobilization and thus could not reach the highest level of participation, *Transformation*. The importance of researchers working with communities from the project outset is reiterated in the framework outlined by Knight (2025). They highlight the importance of 'getting to know the community' prior to beginning research activities and in involving a range of community stakeholders in the initial design phase of the project. One of the main barriers to conducting a fully co-created development process in this project was the academic requirements imposed on the research team by external institutions and the requirements of the funders for a clear project plan from the outset. With the funding and time available it would not have been possible to conduct a preliminary outreach campaign ahead of the project to establish community needs and ideas for project scope. This is not uncommon as external boundaries imposed by academic bureaucracies and funding requirements are often recognized as one of the main barriers to researchers embracing more fully co-creative and participatory approach (Knight 2025).

One of the main limitations of not including community input from the outset of game design was that the initial prototype was still inherently based on our own understanding of DRR, natural hazards and even how board games are played. As discussed above, this meant that initially we failed to capture some of the lived experiences of the communities we were working with, or even simple cultural signifiers (such as schools being yellow rather than blue). The end result was therefore a game that was still somewhat rooted in our westernized understanding of these phenomena and thus was less locally relevant and contextually representative than a fully co-created version of the game may have been. By arriving with an initial prototype, this also created perception over who had ownership and responsibility for the game (i.e. especially as the funding and resources were delivered by us, the outreach team). This arguably meant there remained a hierarchy in the co-creation process, probably enforced by a politics of knowledge where the outreach team still held the position of 'experts' with ultimate decision-making authority and community members as 'participants' (Le De *et al.* 2014; Solinska-Nowak *et al.* 2018; Few *et al.* 2022). This power dynamic may have meant community members felt less able to criticize the game and were more hesitant to propose new ideas. As discussed by Sou *et al.* (2021) and Naismith (2025), the perceived completeness of the illustrations in the prototype version of the game may have also meant people were discouraged from fully contributing as they felt there was limited room left to 'deeply' influence the direction of the work. Higher levels of community participation in co-creation projects require the development of long-term collaborative relationships, which are both reciprocal and creative. As discussed above, the capacity to build these relationships is often limited by external funding criteria and the pressure for fast rather than slow scholarship (Naismith 2025). For example, during our initial outreach campaign with the Disaster Ready! game, we were not able to work directly with teachers for prolonged periods of time. This limited our ability to build collaborative relationships or to work with them to develop ways of integrating the Disaster Ready! game into their existing curriculums. The transfer of agency and autonomy over the Disaster Ready! game to Nepali-based educators was therefore more limited, but is the main priority for future phases of the project if further funding can be secured.

A general framework for serious game development through co-creation

Finally, we present a framework for the use of community co-creation approaches in developing serious games as DRR educational tools (Fig. 6). This framework is based on the levels of community participation framework outlined by Van Niekerk and Annandale (2013). We also draw upon the stages of co-creation outlined by Knight (2025), although we simplify and tailor this to be applicable to the development process of serious games. The stages of game development are based on our own experiences of developing the Disaster Ready! game, and we also include examples of previous DRR serious game projects for comparison. Based on the information provided in Knight's accompanying literature, we assign each game to a level of community participation, depending on their use of co-creation approaches across the development stages of the game.

In our framework the stages of development for DRR serious games through co-creation include the following.

(1) **Community pre-engagement.** Researchers begin their engagement with communities prior to the commencement or design of the specific project. They engage in a process of understanding the community and begin building trusting and creative relationships. At this stage researchers and community participants discuss and identify potential projects, including research questions, aims and preferred approaches.
(2) **Game prototype co-design.** If researchers and community participants collectively decide to pursue the development of a serious game, they can then begin to collaboratively design a prototype. This could be done through ethically approved questionnaires, interviews and focus group discussions, to identify the content and style of the game.
(3) **Iterative development with stakeholders**. The game is play-tested with a range of community stakeholders (with ethical approval) who may then suggest areas for improvement and iteration, including adding or removing content to the game, redesigning the game artwork or adapting the rules of the game.
(4) **Use as an educational tool.** The game is used as a tool for educational outreach in schools and communities. The effectiveness of the game in increasing community knowledge and preparedness can be evaluated through ethically approved questionnaires, quizzes and interviews.
(5) **Training the trainers.** Local educational stakeholders, such as teachers, are trained in how to use the game as an educational resource. Efforts are made to transfer autonomy over the game to local stakeholders and to embed it within an existing curriculum for long-term use. Plans are made for continued dissemination and support for stakeholders to continue using the game (such as hosting the game resources open access online).

By embedding co-creation approaches across the different stages of game development, projects are likely to achieve higher levels of community participation (Fig. 5; Van Niekerk and Annandale 2013). Researchers and potential funders should consider how they can facilitate these principles of co-creation across all stages of future game development projects. This has several benefits. (1) A more fully collaborative and co-creative approach is likely to have fewer power asymmetries between researchers and participants (Knight 2025). This is critical to reducing the prevalence of knowledge hierarchies and in enabling communities to more fully and equitably participate in the development process. (2) By fully participating in the co-creation process, communities are also more likely to retain autonomy over the game even once external actors

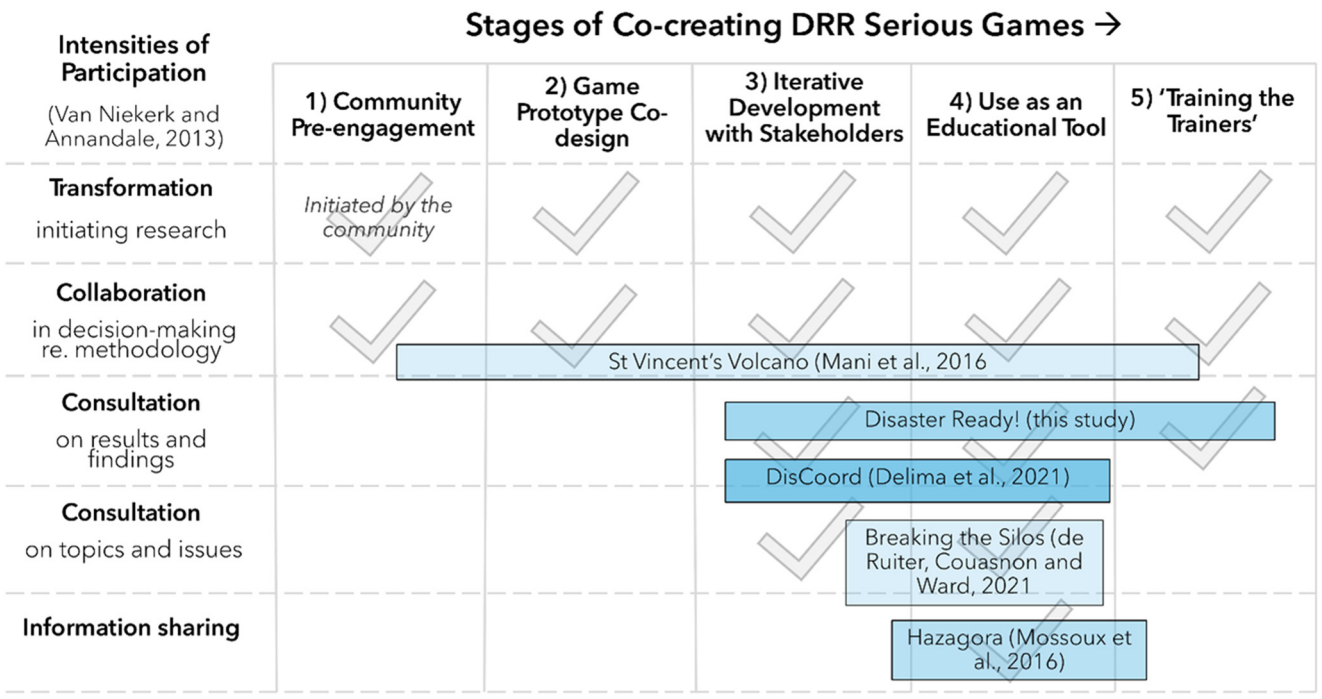

Fig. 6. Framework for the co-creation of disaster risk management (DRR) serious games. The left-hand column shows the levels of community participation outlined by Van Niekerk and Annandale (2013) where *Transformation* is the highest and *Information Sharing* the lowest (*Exploitation* is not included as the use of a serious game as an educational outreach tool inherently meets the requirements for *Information Sharing*). Across the top the stages of developing a serious game through community co-creation approaches are outlined. Blue boxes show the scopes of previous DRR serious game projects in using co-creation approaches.

have left. (3) The more fully co-created a resource is, the more likely it is that it will be locally relevant, bespoke to the intended community and contextually representative, which will also support its long-term use and effectiveness as a DRR educational resource.

Conclusions

In this paper we present and evaluate the process of using co-creation methods and iterative development to create the Disaster Ready! serious game for DRR education in Nepal. We outline the creation of the game from an initial prototype and discuss the importance of community input in shaping the evolution of the game in content, play style and artistic design. Developing the game collaboratively allowed it to better reflect the lived experiences of impacted communities and offer more realistic advice and choices to the players. The co-creation process also made it more culturally relevant and locally specific and thus more engaging to Nepali players. The game was an effective resource in schools where it was positively received by students and teachers and could be integrated into the existing school curriculum. Future projects looking to use co-creation as an approach for resource development should, however, be mindful of the potential for power dynamics and hierarchies of perceived knowledge to limit the creative input of the community. Central to the success of this and future projects is also the extent to which agency can be transferred to local facilitators. By building in external redundancy, namely that there is no longer the need for external support, outreach and communication initiatives are likely to be more sustainable and effective in improving community engagement and resilience to natural hazards.

The Disaster Ready! game is currently undergoing further revision and redesign based on the community inputs outlined in this paper. Our current aim is to secure funding to return with revised versions of the game to communities in which the initial workshops were carried out, as well as for it to be distributed more widely in rural Nepali schools. Recent work has highlighted the value of online serious video games for community outreach (e.g. Mani *et al.* 2016; de Ruiter *et al.* 2021). Given access to the internet is only increasing, globally and in Nepal, a future version of the Disaster Ready! game may be digitalized to reach an even greater audience.

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Data availability The Disaster Ready! game is open source and can be accessed upon request for educational and outreach purposes. All data generated or analysed during this study are included in this published article (and its supplementary material files).

Ethics and disclaimers Disaster Ready! received approval from the Faculty Research Ethics Committee for Business, Environment, Social Sciences at the University of Leeds. Research ethics application reference: 1477.

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