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Exploring the Diffusion Potential of a Collaborative Mobile Platform for Disaster Management and Relief

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EXPLORING THE DIFFUSION POTENTIAL OF A COLLABORATIVE MOBILE PLATFORM FOR DISASTER MANAGEMENT AND RELIEF

by

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ABSTRACT

This thesis describes the creation of a collaborative digital platform for disaster management and relief, focusing on the case study of the city of Petrópolis natural disaster in February 2022. The frequency and intensity of natural disasters are rising, necessitating efficient and timely disaster response efforts. This thesis details the development of a software application that fosters collaboration among governmental agencies, emergency services, non-governmental organizations (NGOs), and civil society to enhance logistical planning and situational awareness during disasters. The proposed platform harnesses the power of social networking and leverages the ubiquitous presence of smartphones equipped with cameras, GPS, and sensors to gather crucial real-time data. Through a secure and user-friendly interface, verified stakeholders can access essential information while the public contributes valuable data through their smartphones. The platform ensures reliable data collection and dissemination by analyzing metadata, assessing human needs, empowering decision-makers with up-to-date information, and providing verified information channels and real-time data analysis. The platform seeks to minimize overlapping efforts, reduce mismanagement of resources, and ultimately save lives and livelihoods in disaster-stricken areas.

Keywords: Disaster Management, Disaster Relief, Collaborative Platform, Digital Platform, Information Communication Technologies, Crisis Communication, Chaos Theory, Social Networking, Smartphone Data, Real-time Data Analysis.

DEDICATION

In the quiet of Petrópolis, where the mountain's breath whispers tales of yore,
To the souls that walked its streets, now a part of its core.
This work unfolds, a tapestry woven from loss and memory's loom,
A dedication to lives halted, yet in our hearts, forever bloom.

For the fathers, their strength mirrored in these steadfast hills,
Whose wisdom, like rivers, carved pathways, fulfilling nature's wills.
My own father, a beacon, his lessons etched deep within my soul,
A testament to courage, resilience—the very roles he'd so nobly console.

And to the mothers, nurturing as the rains that embrace the earth,
Instilling values, those silent seeds, giving rise to rebirth.
My mother, whose spirit, in this work, blossoms with grace and peace,
Her values, the roots from which grew my life's guiding masterpiece.

To Petrópolis, cradle of dreams, where hope's flame still gleams bright,
This dedication stands as a monument to your undying light.
For every tear shed, for the smiles that will return anew,
In memoriam, for the departed, I honor you.

And so, with pen poised, I scribe for the silent and the brokenhearted,
For the spirit of a community, steadfast, unyielded, and unparted.
May this work be a beacon, as my parents' legacy has shone,
In memory, in honor, for the place I call home.

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CHAPTER ONE: THE CRISIS

On the evening of February 15th, 2022, a storm was brewing in the sky of the city of Petrópolis, Rio de Janeiro, in Brazil. Geographically, Petrópolis is in a valley high in the mountains of Serra dos Órgãos. It is a 40-minute drive from Rio, across preserved Mata Atlântica (dense forest biome) forests. Rain is, therefore, common in Petrópolis; it is a part of the city's history, and it was designed to an extent to handle the rain. It is worth noting that the city was the second in the whole country of Brazil to have been planned back in 1843 by Major Koeller, a German immigrant.

Since 1843, much has changed, both urbanistically and environmentally. The landscape of Petrópolis and the world have evolved. However, efforts to contain and address the escalation of natural disasters were left out of this process by other factors, most notably in Brazil, due to governmental corruption, massive land migrations culminating in unsafe land occupations, and mountainside irregular housing commonly named Favelas in Portuguese.

Favelas, also known as c*nidoscolus quercifolius*, are flowers that bloom in the hills and give a name to these structures, which are bound to Brazil's history and land but are also synonymous with disaster proneness. They became marginalized ghettos for people experiencing poverty who needed better living conditions and still do. It was not the first time that Petrópolis experienced this kind of chaos. I remember vivid stories that my father would tell me of the time when this happened in 1988, killing 134 people. Everything seemed different back then, distant as if it were a hurdle already overcome that would not return to haunt us, or so we thought. It did happen again and again. However impossible and unlikely, and as it seems, it will keep happening, if not in Petrópolis, then elsewhere.

Tragedies are terrible, but surely the worst are the avoidable ones. Fast-forward to February 2022; in three hours, a high volume of 258 mm of rain fell (Alcantara, 2023, p. 775), landslides occurred, and more than 270 people died. So much dirt and mud were dislodged that natural dams formed, and rivers overflowed, generating a massive flood. Houses in hillside neighborhoods were destroyed, and cars were swept away (Watson, 2022). After the water drained, a trail of devastation and compacted mud was left, which was impossible to overcome without 4x4 vehicles and special equipment.

Ground Response

I had just gotten home, about a 10-minute drive from downtown Petrópolis, when it started to rain. I remember vividly telling my father, who had accompanied me earlier that day, that I was going to go home before it started raining, and luckily, I did. My dad, however, decided to stay behind with a couple of friends at a parking garage. My mother was working, and he would wait for her to be done and get a ride with her. It started to rain about 15 minutes after I got home. I could always tell how much rain would occur based on how much water would drain from the street in front of my apartment. Water would accumulate and flow like a small river when the rain was heavy. Moreover, that day, it was. The drops of rain seemed fatter and larger, and the noise they made did, too. At first, I paid no attention to it, but after a while, I could no longer look away. I tried calling my parents and friends, but we lost signal reception. One of the communication towers was damaged where I was. I could not imagine the destruction the rest of the town endured. My father, however, was still in the parking garage when it happened.

The water started to accumulate outside, first on the street, then on the first step leading to where he was, to the point where he and his friends had to swim in the river (highly polluted) that formed from the overflow of the one that sat right outside of this garage. When he was out of

there, he was able to talk to my mom, who got to her car in time to escape the flooding that happened moments after in the office where she works. Trees began to fall as the dirt softened, and the peaceful river that once crossed our downtown avenue became an ocean of mud, debris, cars, and materials that began to pull anything that sat in its way. All the shopping district was affected. Stores and products that remained in place were all damaged by the water.

After about six hours of zero communication, I got a call from my dad. He had met with my mom, and they had been stuck in traffic trying to get home for hours. They were about to run out of gas and about 20 minutes' walk from where I was. I packed a bag full of food, water, and clothes for my dad (his were soaked and destroyed) and began my journey to meet them. On the way, there was mud all around. The streets were covered with a thick layer of mud that was still wet, and roads burst open and lay damaged, making it even worse for cars to maneuver. Eventually, I was able to meet them. The car ran out of gas; there were no gas stations that still worked near us. Luckily, one of the houses in the street allowed us to push the car and park it inside their patio; it turned out they were the headquarters of an NGO.

The next day, I returned to pick up the car; while I was there, I left my number and told them I had a 4x4 Jeep that I was willing to use to help in any way I could. On the following day, I joined the relief efforts. We could hear helicopters flying overhead, and people in the regions most affected started trying to dig through rubble, mud, and debris to rescue people who had been engulfed during the landslides. One region in particular, called "Morro da Oficina," was severely hit by a massive landslide, leaving many dead, wounded, and missing beneath the rubble. The first shovels on the ground were from neighbors and family members, trying to rescue whoever they could. The damage to the city's infrastructure from the accumulated and

now compacted mud meant heavy machinery could not travel easily, and neither could any other vehicles that lacked all-wheel drive traction.

Organically, civil society organized to deliver supplies. This was made possible by a network of motorcycle delivery workers commonly referred to as “Motoboys” in Brazil. Usually, Motoboys are looked down upon socially. On this occasion, however, they were heroes. Non-governmental agencies received donations, water bottles, diapers, and non-perishable food items. These items were then picked up by volunteers who drove 4x4 capable vehicles and later took the supplies to wherever they were reported as being needed. Once there, motorcycles would take them the rest of the way if needed. However, it just so happens that this was all created organically. There was no disaster plan to guide it, as civil society was attempting to rescue itself while government agencies struggled to start acting.

Petrópolis Scenario Disaster Relief Flaws

Communication, or lack thereof, was the most significant of the flaws that occurred during the relief effort in Petrópolis, as it generated many of the other flawed and undesirable outcomes. A notable example was the following: Restaurants had no business during the post-disaster weeks. However, they already had supplies to cook food for the month that would inevitably go bad. To help, they started to cook the food and have it delivered. On one occasion, the organization I volunteered at received over 200 freshly cooked meals that one of these restaurants had just dropped off. There were many issues with this practice.

First, we could not tell how or when the food had been cooked or stored, nor could the organization store it, as they had no freezers; they also could not be held responsible for the food that they were not involved in producing, and so that food ended up going to waste. By using an already established platform that could be monitored, traced, and updated in real-time, donations

and relief efforts that would have been otherwise decentralized could be better organized and delivered, eliminating waste and logistical issues.

Another problem was volunteer assignments. There were many people who wished to volunteer, but not all organizations could adequately take them in. This resulted in a decrease in the volunteer workforce, additional vehicle and foot traffic, and an overall decrease in efficiency in the relief effort. Organizations and volunteers could be matched by providing a centralized and secure channel that created a pool of volunteers arranged by age, willingness towards tasks, and availability, speeding up and optimizing recruitment during the crucial moments of a disaster aftermath. This would free up time, resources, and personnel to focus on more immediate tasks.

In underdeveloped countries where poverty is exacerbated, fake news, corruption, and fraud usually accompany disaster scenarios, as freeloaders and other criminals attempt to take advantage of the lack of social order to achieve personal gain. Newly allocated emergency funds meant to provide relief and resources to those affected are often siphoned, partially or whole, from their intended origin and diverted into politicians' pockets. Standard practices often involve fraudulent donation collection spots, requests for cash donations and funds, the spreading of fake news by political adversaries, and taking advantage of exceptions to compliance laws due to the disaster scenario and nature of the emergency funds. A platform could help mitigate these crimes by implementing a verification and validation feature.

For example, users would only be exposed to legitimate organizations on the platform. They would not use the platform to communicate between users but to retrieve essential and verified information. By keeping each organization's profile on the platform, users could retrieve valid and updated information, allowing users to be more aware and less prone to being

unwilling participants in a fraudulent transaction, reach out to authorities, and understand the process.

For instance, to report an occurrence or register a claim with a public entity, people can also make reports by taking pictures with their mobile phones and verifying that information through a series of validation checks. That information would then be passed on to authorities, who could use this filtered and verified information to better support the crisis map and help the relief effort make more informed decisions.

To solve the issues of donation theft and misuse, a process would be established, such as mail tracking, where potential donors could register donation transfers through the platform. For example, if a bottling company decided to donate water to an NGO, this transaction (donation) would be registered and logged into a database. When the NGO needed to deliver those goods, they could log the volunteer who took them in their car. That volunteer could register the collection location that received the goods, which could even potentially log who received the goods, thus creating a register of all steps those donations took to reach people who needed the supplies, who were a part of that logistical chain, as well as how and when each of these steps took place.

The Need for Innovation

Natural disasters are increasingly prevalent due to climate change, and one of the conditions that may increase a country's susceptibility to the impact of natural disasters is its level of economic development (Cavallo, 2012). The case scenario of the Petropolis 2022 disaster is an example. On the 15th of February, the city was struck with disaster, only to be struck again on the 20th of March. This happened amid the rescue and relief effort, creating more chaos and destruction. Considering different countries with variable budgets and levels of

economic development, it is imperative that some innovation is developed to act as an equalizer during times of need. Amongst the possibilities, one of considerable low risk and low investment is the development of the proposed platform, as it could be widely spread and deployed due to the nature of mobile software and its reach.

All phones can currently function as relatively low-cost sensors and geo-referencing tools. Instead of developing a hardware solution or high-cost platform that is uniquely exclusive to one region, developing a collaborative platform would benefit all undeveloped countries and potentially be used by any country regardless of economic prowess or possibilities. The anticipated challenges that are beyond this project's scope would be a language and cultural barrier, as well as specific infrastructure, such as how prevalent cell phones and internet access are amongst the local population. The proposed solution focuses on a comparatively low-cost, high-reward investment, with a high capacity of diffusion and scalability amongst users, at a bare minimum initial investment, as the platform is merely software, and all its features are already available, it is a matter of assembling the platform and making agreements with local organizations and government.

CHAPTER TWO: STATEMENT OF THE PROBLEM

Having been actively involved in the relief effort during the devastating disaster that struck Petrópolis-RJ in 2022, my personal experience provided valuable insights into the challenges faced by various stakeholders in disaster management and relief operations. The situation on the ground highlighted the critical need for an efficient and collaborative digital platform that could empower both official governmental agencies and civil society to coordinate their efforts effectively. Inspired by this experience, I propose the development of a digital platform modeled after social media platforms, specifically tailored to meet the diverse needs of stakeholders involved in disaster scenarios.

The Significance of Situational Awareness

During my participation in the relief efforts, one crucial aspect that stood out was the importance of situational awareness. Situational awareness is defined as the capability to collect and access accurate information in real time, which is essential for making informed decisions and responding swiftly during crises. In the description of the crisis, it was observed that the response exhibited a reduced level of situational awareness. However, existing communication channels often fail to provide a comprehensive view of the disaster landscape, leading to overlapping initiatives and mismanagement of resources. Seeger (2016) discusses the role of technology and information sharing in disaster relief, highlighting how real-time and accurate information sharing is crucial for effective crisis response. Therefore, by harnessing the power of technology and situational awareness, a collaborative digital platform could bridge this gap and facilitate efficient data sharing among relevant stakeholders.

The Potential of a Digital Collaborative Platform

Chaos theory is defined by Strogatz (1994) as the study of systems that exhibit sensitive dependence on initial conditions, a phenomenon popularly referred to as the butterfly effect. This theory explores how small changes in a system's initial conditions can lead to vastly different outcomes, highlighting the unpredictable and complex nature of specific dynamical systems that may appear random but are actually deterministic. Self-organization is a phenomenon often described as a natural process whereby order re-emerges out of a random and chaotic state (Sellnow, 2002).

This process of organic organization was what I observed as a volunteer in the aftermath of the Petropolis disaster. This can be further corroborated by research conducted in Petropolis, which noted, for instance, that some of the areas affected were challenging to access, so there was a considerable contribution from individuals with motorcycles who volunteered to deliver what was needed. From interviews, respondents all had in common the notion that there is a conjoint work in recuperating and preventing other disasters (Afonso, 2022).

Drawing inspiration from chaos theory, which emphasizes the sensitivity of complex systems to initial conditions and the potential for small events to have far-reaching consequences, a digital collaborative platform has the potential to create a ripple effect of positive outcomes in disaster management. Kapucu and Garayev's (2013) study demonstrated how strong interdependencies among organizations within collaborative networks lead to increased network sustainability and, consequentially, improvements in relief efforts through organization and logistics. By bringing together official governmental agencies, emergency services, NGOs, and civil society on a unified platform, collective efforts can be amplified and more effectively directed toward saving lives and mitigating the impact of disasters.

CHAPTER THREE: PROPOSED INNOVATION

In this chapter, the focus will shift toward outlining the design and features of the proposed Collaborative Digital Platform for Disaster Management and Relief. I decided to name this platform **A**daptive **R**esponse **C**ollaborative **A**pplication or, for short, ARCA, which in Portuguese means Ark, such as Noah's Ark, which was also a safe haven intended to protect all life from disaster, namely a flood, similar to what originally happened to my hometown. The application's logo is also designed to resemble an Ark and functions as the user profile page titled "MyArca." The platform aims to leverage the power of information communication technologies (ICTs) and social networking to facilitate efficient communication, data sharing, and collaboration among various stakeholders involved in disaster response. The platform will gather real-time data from verified stakeholders and the general public by capitalizing on the ubiquitous presence of smartphones equipped with cameras, GPS, and sensors, allowing for better decision-making, transparency, and accountability. This section will present the platform's overall framework, its key components, and how it addresses the challenges identified in previous chapters.

Platform Objectives

The primary objective of the Collaborative Digital Platform is to improve disaster response coordination and enhance community engagement during disasters. To achieve this, the platform will strive to:

- *Facilitate real-time information sharing*: The platform will provide a secure and user-friendly interface for verified stakeholders to share critical information, including situational updates, resource availability, and coordination efforts.

- *Engage the public*: Citizens can actively participate in disaster response efforts by contributing valuable real-time data through their smartphones. This data may include images, videos, and geolocation information, which can aid in assessing the situation on the ground.

- *Optimize resource allocation*: By analyzing the data collected, decision-makers can make more informed choices regarding resource allocation, ensuring that aid is directed where it is most needed.

- *Enhance situational awareness*: The platform will aim to provide a comprehensive view of the disaster landscape, reducing the risk of overlapping efforts and improving overall situational awareness.

Platform Features and Functionalities

The Collaborative Digital Platform will be designed with a user-centric approach, ensuring that it meets the diverse needs of various stakeholders. Some of the key features and functionalities include:

- *User Verification*: To maintain the platform's integrity and reliability, users will need to undergo a verification process. Governmental agencies, emergency services, and NGOs will be verified as official stakeholders, while the public users will have a separate verification process.

Real-time Data Collection: The platform will leverage AI metadata analysis and human assessment to ensure the accuracy and relevance of THE data collected. This will enable decision-makers to access reliable information in real-time.

- *Interactive Maps*: The platform will feature interactive maps, displaying real-time data and relevant information about the disaster-affected areas. Users can navigate the maps to access specific data points and areas of interest.

- *Communication Channels*: The platform will include communication channels such as chat and forums to facilitate direct and timely communication between stakeholders, enabling them to coordinate their efforts efficiently.

- *Volunteer Mobilization*: A section of the platform will be dedicated to volunteer mobilization, allowing NGOs and civil society organizations to request assistance and volunteers to offer their support.

- *Training and Resources*: The platform will provide access to disaster response training materials and resources, empowering stakeholders with the necessary knowledge and skills. It also aims to achieve long-term usage and user retention. Recognizing the importance of user training, the platform will offer comprehensive training modules to familiarize stakeholders with its features and functionalities. Training sessions will be conducted for governmental agencies, emergency services, NGOs, and volunteers to optimize their use of the platform during disaster scenarios. Additionally, a dedicated support team will be available to address any technical issues and assist users when needed.

Platform Development Documentation

The application is intended to be developed as accessible, cross-platform mobile software. It was wireframed and mapped out using Figma to account for the functionalities included and proposed. Before the full-scale implementation of the platform, a prototype version will undergo rigorous testing and evaluation. The testing phase will involve stakeholders and users providing feedback on the platform's usability, effectiveness, and potential improvements. The platform will undergo iterative refinements based on the feedback received to ensure optimal performance.

This is the prototype version created thus far:

https://www.figma.com/proto/BYOnoz5FJwDwJpZ11eGRC0/ARCA?type=design&t=hTJ5qgXMkE7gdvHF-1&scaling=scale-down&page-id=0%3A1&node-id=1-873&starting-point-node-id=1%3A873&mode=design

How the Platform Works by Functionality

The following is a theoretical description of functionalities that are already in existence. It will not explain the technical specifics of each implementation in depth but will cover the fundamentals of how each functionality works and will be achieved. It will also, for the purpose of this paper, focus only on the user screens and not account for the NGO and Governmental Agency versions, which would be geared towards other outcomes and functionalities.

Dashboard / Crisis Map Screen

The current prototype can be divided into seven main screens/functionalities: Dashboard (or Crisis map), News and Announcements, Volunteering, My Profile, Courses, and Organizations. The first of these screens is the main dashboard feature. This screen includes a filter icon on the top left corner that works as the filter for the map. Once clicked, it allows the user to sort which hazard symbols they wish to have remain as active on the map. In the top right corner, there is a paper plane icon, where the user receives a visual cue for notifications, which appears as a red dot with the number of pending notifications inside of it. Also, on the top, there is an area reserved for a small banner message to appear for essential government announcements. If that link is pressed, the user is taken to the news and announcements screen, where they can read the complete update.

Underneath the banner space, or in its place if no updates are currently being displayed, there is weather information based on the user's geolocation. This functionality works by pulling data from an API, such as the National Weather Service Weather API, which allows for free and current weather forecasts to be pulled from this database as a JSON packet and used to feed information and display it on the dashboard screen for easy user engagement. Beneath this information and centered as the main piece of information to be displayed is the crisis map,

another piece of data being pulled by an API. The information in question is a situational map based on an API-generated map, such as Google Maps or Open Street Map, which is then overlaid by information from the application's database, namely the hazard maps that are reported incidents that have been verified and approved for display on the public crisis map.

On the bottom left corner of the screen, there is a large circle with a plus sign inside, indicating the option to "add" to the map. This ergonomically designed button takes the user to the "create a report" screen. The last element of the dashboard screen is the navigation menu, which is common to all screens and allows the user to navigate between screens easily and rapidly. This navigation menu repeats on all screens to allow for quick reference and navigation. It is also placed on the bottom of the screen for better user ergonomics and one-handed operation. This screen is intended for users to reference surrounding hazardous areas quickly and make better-informed decisions, such as staying home, evacuating, seeking shelter, or taking specific routes to gather supplies and other necessities.

Report Screen

Users create a report screen, accessible only by clicking the add icon on the dashboard screen, which is built on top of an HTML form structure. On the very top of the screen, there is an "add picture" icon that, once clicked by the user, prompts the phone's camera to open. It also asks the user for proper authorization, explaining that data from the picture will be collected to create a report. With the user's approval, the user can then take a picture. This functionality is enabled by utilizing the mobile's built-in hardware, both the GPS system and camera. The user can cancel the picture by pressing the large "X" icon on the top of the screen or continue by taking a picture.

Once a picture is taken, the picture is saved and added to the form, in which the user must complete all required fields and check a checkbox that includes a statement of truth certifying that the user is aware that the information being shared must be truthful. After this process, the user clicks the submit button and is taken to a confirmation page that also includes a link to the user's profile, allowing the user to track their report's ongoing status or completion. This functionality is geared towards empowering civilians to act as sensors and data collectors, allowing authorities to use that collected information and speed up response times while at the same time raising awareness of the aftermath consequences of disaster.

Organizations Screen

The organizations screen is divided into two categories: government and NGOs. They are separated into two headings that clearly label each category. They are organized in a gallery scroll menu, where each institution can be found through its profile logo and name. After the user clicks on the institution picture, they are taken through a hyperlink to that organization's profile.

On this organization profile page, the user is met with a centralized picture of the organization, their updated contact information, and any courses they have created and offered on the platform. Users who click on this course tab are taken to the course signup page. On the top left corner, there is an arrow icon that allows the user to go back to the previous page, and on the right, there is a bookmark icon that allows the user to save this organization as one of their favorites. This functionality is meant to allow users to have safe interactions with governmental and non-governmental agencies, with the possibility of a record of what was done, allowing for accountability and more transparency in post-disaster interactions.

Courses Screen

The courses screen has a search bar and a filter icon that allows the user to search for courses through terms stored in the application's database; it also allows users to filter courses by organization, duration, and certification. Courses are displayed as circles and organized as a gallery menu that is scrollable to the sides, with the course name and a small profile picture of the organization that created the course on the bottom right of the profile picture. When a user presses on a course, they are taken to that course's signup page. By marking a checkbox and pressing the start button, users can save that course under their profile and watch the course lectures.

On the top right corner of the lecture course screens, there is a text notation of which lecture the user is on. To the left of this mention, the name of the course is displayed. To its left, an arrow icon sits that, when clicked, reveals all chapters and lectures of the course in a navigational menu that expands and retracts and has a visual cue, namely a green checkmark that is highlighted when a lecture is completed.

At the top of the screen, there is room for a video lecture or a picture; if the media displayed is a video, and the user clicks the play button, the video plays, and the user can watch the lecture, add captions, pause, temporarily download a video to the mobile to work offline, and speed up or reduce the speed of the video playback. This is all achieved through the operating system's built-in media player.

Below the media file, a space meant for text and questions is left intentionally so that the user may be tested on their knowledge. If the user clicks the next button and has the correct answer, they are taken to the following lecture; if not, they are given either the correct answer with an explanation or are prompted to retake the lecture. The "courses" functionality is meant to

draw in users, promote retention, and allow users who wish to volunteer to develop and organize themselves further into a local fire brigade, for instance. This functionality intends to promote like-minded individuals an opportunity to enhance their knowledge further so that they can be even more helpful and make a difference during post-disaster situations.

Volunteer Screen

At first, the volunteer screen displays only a plus sign next to a paragraph element that reads “Availability.” Once the user presses the icon, they can set a schedule where they choose a start and end time, as well as days of the week by highlighting the letters, after which they can either cancel or save their choice. If they cancel, they are taken back to the initial volunteer screen; if they continue, their selected availability appears, and other options are formatted in another form to be completed. The user can delete the last availability entered or enter a new one. The user is also prompted to add their date of birth, blood type, zip code, and radius that they would like to be considered for volunteering opportunities.

Below, there are two sets of three icons that read “I can:” and “I have:”. Under each icon, there is a green check box; if the user presses down on the icon or presses the icon, a brief information pop-up appears, revealing a more in-depth explanation of the icon. An example is “I am comfortable around pets. and am willing to care for them.” If users press the icon, a brief information pop-up appears, revealing a more in-depth explanation of the icon; an example is “I am comfortable around pets and am willing to care for them.” If a user presses the checkbox, they will have that noted and registered under their profile in the database.

The same goes for the “I have” and “I know” sections that follow. There is also a certification section that updates with certifications received through the application’s course feature. If the user still does not have a certification, they can click on the “Get certified” link

and be taken to the courses screen. After the user is done with the form, they can click the save button, triggering the information to be saved and stored in the application's database and generating a Volunteer Card that displays the user's profile picture, name, age, blood type, the icons they selected, their availability and a unique QR code that matched the user's unique id in the application's database and which can later be used to identify, register and make logs of presence and other relevant information. This screen and functionality intend to organize users who decide to volunteer and match them with non-governmental organizations.

News and Latest Updates Screen

The news and latest updates screens include a large refresh icon on the top right that the user can press to fetch more updated information continuously. The user is also shown a large clock on the top of the screen that features the last successful update hour and date. Beneath it sits the same weather Api banner common to all screens for the quick reference and key weather risk monitoring aspect in disaster scenarios, and beneath that, there is an image of the most current announcement or news update (published by a government agency and not a news outlet), organized as a gallery side scroll menu. If the user presses the highlighted blue "click for more," they are taken to the complete article.

User Profile Screen

The last screen is the user profile screen, where the user will find relevant information compiled from all interactions with the application as well as the user's unique QR code, generated using an API and using the user's unique ID to the application, which can be used to mark their presence, collect resources and more. There is also a link to add this card to the user's Apple or Google wallet. There are also sections where the user's favorite organizations are stored

for quick reference; their ongoing courses are saved with a progress indication for reference, as well as the ongoing information and updated from any user-generated reports and requests.

CHAPTER FOUR: EXPLORING DIFFUSION OF THE INNOVATION

Diffusion of Innovations

Diffusion is the process by which an innovation is communicated within a social structure (Rogers, 2003, p. 7). It is a different process than mere communication, as it involves passing on an idea or concept to present people with a new method of doing things. Most of all, due to its innovative nature, diffusion also implies a degree of uncertainty, as humans tend to fear what is new or change.

Diffusion of Innovations is one of the oldest social science theories, developed by Everett Rogers in 1962. It is rooted in communication and seeks to explain how ideas and innovations become widespread, what allows for their adoption, what causes their rejection, and how people and organizations can speed up the diffusion process and increase the adoption rate of innovations.

Diffusion scholars have long recognized that an individual's decision about an innovation is not an instantaneous act but rather a process that occurs over time and requires a diverse set of five stages (Rogers, 2003). Diffusion of Innovations is highly relevant to the proper communication and presentation of ARCA to the world, as the platform is undoubtedly an innovation, but it is also a preventive one. Preventive innovations tend to have a slower rate of adoption as their perceived advantages are less apparent in the present. It is an innovation that offers the opportunity to decrease the chance of misfortune in the foreseeable future (Rogers, 2003, p. 234). Optimizations are often used to perfect and increase the speed and success rates of adoption. To achieve this goal, this work will attempt to understand better each of the five stages of diffusion proposed by Rogers and find ways to merge its concepts with communication and

development tactics to either build in features or strategize courses of action that improve the platform diffusion odds.

Knowledge Stage

The first stage of the innovation-decision process is when an individual or other stakeholder is exposed to an innovation and gains some understanding of its functionality (Rogers, 2003). Predispositions, personality, interests, and needs are all in conflict, generating a tendency called selective exposure. Stakeholders need to understand the need for such a platform. Therefore, potential exposure scenarios would most likely involve countries, states, and cities that have gone through recent disasters and tragedies. The need is then the main "gas pedal" of early innovation adoption. Usually, the need for our proposed platform would be created by the lack of it and by disaster, which is the opposite of what we stand for.

However, need can also arise from the realization that a tool exists and, therefore, be created by the innovation itself or its exposure to its existence. Our take on this would be to generate as much social media exposure as possible, focusing on influencers who speak to the local audience or are raising funds and awareness towards disaster relief. Having a social media profile for the platform itself would also be a way to create awareness about the ARCA app. Regularly posting updates, infographics, and engaging content to inform the public, stakeholders, and potential users about the app's existence and purpose.

Another interesting approach would be to create tutorial videos on YouTube explaining the functionality, how to use the app, and the benefits of the ARCA app. These videos can serve as educational resources for users to understand how the app works and how it can contribute to disaster management and their protection, as well as the protection of others; these videos would allow users to be exposed to the application, providing social proof that the innovation works,

raising awareness of the platform's intention and the long-term benefits of adopting the innovation.

Persuasion Stage

At this stage, an individual or agency forms a favorable or unfavorable attitude toward the innovation (Rogers, 2003). It is only after the knowledge state that this decision process takes place. In this stage, considering the decision becomes a more active and aware process. It is when the potential user starts to actively seek information and engage with the information they were exposed to. Perceived advantage, compatibility, and complexity are very important at this stage. Users will compare their present and future scenarios and make decisions based on the resulting outcome. Our proposed platform is considered a preventive innovation (Rogers), which is an idea adopted with the intent to avoid the undesired effects and consequences of a future event. This means that the adoption rate for this kind of innovation is often quite slow. Ways to combat this discrepancy are in the form of incentives or through cues-to-action. This event creates a favorable demand and changes behavior towards the adoption of the idea.

Considering these elements, reaching out during the initial disaster relief efforts seems fundamental. For that reason, the platform must account for a speedy and streamlined onboarding process geared towards all stakeholders, most importantly, the government and NGOs. To ensure this, contact must be made with organizations and agencies of the public and private sectors, and the user interface and experience of the platform must be tested extensively to ensure a streamlined and straightforward onboarding process and functionality usage.

Decision Stage

This stage commences in the innovation-decision process when a stakeholder engages in an activity that will lead to an adoption or rejection of the innovation. Adoption is the decision to

make full use of an innovation as the best course of action available, while Rejection is the decision not to adopt the innovation (Rogers, 2003). At this stage, small-scale trials are common, where users will try to understand if the innovation is helpful to them in their own environments. Innovations that can be partially tried out are more likely to be adopted. Another important consideration is that there is evidence that demonstrations where peers can use and test the idea often speed up and facilitate adoption (Magill & Rogers, 1981). To increase the odds of adoption, the ARCA app could ideally be demonstrated in large fairs, such as technology, military, and others, as well as universities and other large centers, to achieve through a "trial by others" approach, a way to counterbalance the slow adoption rate of preventive innovations.

Implementation Stage

This stage begins when the stakeholder or user actually uses the innovation. Until this moment, the innovation stage is a mental exercise (Rogers, 2003). At this stage, problems often occur as this is the first materialization of thoughts and decisions; the physical aspect of putting the innovation into practice can cause errors, a lack of intuitive and easy-to-use designs and methods, as well as logistical and unavailability of the platform can culminate onto the rejection of the innovation. This is the main area of expertise and control of the developers and designers that effectively develop the platform.

This is where all of the research and work that has been done and created thus far clashes with the expectations and abilities of the average person and results in the implementation or in the abandonment of the platform, even if the decision was to adopt the innovation. When it comes to ARCA, the main focus to counter these risks should be to streamline UI/UX through a lot of testing and debugging, making sure the product is ready to be used and adopted before it can actually be implemented, also making sure the platform is stable and deployed entirely as to

be operational and functional. Due to the nature of the project, an interesting approach would be to reach out to a company sponsor, such as SpaceX, and become a user of their internet satellite systems technology. That way, even in disaster scenarios, the internet could be provided so users and stakeholders could access the platform in the aftermath of a disaster.

CONCLUSION

In the journey of examining the diffusion potential of a collaborative mobile platform for disaster management and relief, this thesis has explored the intricate balance between technological innovation and human collaboration. ARCA, as proposed, stands as a testament to our capability to harness technology in the face of calamities and as a bridge between disparate efforts in times of crisis. The Petrópolis-RJ disaster of February 2022, which served as the backdrop for this research, exemplified the dire need for coordinated disaster management and relief efforts. Through the development of ARCA, this work presents a conduit for real-time data collection and dissemination, facilitating a unified response that transcends organizational silos. The thesis outlined the profound need for innovation in a world where disasters do not discriminate by economic prowess or geographical boundaries.

This research has argued that a collaborative digital platform, informed by the principles of chaos theory and underpinned by the ubiquitous presence of smartphone technology, can revolutionize disaster management. By fostering an environment where situational awareness is heightened, and resources are meticulously marshaled, ARCA aims to be the ark in the deluge—a digital haven for those in the throes of disaster and a beacon for the relief providers navigating the aftermath. However, this innovation's journey from conception to diffusion is mired in complexity. This thesis has delved into the diffusion of innovations theory to chart a course for ARCA's adoption. It underscored the significance of each stage—from knowledge and persuasion to decision and implementation—recognizing the pivotal role of clear communication, stakeholder engagement, and comprehensive user training in fostering widespread acceptance. As we stand at the nexus of potential and implementation, it becomes clear that the success of such a platform lies in its ability to meld seamlessly into the fabric of

disaster management culture. The goal is not merely to introduce a tool but to cultivate an ecosystem that values proactive participation, continuous learning, and adaptive response in the face of disaster.

The path ahead for ARCA is not without its challenges. However, its promise of saving lives, streamlining efforts, and uplifting spirits in times of profound loss impels its pursuit. This platform, embodying the collective aspirations and resilience of communities like Petrópolis, is poised to be a cornerstone of disaster management in the digital era. In closing, this thesis does not mark the end of ARCA's story but rather the beginning of a dialogue—a conversation between technology and humanity, innovation and application, chaos and order. It is a call to arms to take the lessons of the past and the technologies of the present to safeguard our future. For in the wise integration of our resources and the unity of our endeavors, we shall find the strength to endure and prevail over the adversity nature bestows upon us.

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