Children Facing Earthquakes in Mexico City: An Educational Strategy to Promote Prevention Awareness

Daniela Pérez-Sosa, Wulfrano Arturo Luna-Ramírez and Sara Margarita Bustamante-Loya

Universidad Autónoma Metropolitana-Cuajimalpa

Abstract

Mexico is a country with high seismic activity, and its capital, Mexico City, is considered especially vulnerable due to its geographical characteristics, urbanization and dense population. In this context, risk awareness coupled with education focused on emergency and prevention management is key in minimizing the negative effects of such disasters. Increasing seismic preparation in the Mexican population requires disseminating solid theoretical knowledge in addition to actionable and practical recommendations, i.e. life-saving action protocols, as early as childhood. We focus on an educational strategy co-designed with children, through an agile development process, to promote preparedness via a meaningful communication system that is relevant and efficient. Our contribution is two-fold, namely: a workshop involving children, teachers, and emergency staff to encourage interest in risk prevention during earthquakes; and an autonomous and self-managing workshop manual that allows an iterative improvement each time it is performed as required by everyone involved.

Keywords

Natural Disasters, Risk Preparedness, Co-design, Children, Adaptability, Risk Reduction, Security, Earthquakes.

1. Introduction

Mexico is one of the countries with the highest seismic activity in the world. Each year an average of 100 earthquakes reaching up to a IV on the Mercalli scale are registered, and at any time thereis a latent possibility of earthquakes of greater magnitude[1].

A disaster is a social or natural event where population gets affected. Such is the case when an earthquake occurs within a certain level of vulnerability –the predisposition of a system to be negatively affected by a threat–, in addition to the inability of institutions and people to minimize such potential negative consequences.

Risk is inescapable, since human beings cannot prevent earthquakes. However, conditions prior to a disaster can clearly modify the effects, in other words, vulnerability is dependent on what actions were taken in advance. For this reason, it is important to take actions to mitigate and prevent risks, as it is the only way in which the negative consequences of earthquakes can be lessened.

Given this scenario, it could be easy to assume that the Mexican population is prepared for earthquakes. But the consequences of the seismic events that occurred in Mexico City on September 19th, 1985 and 2017 demonstrated the lack of preparedness on prevention, as can be seen in Figure 1.
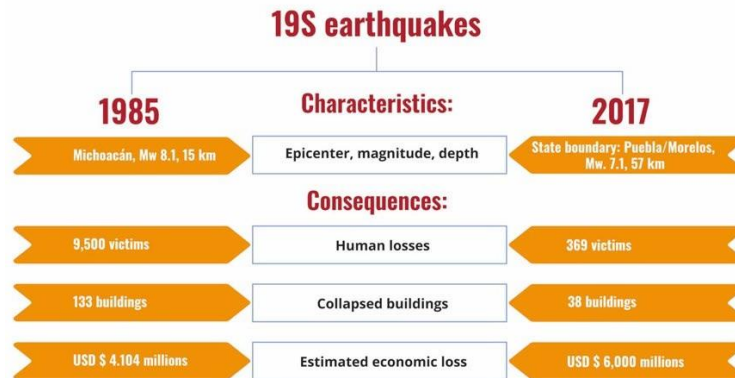

Figure 1. 19S earthquakes: characteristics and consequences. Own elaboration.

As illustrated by Figure 1, despite the fact that both experiences were catastrophic due to material and heritage losses, and more importantly, human losses, it appears that low interest in earthquake prevention and management still persists within Mexican society. Therefore, it becomes vital to promote risk awareness and preparedness as a routine topic amongst the populace.

Becoming accustomed to perceiving natural hazards as integral facets of daily existence, as observed in Japan, is noteworthy. In this context, Japan employs school safety initiatives as fundamental instruments for risk reduction. For instance, their educational facilities serve as focal points for disaster preparedness and response. The values of self-reliance, collaboration, and educational advocacy promoted within these initiatives collectively strive to attain a sustainable future through community engagement at a suitable scale. This approach, in turn, fosters heightened autonomy among the Japanese populace[2].

Mexican institutions have tried to implement programs to that aim. For instance, after the great earthquake of 1985, a security, school emergence and social participation work group was created to[3]: generate an official security and prevention programme in schools. The objective was to face any type of disasters jointly with training focused on staff, teachers and alumni, and to definea social participation mechanism in the event of an emergency in schools and communities; in addition to providing guidelines for schools to manage their own risk mitigation and prevention plans taking into account their social, economical and geographical conditions.

However, in 2017, another catastrophic earthquake exposed the lack of fulfilment of those plans and the ineffectiveness of the implemented measures when facing a disaster. Even more, we observe that existing information is disseminated commemoratively, considering that those significant earthquakes occurred during the same day and month: September 19, 1985 and 2017. Similarly, drills are held with little notice, without clear follow-up. Drills occur rarely year round (3-4 per year, including September commemorative drills). The rest of the year, little to nothing is said about the subject, which does not favour the implantation of risk awareness.

Rescue staff are pursuing improvements to information programmes, but their results are not visible yet. The informative efforts of public bodies tasked with providing materials on risk prevention are deficient and of no consequence to the public. This due to the fact that their length,

formats, and diffusion do not contemplate the population as a whole, as well as the technological and cognitive capacities, and educational level of the intended public.

Therefore, the objective of this project is to devise an educational strategy that enables the wider implementation of earthquake prevention measures. In order to accomplish this objective, it was imperative to consider the fundamental building blocks that constitute a society, such as primary education institutions. These establishments predominantly cater to young children, who, given their young ages, serve as the cornerstone for cultivating habits and effective practices that facilitate the gradual assimilation of precautionary measures. Moreover, the dissemination of these practices should extend to their surrounding atmosphere, encompassing educators, peers, and familial units.

The principal contribution of this study lies in advocating for the cultivation of a prevention culture at an early stage within a society. By prioritizing the dissemination of knowledge and practices concerning seismic events prior to their occurrence, future generations can be equipped with enhanced awareness and preparedness to effectively address such catastrophes. In particular, this research proposes the development of a targeted strategy that focuses on children, aiming to foster the adoption of civil prevention measures and bolster their ability to effectively respond to earthquakes.

It is likely that during an earthquake, the ability to respond rationally is compromised due to the overwhelming fear associated with such an event. According to Karl Slaikeu, in an emergency, there is the possibility of going through a crisis, defined as a "temporary state of disorder and disorganization, characterized mainly by an individual's inability to handle particular situations using customary problem-solving methods, and by the potential to obtain a radically positive or negative result[4].

The conscious deliberation and determination of an appropriate course of action becomes challenging, as it is a complex task requiring cognitive capacity. However, as individuals mature into adulthood, the internalization of knowledge and experience makes it easier to respond effectively during such crises. By consistently providing children with information and guidance on earthquakes and preventive measures, they acquire the necessary skills and understanding required to navigate emergency situations later in life.

In general terms, children are not held significantly accountable for their actions in response to seismic events. Instead, the responsibility falls upon teachers and parents, who are considered the authority figures responsible for providing instructions during such occurrences However, Kohlberg[5] establishes that the role of teachers should be limited to that of a facilitator who, through practical examples and teachings, enables children to engage in reflective thinking about appropriate actions to undertake. The objective is not to enforce rigid indoctrination and prescribea set of totalitarian guidelines, but rather to equip children with the necessary knowledge and habits to safeguard themselves from the imminent hazards associated with earthquakes.

To this account, our proposal is based on the stages of cognitive development proposed by Piaget[6], i.e. a system that deeply analyses the human mind from birth to 12 years of age. In his book's chapter "The stages of the intellectual development of children and adolescents", Piaget divides intellectual development into four stages according to children's ages:

- Sensory-motor: 0 to 2 years
- Preoperational: 2 to 7 years
- Concrete operations: 7 to 11 years
- Formal operations: 12 years and older

For the purposes of this project, we focused on ages ranging from 9 to 12 years. Children of this age are in the second phase of concrete operations. During this phase, children progress beyond being solely guided by appearances and instead engage in reflective thinking before acting on their impulses, referred to as intuition. Moreover, their thoughts are characterized by being reversible and specific. Children in this age group exhibit the ability to establish their own classifications and serializations, as well as formulate simple conclusions. Opinions of other, children exert strong influence on their own[7], therefore, it is possible to leverage this situation to advance seismic awareness promotion.

1.1. The Practical and Intellectual Sense

Once the intended recipients have been determined, in order to foster the development of a preventative culture, it is imperative to comprehend the intricacies of decision-making processes within the human brain. In pursuit of this objective, we rely on the practical and intellectual sense proposed by Daniel Kahneman[8]. The author posits the existence of the *Two systems of human thought*, in other words, the way in which people's minds operate is divided into two: **System 1** (practical thinking) works automatically and involuntarily, with little or no effort at all and **System 2** (intellectual thinking) works on complex mental activities that demand greater effort and concentration.

System 1 encompasses the execution of automatic actions such as eating, walking, listening to music, recognizing odours, and responding to loud noises. These activities can be preformed simultaneously without much effort. For instance, reading billboards while driving on a sparsely populated road. In contrast, System 2 is engaged in tasks that demand heightened concentration, such as performing complex calculations, playing video games, parking a car, and cooking, to name a few. These activities are challenging to execute concurrently, as they require undivided attention; neglecting this attention may result in subpar or incomplete performance of the tasks.

Based on the two systems proposed by Kahneman, we posit that the occurrence of an earthquake elicits different responses from both systems. System 1 prompts individuals to react based on fear-driven impulses, which may result in actions such as running outside, screaming, or even experiencing a state of immobilization and uncertainty. Conversely, if System 2 is activated prior to following the directives of System 1, individuals would adopt specific measures based on the characteristics of their immediate surroundings. For instance, in accordance to Mexican seismic related ordinances[9], if an individual finds themselves on the third floor or higher of a building during an earthquake, they would seek refuge near a load-bearing wall and remain there until the tremors subside, all while maintaining composure despite the presence of fear[10]. This phenomenon is depicted in Figure 2
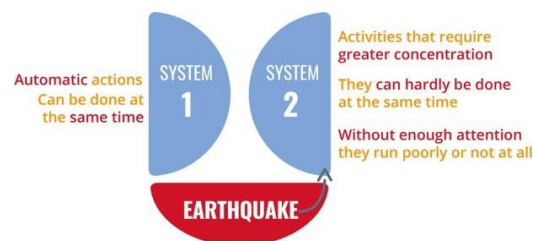

Figure 2. Practical and intellectual thinking applied to the case of an earthquake.
Own elaboration.

Given this premise, what measures can be undertaken to ensure the readiness of System 2 for activation during a seismic emergency? In this regard, Kahneman[8] exposes that when System1

encounters a difficulty, it prompts the engagement of System 2 which offers a detailed and precise procedure to problem-solving, i.e. System 2 is activated when System 1 encounters a problem that lacks a readily available solution. Shock triggers a sudden increase in conscious attention, therefore System 2 is mobilized, to search for a sequence of actions to face the current event.

Following this rationale, the lack of awareness and preparedness regarding earthquakes in the Mexican populace can be understood particularly in children, as they do not apply an informed decision-making and consequently, when faced with an earthquake, they will rely on their instinctual responses (System 1) rather than informed decision-making. Therefore, it is crucial for individuals to be aware of the appropriate actions to undertake in different scenarios, such as school, home, or work, so that in the event of an earthquake, their intuitive responses (System 1) can be persuaded to trigger a more rational decision-making process (System 2), potentially leading to life-saving outcomes.

In the following section, Section 2, materials and methods are presented, followed by the reported results in Section 3, ending with the Section 4 devoted to the discussion of our proposal and findings.

2. MATERIALS AND METHODS

It is crucial to emphasize that the occurrence of earthquakes in Mexican territory is inevitable and uncontrollable. However, it is evident that the circumstances preceding a seismic event can profoundly affect its consequences. Essentially, the degree of vulnerability will be contingent upon proactive measures implemented beforehand. Therefore, the significance of mitigating and preventing risks cannot be overstated, as they represent the sole means of diminishing the devastating effects associated with earthquakes and preventing catastrophic outcomes.

This section delineates the methods employed in formulating a comprehensive strategy aimed at fostering a culture of prevention among children, along with an overview of the materials that were developed for its implementation.

2.1. Towards a Risk Prevention Mindset from Childhood

Risk mitigation is an enduring endeavour that necessitates a long-term approach. In order to foster such efforts, primary schools have been identified as the fundamental entities that could cultivate this behaviour within a society. Within this social sphere, children serve as the foundation for the establishment of effective habits and practices, which in turn aid in the assimilation of preventive measures in the future. Schools, functioning as institutions, assume a critical role within communities as they mainly serve as the environment where knowledge and values are generated and imparted through formal, structured, and organized processes [11].

If a society places early emphasis on cultivating a culture of prevention in the context of earthquakes, it will engender heightened awareness among future generations regarding the appropriate response to seismic events.

This study's primary contribution lies in the development of a strategy that specifically targets children, aiming to enhance their adoption of citizen prevention measures and enhance their readiness to confront earthquakes. In essence, the formation of a prevention-oriented culture is initiated when preventive practices successfully permeate society across generations through the transmission and repetition of protocols, thus becoming normalized.

This habitus, as proposed by Bourdieu, is delineated by socially constructed representations, signifying that it becomes ingrained in the individual through the acquisition of habits (mechanical behaviours) acquired through cohabitation, observation, and interpersonal connections. Consequently, these conduct patterns direct the person in forming cognitive processes, shaping perception, and dictating actions within a framework of acquired, enduring predispositions that create significance and ensuing behavioural responses[12].

Accomplishing this objective requires children to comprehend the phenomenon, which can be facilitated by fostering their interest in the topic and employing age-appropriate, contextually relevant habits that align with their lifestyle and school environment.

The field of sociology of childhood has traditionally examined childhood as a developmental phase during which individuals acquire socialization skills and eventually assume active roles within society. Consequently, sociological analyses often prioritize the examination of the key agents responsible for facilitating children's socialization, namely families and educational institutions. Nevertheless, it is imperative to perceive children as pivotal entities within sociological investigations. This paradigm shift is known as the "new sociology of childhood"[13].

In sum, it is crucial for individuals to exercise mindfulness rather than impulsive behaviour when faced with an earthquake or any other hazardous circumstance. Bratman[14] argues that a rational agent must be able to, in addition to forming immediate intentions –daily prevention activities–, decide in advance what to do and what steps to follow to meet their objectives in the future – earthquake risk–, considering their limitations – emergency fear response–. In this sense, Gaitán[13] mentions that a significant portion of these immediate intentions are constituted from a complex structure of future-oriented intentions and a set of rules associated with these structures: consistency, coherence and stability. The primary role of these standards is evident, as they facilitate the attainment of a wide range of objectives, considering the constraints imposed by our cognitive abilities and the circumstances available for contemplation.

In order to effectively mitigate future risks, it is insufficient to solely rely on personal actions and choices. It is imperative that these measures become integral components of the societal framework-of the habitus-, encompassing the collective behaviour and values prevalent within society. This underscores the significance of incorporating preventive measures into public policies that engage individuals from all strata of society. Thus, when individual efforts are harmoniously integrated within the broader social structure, a collaborative environment among stakeholders is fostered, enhancing the potential for effective action.

According to Grimson, the concept under consideration can be characterized as a cultural configuration: a social space in which there are shared languages and codes, instituted horizons of the possible, sedimented logics of conflict[15].

The approach to prevention lacks a common framework and established rationale, as the prevention and action protocols proposed by public institutions do not align with the cultural norms and practices of Mexican society. These efforts are insufficient in effectively integrating prevention measures into the daily lives of individuals.

2.2. An Educational Strategy to face Earthquakes

Addressing the intricacies of promoting earthquake prevention necessitates an interdisciplinary approach. Thus, this endeavour adopted a multifaceted strategy, integrating practices from diverse disciplines such as Educational Psychology, User-centred Design, and Agile Methods of Software

Development for project management. The objective was to practically construct a solution by combining and establishing connections among theoretical and methodological aspects. Through this approach, the study aimed to provide suitable explanations and solutions commensurate with the magnitude of the problem.

In order to accomplish the aforementioned objectives, the study employed various methodological approaches. These included conducting observations of earthquake drills in elementary schools, administering a survey to gauge perceptions and preventive measures at a state level, and investigating children's learning preferences, emotional responses to earthquakes, personal experiences, and engagement in drills outside the school setting. The study also considered the viewpoints and perspectives of parents and teachers, recognizing their valuable insights and opinions.

Hence, the employment of a qualitative methodology along with the utilization of tools such as in-depth interviews proves highly advantageous in comprehending and formulating a potential resolution grounded in the concerns and interests of the children and their surroundings. The examination of the gathered data adhered to a user-centric approach, with the dissemination of information and implementation of practical activities tailored specifically to the primary school community, aimed at strengthening knowledge and fostering actions.

2.2.1. Children and adults, their perception and knowledge (research and analysis methods)

Gaining knowledge and comprehension of the operational context in which the intended recipients function is a crucial undertaking. This knowledge encompasses an understanding of the procedures involved in earthquake disaster prevention activities, as well as the mechanisms that stem from primary schools. Therefore, our initial exploration of the project environment was conducted with the intention of fulfilling this objective. Employing methods such as observation, in-depth interviews, and engagement with focus groups, significant progress was achieved in formulating a prospective resolution to the identified problem.

The First National Macro Drill, held in Mexico City on January 20, 2020 at 11:00 a.m., involved the collection of data on our part through direct observation. The purpose was to examine the implementation of evacuation protocols in primary schools. Two campuses in the Cuajimalpa borough, situated to the west of the Mexican capital, were specifically chosen for this study: Ramón Manterola School, a public institution, and Colegio Nueva Generación, a private establishment. Both schools exhibited an average evacuation time of 1 minute and 5 seconds, and the children demonstrated similar attitudes in following their teachers' instructions. The evacuation process in both primary schools centred on moving students from classrooms to a predetermined safe meeting point. Notably, particular emphasis was placed on the establishment of safety brigades, assigning roles to different individuals or groups to effectively handle a genuine emergency situation.

After the act of observation, a systematic gathering of data was conducted to explore the central topics, emotions, and sentiments that may manifest in relation to an earthquake, capitalizing on the prevailing atmosphere generated by the simulated event. During the exercise, the participating children were instructed to record the initial three words that spontaneously emerged in response to a series of probing inquiries:

- What is the first thing that comes to your mind when you hear the word 'earthquake'?
- What is the first thing that comes to your mind when you hear the word 'drill'?
- What is the first thing that comes to your mind when you hear the words 'seismic alert'?

The main objective of this instrument was to determine the frequency of significant terms mentioned. A representation of the collected answers can be seen in Figure 3 as word clouds.

Figure 3. Word clouds of significant terms from children when three words were mentioned:
a) earthquake, b) drill and c) seismic alert. Own elaboration.

Figure 3 illustrates a colour-coded system used to distinguish various categories of words in a given context. Negative feelings or behaviours are indicated by highlighting them in red, while positive feelings or behaviours are highlighted in blue. Terms related to theoretical concepts about earthquakes are represented in yellow, and expressions unrelated to the children's personal feelings or theoretical knowledge are denoted in grey.

From this perspective, it becomes feasible to create analytical units that facilitate comprehension of the context, enriching and giving meaning to subsequent interviews, while also aiding in the comprehension of the educational environment in which children spend a considerable portion of their day. The word clouds of Figure 3 demonstrate that the primary cognitive and affective response of children upon encountering the terms 'earthquake,' 'drill,' and 'seismic alert' is characterized by fear. Additionally, commonly observed words associated with this emotional state include anguish, terror, and concern, all of which possess a predominantly negative connotation.

Furthermore, alongside the previously mentioned approach, a survey was devised to examine the overall perception of Mexico City residents regarding measures taken to mitigate the impact of earthquakes. The objective was to obtain quantitative data that could capture prevailing opinions, offer supplementary insights, and enhance the qualitative data previously gathered. The survey aimed to delve into the present level of information, knowledge, and awareness regarding preventative measures, thus functioning as an evaluation of the preparedness of the adult population responsible for equipping future generations. To achieve this, a quantitative survey instrument, comprising 10 closed-ended questions, was administered to a sample of over 100 individuals who reside in Mexico City.

One noteworthy finding pertains to the perception of the surveyed individuals, with 52% indicating that the information provided to the public regarding preventive measures is insufficient. It is crucial to bear in mind that the mere availability of information does not automatically ensure universal accessibility, nor does it guarantee comprehensive understanding. In the context of earthquake preparedness, the Mexican population possesses only a superficial familiarity with the educational materials disseminated by official government entities. This can be seen in Figure 4.
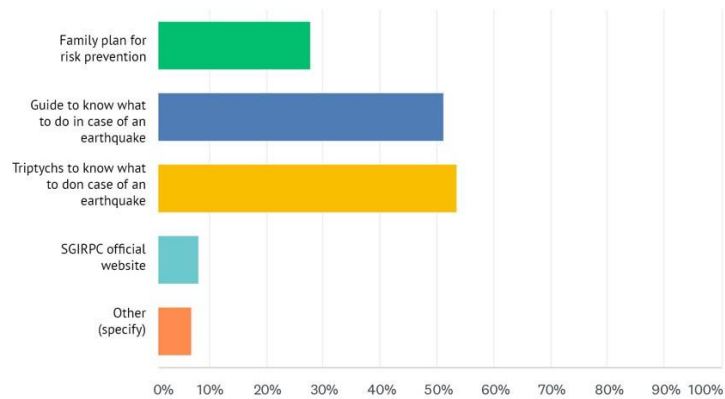
Figure 4. Answers about resource recognition in our survey:

Do you know any of the following resources on risk prevention?
Own elaboration.

In addition to the limited awareness regarding the existence of aforementioned resources, there exists a concern about their comprehension and practical implementation among individuals who possess knowledge of them. Moreover, a majority of the developed materials primarily function as retrospective reminders rather than proactive measures aimed at averting future calamities. This notion is substantiated by the responses of over 60% of the participants, who express a lack of preparedness and inadequate readiness to confront a seismic emergency (refer to Figure 5.
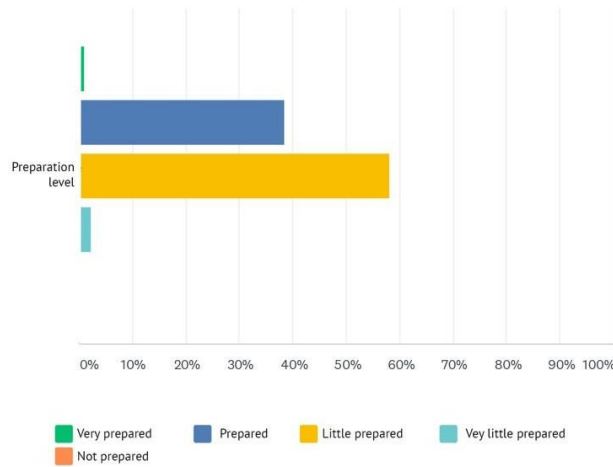
Figure 5. Answers about the perceived degree of preparedness:

How prepared do you feel you are to know what to do before/during/after an earthquake?
Own elaboration.

2.3. Educational referents and their influence on children's learning systems

The primary objective of incorporating a user-centred design approach in this study is to develop solutions that are both appealing and functional for children. Currently, available materials lack alignment with the preferences, tastes, and context of the intended users. The present research seeks to address this imbalance by ensuring that the transfer of information is optimized for effective knowledge acquisition. Such a design methodology places particular emphasis on the

manner in which the message is delivered to the recipient. It acknowledges that not only the content of the message, but also its form, presentation and medium, are crucial factors. This approach enables users to acquire the desired information or fulfil their specific needs in a manner and timeframe that suits their preferences. As a result, the designed object becomes not only utilitarian, but also user-friendly and appealing to the intended recipients.

The employment of a participatory design methodology facilitated the understanding of user emotions, creating a space to foster empathy and consequently enabling the development of ideas rooted in their personal experiences rather than solely centring on the design itself. Through the execution of comprehensive interviews, we successfully obtained supplementary insights from diverse stakeholders, encompassing children, parents, and teachers.

In light of the circumstances arising from the COVID-19 pandemic during the execution of the present study, certain constraints were imposed, leading to a sample size comprising eleven parents, six elementary school teachers, and twenty-two children. The interviews were conducted within a time frame of approximately thirty minutes for children and parents, whereas teachers' interviews lasted around an hour on average. In order to safeguard the accuracy and reliability of the gathered information, all interviews were recorded using audio technology and subsequently transcribed. Both the participants being interviewed, and the interviewers mutually consented to adhere to a confidentiality agreement pertaining to the collected data.

Based on the interviews conducted, subordinate attitudes are more prevalent in parent-child relationships. These dynamics are rooted in a paternalistic tradition where children are perceived as incapable of making their own decisions, leading to overprotection. As a result, adults assume complete responsibility for the well-being of infants, paradoxically adding more stress to their lives. Consequently, it can be inferred that children lack autonomy due to the pervasive need for constant supervision by adults. While it is true that children are initially dependent, they gradually acquire autonomy as they mature. However, adults impede the development of children's autonomy when they fail to engage in meaningful dialogue and neglect to encourage the children's own reasoned decision-making[16].

Piaget asserts that the concrete operations stage, which spans from 7 to 12 years, serves as an optimal period for enhancing reasoning and logical thinking abilities by facilitating the formulation of conclusions. This assertion finds support through interviews conducted with teachers of upper primary school grades, who underscore the keen interest displayed by their students in resolving problems and engaging in practical experiments associated with scientific subjects and their daily experiences. Within these assignments, students are afforded the opportunity to engage in repetitive practice, experimentation, study, observation, and the subsequent development of their own conclusions[17]. Regarding the above, it is important to mention meaningful learning. This consists of relating new information to the cognitive structure –set of concepts, ideas, and their organization– that the individual already possesses in a specific field of knowledge[17].

In the context of seismic events, the cultivation of self-reliant individuals necessitates equipping children with supplementary resources that build upon their prior experiences. Rather than prioritizing the historical and consequential elements of previous earthquakes, it becomes essential for children to obtain a more profound comprehension of procedural guidelines and their effective implementation. The assimilation of information underscores the importance of repetition, and conscious and frequent practice, as these endeavours promote the development of self-control[8].

However, it is evident that the frequency of drills in Mexico falls short of the ideal level required for them to become an integral part of the daily lives of its citizens. This conclusion is drawn from the findings of interviews conducted with children and parents, where it was revealed that while 90% of respondents acknowledge the significance of frequent drills, the prevailing sentiment is that the current frequency is insufficient and that, on numerous occasions, drills are not taken seriously. In order to enhance the effectiveness of learning, it is essential to establish clear objectives regarding prevention that need to be conveyed, along with identifying the methods and measures that genuinely stimulate children's interest in risk prevention. Based on the findings from the interviews, these key points can be summarized as follows:

- Children like stories / feel like experts.
- Digital activities are not necessary.
- They like physical movement and getting benefits.
- They prefer quick, concrete, and small group activities.

According to a study from Cuevas[18], there exists a considerable level of enthusiasm among elementary school students for subjects pertaining to science, notably natural occurrences such as earthquakes, as well as a special predilection for extracurricular activities to learn about these topics.

The authors emphasize the crucial role of teachers in addressing educational issues, emphasizing that insufficient knowledge or enthusiasm on their part can lead to students becoming disengaged. Merely relying on passive activities such as reading books and conducting a limited number of drills —4 throughout the year— is inadequate for children to fully comprehend and develop a genuine interest in specific subjects. Considering the diverse ways in which individuals learn, it is key to provide resources that are tailored to meet their individual needs. To foster effective learning among children, it is essential to embrace Piaget's constructivist methods, which prioritize hands-on learning and the integration of new information into each individual's personal experiences and cognitive frameworks[19].

Hence, we underscore the significance of incorporating the concept of prevention and its associated actions into the daily school routine, ensuring its reach extends to the home environment as well.

2.4. Design of an agile and collaborative solution in a 4-phase cycle (creation methods)

The initial phase of this study involved conducting in-depth interviews and exploring various educational and recreational settings and options. This process served as a crucial starting point for formulating a collaborative solution. Through these interviews and explorations, significant insights into the needs of children, parents, and teachers pertaining to risk prevention emerged. However, it is important to question the rationale behind choosing a collaborative design approach instead of solely relying on interviews and observational data to inform the design process.

According to the principles of *Investigación Acción Participativa* (Participative Action Research), the individuals under study, specifically children aged 9 to 12, along with their parents and teachers, actively participate as co-creators throughout the various stages of the research process. It is crucial for them to be engaged in the planning, implementation, evaluation, and diagnosis of the issue at hand. Their collaboration is also indispensable in the generation and gathering of relevant information, which in this case was accomplished through interviews[20].

In the context at hand, collaborative work can be defined as a procedural undertaking wherein individuals belonging to distinct domains, encompassing children, parents, teachers, and civil protection personnel, engage in the exchange of ideas, resources, and knowledge with the aim of collectively identifying, interpreting, debating, and resolving a predicament that holds relevance for all parties involved, all in pursuit of a mutually agreed-upon and shared objective. The effectiveness of this process relies on the amalgamation of their respective strengths, as well as the sharing and integration of their competencies, dispositions, and implicit knowledge[21].

This approach to work is associated with the software engineering methodologies referred to as agile development. According to agile principles, project productivity is enhanced by the formation of small, highly motivated teams that employ informal techniques and prioritize minimal ceremony and simplicity in the development of work products. Consequently, the adopted process for this project is rooted in agile development principles and encompasses four steps tailored to the collaborative work procedures that align with the project's specific requirements:

1) Planning
    a) The determination of the data or knowledge to be examined.
    b) Categorization of information into four primary topics along with their respective subtopics
2) Design
    a) Planning of the learning task according to the goal or objective –how the topic can be studied–.
    b) Selection of resources to disseminate the information, according to the data analysis.
    c) Design of activities aimed at discerning the clarity of the issues expressed in the information resources.
3) Implementation
    a) Preparation of resources and activities—degree of organization, abstraction, and synthesis of information.
    b) Production of face-to-face and digital resources and activities.
4) Test
    a) Exhibition of resources and activities, carrying out the tests with the participation of the team.
    b) Evaluation –together, with essential feedback from all team members–.

The alignment between the various stages of agile development and the identified requirements for collaborative design offers an opportunity for users, particularly children, to acquire knowledge about desired and necessary preventive behaviours and actions in a manner that best suits their needs[22]. This implies that the devised artefact, which in our case is a strategy, possesses utility while also being easily comprehensible and capable of generating interest and appeal. Gaining an understanding of children's emotions during seismic situations enables us to develop empathy towards them, thus enabling the design of interventions that prioritize their experiences over objects. The primary focus lies in establishing a meaningful connection between children and the designed product, as well as facilitating their learning from it. In this scenario, the central distinction proposed by the strategy lies in fostering an interest in the culture of prevention, alongside imparting knowledge about the associated actions and attitudes that contribute to and activate it in real-life situations.

2.5. Agile development of resources and activities

After gaining an understanding of the situation at hand and actively involving the relevant parties, a proposal for a prevention workshop was developed. This workshop aims to educate and provide a

cohesive approach, employing a manual that contains essential and easily understandable information, with the objective of fostering children's engagement in earthquake risk prevention. The content is presented in diverse formats, such as infographics, narratives, videos, and written text. Consequently, each child has the autonomy to select the preferred format for assimilating information and applying their knowledge through interactive games and supplementary activities.

Upon successful identification of the requirements of the individuals engaged in the issue at hand, as depicted in Figure 6, and in adherence to the guidelines specified in the preceding section, a collaborative group consisting of ten children aged nine to twelve and six primary school teachers —with two representatives from each grade in the selected sample— was formed. Initially, we conducted remote sessions with this team to gather their insights and viewpoints on the available prevention materials. This process aimed to facilitate the development of a novel and efficient information communication system through the creation of a revised proposal.
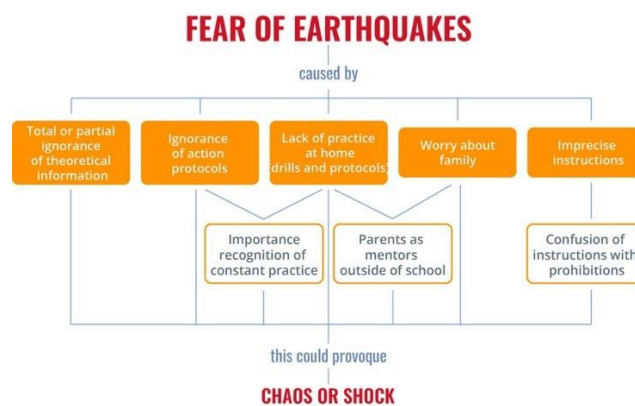
Figure 6. Mapping of children's needs during seismic situations. Own elaboration.

Forming small work teams comprising representatives from various sectors facilitated the decision-making process and enabled us to establish our own organizational framework. This approach afforded individuals the autonomy to self-manage their work based on their respective capabilities, adapt the workflow in response to the local context, and achieve optimal outcomes within a timeframe aligned with their individual requirements[23].

During the group sessions, an examination was conducted on the content and language of the current materials, as well as the utilization of resources within the classroom. Special emphasis was placed on discerning the elements that were readily understood, those that prompted inquiries, and the determination of areas requiring enhancement. Based on this collective experience and prior evaluations, in collaboration with the children, teachers, and civil protection personnel, a comprehensive plan (as depicted in Figure 7) was formulated in accordance with the significance and prioritization of information pertaining to earthquakes and precautionary measures for informed decision-making.

Figure 7. The agenda that was identified during the workgroup sessions. Own elaboration.

After the completion of the topic curation process, the most noteworthy subjects were chosen to proceed further. This involved the collaborative formulation and creation of materials (as we can see in Figure 8) aimed at conveying the selected information to a new work group. Additionally, proposed activities were put forth to assess the comprehension of the presented topics by all individuals. To accomplish this, we modified existing resources to cater to the specific requirements of our target audience, taking into consideration the expertise of each sector. The objective was to establish a methodology that is both replicable and adaptable, applicable to schools, households, or any setting where this information is deemed essential.
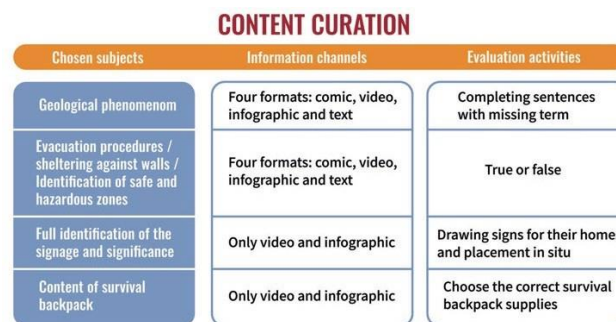
Figure 8. Content curation process: going from chosen subjects to evaluation activities.
Own elaboration.

Consequently, a collaborative brainstorming session was conducted to gather input from all participants on the resources and instructional approaches for teaching and recreational activities, aiming to assess the effectiveness of knowledge acquisition through these resources. As a result, it was determined that a minimum of three materials would be developed for each topic, serving as a framework to streamline subsequent reviews and enhance the assimilation of information. While acknowledging the potential subjectivity inherent in this selection and evaluation process, it is essential to emphasize that it is an integral aspect of the collaborative design methodology, where each group tailors their approach to best suit their specific requirements. Accordingly, the choice of means and materials also varies according to their financial and production capabilities.

During these iterations, four primary information channels were established, namely narratives, videos, infographics, and textbook-style texts. The chosen subject matters encompassedgeological phenomena, evacuation procedures, sheltering against walls, identification of safe and hazardous zones, comprehensive understanding of signage and its significance, and lastly, the essential contents of a survival backpack. Due to the extensive content or straightforward nature of certain topics, it was deemed unnecessary or impractical to address all subjects in all four formats. Therefore, a selective approach was adopted, also the

activities with which each topic was evaluated varied according to the group's own interests and possibilities; in this case, they consisted of the following (Figure 9):

Figure 9. Content curation for material used in workgroup sessions (in Spanish).
Own elaboration.

Following this, the subsequent course of action involved conducting empirical investigations with additional work groups, consisting of ten additional children, in order to investigate various strategies for acquiring knowledge utilizing the aforementioned formats. Each session comprised small groups consisting of approximately three to four children, with the guidance and oversight of a teacher and a parent assigned to each group (see Figure10).

Figure 10. Working groups for the evaluation of the designed resources.

a) *Group 1 completing sentences with a missing term about geological phenomenon.*
b) *Group 2 identification of what the survival backpack should include.* Own elaboration.

The examination of these approaches served as a framework for assessing participants' readiness to undertake various tests upon completion of the available resources. The intention was not to evaluate the participants, but rather to observe and assess the effectiveness of the employed methods and identify potential variations among them. Following a few days of engaging in the activities with the children, a brief discussion was held with their parents. The feedback indicated that their sons and daughters were motivated and highly interested in continuing the activities, as they shared their experiences with other family members. More than 50% of parents (Figure 11) reported that their children returned home with a sense of motivation and a desire to discuss their experiences and conduct further research on prevention.
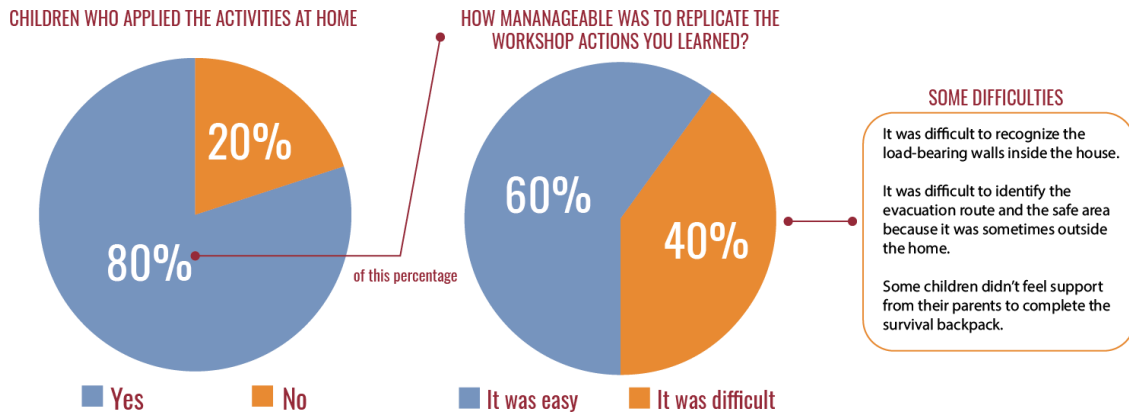

Figure 11. Application of activities at home. Own elaboration.

3. RESULTS

Due to the collaborative involvement of children, parents, and teachers in the planning and development of this project, a decision was made to organize the key themes and activities into periodic sessions, allowing for constant feedback at each stage to enhance their effectiveness. To facilitate the workshop sessions, a comprehensive manual was prepared, further discussed in the subsequent section. Additionally, in order to establish a rapport with the children and reinforce the desired principles such as autonomy, safety, and adaptability, a character named "*Simon Sismon*" (a wordplay combining the Spanish words for "Simon" and "Seism") was created to provide support during the implementation of activities.

The genesis of this particular character emerged from a meticulous examination of interviews and immersive fieldwork. It was discovered that children voiced a strong inclination towards receiving information through characters that bore resemblance to them, exhibiting similar age groups and social contexts as students. Furthermore, they exhibited a preference for easily memorable names or wordplay, as exemplified by the character's name *Simon Sismon* which directly alludes to the topic of earthquakes. *Simon Sismon* personifies a child who ardently cares about both his personal safety and that of his peers, and finds joy in imparting his knowledge to others.

3.1. Prevention workshop

Based on comprehensive theoretical and practical assessments conducted for this study involving multiple sectors, a collective determination was reached to consolidate the central themes and tasks into a workshop format that facilitates regular iterations and ongoing input throughout its various stages.

To ensure the success of the workshop, it is imperative to consistently re-evaluate the subjective concepts and matters associated primarily with children. These matters encompass ethical considerations, moral values, and emotions, as outlined by Kohlberg [5]. Therefore, the suggested activities and exercises should be flexible, subject to a consensus reached through ongoing discussions with the students. This approach allows the students to actively contribute to and shape the decision-making process concerning the workshop's objectives and the manner in which it is executed.

Hence, the suggested activities and exercises will be flexible and subject to ongoing discussions and consensus-building with the students. This collaborative approach will empower them to actively shape decisions about the course of action and the methods employed.

3.2. Manual

A comprehensive manual was developed with the purpose of serving as a flexible and instructive resource for facilitating the workshop. The primary aim of this manual is to impart knowledge, advocate for, and foster a preventive mindset, thereby influencing the participants' behaviours and habits. The ultimate goal is to equip individuals with the necessary skills and critical thinking abilities to effectively respond to earthquakes in the future. Throughout this process, teaching and learning are intertwined, allowing all individuals involved to actively engage in both roles. Daily experiences and theoretical knowledge are crucial and complementary components in the process of acquiring knowledge, and this workshop is no exception. Mere memorization of knowledge is insufficient unless it is applied in practical situations. Despite the unpredictable nature of seismic events, we can draw upon previous experience, preventive measures, and open communication among children, parents, and teachers to enhance our response during an emergency.

The initial two sections encompass basic information, including the problem statement and the objectives pursued by both the manual and the workshop. Section three is derived from the categorization of themes and sub-themes elucidated in section four. Each point within this section presents official theoretical information, articulated in a readily comprehensible manner, aimed at fostering a culture of prevention. Furthermore, it offers practical examples of activities to apply the acquired knowledge and suggests materials that can facilitate the implementation of said activities. This content, represented in Figure 12, can be disseminated through print or digital mediums, and the participating groups can access a compilation of the materials created for this project either through digital storage or direct cloud-based downloading.

¡You'll learn all this!

1 **What's going on?**
Geological phenomenon

2 **What should I do?**
Evacuation and sheltering against walls
Identification of safe areas
Security actions and positions

3 **What do I need to be prepared?**
Survival backpack and first aid kit
Signage recognition

4 **Who can help me?**
Institutions and their role
Emergency contacts

Figure 12. Content list of the proposed manual for the workshops. Own elaboration.

In this sense, it is worth mentioning that both the manual and the activities contemplate that not all boys and girls –and their schools– have the same resources, so the means to send them the strategy and materials to carry out the activities depend on their own needs and possibilities. The

final segment of the manual consists of a feedback notebook pertaining to the strategy implementation. It is anticipated that each community, encompassing various entities such as groups, schools, and teams, actively involved in the execution of the day's activities, will contribute their reflections on accomplishments, challenges faced, and prospective measures for enhancing future progress. This feedback medium can be disseminated through print or digital platforms. Furthermore, the participating groups will be furnished with a collection of project-specific materials, which can be conveniently accessed through digital storage or downloaded directly from the cloud.

4. DISCUSSION

The strategic blueprint for addressing earthquake risks encompasses a broad spectrum of domains, spanning geology, construction standards, economics, psychological factors, and more. Hence, the primary objective of this endeavour is to contribute to the formulation of a comprehensive strategy aimed at instilling a culture of earthquake preparedness among the youth of Mexico City through practical pedagogy.

The implementation and continual enhancement of official educational programs constitute a multifaceted subject fraught with challenges, notably bureaucratic obstacles that hinder progress. Consequently, this research endeavour aspires to provide a foundational framework for the development of innovative educational paradigms, wherein knowledge assumes a role not solely as an intellectual asset but as an essential tool for survival[24].

In the context of the emerging educational environments, two pivotal concerns hold paramount significance: repetition and steadfastness, culminating in the establishment of disciplined preventive measures within the cultural framework. These preventive practices, when assimilated as a series of actions meticulously rehearsed, bear a striking resemblance to the Japanese tradition of *kata* [25].

The objective here is to prepare individuals who engage in them for an actual seismic event. This pedagogical process commences with relatively uncomplicated *kata* and subsequently escalates the intricacy of the actions and their finer nuances, delving into associated subjects while placinga significant emphasis on the imperative of rapid response.

While it is commonly believed that the acquisition of a motor skill like the one outlined in *kata* necessitates extensive physical training, this is not necessarily accurate. The premise here is that through ongoing discourse on earthquakes, regular drills, and the implementation of activities as outlined in the manual, emergency preparedness can be significantly enhanced. This approach posits that by consistently emphasizing the subject of earthquakes, it will become ingrained in the minds of children. Consequently, their bodies will be better primed for effective response, influenced by symbolic learning principles.

This symbolic learning, as described by Piaget[26], is a cognitive process that transcends the limitations of immediate sensory perception. It empowers individuals to formulate hypotheses through diverse means, such as invoking specific memories. This mode of thinking exemplifies the cognitive preparation an individual undergoes prior to executing an action. It entails a mental rehearsal of relevant procedural sequences, a consideration of the spatial attributes of the skill, and a thorough analysis of potential challenges and their corresponding solutions.

While the primary objective of this project is to counteract adult-centric perspectives that marginalize children's involvement, opinions, and decisions within the broader societal decision-

making processes. It also simultaneously strives to acknowledge children as active rights-bearing participants. To ensure the efficacy of this autonomous development in children, it necessitates the support of the adults in their immediate environment. These adults encompass not only their educators, who possess expertise in pedagogy, and their parents, who offer socio-emotional support, but also professionals in civil protection, researchers, designers, communication scholars, and a myriad of other stakeholders.

Moreover, the involvement of governmental authorities is imperative to champion public policies that not only prioritize child safety but also incorporate a comprehensive approach to education.

Hence, it is imperative to consider the prevailing conditions within schools and educational institutions in Mexico in order to accurately define the constraints and the extent of the execution of this strategy. This entails a comprehensive assessment not only of technological resources but also a keen examination of the collective experiences within the educational community pertaining to earthquakes and past encounters.

Such an approach permits the refinement of the proposed strategy in accordance with the specific characteristics of each educational setting and each operational cycle. It is important to acknowledge that numerous factors may pose challenges during the implementation phase, and these hurdles must be systematically addressed in order to attain the anticipated outcomes.

As an aspect integral to project monitoring, an agreement was established with the director of Otolio Montaño primary school in Tláhuac, located within Mexico City. The agreement entails the reimplementation of the instructional manual and workshops among student cohorts aged between 7 and 11 years. This reapplication is contingent upon the normalization of educational curricula after the repercussions of the COVID-19 pandemic. Such a revision serves the purpose of generating a more representative sample, facilitating a discerning analysis of the program's efficacy and progression within a conventional scholastic setting.

Nevertheless, it is important to note that while this strategy may not completely eliminate the fear associated with potential emergencies, its primary objective is to ensure that such concerns do not become insurmountable impediments. Thus, while we cannot offer an absolute guarantee that no child will ever encounter adversity, it is crucial to emphasize that this strategy empowers children by augmenting their capacity to respond effectively when confronted with risks and emergencies.

Through this research, our aim is to make a substantive contribution by combining theoretical frameworks with practical applications, ultimately reducing the adverse impacts endured by children and their support systems during seismic events. Additionally, we endeavour to underscore the significance of preparedness for potential risks, thus promoting the establishment of a culture centred on risk prevention in the Mexican populace.

ACKNOWLEDGEMENTS

REFERENCES

[1] S. G. Mexicano, "Sismos: Causas, características e impactos", 2017.

[2] R. Shaw and M. Kobayashi, "Role of schools in creating earthquake safer environment", ch.2, p.41. United Nations Center for Regional Development, 2001.

[3] G. de México, "Lineamientos para el establecimiento y funcionamiento de los comités de seguridad escolar en las escuelas del sector educativo". Available at https://web.archive.org/web/20230630040822/https://www.dof.gob.mx/notadetalle.php?codigo4 809313fecha = 04/09/1986, 1986. [Accessed 23-Jun-2023].

[4] K. A. Slaikeu, "Intervención en crisis: Manual para práctica e intervención. El Manual Moderno", 1988.

[5] W. E. Conn, "The psychology of moral development: The nature and validity of moral stages" by L. Kohlberg. San Francisco: Harper & Row. Horizons, vol. 12, no. 2, p. 425–426, 1985.

[6] G. Hernández, "Paradigmas de la psicología de la educación". Paidós, 1998.

[7] P. J. Saldarriaga-Zambrano, G. d. R. Bravo-Cedeño, and M. R. Loor Rivadeneira, "La teoría constructivista de Jean Piaget y su significación para la pedagogía contemporánea", Domino de las Ciencias, vol. 2, no. 3 Especial, pp. 127–137, 2016.

[8] D. Kahneman, "Thinking, fast and slow". New York: Farrar, Straus and Giroux, first ed., 2011.

[9] J. Ramírez López and T. A. Sánchez Pérez, "Manual de Protección Civil". Secretaría de Seguridad y Protección Ciudadana, 2a ed., marzo 2014. Versión electrónica, 2021.

[10] S. de Gestión Integral de Riesgos y Protección Civil, "Guía para saber qué hacer en caso de sismo", 2018. [Accessed 23-Jun-2023].

[11] Secretaría de Educació Pública, "Acuerdo que establece la organización y funcionamiento de las escuelas primarias", 1982.

[12] P. Bourdieu, "El sentido práctico". Siglo XXI, 2008.

[13] L. Gaitán Muñoz, "La nueva sociología de la infancia. aportaciones de una mirada distinta", Política y sociedad, vol. 43, no. 1, pp. 9–26, 2006.

[14] M. Bratman, "Structures of Agency: Essays". New York: Oxford University Press, 2007.

[15] A. Grimson, "Comunicación y configuraciones culturales", Versión. Estudios de Comunicación y Política, vol. 1, no. 34, pp. 116–125, 2014.

[16] Y. Kato, "El constructivismo de Piaget y la educación infantil en Japón", Perspectivas: Revista trimestral de educación comparada, vol. 31, no. 2, pp. 223–235, 2001.

[17] M. S. Pineda, J. D. Novak, D. P. Ausubel, and H. Hanesian, "Psicología educativa". Trillas, 1983.

[18] A. Cuevas Romo, R. Hernández Sampieri, B. E. Leal Pérez, and C. P. Mendoza Torres, "Teaching and learning science and research in elementary education in Mexico", Revista electrónica de investigación educativa, vol. 18, no. 3, pp. 187–200, 2016.

[19] A. Parica, F. Bruno, and R. Abancin, "Teoría del constructivismo social de Lev Vygotsky en comparación con la teoría de Jean Piaget", june 2005. [Accessed 23-Jun-2023].

[20] L. Rodriguez, R. Esqueda, A. Tapia, S. Villalobos, and C. Tiburcio, "¿Design thinking? Una discusión a nueve voces". Arts Optika, first ed., 2017.

[21] J. M. Vázquez, J. S. Hernández, J. Vázquez-Antonio, L. G. Juárez, and C. E. Guzmán, "El trabajo colaborativo y la socioformación: Un camino hacia el conocimiento complejo", Educación y Humanismo, vol. 19, pp. 334–356, 2017.

[22] J. Frascara, "Design and the social sciences: making connections, vol. 2". CRC press, "first" ed., 2002.

[23] R. Pressman, "Ingeniería del software". McGraw Hill Education, seventh ed., 2010.

[24] X. G. Alvarez Muñoz, A. Marín Garcilazo, M. A. Ortega Armengol, and D. Pérez Sosa, "Estrategia para incentivar la cultura de prevención ante sismos en la población infantil de la ciudad de México", Master's thesis, Universidad Autónoma Metropolitana, 2021.

[25] I. Navarro, G. Araya, and W. Salazar, "Mental training in karate fighters: Effect of imagination time of a kata on the level of execution", Journal of Exercise and Health Sciences, vol. 2, pp. 55–60, 2002.

[26] O. Castillero Mimenza, "Jean Piaget: biografia del padre de la Psicología evolutiva", 2018.

AUTHORS

Daniela Pérez Sosa Master in Design, Information and Communication (Universidad Autónoma Metropolitana-Cuajimalpa). She studied Graphic Communication Design, and has developed professionally in various areas of graphic arts and research. Worked for the monthly magazine "Espacio Diseño" of the División de Ciencias y Artes para el Diseño of the Universidad Autónoma Metropolitana-Xochimilco and for the Sustainability Committee of the same university. She has also collaborated with "Talleres Gráficos de México" of the Secretaría de Gobernación. And currently as a freelancer has contributed to developing research and strategies to encourage the culture of earthquake prevention in Mexico City.
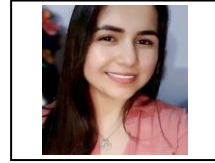
Wulfrano Arturo Luna Ramírez, PhD in Computer Science (University of Essex). Lecturer and Researcher in Universidad Autónoma Metropolitana-Cuajimalpa/División de Ciencias de la Comunicación y Diseño (UAM- C/DCCD) where he is undergraduate program coordinator in TI. He has supervised several graduate and undergraduate thesis. He is director of the research proyect "Early Warning System based on Autonomous Agents" DCCD.TI.PI-64 at UAM-C/DCCD. Research interests: Multi-Agent Systems, Machine Learning, Natural Language Processing, Emergency and Self Organization, Intelligent Systems applied to Education, Emergence Management, Ethics and Phylosophy of Artificial Intelligence.

Sara Margarita Bustamante Loya, Was born in Xalapa, Veracruz in 1993. She is an experience and user interface designer with skills in web and mobile application design, as well as brand creation. She obtained a bachelor's degree in Administration by the Universidad Veracruzana, where she also studied advertising and public relations, and is currently pursuing a Master's Degree in Design, Information and Communication at the Universidad Autónoma Metropolitana.