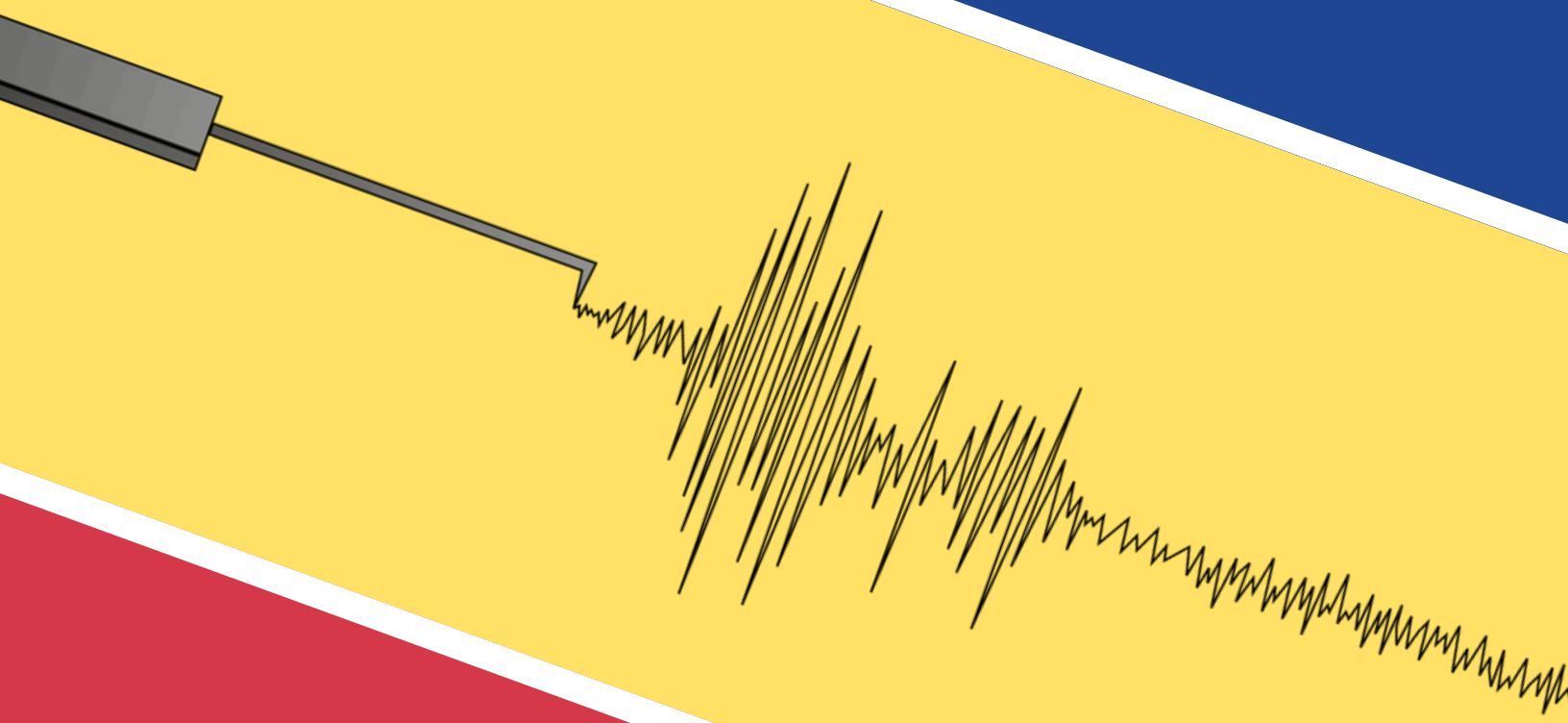
# Earthquake Safety: A Digital Solution for Romanian Children



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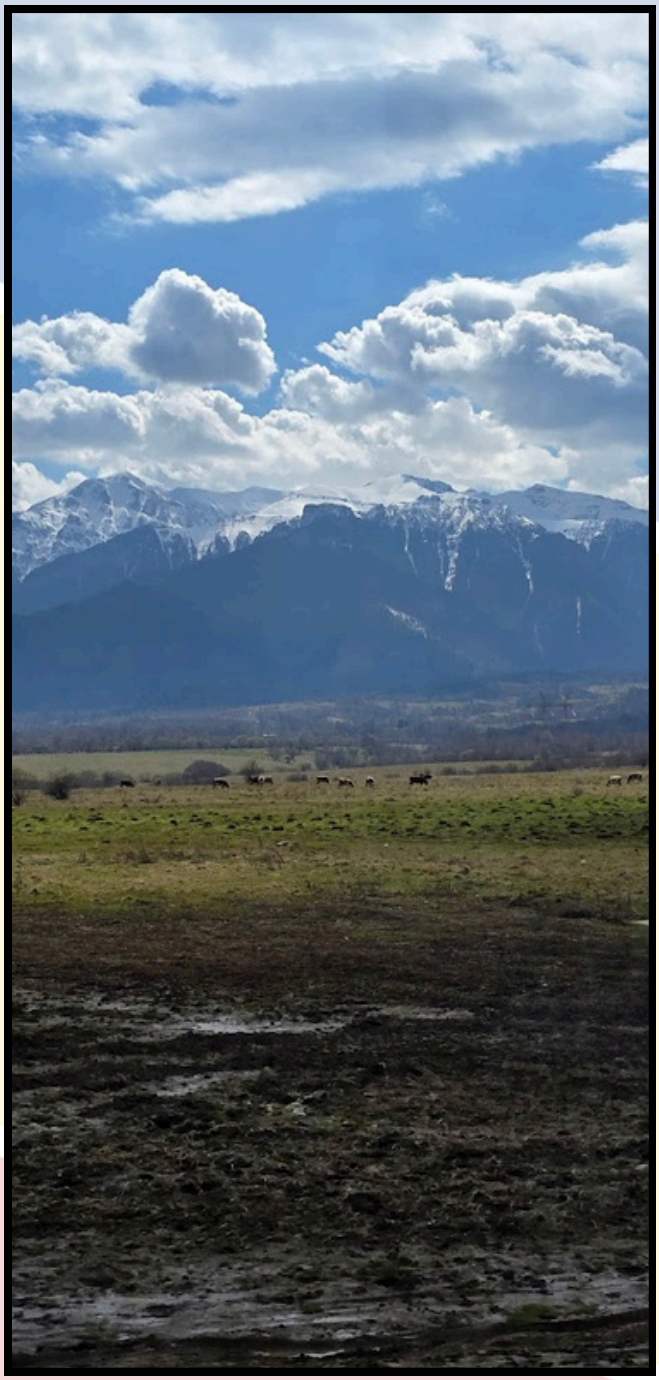

# Contributions

From left to right: Timory, Adam, and Eric

**Timory Goggin**
Computer Science and Mathematical Sciences

Timory took on the roles of primary report writer and visual designer. She researched earthquake safety protocols, the psychology of natural disaster education, and the use of simulations, drills, and stories in earthquake safety education.

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During the project, Adam took on the roles of primary editor and UX designer. He focused on earthquakes, Code for Romania, and psychology of natural disaster education during research.

**Eric Randolph**
Mechanical Engineering

Throughout the project, Eric took on the role of primary content organizer. He researched earthquake risk perception and the use of games in earthquake safety education.

# Abstract

Considering the significant occurrence of earthquakes in Romania and the need to create resources for Romanian children, the goal of this project was to work with Code for Romania to develop content for a digital platform that teaches children about earthquake safety. We researched what content and delivery formats would be best suited for our purpose and what design process should be implemented based on existing disaster education platforms and interviews with experts. To visualize designs and outline recommendations, we created a low-fidelity prototype and a detailed outline of content and delivery formats that should be used in the final product.

# Table of Contents

**Introduction** ..... **1**
**Background** ..... **3**
Earthquakes ..... 3
Earthquake Risk Perception in Bucharest, Romania ..... 5
Code for Romania ..... 5
**Methods and Results** ..... **8**
Objective 1: Earthquake Safety Education Content ..... 9
Findings ..... 9
Objective 2: Earthquake Safety Education Delivery Methods ..... 13
Findings ..... 13
Psychology of Natural Disaster Education ..... 16
Objective 3: Earthquake Safety Education Design Process ..... 17
Findings ..... 18
Brainstorming ..... 18
Decision Trees ..... 18
UX Hierarchy ..... 18
Storyboards/Prototypes ..... 19
Testing/Feedback ..... 19
**Deliverables** ..... **21**
Content Syllabus with Delivery Formats ..... 22
Final Figma Prototype ..... 37
**Recommendations and Conclusion** ..... **38**
Recommendations ..... 38
Conclusion ..... 38
**References** ..... **40**
**Appendix** ..... **43**
Appendix A ..... 43
Appendix B ..... 44
Appendix C ..... 45

# Introduction

An estimated 500,000 detectable earthquakes occur annually worldwide (The U.S. Department of Interior, 2023). These natural disasters occur across the globe and vary in magnitude, size, and frequency across different regions. Romania lies on top of a seismically active region, Vrancea, rendering it susceptible to repeated, high frequency earthquakes of considerable magnitude.

Due to their unpredictable nature and impact on the Earth's crust, earthquakes can inflict significant damage on structures and landscapes, as shown in Figure 1. European and international statistics ranked Romania among the top earthquake-exposed countries in the world (Pesaresi et al., 2017). According to the World Bank, earthquakes have affected 400,000 Romanians over the past century, and financially, earthquakes reduce Romania's GDP on average by about $5 billion a year (2019).

Figure 1: Enei Church in Romania that was almost destroyed due to the 1977 Vrancea Earthquake that had a magnitude of 7.5 (Stefanescu, 1977).

In the face of the unpredictable nature of earthquakes, some measures can be implemented to mitigate risks. Earthquake safety is a comprehensive initiative that involves risk mitigation on the level of the government, schools, and homes. Governments can mandate the construction of earthquake-resistant buildings, while large objects can be secured within schools and homes. Families and school administrators can create earthquake emergency kits and effective communication plans, which reduce the hazards associated with earthquakes. These strategies can be shared through earthquake safety education delivered through online platforms, government agencies, non-profit organizations that aim to teach adults about natural disasters, and actual training drills in schools. This project aims to improve the education and preparation provided in schools and homes.

Although the last major earthquake in Romania occurred in 1977, several smaller earthquakes have occurred in recent years. While adults from seismically active regions are often familiar with earthquakes through personal experience, prioritizing children's education in this regard cannot be overstated. Children are particularly vulnerable during disasters, and there remains a need for comprehensive educational initiatives that are engaging and specifically target children, ensuring they are adequately prepared to respond to seismic events.

Code for Romania is a civic technology organization that addresses and creates solutions for critical social issues such as education, healthcare, support for vulnerable groups, and environmental protection. Recently, Code for Romania has proposed resources for dealing with earthquakes including tools to assess the seismic risk of buildings, and other digital educational tools. These resources are predominantly geared toward adults; however, the organization currently wants to focus its earthquake safety tools on children.

Educational materials on a variety of

platforms are used across the globe to teach children about earthquakes. These range from books and physical models to online games, videos, and drills. These resources can help Code for Romania understand the type of content and strategies that might be considered in an online platform for Romanian children. Interactive digital platforms, in particular, have the potential to make earthquake preparedness engaging for children in ways that traditional lecture-based teaching cannot.

Considering the significant occurrence of earthquakes in Romania and the need to create resources for Romanian children, the goal of this project is to work with Code for Romania to **develop content for a digital platform that teaches Romanian children about earthquake safety**. To achieve this goal, we set three objectives:

1) To compile a collection of comprehensive content for children's earthquake education.
2) To assess what delivery methods are best suited to teach 6-8 year olds earthquake safety in Romania.
3) To identify and implement a design process for the creation of a digital educational platform for this age group.

From left to right: Timory Goggin, Laura Micle, Adam Spencer, and Eric Randolph

# Background

In this chapter, we discuss earthquakes, their causes and effects, why Romania is at risk, and why it is important to educate children about earthquake safety. We go into detail about the safety and educational protocols that exist around the world, considering the types of content that could be covered in an earthquake safety app for children.

## Earthquakes

Earthquakes, natural phenomena mainly resulting from the movements of tectonic plates beneath the Earth's surface, can range from subtle tremors to catastrophic ruptures in the Earth's crust (Light, 2020). These seismic occurrences have the potential to cause widespread destruction, displacing communities and claiming lives (ibid.).

Earthquakes are measured on the Richter scale, ranging from 1 to 10, which is based on the amplitude of the seismic waves measured by a seismograph. Each successive number on the scale is an order of magnitude stronger than the previous, with 2 being 10 times stronger than a 1, and 3 being 100 times stronger than a 1. Although the Richter scale can measure from 1-9, it is most accurate in the lower range, usually less than 5 (Department of Geological and Mining Engineering and Sciences, n.d.). The Moment Magnitude Scale (MMS) is similar to the Richter scale but is more accurate for the higher range of earthquakes, 5 and above (ibid.).

To illustrate the gravity of such disasters, consider the devastating earthquakes that struck Turkey and Syria in February of 2023. Measuring 7.8 and 7.7 on the MMS respectively, these shocks occurred approximately 12 hours and 95 kilometers apart (Noll, 2023). The aftermath was staggering, as more than 50,000 lives were lost in Turkey and at least 8,400 in Syria (ibid.). Beyond the tragic loss of human life, an estimated 1.5 million people found themselves homeless (ibid.). Property destruction in Turkey can be seen in Figure 2.

Figure 2: Damage caused by an earthquake in Turkey (Rafferty, 2024).

There are different types of earthquakes, but tectonic earthquakes are the primary type affecting Romania. According to Light (2020), tectonic earthquakes are born from the ceaseless movements of tectonic plates, which, as they slowly traverse the Earth's crust, occasionally become entangled, building up immense energy released in the form of seismic waves.

As seen in Figure 3, parts of Romania are at high risk for earthquakes. There are tectonic stresses from the interactions between the Eurasian Plate, which Romania sits on, and adjacent microplates that border or interact with the Eurasian Plate (Ioane and Stanciu, 2021). One example of this is the eastern edge of the European continental plate and the Balkan Peninsula microplate. A major hotspot of seismic activity within Romania is the Vrancea zone, a narrow, deep region within the Eurasian Plate. The interface between these plates creates stresses that generate earthquakes ranging from small tremors to devastating earthquakes measuring 7 and above.

Seismic movements from the intermediate-depth Vrancea zone differ from crustal (surface) earthquake movement in other countries (National Seismic Risk Reduction Strategy, 2022). Movement in the Vrancea source has longer periods of

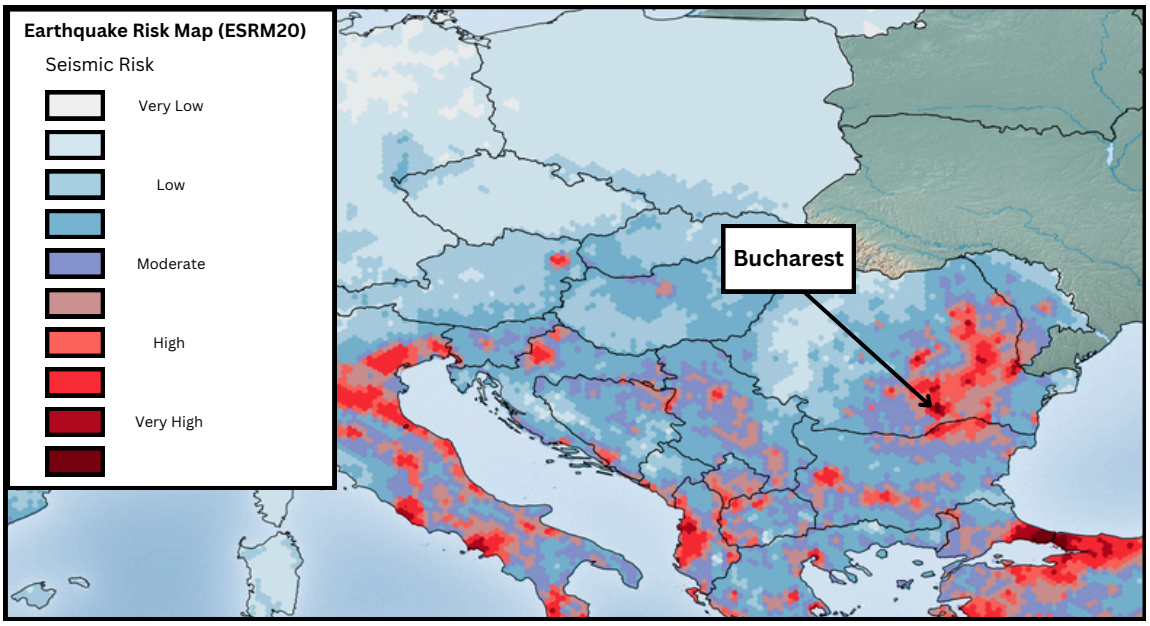



Figure 3: Earthquake risk map of Europe. Darker colors signify higher risk. (Adapted from Danciu et al, 2021)

oscillations which affect long, slender structures more. At the time of the 1977 earthquake, the regulations for seismic design in Bucharest considered that these structures would suffer less instead of more because of predominant information on surface earthquakes which in contrast had shorter periods of oscillation. The 1977 earthquake caused disproportionate damage to buildings in Bucharest because of these misconceptions. The seismic design of buildings was adjusted to account for the longer periods of oscillation after the city experienced a major earthquake in 1977 (ibid). Despite updated design suggestions, many buildings in Romania are not structurally resilient to earthquakes. As a result of poor infrastructure and lack of proper safety practices, lives and money are lost every year.

Bucharest's proximity to areas of high seismic risk amplifies the risk to this crowded city. During the last century, Romania experienced 13 major earthquakes ranging from magnitudes 6.0 to 7.9. These earthquakes collectively affected more than 400,000 Romanian citizens and caused 2,000 casualties (World Bank, 2019). In 2023, Romania experienced 31 earthquakes of magnitude 4.0 or higher, as illustrated in Figure 4 (Earthquake List, 2024).

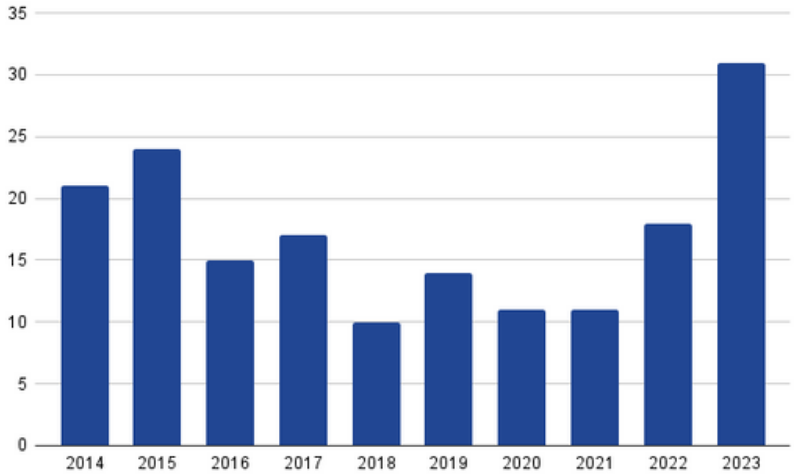



Figure 4: Yearly earthquakes within 300 km (186 miles) of Romania with a magnitude of 4.0 or above (Earthquake List, 2024).

Additionally, as can be seen in Figure 5, earthquakes in Romania cause major losses in capital every year. The darker colors indicate higher percentages of GDP affected annually. The Vrancea region contains the highest loss of GDP, due to its high seismic activity.

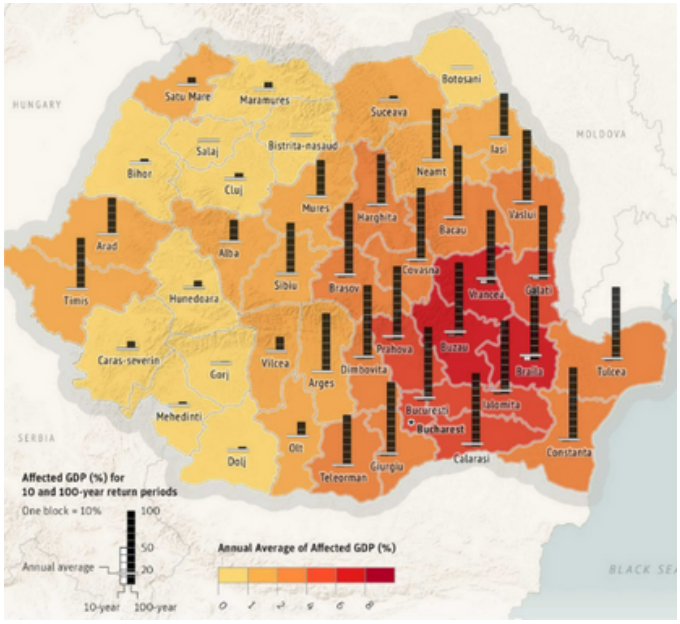



Figure 5: Annual affected GDP by Earthquakes in Romania (World Bank, 2015).

## Earthquake Risk Perception in Bucharest, Romania

A community's accurate perception of risk is an important part of disaster preparation. Given the high seismic risk in Romania's capital, one would anticipate that the citizens are both aware of and prepared to deal with the possibility of an imminent natural disaster. However, in a 2017 survey of 1,300 residents, 64% of the surveyed citizens were worried about earthquakes, 56% claimed not to be prepared, and an even smaller 8% reported having earthquake drill training (Figure 6; Armaş et al., 2017).

Only 60% indicated that they were educated on how to respond to an earthquake in the past three years (ibid.). By applying the 1,300 survey respondents to the population of Bucharest, it can be estimated that 800,000 citizens (as of 2017) have little knowledge of how to respond to an earthquake (ibid.). This data suggests that comprehensive awareness and preparedness initiatives are vital. Yet, at the start of this project, we knew little about where accessible public education on this issue was located in Romania, particularly in terms of children's education; thus, we planned several interviews with local experts once on-site.

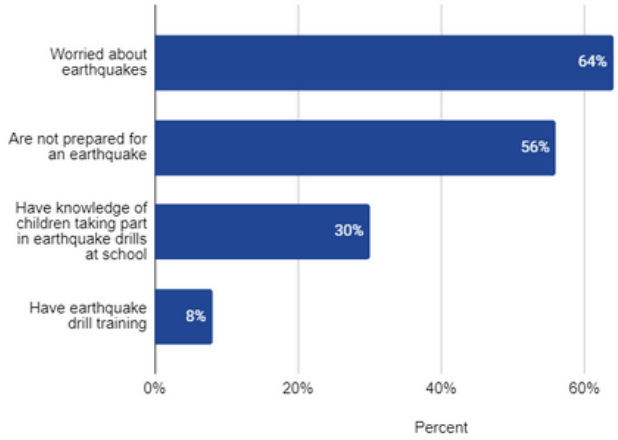



Figure 6: Results of a survey conducted in Romania (Adapted from Armaş et al., 2017).

## Code for Romania

Code for Romania is a non-profit NGO founded in 2015 and funded by sponsorship and grants from companies such as Amazon, Microsoft, and the Romanian American Foundation. They research and develop digital tools for childhood education, healthcare, support for vulnerable groups, and environmental protection. Some of their research focuses on resources for earthquake safety. One app proposed at the time this project commenced, called 'Stay Together,' aims to prevent children from being separated from families during earthquake disasters. 'Stay Together' was proposed to aid families in the construction of an emergency family plan, the creation of an emergency backpack, and provide notifications to remind parents and children about the protocols that they have created (Code for Romania, 2020). Other digital solutions the organization proposed included app concepts like 'Aoleo.ro' and 'Rescue Play'. Some concept art for the apps is shown in Figures 7 and 8. Aoleo.ro is a proposed design for a simulation-based natural disaster game, which

Code for Romania is working on releasing, that aims to educate children about the hazards associated with natural disasters and teach them how to react if a crisis does occur (Code for Romania, 2021). Techniques such as point systems, difficulty levels, quests, and repetition are outlined in the framework to appeal to players and urge them to continue using the application (ibid.). Rescue Play is a proposed gamified safety and precautionary tool that teaches children through text and video about natural disasters (Code for Romania, 2023). Conceptually, it would provide text and video information about natural disasters, first aid, and correlating safety measures to encourage collaboration with school teachers. Additionally, each user has an avatar that can gain knowledge points, accumulate skills, and unlock rewards - including backpacks, safety kits, or fire extinguishers. A monthly alert would be incorporated into the app to urge users to participate in an evacuation drill. Another feature that Code for Romania plans to implement is a safety issue reporting system. Reports could be directly sent from students to the Romanian General Inspectorate for Emergency Situations, allowing for a quick resolution. Both applications are conceptual and exist as a starting point for the scope of our own application proposal based on what Code For Romania would like to see implemented.


Figure 7: Concept art for Aoleo.ro (Code for Romania, 2021)

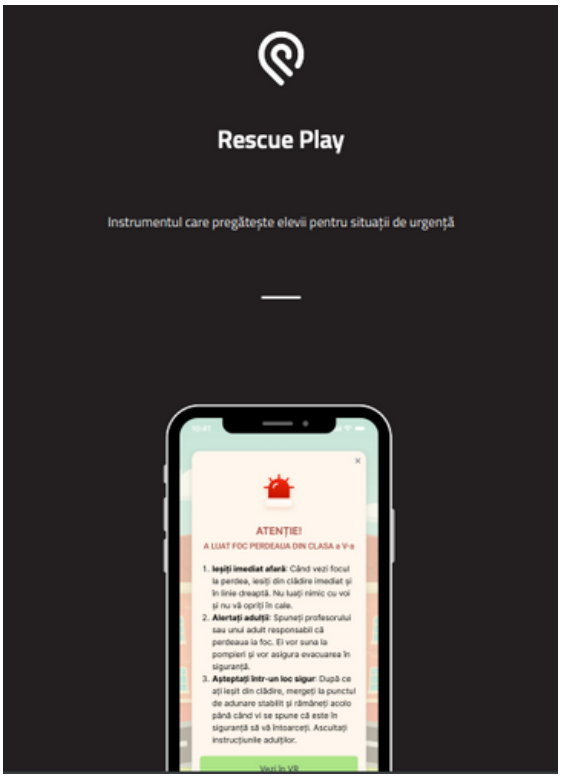



Figure 8: Concept art for Rescue Play (Code for Romania, 2023)

Like Code for Romania, organizations such as the Red Cross and governments in countries like New Zealand and the United States have recognized the need to prepare children for natural disasters. Involving children in preparation is important because, as King et al. (2013) have argued, “[it] can have the dual benefits of improving outcomes in the event of a disaster and relieving some of the child’s anxiety by demonstrating that those around them have the intention and skills to survive and cope” (p. 24). This New Zealand study found that when encountering an unpredictable natural disaster, negative emotions can interfere with a child or adult's ability to respond optimally (ibid.). By including children in preparation methods, they are less likely to be overcome with fear and helplessness in the event of a natural disaster, which allows them to respond and improves their likelihood of survival and avoiding injury.

Including children in preparation methods involves educating them on earthquake safety protocols. There are a multitude of safety protocols commonly used for adults and children around the world, which can be categorized based on when they are applicable: before, during, or after an earthquake. These protocols are generally distributed by governments, non-governmental organizations, schools, and families. Determining educational content, delivery formats, and design processes were the three major steps in working toward a proposal for an earthquake safety application. The methods we used to achieve these steps are outlined in the following chapter.


From left to right: Laura Micle, Eric Randolph, Adam Spencer, and Timory Goggin

# Methods and Results

The goal of this project is to design and propose content for a digital application that educates 6-8 year olds in Romania about earthquakes and their related safety/preparedness measures. We created three objectives to achieve this goal. In this chapter, we describe the methods and results for each of these objectives, which are outlined in Figure 9.

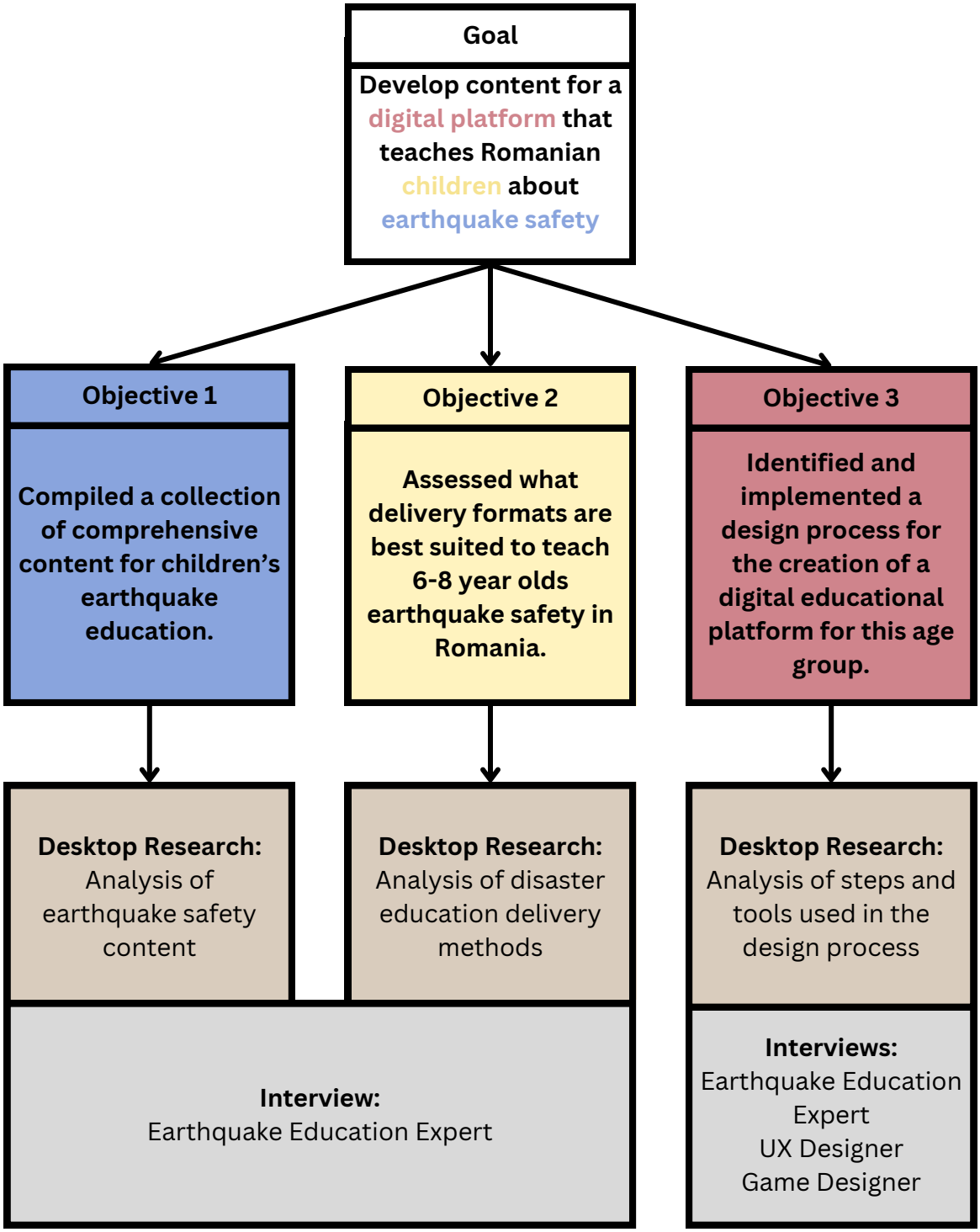



Figure 9: Our goal, objectives, and related methods

## Objective 1: Earthquake Safety Education Content

We conducted desktop research on existing earthquake education content and organizations that provide training outside of schools. By interviewing Delia Moleş, an earthquake safety education expert who works for the World Bank, we learned about gaps in existing education in Romania, identified additional content to teach, and asked about the content specifically taught to children (see Appendix A for consent script and Appendix B for interview questions).

### Findings

Drawing from eight published resources, we found that earthquake education involves safety protocols before, during, and after an earthquake, often including the content outlined in Figure 10.

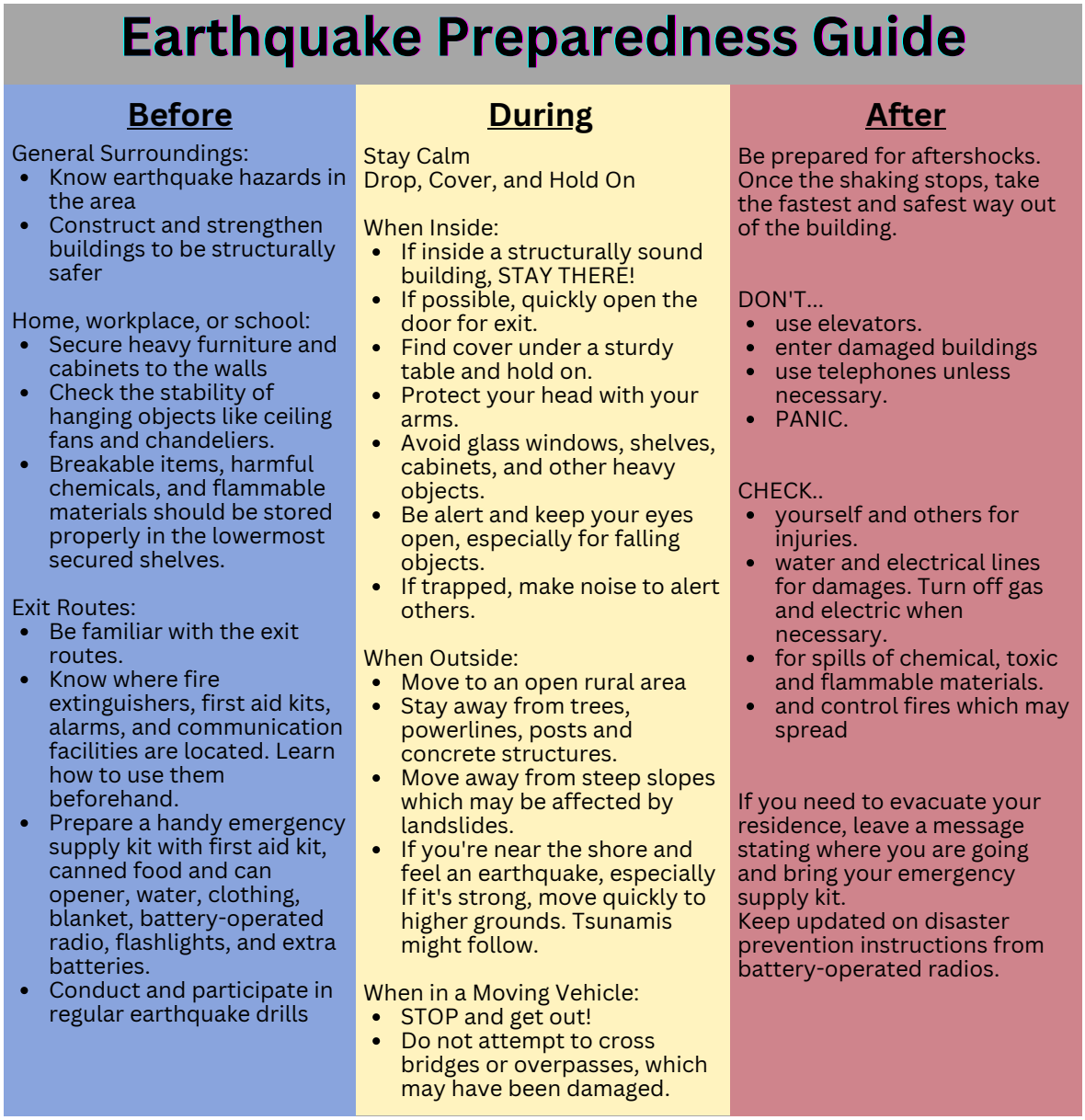



Figure 10: Earthquake preparedness measures to take before, during, and after an earthquake (Philippine Institute of Volcanology and Seismology, n.d.; Adapted from Security Matters, 2011)

Before an earthquake, education protocols raise awareness about what earthquakes are and the risks involved, as well as what to do to prepare. This education often starts in school science programs, which **explain the processes that occur below the earth's crust and illustrate the causes and danger signs of earthquakes**. In addition, government agencies and non-government organizations provide **actionable measures**, such as preparing a house, workplace, or school by securing large pieces of furniture or breakable items (USGS, n.d.). Governments can also provide ordinances to ensure safer buildings and to "address structural deficiencies known to pose a collapse risk" which "drastically improve resilience against earthquakes" (Gebeleine et al., 2017, p. 14).

In addition to earthquake-proofing buildings, people can proactively **assemble supplies for an earthquake safety kit**. There are two primary forms of safety kits that can be prepared: a shelter-in-place kit and an emergency backpack (Figures 11 and 12).

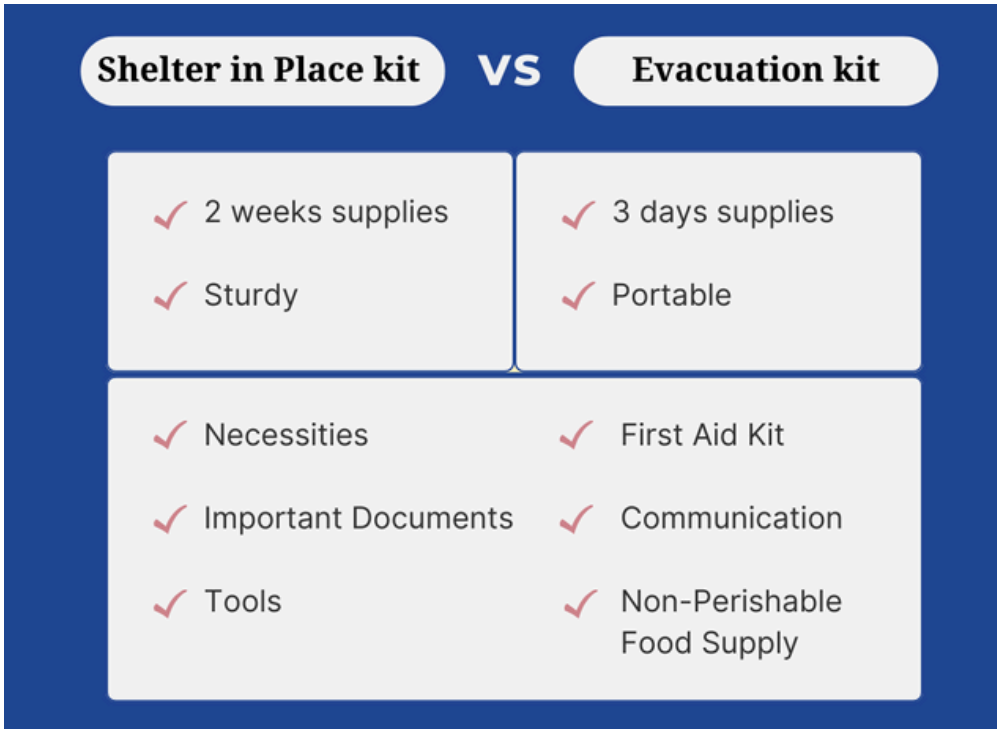



Figure 11: Similarities and differences between a shelter-in-place kit and evacuation kit.

When preparing for what to do during an earthquake, **earthquake drills** can be performed in schools, workplaces, and communities. Schools, such as those in Turkey, use drills to prepare students on what to do in the event an earthquake takes place while they are in the building (Çoban and Göktaş, 2022). These drills involve the standard practice of **dropping, covering, and holding on when an earthquake occurs.** During an earthquake, one should drop or crouch down low to the ground to limit the effects of the shaking. Then, cover yourself by moving under a sturdy table or desk for protection from objects that might fall or break. Finally, hold on to a sturdy object to resist shaking. New preparedness protocols in Mexico have also included evacuation drills at a larger scale, i.e. across states (American Red Cross, 2021). Drills allow individuals to practice location-specific procedures in a safe environment, identify possible problems, and adjust before an actual disaster. Families can also prepare their homes or instructions for children, detailing where to go and what to do when a disaster strikes.

Preparedness protocols also include what to do after an earthquake occurs.

# Earthquake Safety Kit Checklist

## Necessities


- Water supply
- Supply of nonperishable food
- Can opener
- Prescription medications
- Toilet Paper
- Whistle

## Non-Perishable Food


- Ready-to-eat canned meats, fruits, veggies
- Canned juices, milk, soup
- Sweetened cereals
- Salt, pepper, sugar
- Peanut butter, jelly, crackers
- Granola bars, trail mix, dried fruit
- Cookies, hard candy, instant coffee, tea bags

## Important Documents


- Passports
- Licenses
- List of needed medications
- List of medical history, doctors, insurance company, and contact persons
- Photos of family members
- Cash: small bills are the best for emergencies
- Local maps (paper)
- Extra pair of glasses

## First Aid Kit

- Tape roll
- Scissors, tweezer
- Foil Blanket
- Examination gloves
- Allergy medication
- Adhesive bandages, in all sizes
- Instant cold pack, hot pack
- Antiseptic cream, burn cream
- Aspirin or Acetaminophen
- Alcohol pads, gauze pads, and gauze roll
- Finger splints/tongue depressors
- Eyewash

## Tools

- Fire extinguisher
- Duct tape
- Work gloves
- Dust mask
- Sterno
- Flashlight with extra batteries in every room
- Matches in a waterproof container
- Knife, pliers, and scissors
- Manual can opener
- Water purification tablets
- A water-resistant or waterproof tarp

## Communication

- Battery-powered AM-FM radio
- Power packs for phones
- Paper: notebook
- Writing Utensils: pens and pencils
- Download information onto phones and tablets
- GPS tag

Figure 12: Supply list for an earthquake kit (Adapted from California Earthquake Authority, 2019).

**Communication procedures**, such as where to access public service messages, warnings, instructions, and aid in times of disaster, can help people to stay informed and find safety after an earthquake occurs. **Knowing places to avoid and possible signs of danger can** be vital to survival and minimizing injury. Protocols that distribute information or coordinate response actions are often organized by governments, non-governmental organizations, schools, and families. National or local governments, as well as non-governmental organizations, outline plans for how to distribute aid resources in the event of an earthquake and how to update the community as the disaster unfolds.

In Romania, the government helps citizens know what buildings are unsafe through a classification scheme. Romania has a **building classification for types of seismic risk**, which uses a scale of 1 to 4 to indicate how affected it would be by an earthquake similar to the one in 1977 (Ilie, 2017). Buildings with seismic risk 1, the ones that will suffer the most damage during an earthquake, are required to be labeled with a red warning dot as seen in Figure 13 (ibid.). Owners of these buildings are subject to fines if they rent them to other tenants.

Figure 13: The red circular sign posted on buildings of class 1 seismic risk.

The earthquake safety protocols described above are generally targeted toward older children and adults. Children aged 6-8 were chosen as the intended age range for this proposed application, but in the future, it may be expanded and adapted to other age groups as well. Moleş highlighted some key points that aided in this decision:

- Though some schools implement drills, earthquake education is not mandated in schools in Romania, so an app for children would be useful to use at home or in school
- Most existing material is for adults, so more simplified information for young people is needed
- Very young children will have no recent memory of an actual earthquake and they may not yet have experienced a drill, so they may need a great deal of explanation
- Children are more open minded toward learning safety measures than adults, and by targeting very young children, the app could also reach their parents
- Most information taught to adults can be taught to children by adapting it and limiting details (e.g. rather than explaining the difference between an emergency backpack and a shelter-in-place kit, teach about safety kits and what supplies goes in them)

Regarding content that should be included, Moleş also stressed that:

- There is a lot of outdated information and blatant misinformation about earthquakes in Romania that needs to be addressed
- When an earthquake occurs, people often become disoriented and less mobile, which is why it is crucial to prepare ahead of time aids for effective responses.

While compiling comprehensive earthquake education content, we also learned how to deliver these concepts specifically to children. The techniques for teaching adults and children can vary immensely, especially when considering sensitive topics, such as earthquakes, which can cause death and destruction. Evaluating how to deliver content about earthquakes and earthquake safety to children effectively was the next major step in working toward creating the application proposal.

## Objective 2: Earthquake Safety Education Delivery Formats

For this objective, we examined delivery formats used in nine sources, mostly focusing on digital components, and we interviewed Delia Moleş to investigate effective delivery strategies. In the interview with Moleş, described in methods for objective 1, we also asked how earthquake safety is taught to children in Romania and what delivery formats could be applied to the digital platform we designed (see Appendix A for consent script and Appendix B for interview questions).

### Findings

Through this research, we found four primary techniques: **simulation, stories, physical models, and games.** Figure 14 contains a summary of these practices and the reasons why they are effective. Online tools are becoming much more common for teaching earthquake safety. According to Çoban and Göktaş (2022), user interaction in a digital platform improves engagement compared to lecture-based learning. They researched earthquake safety education practices for children in Turkey and found that "activities, which allow the students to have real experiences in the learning process, can increase the success of earthquake education" (Çoban and Göktaş, 2022). **Experience-based learning, like simulations, allows information to be connected to a physical memory.** It also allows children to make mistakes and correct them within a safe practice experience, which is why simulations through drills and games are an effective method for earthquake education. Within their study, Çoban and Göktaş used an interactive game, shown in Figure 15, to simulate the experiences children would encounter during an earthquake. Although noting that physical drills are normally the most effective for children, they found that digital simulations are helpful supplemental tools. Simulations can be used within a digital application to show children what to seek–such as supplies–where to find safe shelter, and how to reach out to emergency responders. A simulation can also demonstrate the need to avoid unsafe areas and stay with trusted individuals in the event they experience an earthquake.


Figure 14: Summary of practices used in earthquake education (Çoban and Göktaş, 2022; Moles, 2020; Earthquake Simulator, n.d.; BabyBus, 2016).


Figure 15: A scene in the digital game that children played in a study regarding children's earthquake education practices (Çoban and Göktaş, 2022).

Physical models can also be useful. A study conducted in Romania had 4th-grade students model a building using office supplies, as depicted in Figure 16 (Dobre et al., 2015). The students then simulated an earthquake by shaking the base in both horizontal directions to demonstrate weaknesses and underscore how building stability is critical (ibid.). **Modeling can illustrate the effects of earthquakes on various structures.** A similar model could be achieved on a digital platform using drag-and-drop features to build physical structures and test the effects of different earthquake magnitudes. A digital platform could also instruct a child to build the model using supplies from their surroundings. Based on how the structure was built or shaken, various outcomes could occur which would aid in a child's ability to spot unsafe structures during or after an earthquake.

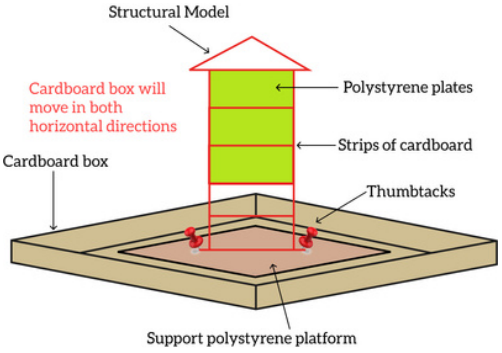



Figure 16: A model of the structures built by fourth graders to simulate earthquakes effect on buildings (Adapted from Dobre et al, 2015).

Current earthquake educational practices for younger children involve story books, which feature bright visuals, simple plots, and basic vocabulary. An example of such a story is depicted in Figure 17, which features some of the components used to gain and maintain a younger child's attention. Although Earthquake by Bauer and Wallace does not teach earthquake safety protocols, other research involved storybooks that incorporate safety protocols within the plot. A study conducted in Turkey that used storybooks to teach children about road safety indicated that content with illustrations and elementary text was an effective method of teaching young children (Ahmad et al., 2018). **Including vibrant visuals, clear plots, and relatable characters within specific aspects of the digital platform will help engage younger children who are not skilled readers and who may have trouble understanding abstract concepts.**

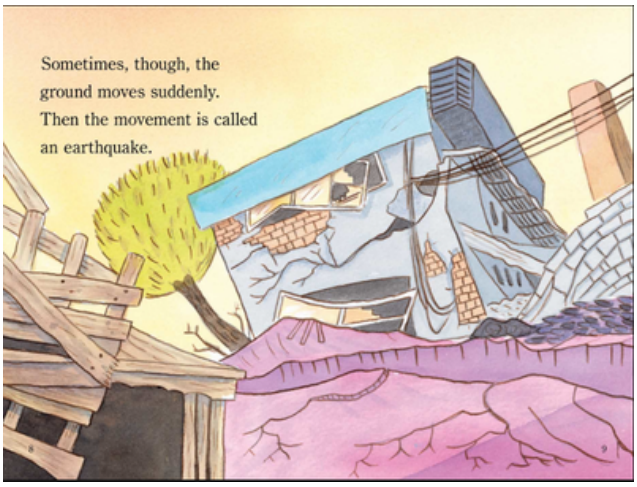



Figure 17: A page in a children's story book about earthquakes (Bauer and Wallace, 2019).

To appeal to younger age groups, many educators have gamified educational content incorporating game features. Games need a story with a challenge, an end goal, characters, settings, rules by which the characters can act or progress, and rewards for when players do progress. Game aspects, such as rewards, badges, levels, experience points, leaderboards, etc. enhance extrinsic motivation which gives the user a reason to want to continue to play. Numerous instances worldwide showcase gamification as a way to teach about natural disasters. These applications aim to both enhance the retention of natural disaster knowledge and to appeal to younger audiences, sustaining their interest in learning. Two of these applications are described in Table 1.

| Application | Description | Key Features |
|---|---|---|
| Baby Panda Earthquake Safety (Baby Bus) | An animated panda avatar guides players through mini-games and earthquake survival scenarios. The engaging games stimulate users' interest and aids in information retention. | • Avatar<br>• Mini-games such as matching and building games<br>• Tactile interactivity |
| Stop Disaster! (United Nations Office for Disaster Risk Reduction) | An online game that aims to educate its users on the risks of natural disasters such as earthquakes. Players are given money to use to protect the population from a natural disaster. | • Intrinsic motivators: visually appealing UI and engaging content<br>• Extrinsic motivators: score and levels<br>• Goal and rules: protect a population from natural disaster by building resources |

Table 1: Two applications that showcase gamification as a way to teach about natural disasters (BabyBus, 2016; Kankanamge et al., 2022).

To motivate a user to continue to engage in the activity, a game can provide the user with a sense of intrinsic and extrinsic motivation. Intrinsic motivation is driven by the internal satisfaction of an activity because they enjoy it, think it will be useful, or feel pressure to finish. Whereas, extrinsic motivation is driven by an external reward such as badges or points. One study that evaluated the impact of Stop Disasters! on children's awareness of natural disasters and their motivations to keep playing, found that participants believed interest and value were the highest-ranked internal motivators while risk meter and score were the highest-ranked external motivators (Kankanamage et al., 2022). Another study found that 5th grade children who learned from an android-based earthquake game had a higher average earthquake preparedness test score (87%) than those who learned the same information from an educational video (79%) (Winarni et al., 2021). These findings suggest that **gamified education may be more appealing and may lead to enhanced retention rates compared to traditional methods**, which would be beneficial in an online platform for 6-8 year olds.

Instructions are a common component of games that should be available for users to reference as needed. Long tutorials and interrupting gameplay should be avoided whenever possible because they can disengage users (Fisher, 2017). Instructions should identify the goal state, start state, and how to achieve the outlined goal such as through a cursor demonstration (Experience, n.d.). When creating games for 6-8 year olds, it is important to consider their **developmental point**. This age range is "able to follow multiple-step instructions and can switch tasks easily while holding multiple rules in mind" (Fisher, 2017). They understand different perspectives and show a preference for stories or characters that involve rhymes or humor (ibid.). Game designs can include multiple-step instructions delivered through characters to improve engagement. Some game genres that would be useful for this age group include maze, puzzle, adventure, simulations, and resource management where users are given a collection of resources and decide how to use them to achieve a goal.

Simulations, models, stories, and games are used in disaster education. In simulations, the user gets to make decisions about what to do in earthquake scenarios. Physical modeling allows people to test the effects of earthquakes on a small, visible scale. Stories about earthquakes embed lessons where the characters use preparation and response strategies. Games act as an interactive tool that can encompass all of the important aspects of the other three practices. Each of these practices has valuable aspects to them, which we took advantage of when creating content for a digital solution.

In addition to the formats of delivery that were found through desktop research, the interview with Delia Moleş highlighted some important delivery strategies to consider when teaching children:

- Children need time and repetition to retain information
- Information should be broken into smaller sections
- Content should be delivered through relatable characters that are their age or a personalized avatar
- Incorporating activities with parents can help to educate both groups at the same time

## Psychology of Natural Disaster Education

Educating children about natural disasters involves potential psychological risks, so delivery must be designed to reduce the possibility of traumatizing them. A study conducted in Romania explored the differences between proactive and reactive earthquake education, revealing that if "children understand the nature of the seismic hazard, have knowledge of protective behavior, and know they have strategies for coping with the event, it is likely that negative emotions such as fear and distress can be tempered" (Dobre et al., 2015, p. 41). Employing techniques that diminish the effect of negative emotions, such as activities involving safety measures, are proven most effective in preparing children for earthquakes and can be implemented as early as primary school (ibid.). Each related activity forms a deeper understanding of earthquakes, which tempers potential fear of the unknown and provides participants with strategies to help when experiencing an earthquake.

Furthermore, a study conducted by Marti et al., found that inducing mood, manipulating perceived risk, and use of gain/loss frames can significantly change homeowners' attitudes toward earthquake precautionary measures (2018). Before presenting information to the participants, positive and negative moods were induced in them using motivators like jokes or sad images. The perceived risk was manipulated using specific language; an example of a high-risk sentence that was used is, "the next strong earthquake is overdue", compared to one that portrays low-risk, "the next earthquake is impending" (ibid.). Similarly, gain and loss frames were used to characterize the effects of taking or not taking particular actions in an emergency situation. Gain frames stress that if the person is proactive and applies certain actions, there will

be a positive outcome. An example of the wording used in the study is, “homeowners taking responsibility for earthquake safety only create benefits.” Loss frames stress the negative outcomes a person will experience if they do not take the prescribed actions. This was done in the study using the following phrase, “homeowners not taking responsibility for earthquake safety only create losses” (ibid.). As can be seen in Table 2, people were most likely to positively react to general earthquake safety information when it was preceded by a negative induced mood, high risk, and a gain frame; only considering positive induced mood, the second best option, and a more ethical and light-hearted way, uses low risk and a gain frame. While the former is the most efficient way to provide information, inducing a negative mood, and emphasizing the negative outcomes of earthquakes too much could have adverse effects on children, possibly inducing excessive fear or anxiety in them. Referencing triggering content to children would be ineffective when trying to communicate information to them, as they may become upset or cry, rather than being open-minded. Keeping the mood positive, risk perception low, and using a gain frame when presenting information will be the best way to educate children on the matter of earthquakes. Retaining a positive mood in the children will help them to keep an open mind and be willing to accept the information being presented to them. Stressing the positive impacts of an action, while maintaining a realistic level of risk, will help the children remain secure within their emotions and not worry more than necessary about the topic. This will ensure that the information presented is retained as much as possible.

| Mood Manipulation | Risk Manipulation | Frame-Type Manipulation | M | SD | p |
|---|---|---|---|---|---|
| Positive Mood | High Risk | Gain Frame | 3.02 | 0.26 | 0 |
| | | Loss Frame | 3.05 | 0.24 | 0 |
| | Low Risk | Gain Frame | 3.24 | 0.21 | 0 |
| | | Loss Frame | 2.96 | 0.22 | 0 |
| Negative Mood | High Risk | Gain Frame | 3.3 | 0.22 | 0.002 |
| | | Loss Frame | 3.66 | 0.25 | - |
| | Low Risk | Gain Frame | 3.3 | 0.22 | 0.12 |
| | | Loss Frame | 3.04 | 0.19 | 0 |

Table 2: Homeowners’ attitudes toward general precautionary measures for earthquakes relative to manipulated mood, risk, and frame type (Adapted from Marti et al. 2018)

While completing research on content to include and how to deliver it, we learned about the design processes used when creating a digital application. The next part of the process was to evaluate how to effectively design an application to teach children about earthquake safety.

## Objective 3: Earthquake Safety Education Design Process

By examining resources about designing children's games and collaborating with Simina Harla, a UX design volunteer at Code for Romania, we identified the steps and tools used in the

design process. By conducting interviews with a game designer, who has spent roughly eight years in mobile app development, and Delia Moleş we received feedback on existing designs for the application (see Appendix A for consent script).

## Findings

Through our collaboration with Harla, we learned efficient ways to **brainstorm**, **organize**, and **prototype** ideas. The general design process we followed is outlined in Figure 18.

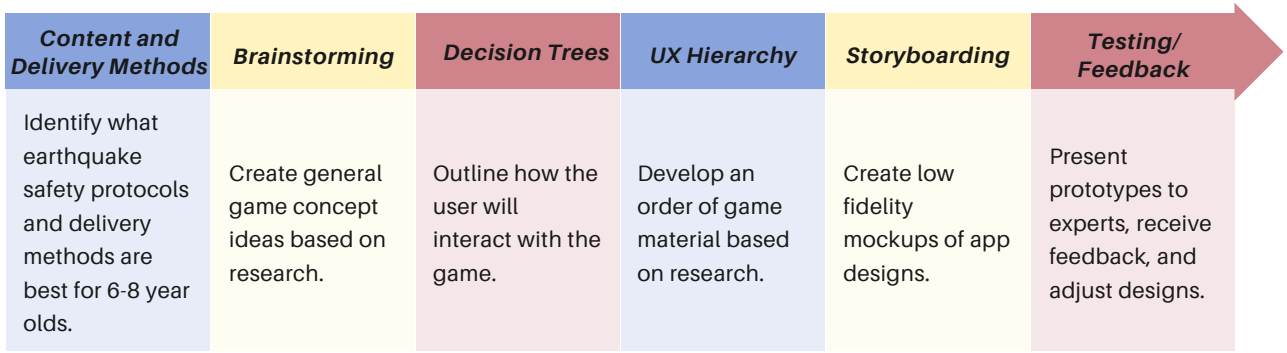



Figure 18: Stages of design followed within this project.

## Brainstorming

In our discussions with Harla, we learned about design tools for the early stages of development and gamification. We asked her about her experiences with UX design, the processes that she has used, and what tools she recommended we use for our use case. The first, and simplest of these, involved techniques for brainstorming app/game ideas, which are summarized in Appendix C. The three tools that we used were crazy 8s, lightning demos, and research of existing games. Our designs started on pen and paper with low fidelity, as **jumping to conclusions and too much detail at the start can lead to wasted time** and scrapping work. As a result of these techniques, we came up with four initial concepts for games/activities that were developed into the final prototype. The first was a series of activities meant to be completed with a guardian, which covered family emergency plans and preparation methods. Second, a safety kit building game. Third, an earthquake simulation game, allowing children to see what could happen during one and what they can do to protect themselves. Last, a trivia game that would be used to provide repetition.

## Decision Trees

After solidifying initial game concepts, we considered user interactions with the games. To do this, we created **decision trees - flow charts depicting what the user would see in the application and how they could interact with game elements**. We created decision trees for major components of the application, indicating prompts that would be displayed on the screen and choices the user would be given, without actually creating visuals or in-depth content that would need to be updated as designs changed. An example of one of our initial decision trees can be seen in Figure 19. The yellow circle denotes a starting screen, the green rectangles signify screens or prompts within the game, and the red triangles identify transitions based on user input.

## UX Hierarchy

After activities, games, and instructions were decided, outlining the order in which they

should occur was the next major obstacle. A UX hierarchy, which is a flowchart of the content and sections in an application, helped us to organize the app segments. The hierarchy provided an overview of the app's proposed flow, which made planning and editing easier. Ensuring engagement was an important consideration in this. If the segments of the application were presented in an order that was not appealing to a child, none of the content would even matter — they would be bored from the start and not want to continue playing.

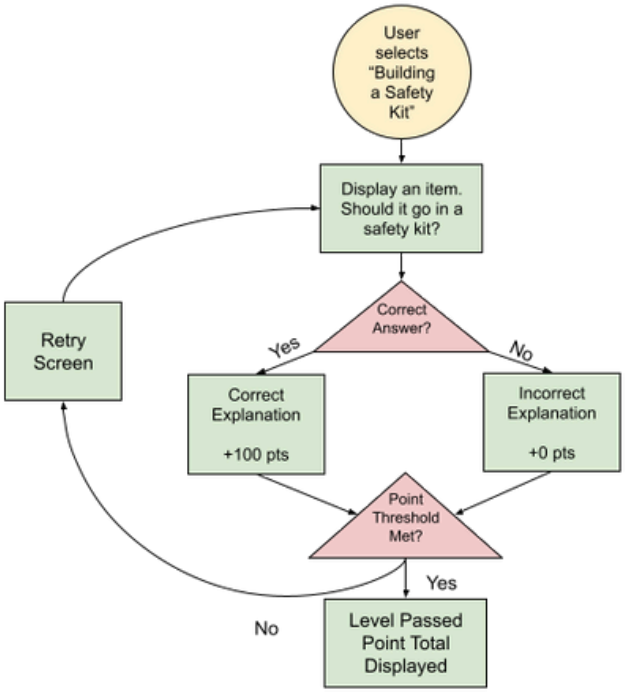



Figure 19: Decision tree for an initial version of a earthquake safety kit game .

## Storyboarding/Prototyping

With an outline of the intended content, delivery, and app flow, we began the process of storyboarding the designs. Storyboarding provided detailed visuals of the app's flow, screen designs, and activities within the app. Although it began on paper, storyboarding was primarily done on Figma, a prototyping tool where different screens can be clicked through. This stage of the design process aided in feedback and **exposed flaws in ideas that were not previously considered**, allowing us to correct mistakes efficiently.

## Testing and Feedback

Using the storyboards as a prototype, we sought feedback on the designs. User testing with the intended age range would have been useful, but given the fidelity of the prototypes, other sources were ideal. Throughout the process, we showed our ideas and designs to our advisors, our contacts at Code for Romania (Micle & Harla), as well as Delia Moleş and the game designer. These individuals provided feedback in the iterative design process, which allowed for continuous improvement. Points of feedback and corresponding improvements are outlined in Table 3.

It was important to get feedback early and frequently to correct mistakes before we delved further into the design process.

| Feedback | Adjustment in Prototype |
|---|---|
| Prioritize Engagement | • Maintain a short and relatable introduction video<br>• Put attention-grabbing activities first in the game flow<br>• Teach users how to use game mechanisms<br>• Vary the types of activities used<br>• Have the child act as the leader so they are motivated<br>• Use positive reinforcement for encouragement |
| Adapting for Children | • Use age-appropriate wording<br>• Avoid abstract visuals or icons<br>• Consider how information can be misinterpreted and how that could be harmful to children<br>• Account for accidental screen touches<br>• Include audio or visual feedback when users touch the screen |
| Repetition | • Repeat information within each section's activities<br>• Repetitive format in application flow |
| Children's Psychology while Learning | • Avoid presenting information in a loss frame and high risk so anxiety or fear are not induced in children<br>• Focus on teaching proactive measures that will have positive outcomes (i.e. gain frames and low risk) |

Table 3: Feedback received during the design process and the adjustments made as a result.

After fulfilling our objectives, we produced several deliverables that detailed our designs for a digital application to teach Romanian children about earthquake safety.

# Deliverables

Our proposed design is detailed in a UX hierarchy, content and delivery table, and a final prototype. The UX hierarchy shown in Figure 20 outlines the parts of the application and the general flow between each part. Within the hierarchy, there are seven major segments. The first teaches what earthquakes are and how they can be harmful. It includes an opening animated video that shows the causes and effects of earthquakes followed by two activities: an activity where children would construct a simple structure with supplies at home and shake it to show the effects of earthquakes, as well as a coloring activity. The next four segments, which are the main gamified section of the application, contain a mix of games and at-home activities, as well as trivia and coloring activities. In the game for safe spaces, we used a simulation that shows the inside of a bedroom and other locations, where the user can pick which places they think are good to hide during an earthquake. The at-home activity follows a similar format: identifying good places to hide in their own home and taking photos of them with their parents/guardians. Following the safe spaces segment, we teach about earthquake safety kits, again including the four parts listed in the previous section. The game follows a "this-or-that" format, in which the user picks one of two items to include in a safety kit. The at-home activity provides a checklist and the children are instructed to assemble a safety kit from supplies at home with their parents. There is a section about evacuation plans, including a game and at-home activity that teaches how to find meeting places and how to interact with first responders. In the section about communication plans, children learn how to get help if they're left alone during a disaster. The at-home activity consists of creating an emergency ID card to help children get help from trusted adults after an earthquake. There would be an additional trivia game at the end, repeating all of the information covered throughout the game. A parent information menu is also available for those who want to learn more about the concepts being taught to their children. It includes educational videos and text, as well as embedded links to websites and other sources of information.

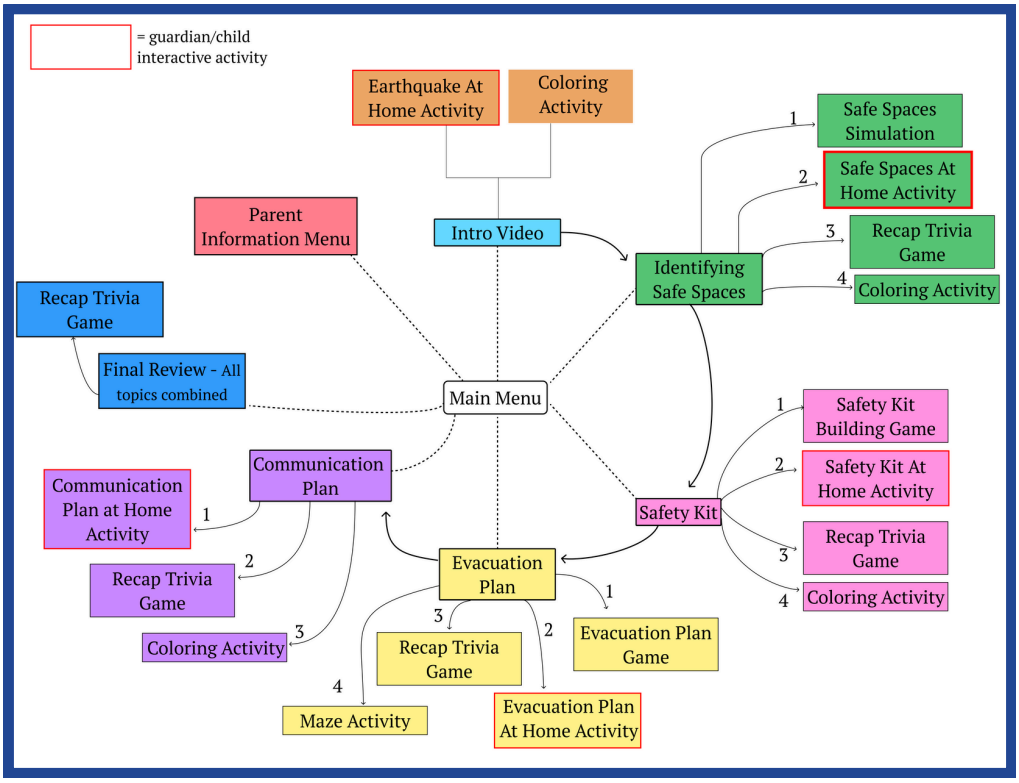



Figure 20: The UX hierarchy used to outline the flow of the application.

## Content Syllabus with Delivery Formats

The content syllabus contains a comprehensive overview of the content that should be included and the formats in which the content is intended to be delivered. A visualization of each content section from Figma with details on functionality is also provided.

| Content | Delivery Format |
|---|---|
| Topic I: What is an Earthquake?<br>**Goal:** Inform the user on what an earthquake is and its possible effects to create a foundation for earthquake knowledge, safety, and preparedness.<br><br>An **earthquake** is the sudden shaking of the ground as a result of the Earth's tectonic plates moving, causing the release of seismic waves.<br><br>During an earthquake, **seismic waves** cause the ground to shake. This can cause buildings to sway, shudder, or even collapse entirely. Objects hanging on walls can fall and break or cause injury. The walls of buildings may crack and groan, gas lines can rupture and cause fires, and water lines can rupture and cause flooding. Glass windows will rattle and potentially shatter. Any furniture or objects not securely attached to the floor or wall can topple over and fall.<br><br>**Aftershocks**, or lower-intensity tremors originating from the same location as the original earthquake, can occur in the time after an earthquake subsides. These aftershocks can occur within the first hour of an earthquake, and the sequence of aftershocks can persist for days after the earthquake has subsided.<br><br>**Child Adapted Content**<br><br>What is an Earthquake?<br>• An earthquake causes the ground to shake<br>• There are big and small earthquakes. | **Interactive Video**<br><br>Objective: Introduce the concept of an earthquake and its effects; provide background context on Romania and its seismic vulnerability; why do we need to know about earthquakes in Romania?<br><br>Topics: I, II<br><br>Executive Summary: The viewer follows an animated cartoon character as they experience the effects of an earthquake. This draws inspiration from the Prepare with Pedro video linked below. The character could then briefly explore what an earthquake is and what causes them through other characters.<br><br>The first few minutes of engagement with the application are critical to keeping the child's interest. As such, it is important that the visuals are simple, colorful, and attractive.<br><br>To aid in engagement, the video is intended to have a simple interactive element. This could take the form of something such as having the character ask the child to tap on an item they are looking for before the video resumes. Another way to do this would be to use a slider to demonstrate the effects of different magnitude earthquakes on a building.<br><br>Examples: Prepare with Pedro<br><br>**Optional Earthquake Home Activity** |

What Causes an Earthquake?
- Movement underneath the ground

What are the Effects of Earthquakes?
- Small earthquakes might shake things around your house
- Large earthquakes shake the ground and might knock down furniture or paintings on your wall. It could even knock down some buildings
- Buildings and trees will shake
- You will feel shaking and may fall down
- Things around you might fall or break

Topic II: Romania and Earthquakes

**Goal:** Provide context as to why it is important to be prepared for earthquakes in Romania by highlighting its seismic vulnerability and high frequency of earthquakes.

Romania has one of the highest seismic risks among all European countries. The Vrancea intermediate-depth seismic zone, a region of recurring high-intensity earthquakes, is located 160 km from Bucharest.

On average, Romania experiences 15.2 earthquakes per year that are of magnitude 4 or higher, with the strongest earthquake since 2000 being a 5.9, and the strongest since 1950 being a 7.8 (Volcano Discovery, n.d.).

The last major earthquake that Romania experienced occurred March 4th, 1977, and had a magnitude of 7.8. The earthquake lasted 56 seconds and resulted in (47 Years Since The 1977 Earthquake, 2024):
- 1,578 deaths (1,424 in Bucharest)
- 11,321 injuries (7,598 in Bucharest)
- 32,900 homes severely damaged
- ~200,000 people directly affected

Buildings with seismic risk class 1 in Romania are marked with a red circular sign denoting the risk. These buildings are often referred to as “red dot buildings.” These buildings are in imminent danger of collapsing or experiencing major structural damage in

Objective: Teach the child the effects of an earthquake. Prompt the child and their family to participate in an actionable task that can prepare the whole family about earthquake knowledge.

Topics: I (Earthquakes)

Executive Summary: Guardians and children work together to build a structure with household supplies based on what they have available. Children can be creative in their designs of a structure. They will be instructed to shake the structure, maybe by shaking the table, to simulate an earthquake occurring. Following the activity, parents and children should discuss what happened when the structure was shaken, identifying any movement, breaking, or falling.

the event of a moderate to strong earthquake.

These buildings are not safe to be around or inside in the event of an earthquake strong enough to cause damage to buildings.

**Child Adapted Content**

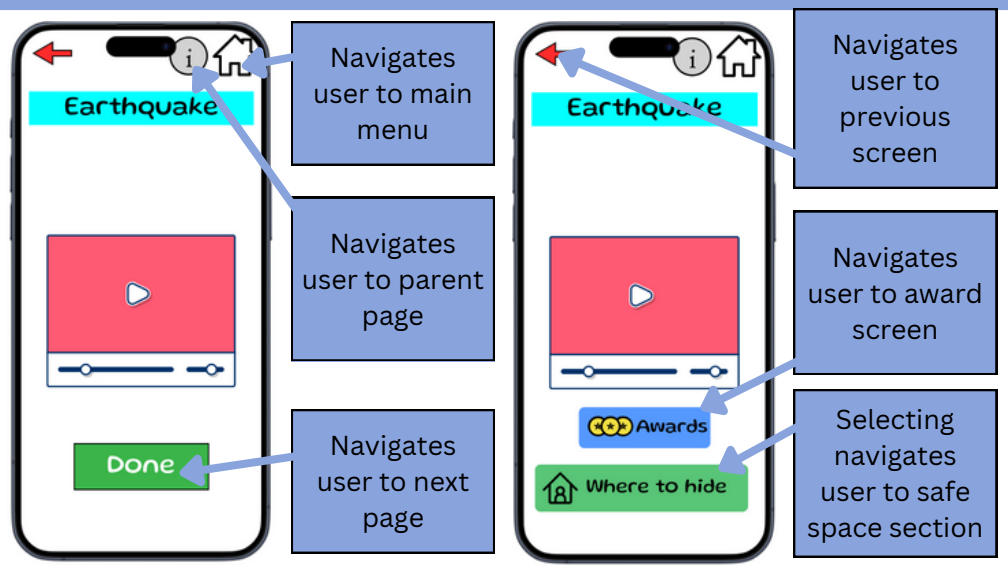
Does Romania have earthquakes?

- Yes, there are many earthquakes in Romania
- Earthquakes happen almost every day, you usually just can't feel them

What do the red dot signs on buildings mean?

- Red dot signs are on buildings that are not safe during an earthquake
- These buildings are more likely to break or fall when shaken
- Stay away from buildings with these signs
- While the red dot buildings are definitely not safe, that doesn't mean every other building is safe during an earthquake

## Figma



| Content | Delivery Format |
| --- | --- |
| Topic III: What to do During an Earthquake<br>Goal: Provide instructions/steps for what to do when an earthquake occurs, depending on whether you are inside or outside; provide instructions for the Drop, Cover, and Hold technique.<br><br>Do not attempt to enter any buildings during an earthquake if you are already outside. It is important that you move away from trees, buildings, or other tall structures that could potentially fall or collapse during an earthquake.<br><br>As soon as possible, get low to the ground, cover, and hold onto something sturdy until the earthquake passes.<br><br>**Child Adapted Content**<br><br>What do you do when you feel the ground shaking?<br>• Stay calm<br>• **Drop:** Get close to the ground. When the ground shakes it can knock you over. By being low to the ground you are less likely to get hurt if you are knocked over.<br>• **Cover:** Move under a strong table or desk. This should protect you from anything that falls or breaks. If you can not find a table or desk, cover your head with your arms.<br>• **Hold On:** Hold on to the table, as it or you could move during an earthquake. If you are not under a table or desk hold on to a strong object that does not seem like it will move. Hold on until the shaking stops. Sometimes more shaking will occur after it stops. Be prepared for this and stay close to something you can hold on to.<br>• Being outside when an earthquake happens can be safer and you should not go into a building if an earthquake happens. If you are outside, stay away from trees, buildings, or tall things because they could fall. Always drop, cover, and hold on.<br><br>Topic IV: Family Emergency Plan | **Identifying Safe Spaces**<br><br>**Earthquake Simulation**<br><br>Objective: Simulate the experience of an earthquake in a household/school/outside; teach the player about safe spaces by allowing them to make their own decisions and experience the effects; demonstrate what constitutes a safe space<br><br>Topics: IVa (Safe Spaces), III (During an Earthquake)<br><br>Executive Summary: The user controls their avatar in a variety of locations during an earthquake. They are prompted with options for where to go and what to do during the shaking and can choose where and what they think is best.<br><br>It is critical to consider extrinsic motivators for keeping children engaged in the application, and this is one place in which they could be utilized effectively. Such motivators include points, levels, awards, leaderboards, etc.<br><br>Chosen options that are not safe will be met with a demonstration on why that is the case, and the user will be prompted to select a different location. If there are fragile objects hanging in the vicinity, they will fall and break, for example.<br><br>**Safe Spaces Home Activity**<br><br>Objective: Teach the child how to locate safe spaces in their surroundings. Prompt the child and their family to participate in an actionable task that can prepare the whole family unit.<br><br>Topics: IVa (Safe Spaces)<br><br>Executive Summary: Guardians and children work together to |

**A. Identifying Safe Spaces**

**Goal:** Teach children and adults the types of places that they can hide during an earthquake. Reinforcing the concept of a safe space will help people to identify them in whatever area they are in if an earthquake were to occur.

Safe places within the house are away from objects hanging from the walls that could fall and break. There shouldn't be any tall furniture that could topple and break, cause damage, or block entryways. Additionally, there should be areas of the room or space that are not near any windows, which could shatter and cause additional injury. Safe spaces are **not** places in which someone can get trapped; inside a cabinet is not an earthquake safe space, as it can fall over and trap someone inside.

There is no guarantee that every location will have a space that meets all of these criteria. It is important to find spaces that meet as many as possible and reduce the risk of injury or entrapment.

During an earthquake, there is a tendency for unsecured objects to shift and move around the room. Without proper precautions, these objects could shift and block exits, or collapse and cause damage to people or the room.

In order to ensure that a space is as safe as possible in the event of an earthquake, certain precautions can be taken. Furniture can be secured to the floor or wall, heavy objects moved to the bottom of shelves, and entryways can be cleared of potential falling hazards that could block the doorway.

**Child Adapted Content**

What makes a space safe during an earthquake?

- Objects/furniture are secured to the wall or floor and cannot move
- Nothing hanging above your head
- Heavy objects are low to the ground
- Under something sturdy like a table or desk

establish safe spaces within their surroundings. Through the use of a camera on the app, users can take pictures of areas within the home to record the spaces they identify. As the users take pictures of spaces, guardians and children should discuss what makes them safe and what makes other areas unsafe.

**Safe Spaces Coloring Activity**

Objective: Reiterate previous information from the section in a new format.

Topics: IVa (Safe Spaces)

Executive Summary: The user can select from a range of colors to color in different portions of the picture. Similar in concept to a digital "paint by numbers" without the sections having a predetermined number (the child is free to color in each section as they please). Tapping a color and then one of the sections automatically fills in the section, you do not have to scribble or manually color it in.

- Not a space that can trap you
- Away from glass

**B. Evacuation Plan**

Goal: Inform the user on the proper protocols for evacuation during/following an earthquake, most importantly that it is safer to shelter in place until the building is deemed safe to evacuate by first responders.

During an earthquake, moving around can cause injury. Following an earthquake, it can be extremely difficult to determine if the structural integrity of building components, such as stairs, are safe to walk on. In the case of an earthquake strong enough to cause damage to the surrounding area, the generally safest protocol to follow is to shelter where you are until first responders are able to find you.

Even if an earthquake doesn't appear to have caused any visible damage, it does not mean that none occurred. When leaving a building, after first responders confirm exiting is safe, it is important to be aware of damages.

**Child Adapted Content**

When should you evacuate?
- Don't leave the building unless it's falling or a firefighter/ police officer says it is okay
- If there is still shaking, stay where you are

How can you identify a safe exit route?
- Do not use the elevator and avoid stairs
- Clear path
- Nothing is moving, shaking, or falling

Where should you go after you evacuate?
- Stay with a known or trusted adult (parents, teacher)
- Find a safe space outside or begin moving to a meeting place

**Evacuation Plan**

**Evacuation Plan Game**

Objective: Inform the user about the proper protocols for evacuation depending on whether you are indoors or outdoors.

Topics: IVb (Evacuation Plan), V (After an Earthquake)

Executive Summary: The user is presented with two scenarios, which cover evacuation protocols for indoors and outdoors respectively. The game is played from an overhead third-person point of view of the user's avatar as they play through each scenario.

The user is presented with a short, colorful animation of their avatar, inside a house, performing the Drop, Cover, and Hold protocol during an earthquake. Following the earthquake, the avatar pulls out a flashlight from their safety kit and uses it to see since the lights went out. The avatar is then rescued by first responders and led out of the building.

Since this section directly follows the safety kit portion in the flow of the application the inclusion of the safety kit in the initial animation serves to help reinforce one of the concepts taught there.

When outdoors, the user is presented with a short colorful animation of their avatar performing the Drop, Cover, and Hold protocol. Following the earthquake, the avatar is presented with a number of potential paths to take. The user must select the route they want to take and should aim for an open field or space away from buildings or other potential dangers.

place that was chosen with family

What is a meeting place?

- A safe place outside where you go after an earthquake
- A meeting place should be chosen with the family.
- It should be a place everyone knows and can easily find if anyone gets split up

Chosen options that are not safe will be met with a demonstration of why that is the case, and the user will be prompted to select a different path. Similarly, correct answers will be supported with rewards.

Example: Baby Panda


**Evacuation Home Activity**

Objective: Teach the child where to go after an earthquake and once they have been evacuated from a building. Prompt the child and their family to participate in an actionable task that can prepare the whole family unit.

Topics: IVb (Evacuation Plan), V (After an Earthquake)

Executive Summary: Guardians and children work together to establish a safe meeting place in the area that surrounds the home or the child's school. They are instructed to use their knowledge of safe spaces and can use a map to find locations close to them. Following the decision, they should walk to and from the designated meeting point so that the child becomes familiar with the path there. Along the way, guardians and children can discuss potential dangers in surrounding areas around their meeting place and how best to avoid them after an earthquake. Children should be instructed to stay with a trusted adult in the event of an emergency, but knowing how to get to a meeting place is beneficial in any circumstance. This location should be visited semi-frequently to help the child remember.

| | |
|---|---|
| | **Evacuation Plan Maze Activity**<br><br>Objective: Reiterate previous information from the section in a new format and also reinforce the concept behind what kinds of things you should avoid when evacuating (stairs, fires, etc.).<br><br>Topics: IVb (Evacuation Plan)<br><br>Executive Summary: The user has to draw a path through a maze from the start to the finish. Each of the dead ends contains something that the user should want to avoid when evacuating, such as stairs, fires, or falling trees. Completion of the maze activity rewards the user with the activity's badge. |
| **C. Communication Plan**<br><br>**Goal:** List the specific emergency services number for Romania, and explain what information should be memorized or collected for use during/after an earthquake. Children should know how to contact their guardians, where they live, and any important phone numbers.<br><br>The Romanian Emergency Services phone number is **112**<br><br>A contact card should be created and stored in an emergency backpack/shelter-in-place kit for use after an earthquake. This contact card should contain important information such as phone numbers, names, addresses, and important medical information.<br><br>**Child Adapted Content**<br><br>How can I get help after an earthquake?<br>• Call the emergency number 112<br>• Find an adult (parent, teacher, police officer, firefighter, medic)<br>• Use the contact card to find parents if lost<br>What will they ask when I call 112? | **Communication Plan**<br><br>**Communication Plan At-Home Activity**<br><br>Objective: Children should be able to provide the emergency services phone number, as well as the contact information for a dedicated person they can call in an emergency. They should understand how and when to contact someone if they need help.<br><br>Topics: IVc (Communication Plan), V (After an Earthquake)<br><br>Executive Summary: Guardians and children work together to establish phone numbers to call in an emergency and learn how to describe guardians to authorities if they get lost. They are instructed to make an emergency contact card that has their guardian's phone number, the emergency phone number, as well as important peoples' names and addresses. This card should be placed in the safety kit or another safe place with a string or lanyard so the child can wear it around their neck.<br><br>**Communication Plan Coloring Activity**<br><br>Objective: Reiterate previous information from the section in a |

- Name
- Where you are
- What happened

What information should be included on my contact card?

- Name
- Address
- Parents' phone numbers
- Medical information
- Any other important information (disabilities)

Topic V: What to do After an Earthquake

**Goal**: Provide instructions/steps for what to do following an earthquake.

It is important to understand the protocol for responding to an earthquake following the initial shaking, as there is still the possibility of injury, given the potential damage to the surrounding area.

**Child Adapted Content**

What happens after an earthquake?

- After an earthquake, the shaking will stop, but shaking could start again if an aftershock happens.
- An aftershock is shaking, like an earthquake, but generally smaller.
- Even though the shaking stops, it is possible that things continue to shake, break, or fall.

What should you do after an earthquake?

- After an earthquake, you should be prepared for an aftershock. This means you should be prepared to drop, cover, and hold on if you feel shaking again.
- You should not use elevators or stairs. If inside a building stay until a firefighter or police officer tells you it's okay to move.
- Once you are outside, you should not go inside any building.
- Check yourself and others for injuries. If you were hurt, ask for help.
- If there is a meeting place that you discussed with your family,

new format.

Topics: IVc (Communication Plan)

Executive Summary: The user can select from a range of colors to color in different portions of the communication plan picture (picture example: child wearing their emergency contact card). Similar in concept to a digital "paint by numbers" without the sections having a predetermined number (the child is free to color in each section as they please). Tapping a color and then one of the sections automatically fills in the section, you do not have to scribble or manually color it in.

consider heading there.

- If you are near a body of water, go to high land.

## Figma

| Content | Delivery Format |
| --- | --- |
| Topic VI: Earthquake Safety Kit<br>**Goal:** Define an emergency safety kit; provide a comprehensive list of the items that can/should be included in the emergency backpack/shelter-in-place kit, and their functions.<br><br>The difference between an emergency backpack and a shelter-in-place kit will be noted in guardian instruction screens, but not differentiated for the children. The creation of a kit will primarily fall on the guardians. As such, the main objective is for children to understand the purpose of the kit, its contents, and how to use the items inside. Refer to Figures 11 and 12 for a comprehensive list of things to include in a safety kit.<br><br>**Child Adapted Content**<br><br>What is a safety kit?<br>• A group of important supplies that are stored in a backpack or bin<br>• Supplies can help during and after an earthquake<br>• It is put together before an earthquake<br><br>What goes in a safety kit?<br>• Supplies that can help during and after an earthquake.<br>• First aid kit to help if people get hurt. These kits should include band aids, medicine, and wipes to clean injuries.<br>• Food and water in case people get hungry. These foods should be ones that last a long time before going bad and do not need to be in the freezer or refrigerator.<br>• Tools that can help people get free if they are trapped such as flashlights, masks, and gloves.<br>• Radio to help communicate if power goes out from the earthquake.<br>• Necklace card that has a child's name and their parent's contact information | **Safety Kit**<br><br>**Safety Kit Building Game**<br><br>Objective: Teach the child what a safety kit is, what items belong in a safety kit, and how to use some of the items<br><br>Topics: VI (Safety Kit)<br><br>Executive Summary: The user is presented with two items at a time and instructed to choose one. Ideally, one item belongs in the kit and one does not (a "good" item vs. a "bad" item). This idea has the added benefit of reinforcing the habit of choosing the correct item over the incorrect item in a more visual manner.<br><br>In all of these cases, the answers they choose will result in a short demo/explanation by their avatar about the item, its use, and why it may or may not be a good idea to put it in a kit. These items are weighted (by point value) depending on whether they should belong in the kit, selecting the correct choice will result in a point (or coin) reward.<br><br>While it is important to have the vocal explanation available, "show not tell" is critical with this age range, as they primarily learn through visuals and examples rather than words. Showing them how an item is used would be far more effective than explaining it vocally and moving on.<br><br>**Safety Kit Home Activity**<br><br>Objective: Teach the child what items belong in a safety kit. Prompt the child and their family to participate in an actionable task that can prepare the whole family unit.<br><br>Topics: VI (Safety Kit) |

How do you use items in a safety kit?

- Flashlight: Hold in your hand. Turn the wide part of the flashlight away from you. Turn on the flashlight using the button or switch found on the side of the flashlight. It should produce light to help you see.
- Whistle: Place one end in your mouth and blow. It should make a noise that tells others where you are.
- Mask: Take strings and place one around each ear. The rest of the mask should be over your nose and mouth. This will help not breathe in dust from damage.
- Communication Card: Take the card and place it around your neck using the string. When getting help from an adult, show them the card.

Executive Summary: Guardians and children work together to assemble a basic safety kit. They are instructed to use the provided icon-based checklist to gather items for their own safety kit and then put the created safety kit in an easily accessible location. A list of more complex safety kit items will be included in the parent section.

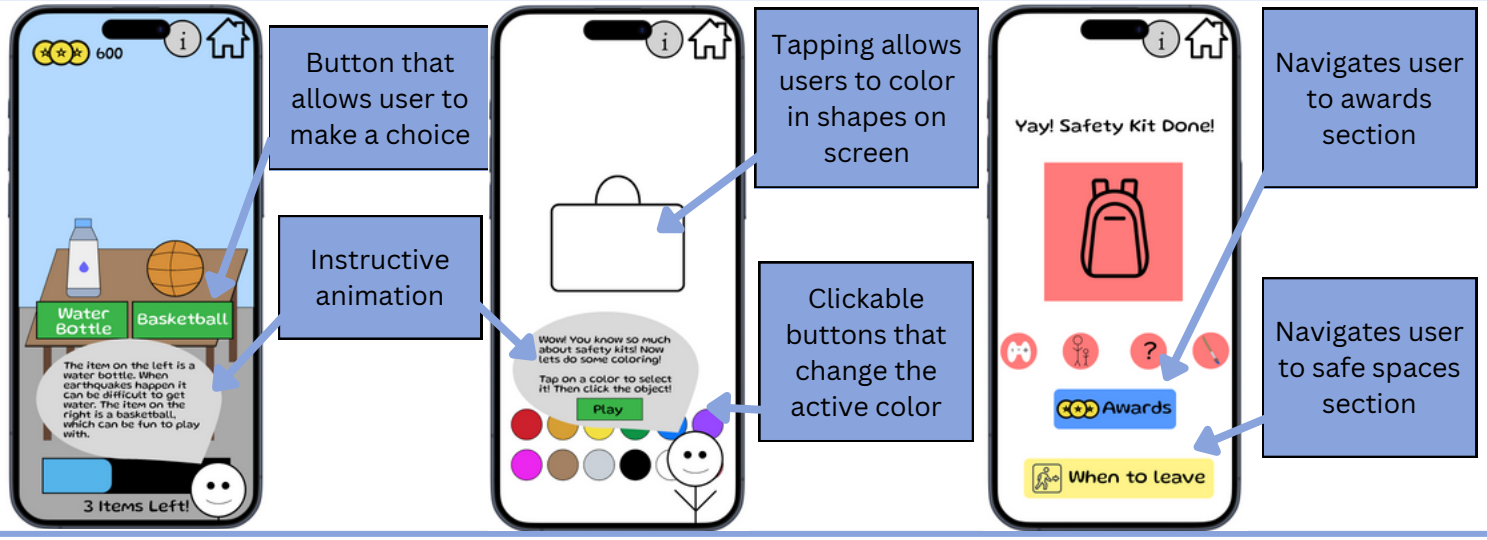
**Safety Kit Coloring Activity**

Objective: Reiterate previous information from the section in a new format.

Topics: VI (Safety Kit)

Executive Summary: The user can select from a range of colors to color in different portions of the safety kit picture (picture example: safety kit supplies on a table). Similar in concept to a digital “paint by numbers” without the sections having a predetermined number (the child is free to color in each section as they please). Tapping a color and then one of the sections automatically fills in the section, you do not have to scribble or manually color it in.

## Figma




## Content

Topic VII: Earthquake Review
The content in this section draws from the other sections of the syllabus, and takes the form of a trivia game that reviews content learned in other parts of the application to test the user's knowledge.

## Delivery Format

**Earthquake Review**

**Earthquake Safety Trivia**

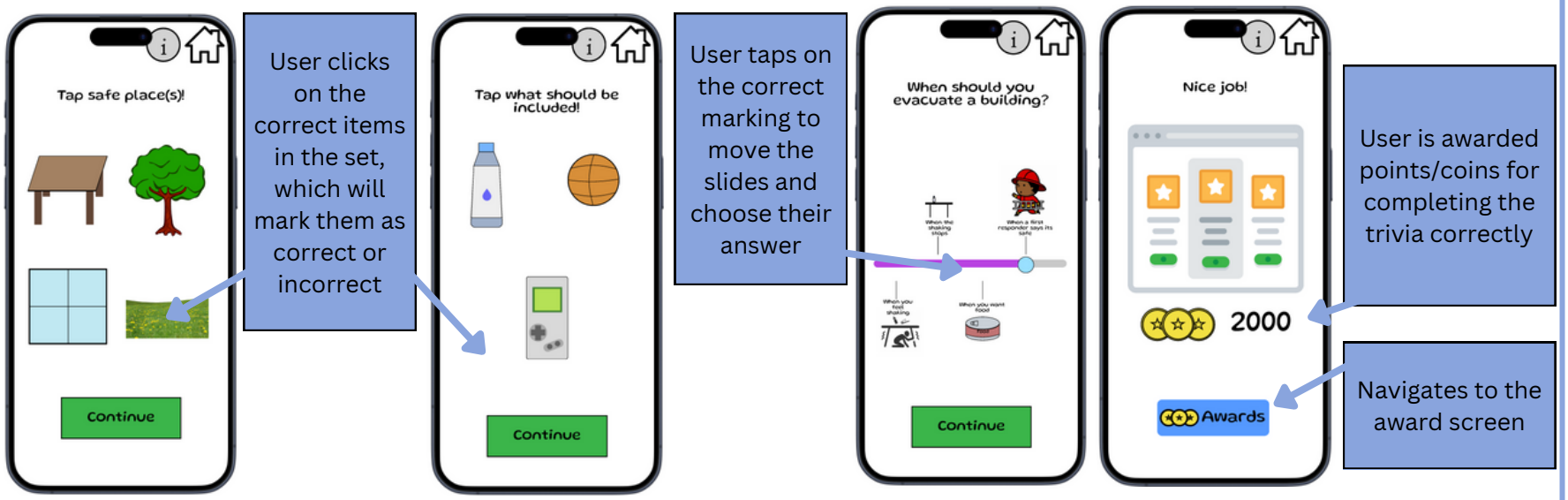
Objective: Review and expand on the information previously presented in the app. Allows the child to test their knowledge and identifies areas for improvement

Topics: I, II, III, IV, V, VI

Executive Summary: The user is presented with questions based on content taught in the previous sections. These questions begin as

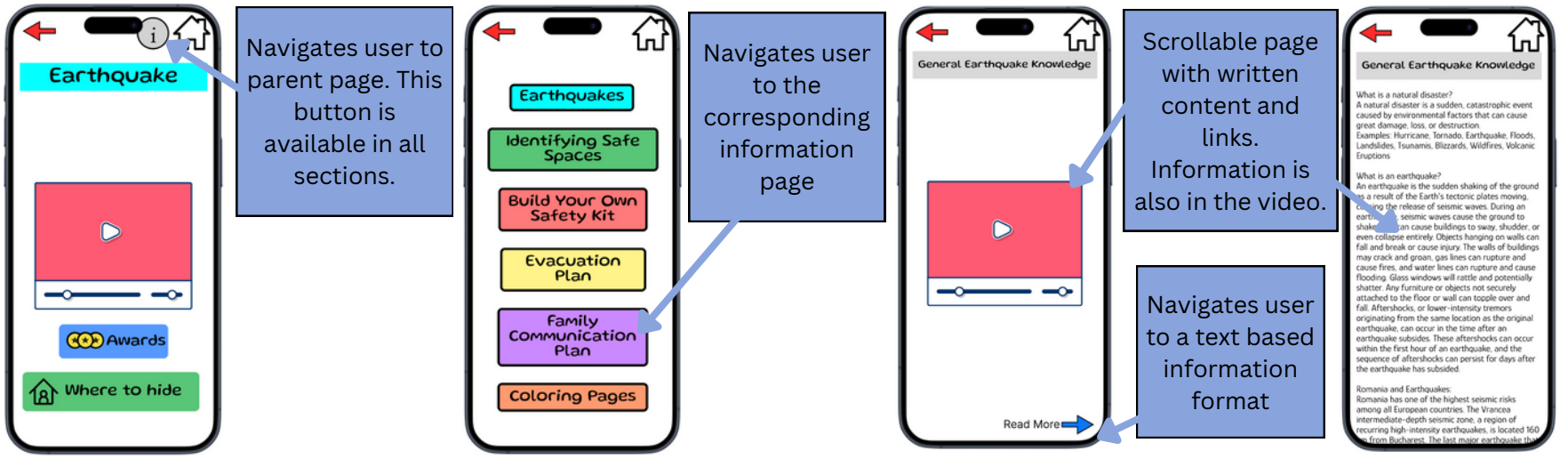
| | |
|---|---|
| | the same ones used at the end of each subsection to build the user's confidence and limit frustration. Although the example screens display text-based questions, they would be delivered to the user through a combination of text, visual, and audio like in other aspects of the game. As the user answers previously seen questions, new questions are added.<br><br>This is one place in which extrinsic motivators could be utilized effectively. Such motivators include points, levels, awards, leaderboards, etc. |

## Figma



| Content | Delivery Format |
| --- | --- |
| Parent Section<br>The content in this section is a more advanced and detailed version of the information presented in the other sections of the application. It provides additional links to more earthquake preparedness resources. Printable versions of the coloring activities and instructions for the activities are also provided within this section. In addition to the extra content for parents, this section also provides detailed instructions for the at-home activities that parents and children are meant to do together. While the child is meant to lead the activity, it is helpful for the parent to understand the goal so they can help them do the correct things. | **Parent Section**<br><br>Objective: Provide supplemental information for parents to read and/or watch; provide additional resources for earthquake safety education.<br><br>Topics: All<br><br>Executive Summary: The parent information menu is divided into the same categories as the rest of the application is, but contains additional information presented in the form of both video and text. It can be accessed from the home page or through an information button found in all other sections. There is also an additional resources section that contains links to other sources of information and/or tools on earthquake safety education, should the parents want to research further. |

## Figma



## Final Figma Prototype

The prototype is a low-fidelity interactive design in Figma. At a basic level, it can be clicked through to see preliminary designs. The file is also accompanied by developer notes, which detail the intended content and functionality not explicitly stated within the visuals. It shows ideas and concepts for game components to illustrate how the app functions. In the future, professional graphic designers and game developers will use our content and designed concepts to create a complete application with appealing visuals and animations. Scan the QR codes or click the links below to access the Figma designs and the corresponding prototype.

**Figma**

**Interactive Figma Prototype**

# Recommendations and Conclusion

## Recommendations

Based on our findings, we developed 4 major recommendations for those who continue to develop the earthquake safety education platform:

1. **User testing**

The application should be tested with 6-8 year olds as designs are created, to correct assumptions on content and engagement. Additionally, user testing should be conducted with parents to verify the effectiveness of parent/child activities and the engagement of the parent section. Since the app has a secondary purpose of educating adults, engagement in the adult section should be considered as much as engagement in the child sections**.**

2. **Accessibility and inclusion**

Both the content and user interface of the application should be tested and adjusted for groups with disabilities and other needs, such as people experiencing blindness, hearing impairment, and cognitive disabilities. This is critical in ensuring that all groups are as prepared as possible for when an earthquake happens.

3. **Content review**

Content review should be completed from various sources, providing multiple points of view from which to see the application. Governments and NGOs should review the content to identify anything that needs to be changed and updated. A specialized child psychologist review should be implemented to ensure that the content and delivery are effective for children and do not cause any trauma or distress.

4. **Adaption for other uses**

To extend the use of the application, it should be considered how it could be adapted for in-school use. Involving educators in feedback iterations and adjusting the content for a school will be useful in this adaptation. Similar content and delivery methods could also be used to expand or adapt the application for other age groups. Older age groups could involve more complex information and feature less repetition.

5. **Extrinsic motivators**

Current designs and delivery formats outline external and internal motivators on a basic level, such as a point system and badges. These elements should be expanded on in the final design, such as allowing users to trade in earned points for customizations for their avatar.

## Conclusion

Despite the frequency of earthquakes in Romania, there is a lack of earthquake education resources for children. The goal of this project was to work with Code for Romania to develop content for a digital platform that teaches children about earthquake safety. Through interviews with experts and research of existing disaster education platforms, we investigated what content, delivery formats, and design processes should be used for an earthquake safety education platform. We found that educational content should include general information about earthquakes and safety protocols for before, during, and after an earthquake. Content for the age group should be as comprehensive as possible, but most of it will need to be adapted and fine details limited to ensure comprehension for the age group. Delivery formats with interactive practices such as simulations, stories, physical models, and games are common within children's education. Combining these formats with techniques like repetition, extended time, physical activities, and smaller information segments, will aid in children’s engagement, comprehension, and retention.

To visualize designs, we created a low-fidelity prototype and a detailed outline of content and delivery formats that are recommended to be used in the final product. The Figma prototype of the application can be clicked through to see preliminary designs. The file is also accompanied by developer notes, which detail the intended content and functionality not explicitly stated within the

visuals. It shows initial ideas and concepts for game components to illustrate how the app functions as a starting place for future developers.

> No one is really aware. Until they go through a preparedness module...they don't really understand what is happening and what the real risk is. I think it's like a movie in their head.
> - Delia Moleş

Earthquake preparedness education is crucial to bridging the gap between perception and reality and turning the abstract concept of seismic risk into tangible, actionable steps that one can take to prepare and mitigate the destructive effects of an earthquake. This application is important because it serves to provide the necessary resources for young children to learn about these steps. Educating children is critical in fostering a community of resilience, targeting misinformation before they experience it, and creating a more informed generation that can share their knowledge in the future.

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# Appendix

## Appendix A

**Informed Consent Script for Adults**

The purpose of this study, sponsored by Code for Romania, is to investigate earthquake education and safety practices for 6-8 year olds and how a digital platform could be used to teach children about earthquake science, preparedness, and response. We are conducting interviews with experts who are familiar with earthquake safety curricula and training to understand what materials 6-8 year olds are provided and how it is delivered. We also seek to understand your perception of how effective these materials are and any suggestions you may have about how they may be improved. This information will be used to evaluate the existence and effectiveness of earthquake protocols. We will use this data to propose a digital platform for children's earthquake education. Study results will be published on our university website (Worcester Polytechnic Institute, MA, USA) and shared with Code for Romania.

Should you choose to participate in this interview, you are free to end the interview at any time, and you may choose not to answer any of the questions. If you agree, audio from the interview will be recorded, but the recording itself will not be available to anyone but our research team. This interview should take approximately 30 minutes.

Please confirm that you understand the purpose of this study and agree to participate in this interview.

To be distributed physically:
If you have further questions about this study or wish to read our final report, please contact us at gr-quake@wpi.edu or our WPI faculty advisors, Lorraine Higgins (ldh@wpi.edu) or Yury Bosin (ybosin@wpi.edu).

# Appendix B

**Interview Questions for Delia Moleş (Earthquake Education Expert)**

1. How long have you worked with earthquake safety protocols?
2. What **preparedness** protocols have you designed to teach the public about earthquake safety?
    a. You mention that you helped to provide earthquake training and increased earthquake education to at least 850 preschool children in Bucharest.
        - What content was taught in these initiatives?
        - How was the content delivered to these groups?
        - Can we access the content delivered to these groups?
        - Would it be possible for us to attend one of these trainings or one that is similar?
    b. You also mention an emphasis on awareness strategies and programs in your work.
        - Could you tell us a bit more about awareness strategies or programs that you have worked on?
        - Can we access the content used to communicate awareness?
3. Have you helped to develop any content that was used in online/digital materials?
    a. Are they available for us to view?
        - Where can we find them?
4. What **response** protocols do you organize to assist in the event of an earthquake?
    a. How is this information communicated?
5. Do you have specific earthquake-related topics that you teach children, compared to adults?
    a. What is the difference between material for adults and material for children?
    b. Is there anything that you intentionally DO NOT teach children about earthquake safety?
    c. Our target demographic for our project is children aged 6-8, what do you consider to be the most important things this age group needs to know?
    d. How are children able to access the content you provide?
6. Are there common incorrect things that people believe about earthquake preparedness?
7. Is earthquake education mandated in Romanian schools?
8. Is earthquake safety education included in this?
9. What concepts and practices specifically must be taught?
10. How is this typically delivered? (guest speakers, books, multimedia, training drills, etc.
11. Where might we find some of these materials?
12. Do you think a digital platform could be used in schools for earthquake education?
13. Are there any areas in earthquake education that you believe should be enhanced?
14. Is there anyone that you know that you would recommend we talk to?

# Appendix C

**Brainstorming Techniques from the Design Process**

| Tool | Instruction | Result |
|---|---|---|
| Crazy 8s | • Fold a piece of paper into 8 sections<br>• Set a timer<br>• Sketch an idea into each square | • Not much detail<br>• Quick thinking<br>• Many ideas in a short time frame |
| Lightning Demos | • 25 minutes for research<br>• 5 minutes to present ideas<br>• Another person sketches the idea as it is being presented. | • Elaborate on basic concepts<br>• More detail<br>• Various perspectives on an idea |
| Existing Games | Research games with related aspects such as<br>• Targeted towards 6-8 year olds<br>• Cover earthquake safety content | • Comparison of ideas<br>• Review what is effective and tested |