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# Promoting Tsunami Risk Awareness through Service Learning and the Application of the Disaster Imagination Game (DIG) in Ocean Engineering: an Analysis of Students' Perceptions Years Later

**Gianina Morales, Universidad de Valparaíso, Chile**

Gianina Morales is a Faculty at the Universidad de Valparaíso, Chile. She has an M. Ed degree and is currently a Fulbright Ph.D. student at the School of Education at the University of Pittsburgh. Her research focuses on disciplinary literacy in engineering and the improvement of instructional practices to foster persistence and equity in undergraduate engineering education.

**Mr. Mauricio Reyes Gallardo, Universidad de Valparaíso, Chile**

Mauricio Reyes Gallardo is associate professor at Universidad de Valparaíso. He is Civil Engineer and has a Master degree in Disaster Management . His research is focused on several topics related to disasters and coastal engineering, bussines continuity planning, disaster education for resilience and risk management.

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## Abstract

The *Disaster Imagination Game* (DIG) is a Japanese method to promote disaster risk awareness and resilience. It is a simple, low-cost, versatile, and effective methodology for strengthening local capacities for disaster prevention. The game's core is a teamwork exercise around a printed map, where people discuss and record information about the territory under study. We used an adaptation of the DIG methodology in the context of a service-learning third-year course in an Ocean Engineering program at a regional university in Chile. During the course, students were first introduced to the theoretical and empirical aspects of earthquakes and tsunamis. Then, they were guided through the conceptual and practical learning of the game to prepare them as facilitators. At the end of the course, students led a DIG workshop with community members that allowed participants to identify evacuation routes and vulnerabilities in the city. After more than two years and a pandemic hiatus, we wonder: how might this experience have impacted students' tsunami and earthquake awareness? In this article, we present a small qualitative inquiry. We interviewed students who actively participated in the service-learning experience to analyze their perceptions of their disaster risk awareness learning promoted by the course. The results indicate that students value the experience as a catalyst for their risk awareness, identified in actions such as paying attention to evacuation routes in diverse settings or creating preparation strategies. Moreover, students value the opportunity to work closely with the community as a contribution to their professional identity. Findings offer implications for engineering educators interested in applying service-learning experiences to promote professional learning and community engagement.


## Introduction

Chile is located in the *circum-Pacific seismic belt*, a zone where most of the largest earthquakes occur. Its coast is frequently affected by earthquakes and tsunamis, including the biggest earthquake and tsunami ever recorded, the M9.5 *Valdivia Earthquake* (1960) [1]. Chile's propensity for earthquakes and tsunamis makes it essential to advance educational proposals to increase its inhabitants' risk awareness and resilience. After the tragic loss of lives in the tsunami that followed the *Maule Earthquake*—an M8.8 event that struck the central region of Chile on February 27th, 2010—a joint research project between Japan and Chile was established to advance the development of technologies and resources to foster tsunami resilient communities. The SATREPS (The Science and Technology Research Partnership for Sustainable Development Project) program [2] allowed the introduction of the Disaster Imagination Game (DIG) in Chile.

DIG was created as a method for disaster drill in Japan [3] and has been used in different contexts since then (e.g., [4], [5] ). The game's overall goal is to promote disaster risk awareness and resilience. Its core is a teamwork exercise around a printed map, where people discuss and record information about the territory under study [6]. We used a local adaptation of DIG [7], [8] in the context of a service-learning third-year course at an Ocean Engineering program at a regional university. The university is located in a populated coastal city (Valparaíso) that requires private and governmental initiatives to strengthen its inhabitants' disaster preparedness and resilience. To enhance disaster prevention capacities in the community and prepare our students

to lead efforts in this area, we have employed DIG since 2018 as a systematic educational tool for students' community engagement.

Service learning is an educational method that impacts students' development beyond the classical understanding of disciplinary learning objectives [9]. According to Bringle and Hatcher, service learning can be defined as:

> A credit-bearing educational experience in which students participate in an organized service activity that meets identified community needs and reflects on the service activity in such a way as to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility [10, p. 222].

Although primarily associated with disaster recovery, several examples show the potentialities of service learning methodology in disaster education [11]–[13].

Guided by the service learning methodology, we designed a course in which students gradually move from *players* to *facilitators* of the DIG. The course starts with the theoretical and empirical aspects of earthquakes and tsunamis to soon focus on the conceptual and practical learning of the game. After experiencing the game, students work in teams to prepare and lead a DIG workshop with community members that allows participants to identify evacuation routes and vulnerabilities in the city.

Although the literature on DIG suggests its effectiveness (e.g.,[4], [5], [8] ), the research on its long-term impacts is limited [14]. Additionally, scarce attention has been given to its applications and results in higher education. Therefore, we designed a small qualitative study to answer the question: How might the experience in the DIG service-learning course have impacted students' tsunami and earthquake risk awareness? In this article, we present our findings from the analysis of the interviews we conducted with eleven students from the first cohort that participated in the course. We focus our analysis on their perceptions of the disaster risk awareness learning promoted by the course.

**Disaster Imagination Game as a Tool for Disaster Risk Reduction Education**

Disaster risk reduction (DRR) "is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development" [15]. It involves implementing organized efforts to lessen the impact of disasters in communities by improving preparedness for adverse events [16]. The Sendai Framework for DRR stresses the fundamental role of education at all levels to achieve world, state, and local goals on this matter [17]. Disaster risk reduction (DDR) activities aimed to provoke changes in people's actions, emotions, beliefs, and perceptions are essentially learning activities [18].

As one practical tool for disaster prevention education, the Disaster Imagination Game (DIG) was initially developed in Japan to be used as a training and educational method, thanks to the joint work of the Prefectural Government of Mie and the National Institute for Defense Studies [6]. It is a simple, low-cost, versatile, and robust methodology for strengthening local capacities for disaster prevention. Devastating disasters such as the tsunamis triggered by the *Maule Earthquake* (2010) in Chile and the *Tohoku Earthquake* (2011) in Japan mobilized the joint SATREPS program (The Science and Technology Research Partnership for Sustainable Development Project) to foster preparation and scientific research for the understanding of

natural hazards, with particular emphasis on earthquakes and tsunamis. In that context, DIG was introduced in Chile as a tool to reduce vulnerabilities in coastal zones. The game was first tested in Chile with adults and youth from some cities hit by recent tsunamis or earthquakes before being adapted to the local context [8].

Youth and adults from any background and age can play DIG. It does not require more than a basic understanding of maps and can be adapted to diverse contexts. The base materials for implementing the game are printed maps or satellite images of the territory and color markers. In the adaptation we applied [7], the game starts with a technical talk introducing the participants to basic earthquake and tsunami concepts. Then, the workshop facilitators organize the participants into teams and explain the game's generalities. During the game, the structure and rules lead the participants to analyze the spatial and socio-natural risks of the territory, taking into account the constitution and vulnerabilities of the system—in this case, the city. After the analysis, participants assume several roles in an imaginary disaster scenario and assess their possibilities for coping with the emergency and evacuation. The last stage involves participants' discussion about the lessons learned in the game. Figure 1 represents the stages of the game.

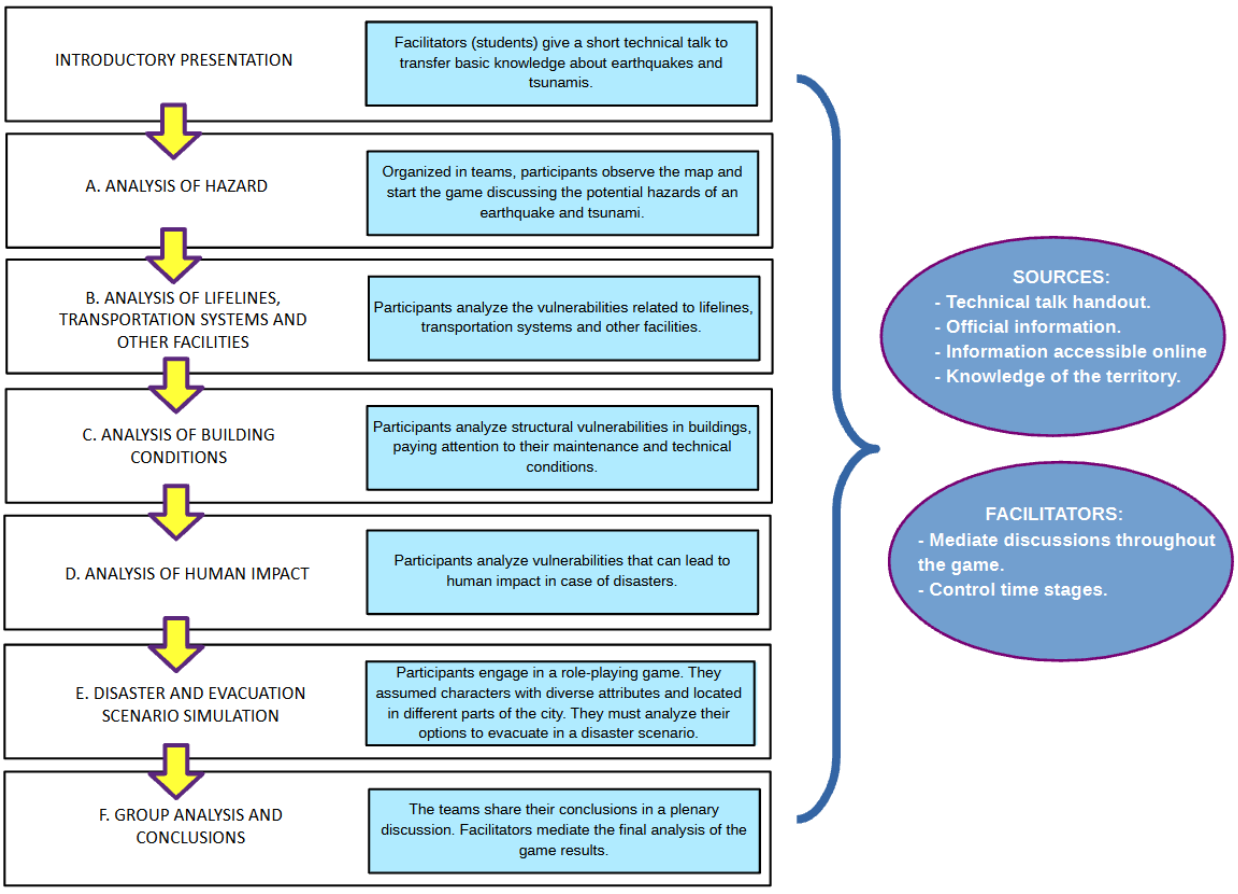


Fig. 1: Stages of the Disaster Imagination Game (DIG) implemented in the course.

We prepared several DIG exercises and three formal workshops in the service-learning course. Two in which the students played and one in which students facilitated the workshop with the community. Participating students and citizens in the workshops lived in the area of Valparaíso, so we used descriptions of possible earthquake and tsunami disaster scenarios in the city. Valparaíso is a port city surrounded by a mountain range that forms a bay oriented to the north and protected from the dominant southwestern winds and waves. It is a World Heritage City, with many old buildings surviving from the 19th century. At the same time, part of its population lives in precarious housing and conditions of social vulnerability. DIG workshops were focused on the area of the city where the exposure to tsunamis is more extensive and evident, prompting participants to engage with imaginary high-risk situations.

Fig. 2: Participants in a DIG workshop identifying the territory's characteristics.

**Theoretical Framework**

Extensive research on disasters and crises has led to the construction of concepts for studying and enhancing DRR initiatives. Among them, risk awareness, resilience, and vulnerability are interrelated constructs that educational efforts can impact. Such concepts are based on complex social phenomena, positively or negatively intensified by crises and natural disasters. Morsut et al. [19] developed a model that links these concepts through a systematic review of the literature and experts' validation. According to the authors, *resilience* involves processes of adjustment, adaptation, and transformation especially enacted to afront disasters and crises. By its side, and regarding individuals, groups, or the whole society, *vulnerability* is the "dynamic characteristic of being susceptible to harm or loss" [19, p. 141]. Vulnerabilities are situational and represent the difficulties of accessing protective resources to anticipate, handle, recover, and learn from the impact of natural or human-made disasters.

Regarding *risk awareness,* Morsut and colleagues argue that the literature defines the concept from different perspectives. Some scholars consider it close to the concept of knowledge ([20]), while others focus on perceptions and collective construction of awareness and resilience in the face of risk [19]. According to the United Nations (UN), public [*risk*] awareness is defined as "the extent of common knowledge about disaster risks, the factors that lead to disasters and the actions that can be taken individually and collectively to reduce exposure and vulnerability to

hazards" [16, pp. 22–23]. This article considers the individual aspect of risk awareness defined by the UN. Morsut and colleagues also indicate that *Social Capital* influences resilience and vulnerability positively and negatively during crises. As such, it can include "norms, values, trust, and networks, embedded in societies and their inequalities (...) which may offer resources for mutual support and for facilitating coordination and cooperation in the face of risks and crises" [19, p. 142].

In this article, we focused on risk awareness because it is crucial to developing preparedness and resilience capacities to affront disasters. However, its strong interrelation with vulnerability and resilience makes it essential to include aspects of preparedness and resilience in our study. To analyze these concepts in interrelation to risk awareness, we draw on the framework proposed by Cardona and Carreño [21]. They argue that resilience involves three capacities in a system facing a disaster: capacity of anticipation (preparedness in advance of the disaster), capacity of coping (managing and controlling during the emergency), and capacity of recovery (recuperation from the disaster). Far from doing a specific knowledge measurement among the participants, we look for changes reflected in their declared actions in everyday and extraordinary circumstances—before, during, and after the theoretical occurrence of an earthquake and tsunami disaster. Thus, we are looking at the students' perceptions of the impact of an educational process on their risk awareness.

## Method

This qualitative study aims to examine the possible impacts of a service-learning course centered on DIG on the risk awareness perceptions of the participant students. Our research question is: How might the experience in the DIG service-learning course have impacted students' tsunami and earthquake risk awareness? Our data collection method was the development of semi-structured interviews with the students of the first cohort that participated in the course.

The participants are eleven former ocean engineering students that engaged in the course in 2018. They represent 65% of the students that took the course that year. Each interview lasted between 25 and 40 minutes. Our interview protocol reflected the conceptualization of risk awareness and its associated constructs (e.g., vulnerability, resilience, preparedness)—previously described in the theoretical framework.

For the analysis of the interviews, we employed an eclectic code [22]. Based on our theoretical framework, we started with a provisional code. However, the coding scheme grew and shifted throughout the analysis by including inductive codes resulting from constant data comparisons [23]. In this article, we present the main patterns identified across the interviews.

## Findings

### *Increased risk awareness*

Most participants declared that their experiences in the DIG service-learning course somehow impacted their risk awareness. They remembered the experience and described their most significant learnings. For example,

> "*And what really stuck with me the most is knowing what to watch out for, where to go, and where the most important entities are in case of an emergency. Knowing how to evacuate, knowing whom to go for assistance, and what not to do! For example, how to*

*help; understand if I can be useful or not, and I need to stand aside so as not to get in the way. And, above all, to have prior knowledge before something happens"* (Eva).

However, considering the importance that the Ocean Engineering program attributes to risks and disasters (in relation, for example, to coastal engineering design criteria), many students indicated that the experience in the course launched their deep awareness of disaster risks—reinforced later with other courses:

*"In fact, well, the course helped me to learn about things that I have to be careful about in case of an earthquake or tsunami. For example, what most impressed me was that you have to be careful with subway channels in case of tsunamis... but besides the course, I have developed my awareness throughout the program. Before studying this, I knew nothing about tsunamis because I come from a rural region, without shore, and I have never had detailed preparation in school about what to do in case of tsunamis or earthquakes"* (Cate).

Some participants' comments pointed out examples of actions that demonstrate their awareness. These actions are related explicitly to awareness of earthquake or tsunami risks but also demonstrate a further application of principles of risk awareness to other contexts. For instance, regarding tsunami risk awareness, a participant described a change in her perceptions of the surroundings near the shore:

*"Yes, it [the course] did have an influence because since then, since the course, I have done other things that I did not do before. I have done new things, like in case of an earthquake I go to a safe place and I avoid being on the coast in case of tidal waves (...) regarding evacuation routes, we didn't know about them before, they practically didn't exist, and now that we know about them, if I look at them I say, here is a place to climb or to move around…"* (Ana)

Another participant narrated a common action that shows his awareness of risks in crowded spaces, primarily thinking about earthquakes but also considering any kind of disaster:

*"I do believe that this course gives rise to risk awareness, to consider risk...for example, in the location of evacuation routes (...) And I look everywhere, especially when there are many people, crowds (...) for example in commercial areas, such as the mall, in the closed parking lot I look for signs, where I would have to go in case of an earthquake or another dangerous situation*" (John).

Similarly, another former student also recalls being concerned by her surrounding spaces and looking at exits in enclosed and crowded spaces such as discotheques:

*"It happens to me a lot that if I go to a disco, I look at the stairs, how many people are there and I imagine what happens if an earthquake happens? How many people are going to go down that staircase? so I start to think of an escape route to be prepared in case of an earthquake"* (Sandra).

Notably, more than one participant indicated that the course made them pay attention to possible dangers in streets, beyond the risks associated with earthquakes. For example,

"*Yes, I think so. I think that after the workshop, I realized, when I was walking down Valparaíso, I started to pay attention to the facades of the buildings, for the ledges, and I*

*said to myself, 'You have to be careful when walking here'. And not only in case of an earthquake! That is something that I still do, to pay attention to…*" (Rosa)

Along with the actions, participants also declared to gain knowledge about earthquake and tsunami risk reduction in the course. However, they recognize that it is difficult to distinguish how much of this knowledge can be attributed to the experience or other courses of their program.

***Understanding of vulnerabilities and improvement of preparedness***

At least half of the participants declared that the experience impacted their preparedness to affront earthquakes and tsunamis. They presented examples of actions that match the *capacity of anticipation* described by Cardona and Carreño [21]. For example, three students indicated that they have agreed with their families on meeting points in the event of a catastrophe. Also, a participant gave a detailed description of her emergency bag (*survival kit*) and plans in case of disaster:

*"One of the things the course taught me is to be prepared and now, as a mom, even more! So I have a little bag prepared with food, clothes, diapers for my baby...emergency materials...also, of all the houses I usually go to, I have a kind of map where the safe zones are marked, the places where I can go in case I have to evacuate alone with my child.... I feel super conscious"* (Eva).

Preparedness actions in advance of potential risk demonstrate the participants' understanding of the vulnerabilities of the territory in which they usually move and the city. It reflects an application to the real life of the principles of the DIG. What they applied during the game in maps was training for their lives.

***Coping with disasters and recovering***

Some students indicated that the course supported their coping capacity. For example, one student described how the knowledge and experience associated with DIG give him tools to stay calm during earthquakes. Another student indicated that she experienced something similar but with a family member. The course taught her the necessary resources to help her sister understand earthquakes and remain calm during the movement.

Regarding recovering, most students reported not having a clear plan. However, concerning using tools to get back to work after a disaster, participants indicated having a cloud backup of their computer information in several interviews. In addition, one of the students emphasized how his engineering background represents an asset in helping the community recover:

"*Well, I think that in this sense, the engineering formation—which is basically problem, solution, problem, solution—helps to find quick ways to get ahead. So I think that in case it gets very bad, the first thing I would do is to analyze the situation, for example, here in my community where I live, to verify that everyone is fine, what is working and what is not, and from there, I will go and thinks gradually in macro things. Because, of course, the first thing is to build the house, then come all the other things*" (Pablo).

Preparedness, coping, and recovering ideas and actions are essential for forming resilience capacities. Participants' answers indicate how the risk awareness motivated by the course has potentially impacted their disaster resilience.

### *Impacts on the professional identity*

Finally, we found that the DIG service-learning course also impacted the participants' professional identity. All positively remember the experience with the community. Some indicated that the experience was the first time they worked closely with the community, applying their engineering experience. Three former students went further and created a project for a capstone course to implement DIG workshops in high schools close to the city's shore. They used the knowledge acquired in the course as facilitators and extended it, assuming the role of planners. This activity demonstrates how the service-learning methodology can impact students' community engagement in the long term.

## Discussion

The analysis of the interviews suggests a general participants' improvement of their risk awareness. They recognize their attitudinal changes and recall actions showing increased knowledge, consciousness, and alertness concerning disasters. Students' answers also show a general understanding of the vulnerabilities of the territory in which they live. Some participants further develop strategies to be prepared in the face of earthquakes and tsunamis.

As a learning activity, the DIG service-learning course is recognized as the beginning of a series of courses that fix relevant concepts regarding disasters along the program. As this is Ocean Engineering, the technical concepts students have acquired after the course reinforce and consolidate the lessons learned in the DIG workshops.

The involvement with the community during the course furthers the imprint that the play of the game left on students. First, they learned as first-time game players, but second, they planned and facilitated workshops with the community. The experience consolidated professional knowledge and community engagement, helping students to look beyond their vulnerabilities to attend to the community vulnerabilities and their role in leveraging disaster risk reduction there.

Finally, we recognize that our study has some limitations regarding data collection. We hope to extend the research in the future with other cohorts of students.

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