Qatar University

College of Engineering

Department of Computer Science and Engineering

Senior Project Report

Harassment Prevention Helping Tool Using Heat Map

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This project report is submitted to the Department of Computer Science and Engineering of Qatar University in partial fulfillment of the requirements of the Senior Project course.

Declaration

This report has not been submitted for any other degree at this or any other University. It is solely our work except were cited in the text or the Acknowledgements page. It describes work carried out by us for the senior project. We are aware of the university policy on plagiarism and the associated penalties, and we declare that this report is the product of our work.

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Abstract

Harassment has been a toxic phenomenon that proved hard to drastically countermeasure due to its random and unexpected nature. Additionally, this phenomenon helped draw a faulty image of societies where many harassment events occur, regardless of the movements that are publicly against it. Creating a tool that puts the power of opposing this phenomenon in the hands of everyone, all while being effective and responsive, is what inspired us to adopt this as our senior project. Accordingly, we targeted the prevention prospect of fighting against harassment by implementing a heatmap that reflects the density of harassment in an area and additional functionalities to aid people in the case of incidents occurring. One of the aiding functionalities is the immediate help functionality, where the victim will press a button to call emergency forces like the police and ambulance to help the victim. Moreover, we provided a “view near facilities” functionality, where the user can view facilities on the map, such as hospitals and police stations.

A program like ours with the same characteristics has not been made before and has not been used in the region before, and this is what makes it a unique program with an easy, simple, and robust design.

Acknowledgment

Firstly, we thank Allah for giving us the patience and power to finish this project. Additionally, we would like to thank all those who helped us during this project, from the survey participants who inspired us with strength and patience to complete the project.

In addition, we would like to thank Dr. Sayed El Sayed for teaching us software engineering, which immensely helped us in this project. In Addition to the instructors mentioned above, Dr. Abdelkarim Errady and ENG Abdullahi Hassan played an essential role by helping us learn the basics of mobile development. Finally, we would like to thank Dr. Mohamed Saleh for his support and periodic follow-up along with phase one, by giving us advice and comments, which helped us provide the best possible production.

In conclusion, we thank all our families and friends who have supported us from the first moment until the end.

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1. Introduction and Motivation

1.1. Problem statement

Harassment is the act of aggressively pressuring or intimidating an individual by saying or doing unpleasant things to them [10]. Consequently, our goal is to tackle as many harassment cases in society as possible. This problem is spreading rapidly nowadays in the region, but it has been proven difficult due to its randomness, unpredictability, and anonymity issues.

Although harassment negatively impacts many social groups in society and the region in general, a platform that encourages the public to face such phenomenon actively and safely is missing. Other platforms might not provide enough anonymity for their users to safely report an incident without being vulnerable to blackmail. Also, the police forces might face problems related to the language barrier imposed by the responders; this will lead to a delay in the enforcers' interference due to the unpredictable nature of the harassment.

Hence, we figured that we must try and provide an application for everyone to try and be a part of being the solution that can tackle and contain this problem effectively and efficiently.

- Technical challenges:
    1. Responsiveness speed of the system (low latency)
    2. Ensuring privacy and anonymity
    3. Using a meaningful algorithm to determine the "heat" of an area
- Non-technical challenges are:
    1. Spamming, which Can be solved easily
    2. Countries' Acceptability to support this kind of platform

1.2. Project significance

This platform will be an essential steppingstone for solving this issue since it provides a safe and reliable outlet for those who face harassment, ranging from physical harassment to workers’ abuse. Additionally, it will help address this rising trend of harassment dynamically by and for the people.

More than 40% of the population in one of the countries in GCC experienced some harassment in 2016.[3] Five years go by, and the problem is not getting any smaller. The world reached the year of disasters in 2020; the problem was not reaching a solution. It was getting bigger and bigger," Not Ignorable" was a whole campaign created by the gulf health council. It was targeted only towards pedophilic harassment, showing that the problem is only getting more gruesome and disturbing [2]. Harassment is not a problem for one type of person, as men also get harassed in many ways, and it affects them in a terrible way that can show an impact on their productivity and mental health [4][5].

Moreover, it is not a secret to anyone that women are getting harassed nowadays globally; this phenomenon is not prevalent in a region or two. One in three women worldwide has experienced physical or sexual assaults, and in some countries, the ratio gets bigger [1]. As the world focuses more on this type of harassment, emerging campaigns impact society, but still, the numbers are not getting any less. In the middle east, verbal and physical harassment numbers against women are growing every day. In 2019 harassment percentage reached 63%, which is more than half of the women in the country, including elder women [8].

In Addition, Labor mistreatments do not get enough attention from the press, as it is hard to find eligible resources to address the problem. Foreign workers in GCC sometimes get treated like their employer-owned them. While we were searching on this problem, we found some points that should be highlighted; in our application, we will be focusing on actual harassment. We will leave the generic points regarding labor mistreatments held by similar research. For example, when covid-19 started to occur globally, many foreign workers were sent to their homes without getting paid for what they had done. As Shashi Tharoor, the famous Indian diplomat, said, "In my letter to the Indian Minister of External Affairs on 25 July, I called for the development of a model in which our citizens who leave the country can register work-related grievances" [6][7].

According to a study done by the Office for National statistics in the figure shown below, there is a clear correlation between harassment and other violent crimes to put the final nail in the coffin. That being said, working on decreasing harassment counts will reduce the rate of other crimes.

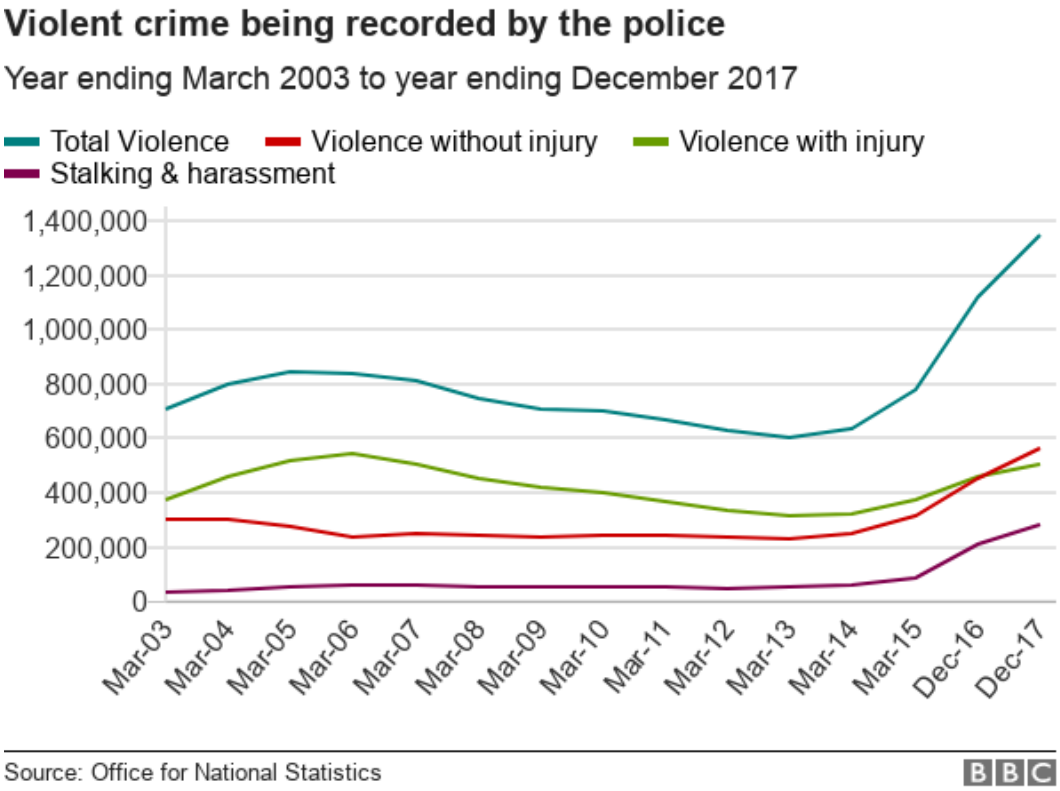

Figure 1: violent crime rate in the U.K.

Figure 1 shows the violent crime rate. Moreover, since Qatar is a very influential country in GCC and the Middle east, utilizing our application will pave the way for the whole region to address and fix this toxic phenomenon impactfully.

Key problems:

1- Security and anonymity

The person's security and anonymity usually stop him from reporting the incidents to avoid the negative stigma linked with harassment incidents, especially the stigma surrounding people who get sexually assaulted. Additionally, some victims get blackmailed after being harassed, so they do not go to a police station or contact the authorities can be handled by having a mechanism that allows the victim to safely and secretly report or ask for immediate help, all while preserving their anonymity.

2- Responsiveness

Due to the nature of most harassments, it is challenging to predict and prepare for them since they usually happen in public spaces when victims commute, shop, or even work.

Consequently, emergency forces such as the police or the civilian defense will arrive at the scene after the incidents occur. Hence, we believe that providing a sixth sense to these forces will allow them to respond quicker; This will be achieved by observing the Heatmap and the fluctuations in intensities and their repetitiveness in a specific place and deploying nearby forces accordingly. Additionally, by implementing an effective way for the users to ask for immediate help, it will be safer for them to request help from various parties such as their emergency contacts or/and the police forces.

3- Dangerous trips

Whenever someone gets harassed, their sense of safety is heavily negatively impacted, which will make it harder for them to go out of their house knowing that they might get involved in a similar incident again. Furthermore, not knowing which places are places with frequent harassment incidents might put them in further harm later when they decide to go out again. Accordingly, we think that providing a visual aid for them to help them decide how safe a place is by looking at the heat map before they head out will drastically increase their sense of safety and their ability to avoid future cases.

4- Bullying

Schools have a very high impact on how the students' personalities are structured, and such a vital process usually gets obstructed and hindered by the students getting bullied. Although there are methods implemented in schools to fight this phenomenon, it is still inevitable for most cases to not get treated effectively; due to the difficulty for students to preserve their anonymity while giving in a report. Additionally, by providing an additional metric for parents to pick which school is the safest for their child, it will allow the parents to have a hand in preventing this phenomenon from impacting their child and incentivize schools to provide more protection and prevention methods against bullying.

5- Harassment and tourism

One of the main things a tourist considers before deciding to go to a country is the security of the country he will go to, and if the country is known to be unsafe, the tourist will most probably change his mind in favor of a safer country. Furthermore, some countries might grow a bad reputation due to harassment incidents that get reported consistently. If the country's harassment rates improve over time, it will be hard for the country to prove it to regain its tourists' trust. By creating a tool that indicates the rate of harassment in a country, tourists will

find it easier to decide which place is safer to visit, and countries will have higher responsiveness, as mentioned above as well as a reliable and live method to advertise their viability and security to incentivize tourism.

6- Blackmailing

Being threatened by criminals and abusers after being the victim of an incident reduces the chances of the victim reporting the crime due to the fear of further consequences. By providing a safe medium to report their incident, victims will be encouraged to speak up about any harassment they experienced without the fear of getting blackmailed.

7- It knows where the nearest facilities are.

After moving to a new area or traveling to another country, knowing where the nearest facilities are can pose a challenge caused by language barriers or being in a rural area.

8- Proactivity

After considering anonymity and the prevention of blackmailing, as mentioned above, users will be more proactive when reporting crimes and harassment that occur to them or others. Furthermore, such mass proactivity will build a virtual safety net in the community, which will both safeguard people who are vulnerable to these kinds of incidents and will disincentivize harassers and abusers from committing more crimes due to the fear of facing the consequences while not being able to use techniques such as blackmailing to cover up for their evildoings.

1.3. Project objectives

- Increase awareness of harassment in the region
- Decrease the stigma around girls reporting incidents that happened to them
- Safer Environment for both genders.
- Make countries safer for tourists.
- Allow the cop's quick interference.
- Show people safe areas and dangerous areas
- Amazing learning experience.

According to the chosen software model (V-shaped model), we will publish a prototype to test our project in the field and how efficient it is. We will choose a certain number of people to test the published prototype in their daily life and start using its features to the fullest. After

some time, we will ask them about their experience and get to know whether it helped them and did the needed objective or not. Additionally, the fantastic learning experience will be measured by how we enjoyed working on it and how we evolved and became better programmers and humans by finishing this project.

1.4. Market research and Business

Market Need and size

There is an apparent void in the GCC region regarding this kind of application; instead, there are some movements that address this problem. Consequently, users must contact the organization, which requires much courage for victims. Hence, by providing an app for people and anonymity for the victims, the entrance requirements will be drastically reduced and simplified, making it possible for us to fill the void effectively.

Additionally, the market size for this kind of application can be deduced from the statistics provided in segments 1.2 and chapter 2. By analyzing the traction that recent harassment cases gathered on social media, we can also conclude that our application's impact and usage will be positively high.

Target Consumers and their demographic

Our application will mainly target the people who get harassed, like:

- Women who are victims of physical harassment
- Men who are victims of physical harassment
- Workers who are victims of labor misconduct
- Kids who are victims of physical harassment
- Students who are victims of bullying

Consequently, we expect that the first two segments will present the majority of the users, followed by students, kids, and workers.

We collected a survey through WhatsApp groups in Qatar where 112 people of different ages and genders participated in talking about the problem of harassment. The percentages of males and females were similar, the percentage of females is 59.8% and males 40.2%. Most

of the participants were between 16 to 24 years old, and most of them were still students, as shown in the picture below.

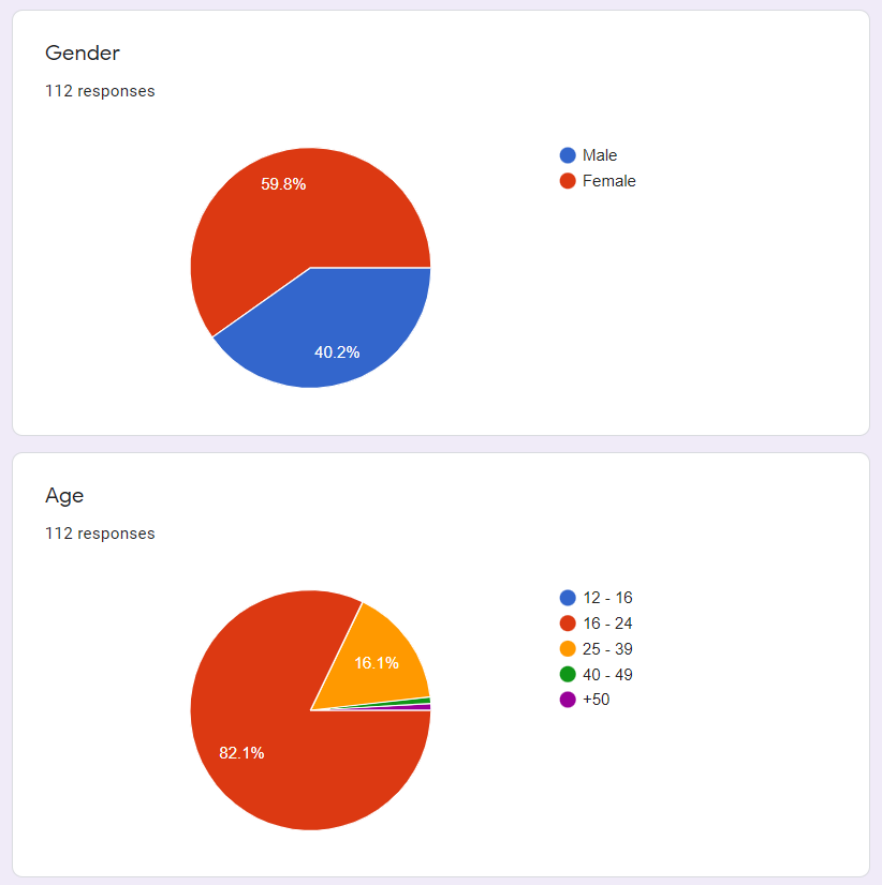

Figure 2: survey pie chart

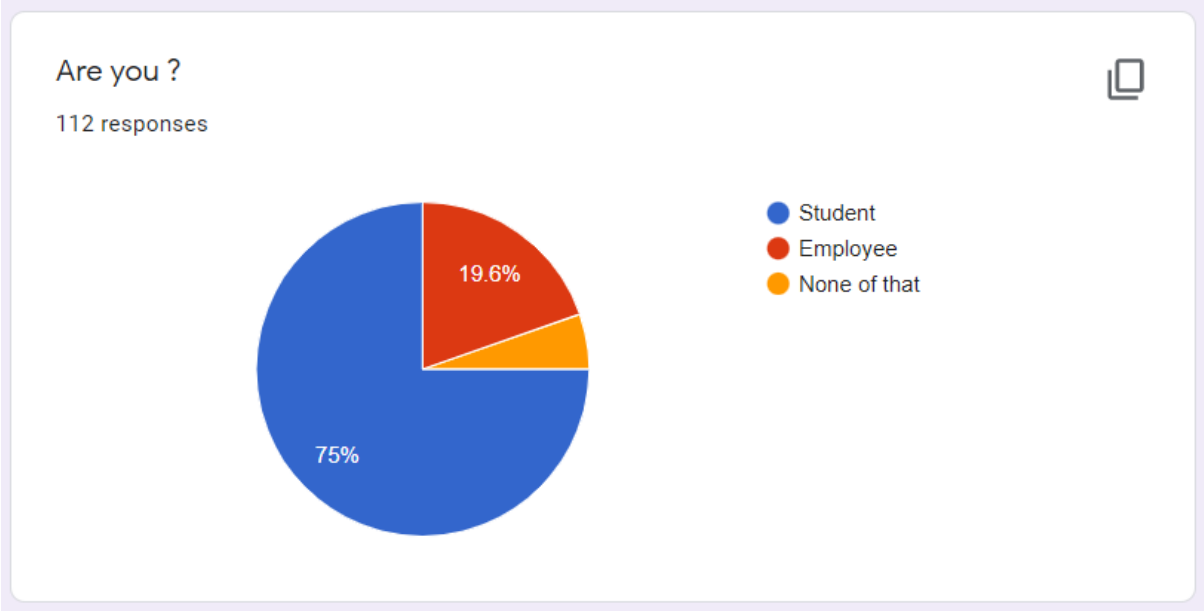

Figure 3: survey pie chart

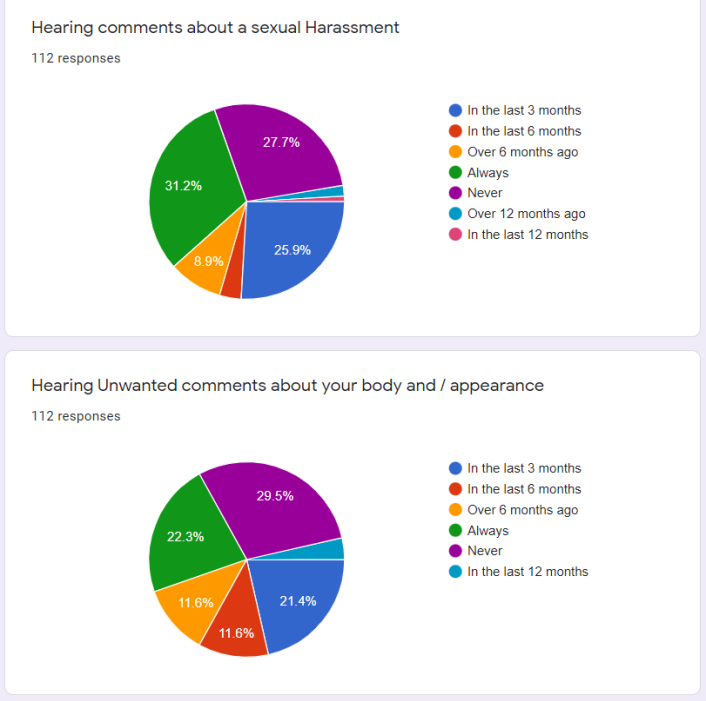

Figure 4: survey pie chart

As shown in figure 4, we started by asking whether people had faced or heard about incidents related to harassment during varying periods. The percentages were as shown in the image below.

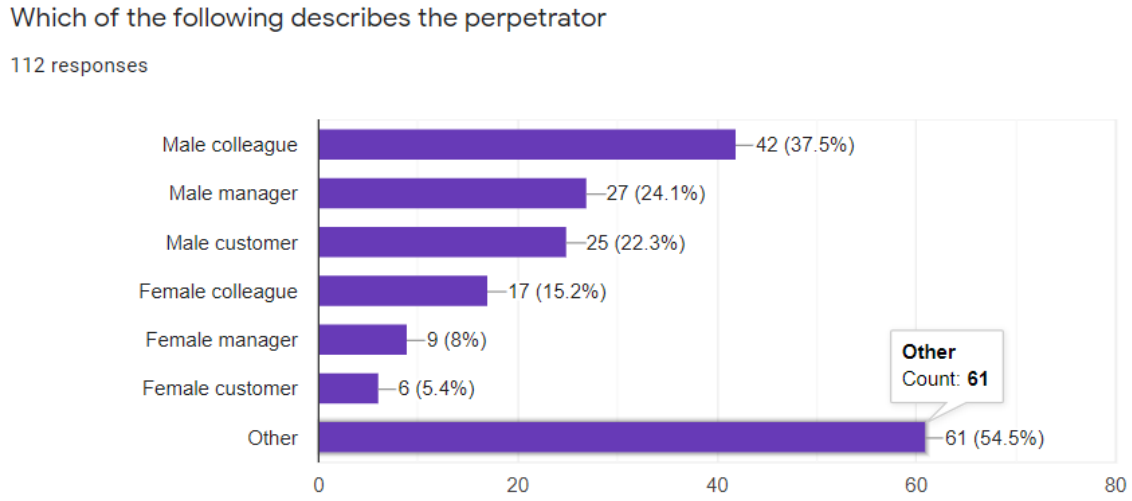

Figure 5: types of predator percentages

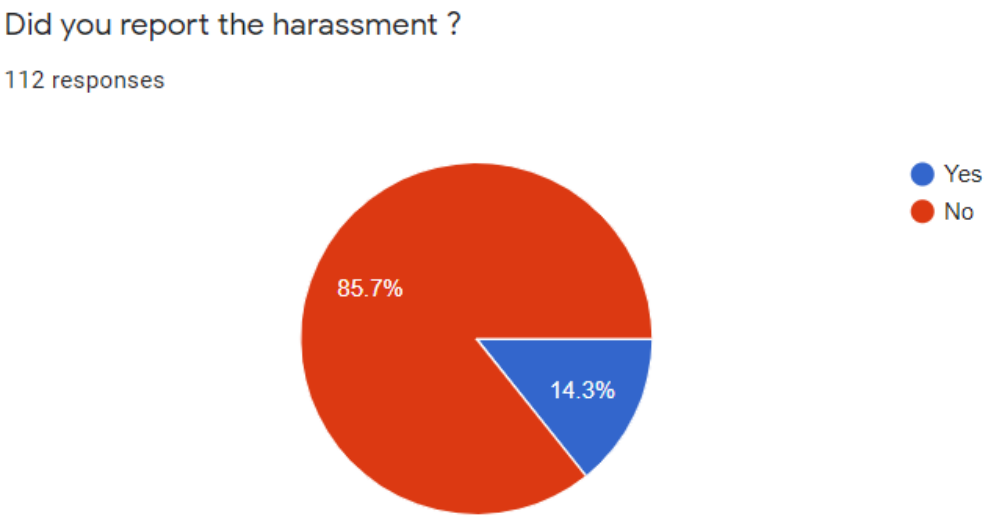

Figure 6: percentage of reporters

If there is an app that could help you to call for immediate help if you see or got harassed would you use it?

112 responses

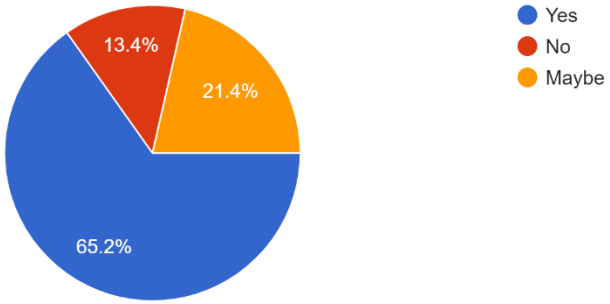

Figure 7: social acceptance of the application

If a mobile number is mandatory for using the previous feature would you still use it?

112 responses

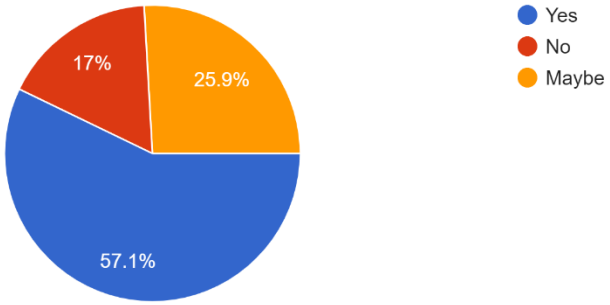

Figure 8: social acceptance of using mobile number

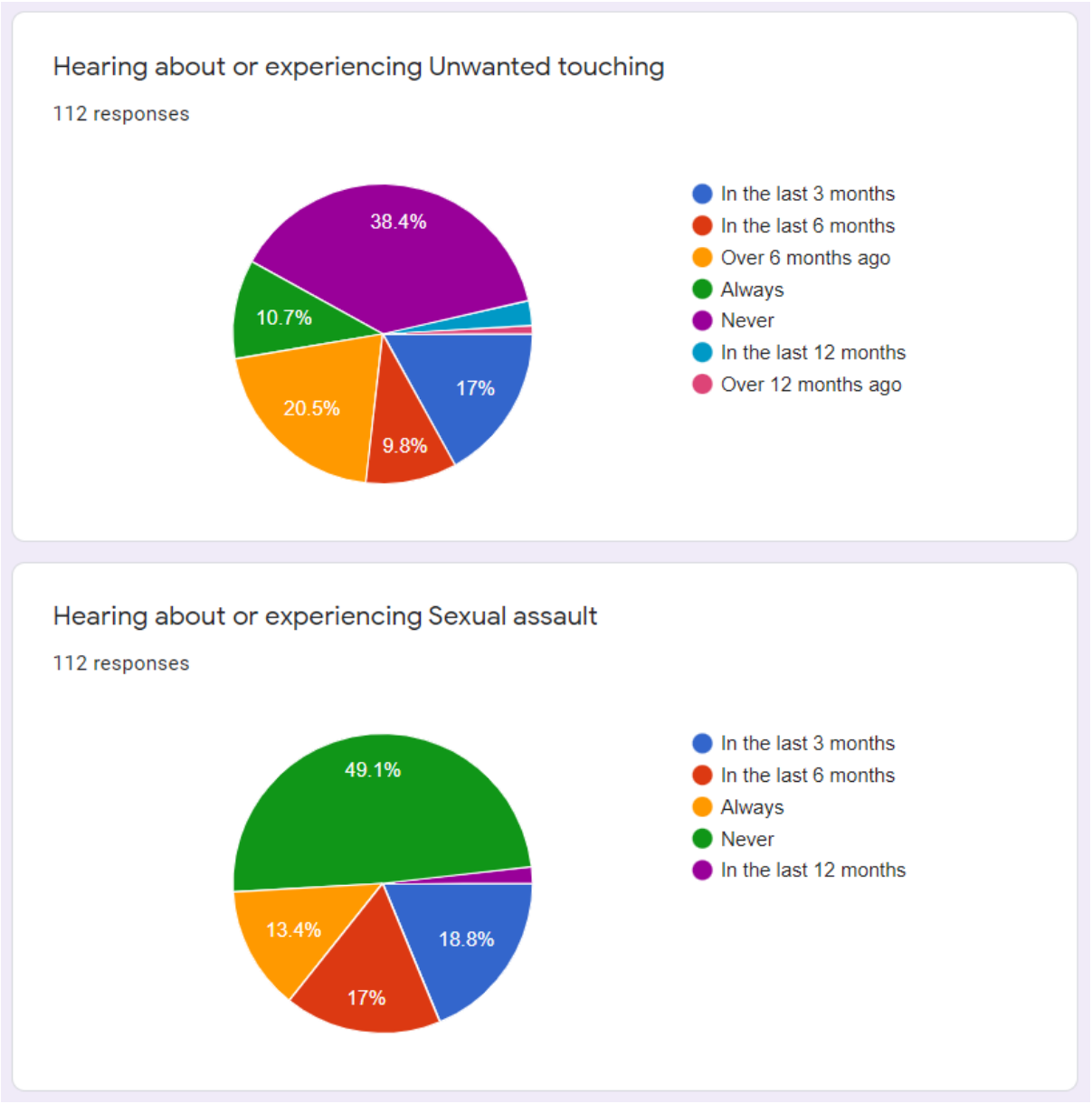

Figure 9: survey pie chart

In Figure 9, looking at the answers, we can see that the problem of harassment exists in a not small proportion. The participants confirmed that they had heard or experienced harassment from the first question. Also, that appeared in the other questions, it was always confirmation of the existence of harassment, even if not permanently, it still exists, and most of the participants in that complex process were unknown people, meaning not work colleagues or close people, so they are people in public places such as streets or large gatherings.

In a second part of the survey, the participants were asked whether they reported the incident, and the answer was expected, which is that they did not report the incident at a rate of 85.7%. The reasons ranged from a psychological unwillingness to confront the aggressor or fear of people looking at them or their fear of not believing them when they report, and this is what we do in our project by maintaining the confidentiality and making the support reach the needy as soon as possible and warning users to reduce the rate of harassment.

The participants were asked whether they had heard about another type of harassment. There were other harassments such as child abuse, Spying, photographing, Stalking, or even family hokes about bodies and touches, Domestic harassment and Gaslighting, and General Psychological/Emotional Harassment.

We asked the participants If a mobile number is mandatory for using the previous feature, would they still use it? The answer was yes by 57.1% and 25.9% for maybe, and only 17% refused.

In conclusion, after collecting the responses, it was concluded that there is a need to create a tool that reduces the rate of harassment or protects the needy. The presence of harassment is a settled matter and is not hidden, and it is not only in Qatar but rather a global problem; as we saw in the survey, the victims were afraid to report it to the police or someone incident, and this is what we will try to change through the project.

Competing Products and our added value

When we took the GCC region as our scope, we could not find any relevant applications that compete with our product. However, when we looked at other regions, mainly the Americas, we found some applications that have similarities with our product:

- Citizen
- Neighbors by Ring
- Next Door

Citizen and Neighbors had the most resemblance due to a map indicating accidents. However, their focus was on disasters, accidents, and criminal activities, and users were not anonymous and had to post the reports on a feed-like timeline. On the other hand, our application will focus on harassment and social misconduct while making the victims anonymous due to the reasons mentioned in chapters 1 and 4. Furthermore, the targeted

customers of the applications mentioned above do not include workers that went through labor misconduct and children that are victims of physical harassment

Price of our product

Since availability is one of our main goals, our application will be free for all of our targeted customers to use. However, we plan to impose some service fees for organizations that want to integrate with our application, for example, the ministry of interior. Additionally, if charities or rehabilitation organizations plan to advertise their services on our application, we will also impose a fee.

2. Background and related work

2.1. Background

2.1.1. Heatmap

2.1.1.1. What is a Heat Map?

A heatmap is a way to visualize data to reflect the magnitude of a particular phenomenon on a map layout. Magnitude is reflected by the intensity of the hue in an area, and the spread indicates the areas that withhold this phenomenon [9].

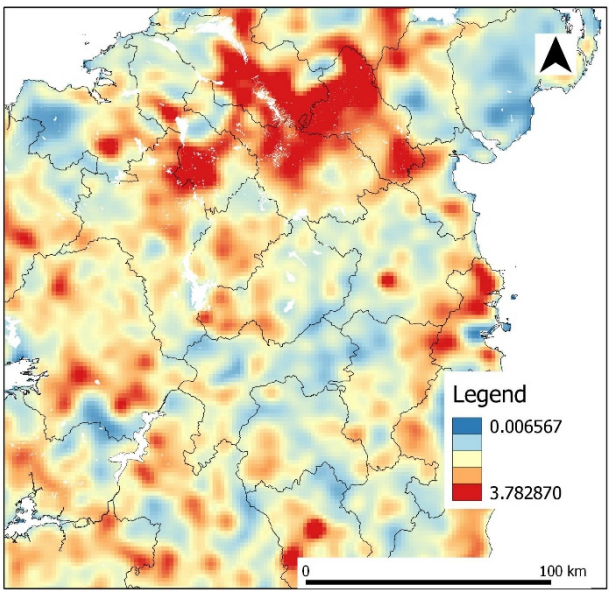

Figure 10: Heat Map

Figure 10 shows a heatmap with the red areas where the phenomenon happens with high intensity, and the blue ones are the ones with the lower intensities.

2.1.1.2. Heat Map Usage

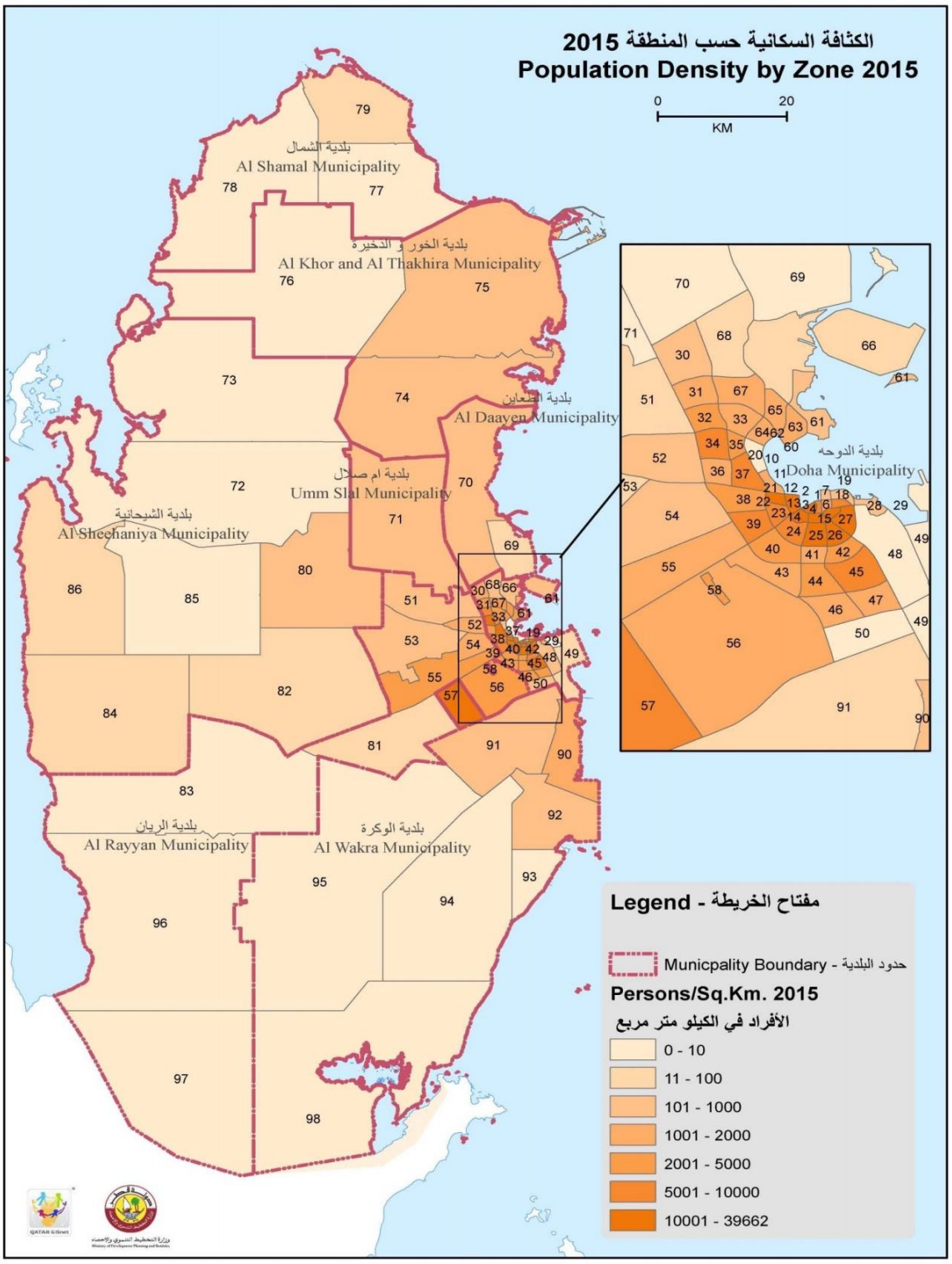

Figure 11: Map heated with a population in Qatar

Figure 11 shows a population heat map of Qatar is illustrated, where the phenomenon at hand is the population magnitude of people living in a specific city. Additionally, the intensity/hue of the city signifies the magnitude according to 7 thresholds as shown in the map key, where dark brown reflects the highest range of population, and the very light brown signifies the lowest range of the population.

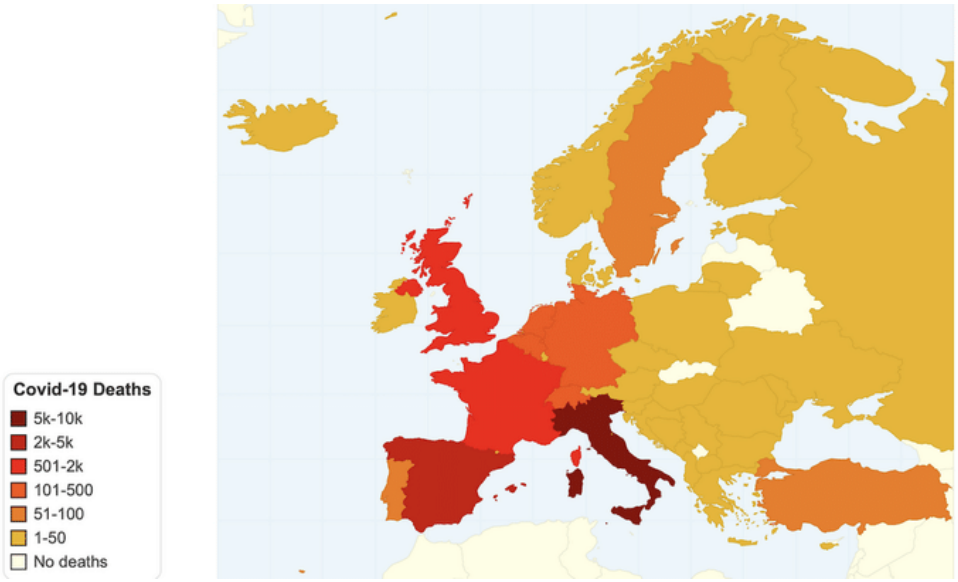

Figure 12: map heated with covid deaths

Moreover, Figure 12 reflects COVID-19 fatalities in Europe, where the countries colored with a darker shade of red have the highest number of deaths, while the light shades reflect the least number of fatalities.

2.1.2. Harassment

2.1.2.1. What is Harassment?

Harassment is the act of aggressively pressuring or intimidating an individual by saying or doing unpleasant things to them [10]. Consequently, our goal is to tackle as many harassment cases in society as possible. People that are vulnerable to harassment are:

1. Women and men that get physically or verbally harassed publicly
2. Workers and maids that get mistreated in their work

3. Students that get bullied in schools
4. Kids that get harassed

Some forms of harassment can be more aggressive, such as kidnappings and sexual harassment.

2.1.2.2. Efforts Against Harassment

Harassments have been a vital global problem, making more companies and governments target this phenomenon to try and reduce its frequency and spread. Hence, some apps and movements have a similar mechanism to our idea, where people report incidents using their phone, such as the app: Citizen. The app aims to create a social network that defends against general public incidents, such as robberies, fights, fires, kidnappings, sexual harassment, and car accidents. They do that using a timeline-like feed where people can post videos of the incident happening so that nearby people and authorities can help or that emergencies can interfere quickly.

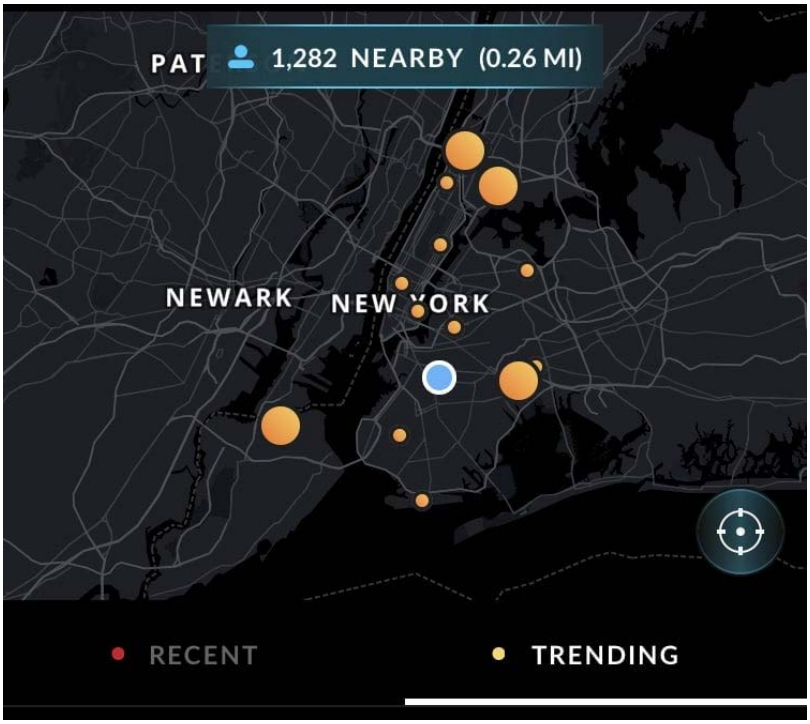

Figure 13: application screenshot

Moreover, the #MeToo movement targeted sexual abuse and sexual harassment by utilizing protests and media campaigns to shine light over and aid victims of such acts. The movement attracted global attention and shed light on abusers in several positions, and it aided the victims' communities vastly by providing healing programs for those in need.

Figure 14: hashtag #metoo

2.1.3. Emergency

2.1.3.1. What is an Emergency?

An emergency is a serious, unexpected, and often dangerous situation that requires immediate action [11]. Accordingly, the emergencies we will focus on in our platform will be the following:

1. Sexual Harassments
2. Kidnappings
3. Physical Attacks

Some situations that are not considered emergencies might get reported on the app, adding a hurdle for us to resolve. Such cases might be where the reporter felt uncomfortable in a safe environment due to personal ideologies such as racism or personal grudges. Consequently, we specified what kind of emergencies will be reported to avoid spamming/untruthful reports. We ensured that the mechanic we will implement for emergency reporting would reduce the false-positive reports as much as

possible. One example of false-positive reports is when a user reports harassment without being harassed.

2.1.4. Spamming

2.1.4.1. What is spamming?

Spamming is any kind of unwanted, unsolicited digital communication that gets sent out in bulks [12]. In our case, spamming is giving in untruthful reports in bulks. Such action will cause the intensity of the targeted area to be high without any incidents happening in the area, which might cause false distress in the country and tourists who plan to come to the country.

2.1.4.2. Precautions against spamming?

Usually, spam is faced by utilizing the user's identification so that if any false reports are given, the user will be held liable. Furthermore, by using the identification of a person, the number of fake accounts that can get created gets vastly reduced; due to the personal identification being unique. Accordingly, we will utilize the mobile number of the users as the primary identification since it will simplify scalability and be able to contact the person to verify and validate their identity.

2.1.5. Anonymity

2.1.5.1. What is Anonymity?

Anonymity is when the acting party’s identity is unknown while being unreachable and untraceable [13]. Accordingly, our platform will have to ensure the anonymity of the users so that they do not have to fear possible consequences after a report such as:

- Black Mailing
- Social Stigma
- Family Complications

2.1.5.2. How will we ensure anonymity?

In our platform, users will not be able to identify other users who reported, where the map will only show the report with the description of the incident. Additionally, there will be two kinds of accounts, Users' Accounts and Admins' Accounts. Each of those types will have certain privileges so that Users stay hidden between themselves and allow Admins to communicate to users who reported and get alerts/information regarding nearby incidents. Finally, we will be able to secure the data on Firestore by defining data accessing rules, such as users having to be authenticated before querying data.

2.2. Related work

As mentioned before, harassment is a huge global problem that is not new to our society. Many people were affected in heinous ways due to the consequences of such an issue; hence people decided to try fixing the issue. Many trials and approaches were made throughout history, as governments started to put a punishment for this specific problem and address it as a crime. Even though people started to act, the problem became bigger as days passed. So, the solutions kept changing over time.

At first, it was all about raising awareness of the problem. Moreover, a study was made on a secondary school in Nepal as 441 girls took part in it. The study showed how people are not aware of the problem, and its result recommended starting and improving the awareness for the people [17]. This is just an example of many experiments that showed the considerable lack of acknowledgment of the issue and how to deal with it.

Studies were also made about why people do not report harassment incidents and how many women are more likely to report than men, and a vast difference in numbers was shown. Only 4 out of 16 men reported incidents, while 20 out of 50 women reported harassment incidents in their workplace [19]. That may be because people get afraid of reporting and speaking up about what happened to them. Victims ignore the incidents and walk by as if nothing happened, and harassers think it is fine, but it is not; it leaves a mark in the victims' lives, and some get depressed and frustrated [17]. Most of the time, people get afraid of reporting what happened to them and start speaking up and claiming their rights, and that is because of society; they get afraid to talk because they fear they will be blamed for what happened to them, and they will not be believed, it was not harmful enough for them to take action, and the most disgusting one is reason shame that the community will look to the

victim with for something they have nothing to do about [21]. So, encouragement of training for people to know how exactly to deal with harassment, for example, to have training for athletics about harassment, whom to report to, and how to handle it [18] training also started to take place. People started to attend them more. Companies started to give anti-harassment pieces of training for their employees like the one associated with the hashtag #me_too [23]. In Addition, teams were being created, and people joined to support each other and find solutions, like in Egypt after the 2011 revolution [22].

Moreover, as the technology grows and improves, solutions improve with it, where applications started to set their target to solving the problem of harassment. People also started using technology to help raise awareness of the problem, where it was always there, yet the problem was small because not many people heard about it. However, after social media and the idea of hashtags, the problem is being acknowledged by many people now. One of the most famous hashtags that started in 2017, the actress Alyssa Milano, helped women speak up about the sexual harassment they faced and share it with people on social media [29]. So many hashtags and campaigns blew out the internet in the past decade (after the appearance of social media); for example, #not_ignorable started in the GCC in 2020 about child abuse and so much more. Technology did not stop at the point of social media, so the researchers started calling out for developers to create apps about harassment and crime prevention. A study about whether to have reporting apps in schools or not showed that the main concern for parents is their kids' mental health. In the U.S., two high schools arranged meetings in two waves for parents, staff, and administrators in 111 persons; all agreed that having an app like this would help kids have a better school experience [30]. Also, crime prevention apps were recommended to exist to solve some of society's problems [31].

Developers listened to people and started giving some technology solutions, whether in a hardware or software way. For example, an unmanned aerial vehicle solution was presented in a paper that will be done using a physical gadget that will update the victim's location and send it back to the server to allow the detection of them. Then another gadget will be there as a headband that contains LED lights that will ease the camera detection of the victim and tracking them [26]. Another solution was by a physical device based on Arduino and GSM module that will be with the victims; it sends alarms to the authorities, friends, and family. It also generates shock to be used as self-defense for women, and all of this will be done by pressing the button on the device [28]. Smartphone apps were developed t assist people through these traumatizing events for the software solutions. An app for kidnapping

and harassment was developed in Bangladesh; it contains four main sections; the first one is a notification module; using the SOS button on the phone, the app will notify the numbers that the user selected that help is needed and provide them with the current location of the user. The second one is the sound module, which listens to the user whenever s/he says “HELP” the app will do the same as module 1.

Then we come to the sensor module, which monitors the user’s movements using a compass. It will be activated when an incident is reported and take action according to the report presented. Then there is the accelerometer that detects the shaking, where if the user shakes their phone three times, it will also trigger. Finally, the spy module. In this module, a hidden camera that captures hidden photos and saves them on the cloud or the phone depends on the internet connection, and they will get taken as evidence [27]. Another mobile application could be accessed through hardware buttons to help the victim women as quickly as possible. In this application, the user experience is enhanced by introducing tap-based emergency contact with the family person/s, also sending a short message or a phone call that would generate a loud siren from the destination device to ensure a fast response. Also, the application has a database that includes all the nearby hospitals, police stations, and assistance centers. Any data related to the user do not get saved on any external servers to avoid any future privacy problems or dangers [25].

Related work will be represented in the following table.

System	Features	Drawbacks
Government laws	• It punishes the criminal for what they did. • Give the right to report	• Does not always catch the criminal • The outcome is not always satisfying for victims • Do not always see the whole picture • Sometimes gives the wrong judgment
Anti-harassment training	• Raises the awareness of the problem	• It helps, in theory, more than in practical

	• Teaches people how to deal whenever they face an incident • It fixes how harassers act	• It helps only in work-places most of the time • Helps before the incident, not after
Anti-harassment teams	• Provide mental health support for victims • Provide legal support • Try and catch the criminals	• Does always catch the harasser • Some harassers might exist inside these teams and use them • Not a very practical way to prevent harassment
Hashtags	• It raises the awareness of the problem • People being able to speak up freely • Encourages other victims to share their stories and deal with • Provide support for victims	• This can lead to blackmailing • Reveals the identity of the victim • It gives so much information about the victims to harassers
UAV harassment prevention	• Provides precise location • Easy to use • It can scare the harasser	• Too many gadgets to deal with • Lights that will inform the harasser about the report • Harm can be done to the victim after knowing about the report
Hear me app	• Provide help for the users	• Helps post-incident only

	• It gives the location of the nearest emergency institutions • Sends emergency messages to the chosen contacts	• Do not inform the authorities
Anti-Kidnapping and Anti-Harassment	• Easy to use with the SOS button of the phone • Notifies emergency contacts that there is an incident • Provide the current location of the victim • It can also work with voice when the user says “HELP.” • It can work automatically by measuring the movement of the user • It can be activated by shaking it three times • It will record a short video/voice to be taken as evidence later on.	

Table 1: Related work

From Table 1, it is clear that our idea is similar to some of the previously shown ideas, or we would rather say a combination of them with some modifications. Of course, all of the mentioned projects have a similar purpose relative to our project. The main idea is to report the incident immediately and provide help as soon as possible with the resources we have. The reporting mechanism is almost the same using the SOS button, providing the victim's location, and giving the location of the nearest emergency services. Our implementation of this idea will also inform the authorities about the incident as well as metadata regarding the victim; our application will also inform the users of the locations with the most harassing rate as dangerous areas so the victim can avoid them and not get involved in something like this from the beginning using the heat map. Our map will be a significant step up in the market. No one has used a heat map to detect the places with high harassment rates; our app will also notify the nearby people about the incident so immediate help can be provided faster.

3. Requirement's analysis

3.1. Software development process

We chose the V-shaped process since it is the most suitable process for our development flow due to many reasons. Firstly, our project's structure is static and clear, and there will not be many changes along the development process. Secondly, the waterfall process is the best life cycle model for static projects, so why V-shape? Even though we have clear and static steps ahead, still, in our case, there might be some changes as we move on with it. Thirdly, we have due dates and deadlines for every step to submit the project's milestones; hence, we needed a life cycle that exploits this workflow. These are the main three reasons, but from our point of view, these are the most critical reason, and they are enough to decide to go with the V-shaped model.

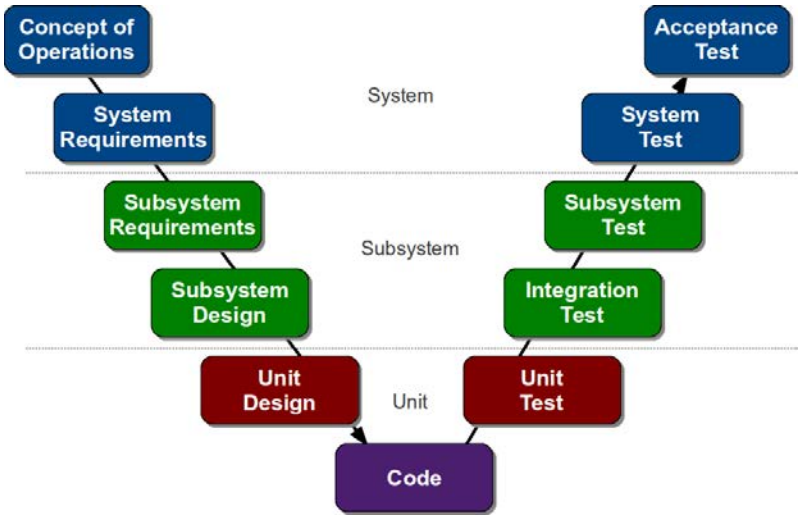

Figure 15: V-shape model

3.2. Functional requirements

In order to build the application, we need to introduce some functional requirements. In the following figure, we will introduce our use-case diagram.

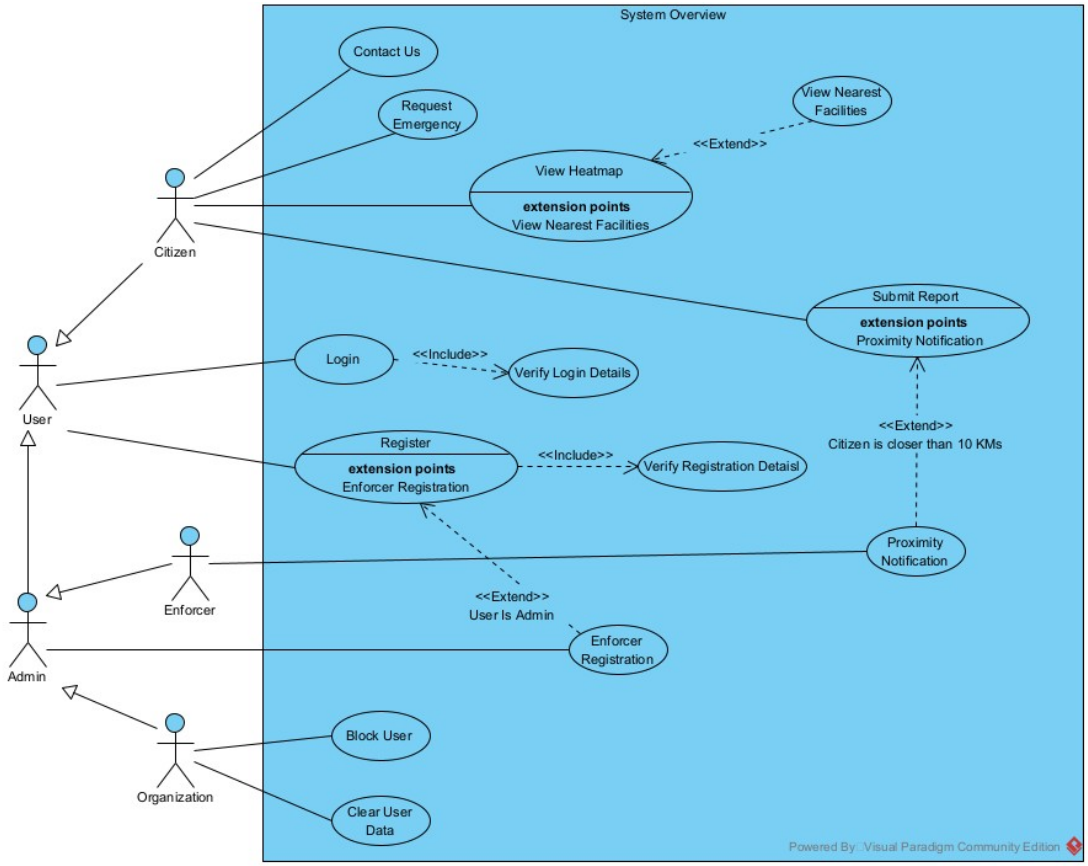

Figure 16: use case diagram

Use case	Brief description
Register	The user registers an individual account using his details, then stored in the D.B. An OTP is sent to verify the user.
Log in	The user logs in into the system using their credentials
Submit Report	The user opens the Report form, fills in the needed information, and then submits the report.
View Heatmap	Users Navigate to the home screen and observe the Heatmap, which contains different views according to the category they want to analyze
Ask For Emergency	The user presses the Ask for Emergency Button, which then alerts the intended parties along with the user's emergency contacts.
View Closest Facilities Map	Users Navigate to the home screen and press the View Closest Facilities button, which shows various facilities on the map view.
Proximity Notification	When a superuser/admin is near a place where an incident just got

	reported, they will get notified to simplify quick interference.
Block User	If Admins Suspect a user spamming false reports, they can block the user from further using the platform / from giving reports.
Donate	Users can donate to us through a link provided on the account screen.
Contact us	Users can send emails and inquiries/complaints when it comes to their experience with the system.
Admin Registration	Third-party partners such as the police and the emergency teams can sign up as admins to get the admin privileges.

Table 2: Use cases summary

3.3. Non-functional requirements

Name	Description	Evaluation Plan
1- Portability	the application could be efficiently executed on a different software/hardware platform.	Testing the application on different software/hardware platforms such as smartphones, tablets, and P.C.s ensures that the main features are working.
2- Performance	Application performance must provide 5 seconds response time for 99% of requests.	Measuring the response time for reporting a harassment incident and how the data in the entire application is changed should not exceed the decided time.
3- Security	stat of the art technologies will be used for data storage and transmission to provide maximum security.	Security will be provided at the infrastructure level from Amazon's web service. The database will be secured by using the IPSEC security protocol.
4- Usability	The application will be accessible in multiple ways.	The user interface component must be accessible in any situation; for example; the application

		can be accessible from lock screen mode.
5- User Friendly	The application interface is friendly and will help users access the application easily.	Using surveys focused on the Ease-of-use points in the project to measure user-friendly parts.
6- Availability	The application will be available all the time.	The application will run 24x7, with the overall availability of 100%
7- Reliability	User's reports and connections will be granted anywhere, any-time.	No message or connection loss is allowed, and all message delivery outcomes must be known within 5 seconds. An error can be recov-ered correctly for a fast correct re-sponse.
8- Scalability	The application must be able to scale up with the spike of users and scale down when the number of active users is low.	By using amazon web service, we can provide scalability features.
9- Modifiability	The application will be easily modifiable.	A layer scheme will be used to provide the least coupling and heights coherence.
10- Maintainability	The application will be maintain-able and upgradable in the future.	Extra features could be added in the future after getting user rates for the application.

Table 3: Non-functional requirements

3.4. Assumptions

- The user will be connected to the internet
- Users will have the application updated in case there is an update available.
- User can reach their smart device.

- Police officers will have their special application edition, so they will take quick action to save the victim if an incident happens.

3.5. Ethics

The following points from ACM and IEEE Code of Ethics are related and will be applied in this project.

Code of ethics	Project application
1.1 Contribute to society and human well-being, acknowledging that all people are stakeholders in computing.	Team members should work for the benefit of society and not for personal reflection. Putting users into consideration while developing the application.
1.6 Respect privacy	Team members have to believe in privacy and work on making it one of their first goals in this project.
1.7 Honor confidentiality	Team members should implement the project so that other users cannot modify the data stored in the database.

Table 4: ACM Code of Ethics

Code of ethics	Project application
1.2 to improve the understanding by individuals and society of the capabilities and societal implications of conventional and emerging technologies, including intelligent systems.	Team members should work together to deliver a task that will make individuals know that intelligent systems can help them during their life situations.

1.1 to protect the privacy of others.	Team members should not use any data stored in the database for personal usage. Also, they have to provide privacy and security for this data.
1.4 to avoid unlawful conduct in professional activities and to reject bribery in all its forms.	Team members shall not accept or even hesitate to refuse any bribery offered to them by anyone to obtain a specific service.

Table 5: 7.8 IEEE Code of Ethics

4. Proposed solution

4.1. Selected solution overview

Our solution is an application where people can easily report and speak up about their incidents and ask for immediate help in case of critical situations. Additionally, the application will introduce a heatmap, which will give the user an overview of the areas and the density of harassment in those areas to allow the user to avoid harm by not going to problematic places. On top of that, the police and other emergency forces can succeed in intervein in problematic areas to prevent any more harassment by dealing with the problem most properly.

By utilizing this application, users will ensure anonymity since other users will not be able to identify the person who gave in the reports and allow police forces to react faster and more effectively to these kinds of situations by controlling or patrolling problematic areas.

4.2. Architecture Diagram

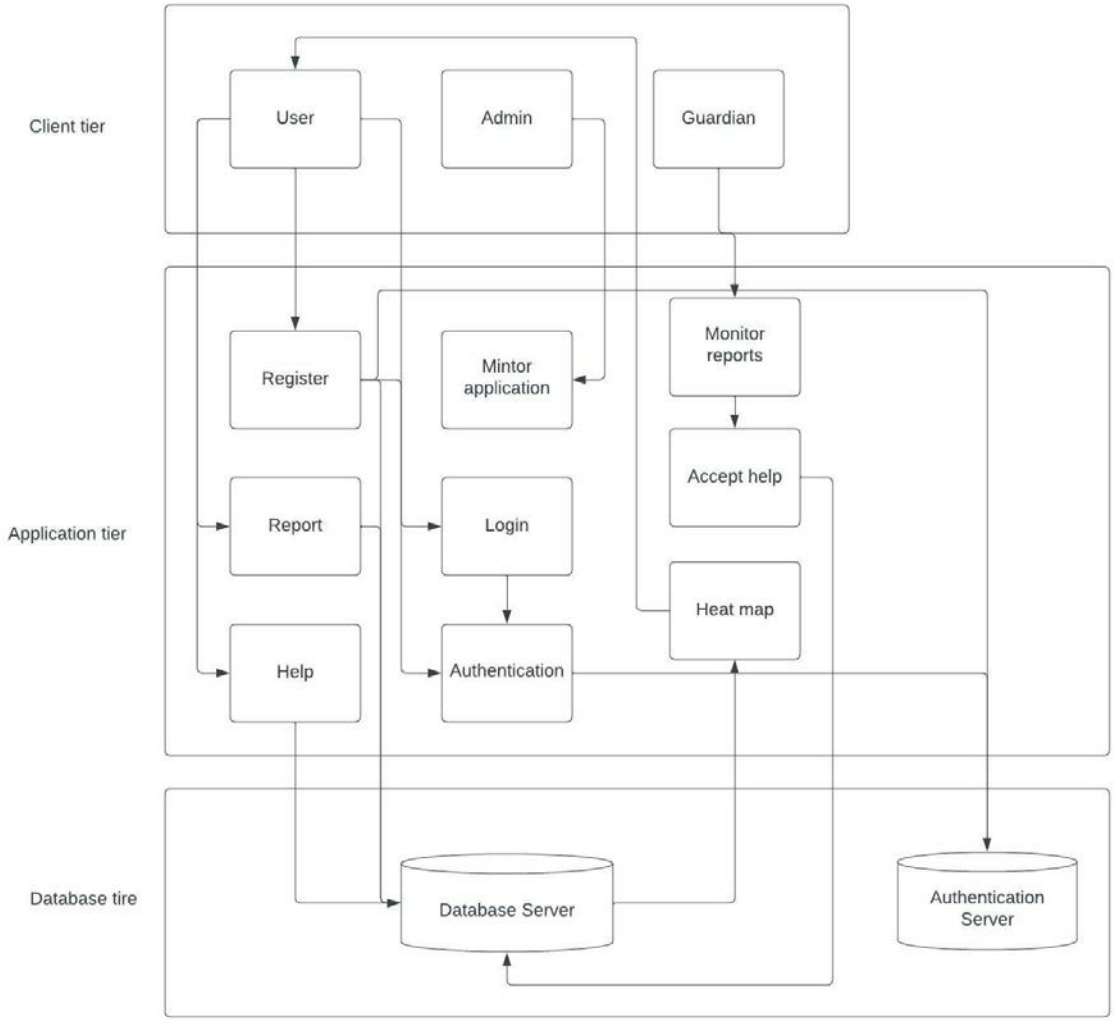

Figure 17 Architecture Diagram

The previous diagram shows three tiers of our system, every tier representing different actors and processes. The client tier shows the clients involved in the system, every one of them has its process and access to the second tier.

Second-tier represents the process and its relationship with the database in the third tier and the actors in the first tier. The last tier is the database tier; it contains the database server responsible for retrieving data and sending data and the authentication server responsible for making the authentication service.

4.3. Structural model

As shown in figure 18, the Location class is the steppingstone in our application, where all the pivotal elements in our application, such as the Heatmap, Report, and weighted Lat Lang. are built around it. On the other hand, the user class depends only on the auth controller. We avoided coupling the user's information with any of the information shown on the Heatmap to ensure anonymity and avoid data leaks.

Moreover, we avoided linking the dependability of the Report class with the Heatmap class, reflecting that the Heatmap will only reflect the location information of the reports, which serves a similar reason to the last point, to avoid any data leaks or the inclusion of the report details to the point shown on the Heatmap.

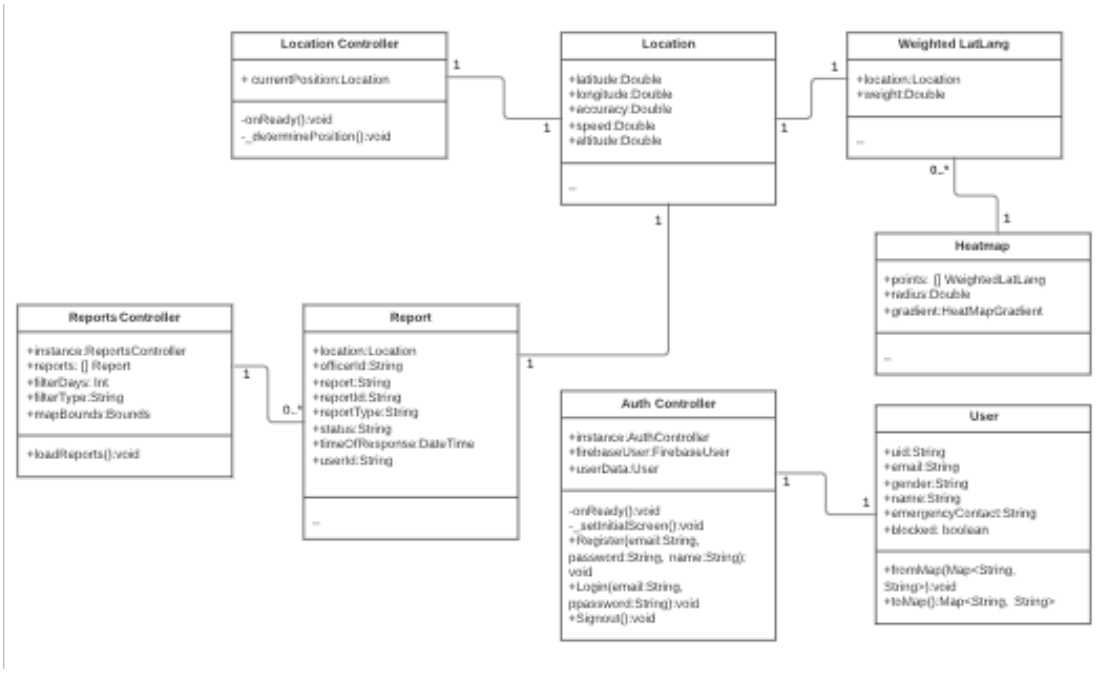

Figure 18 Structural Class Diagram

4.4.Behavioral model

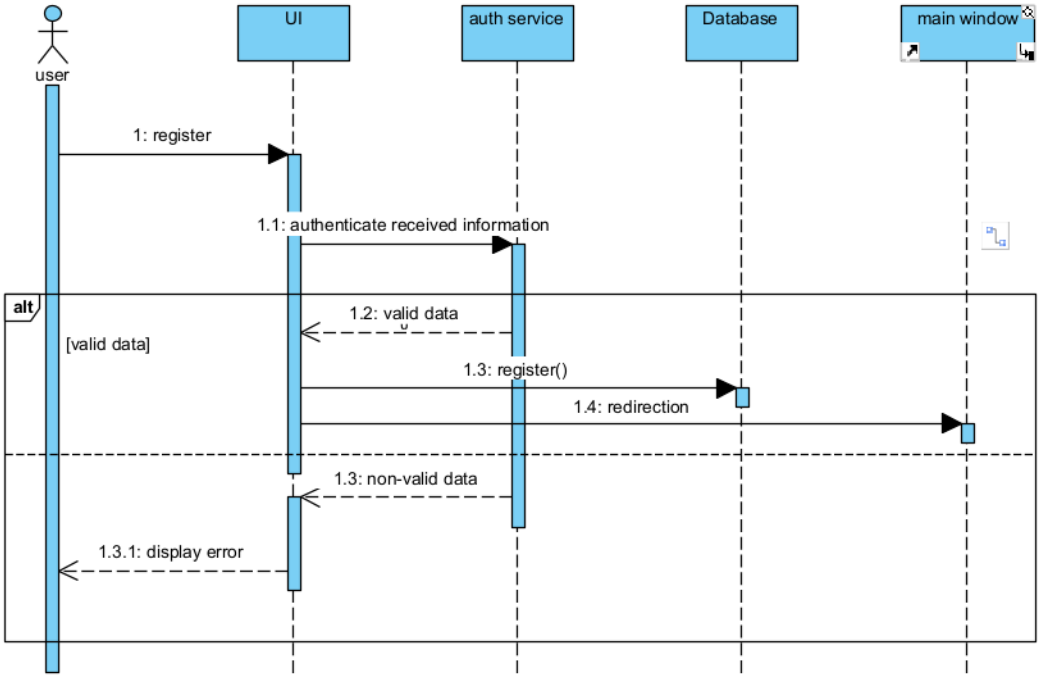

Figure 19 Sequence Diagram of User Registration

Figure 19 shows the sequence diagram for user registration. The user enters his data and email; then, he will receive a verification email to verify his identity; if successful, his credentials will be saved into the database; if he did not authenticate with the verification link, his account would not be saved.

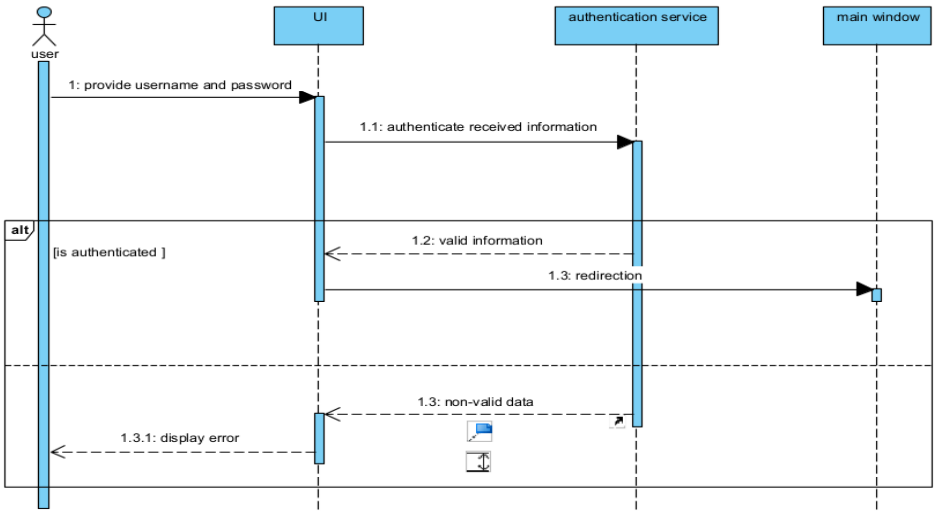

Figure 20 Sequence Diagram of User Login

Figure 20 shows the sequence diagram for user Login. The user enters his credentials; the authentication system will check credentials; if his credentials are correct, he will be redirected to the main window in the app; if not, an error message will appear to him/her.

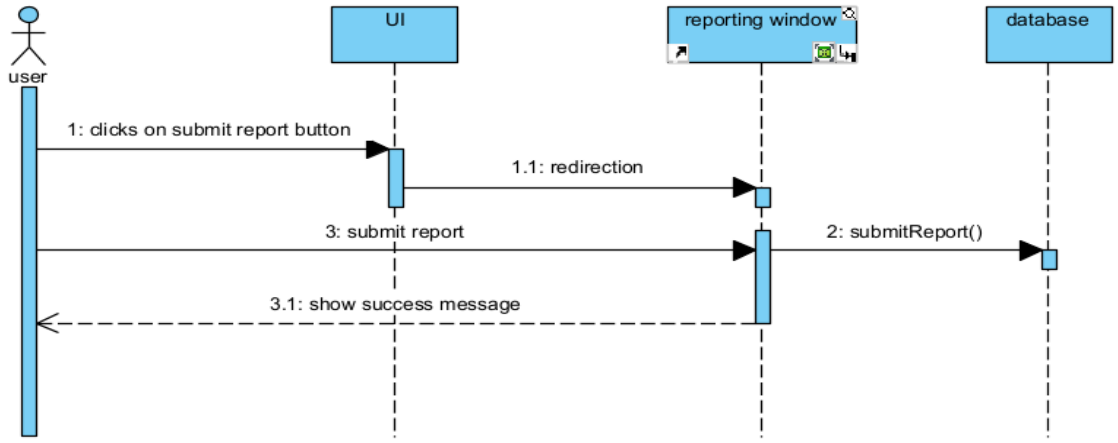

Figure 21 Sequence Diagram of Submit Report

Figure 21 shows the sequence diagram for submitting a report. The user clicks on the submit report button and fills in the details. If he/she enters valid data, the report will be saved into the database, and a success message will be shown to the user.

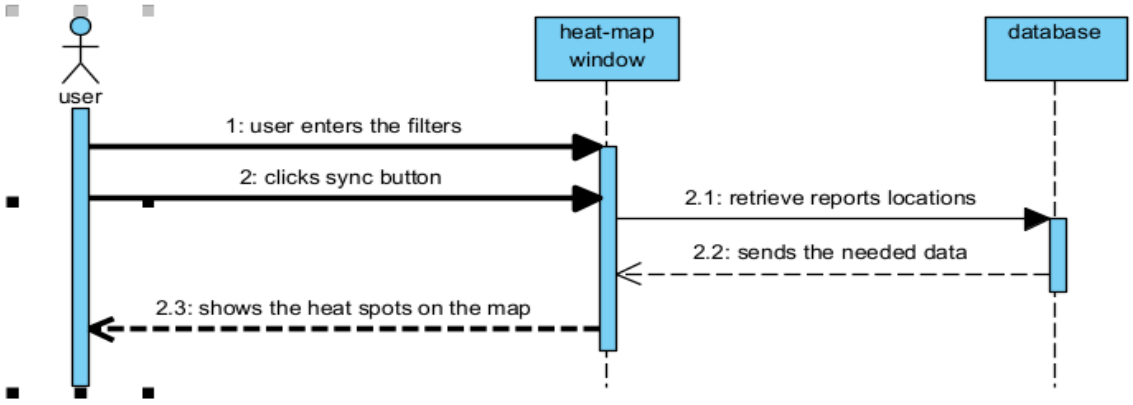

Figure 22 Sequence Diagram of View HeatMap

Figure 22 shows the sequence diagram for viewing the Heatmap. The user clicks on the sync button. The data will be retrieved from the database and will show as heated points on the map.

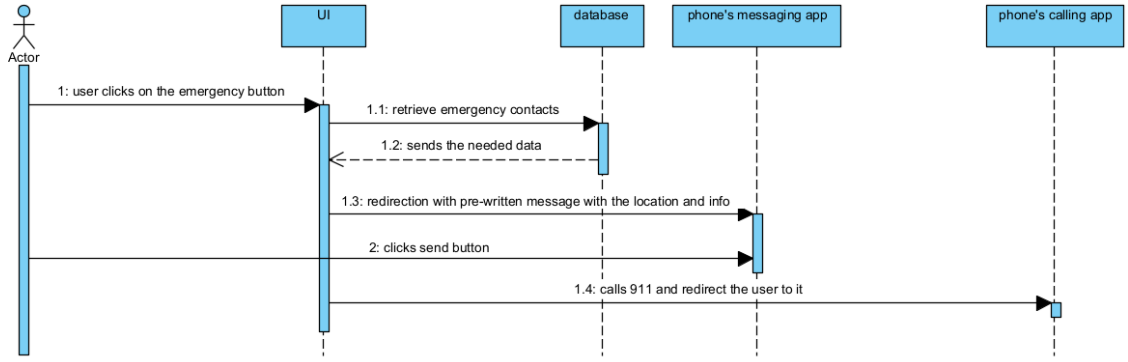

Figure 23 Sequence Diagram of Ask for Emergency

Figure 23 shows the sequence diagram for asking for emergency help. The user clicks the emergency button and clicks Help me. The emergency contact will be retrieved from the database, and the phone will automatically call the phone number.

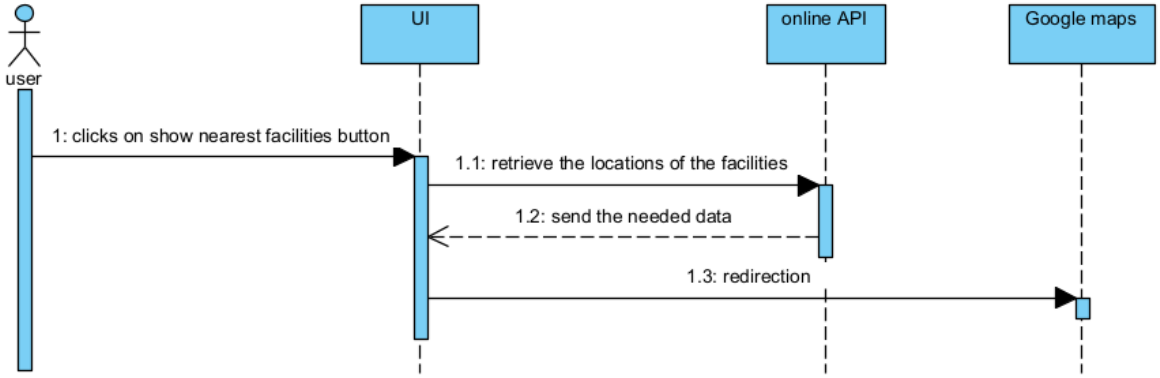

Figure 24 Sequence Diagram of Nearest Facilities

Figure 24 shows the sequence diagram for showing the nearest facilities. The user clicks the emergency button and clicks on the facilities he seeks to see. He/she will be directed to google maps to show the nearest facility around him/her.

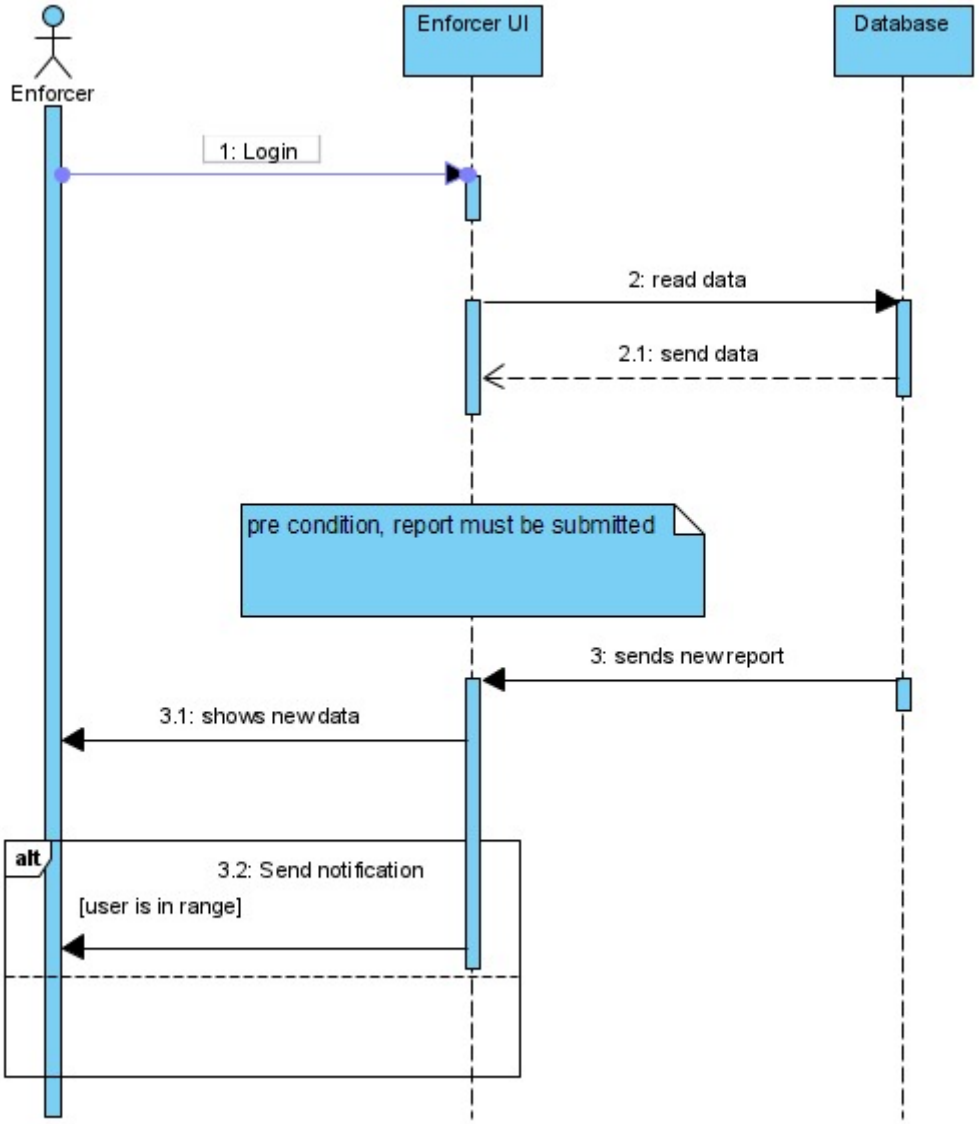

Figure 25 Sequence Diagram of Proximity Notification

Figure 25 shows the sequence diagram for proximity notification. User submits a report, a notification saying that “there is a report was submitted near you” will be sent to the guardian on his device.

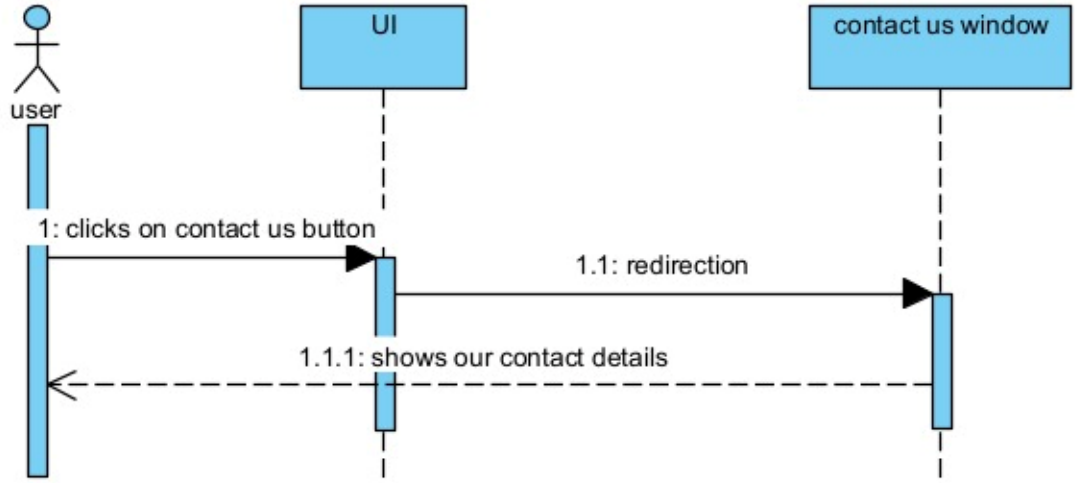

Figure 26 Sequence Diagram of Contact Us

Figure 26 shows the sequence diagram for contacting us. The user clicks on the contact us button. A new contact window containing contact details will appear to him/her.

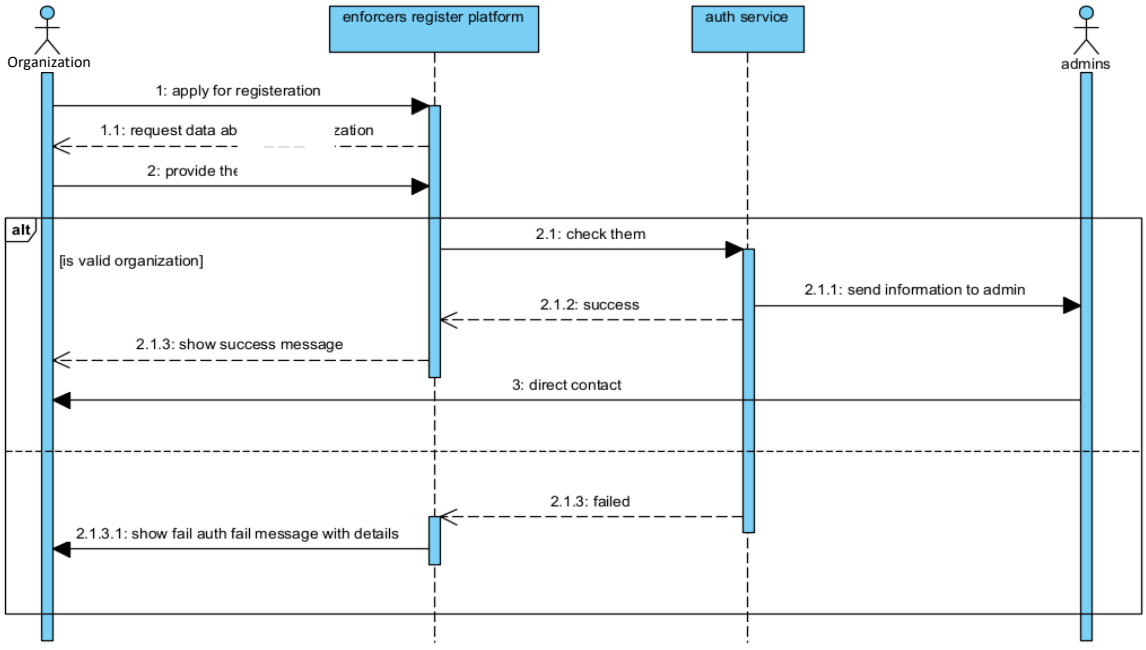

Figure 27 Sequence Diagram of Enforcer Registration

Figure 27 shows the sequence diagram for Enforcers registration. The user enters his data and email and organization data; then authentication service will begin; if successful, his credentials will be saved into the database, and a success message will be sent to him/her; else, a fail message will be sent.

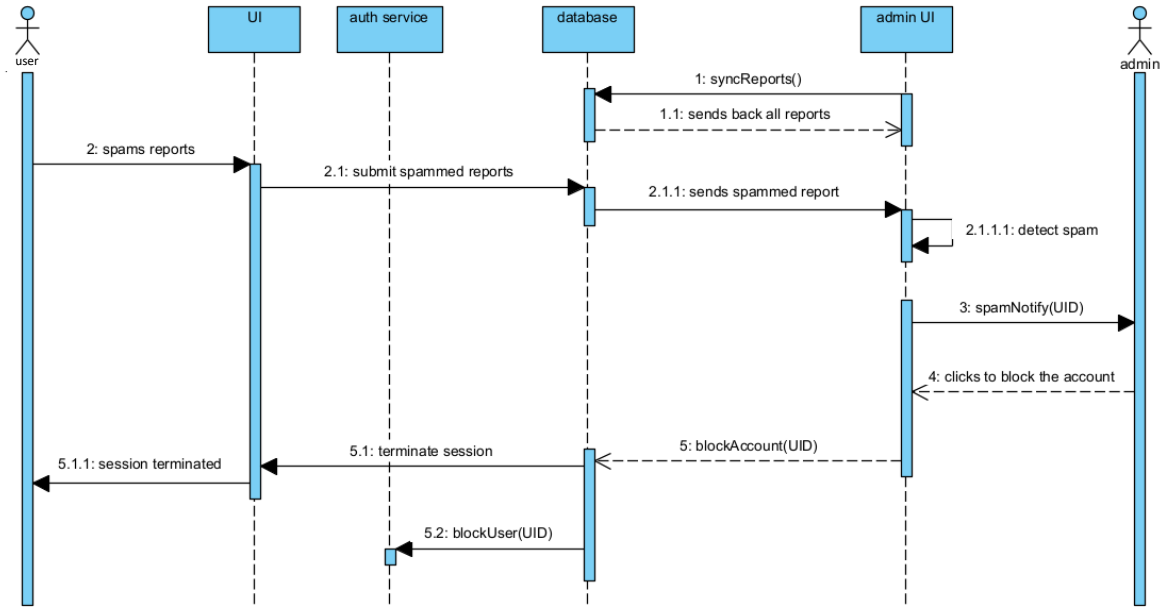

Figure 28 Sequence Diagram of Spam Handling

Figure 28 shows the sequence diagram for handling spam that users might do. When users spam reports, the admin will be notified by the spam detector method. Admin can click the block button that will trigger blockAccount(); if the user is blocked, the session will be terminated, and he will lose access to the application.

4.5.Database design

We used a real-time database firebase; it is a no-SQL database, so we do not have a database design. Even though there is no diagram for the database, we still have class relationships defined in Figure 18, and firebase was based on that structure, which is how data is being read.

4.6.User interface design

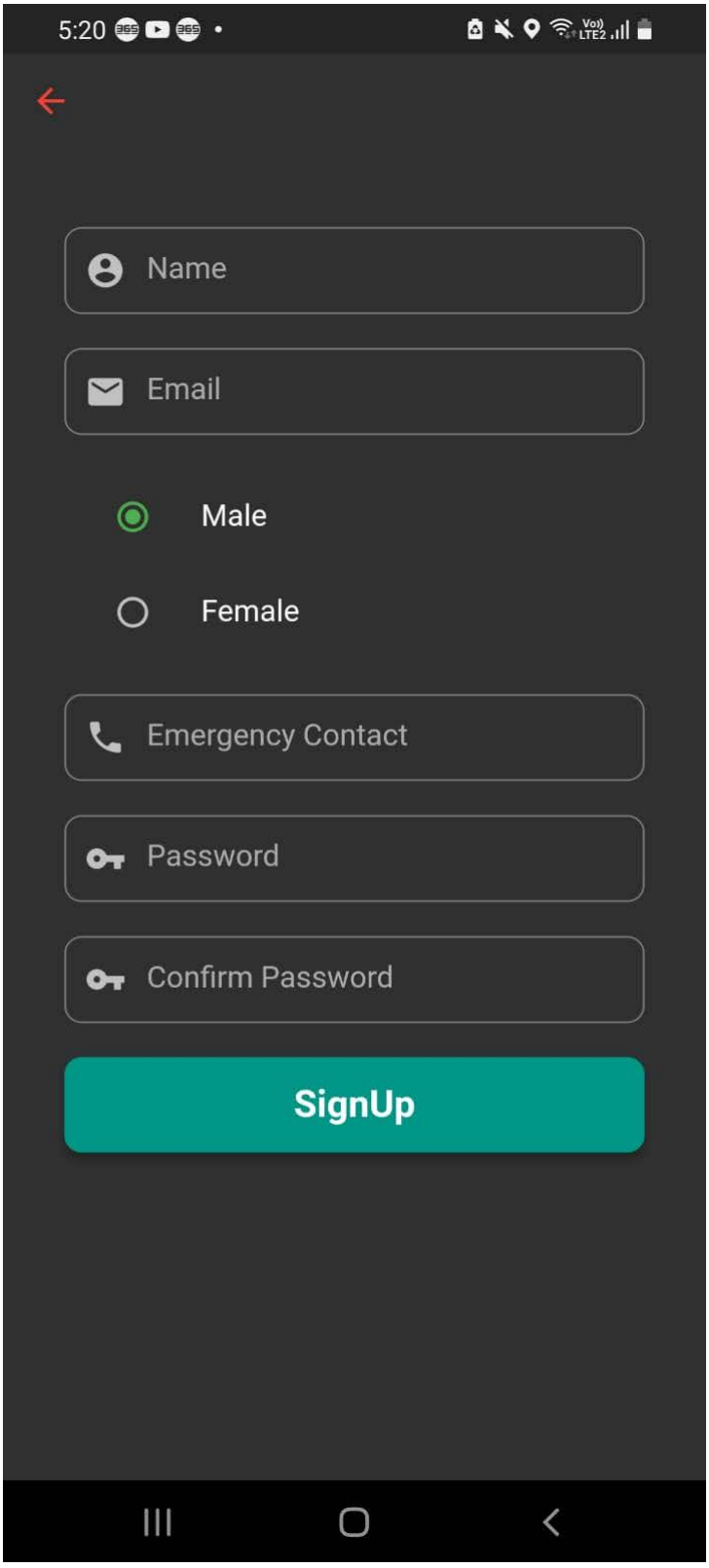

Figure 29 Registration Screen

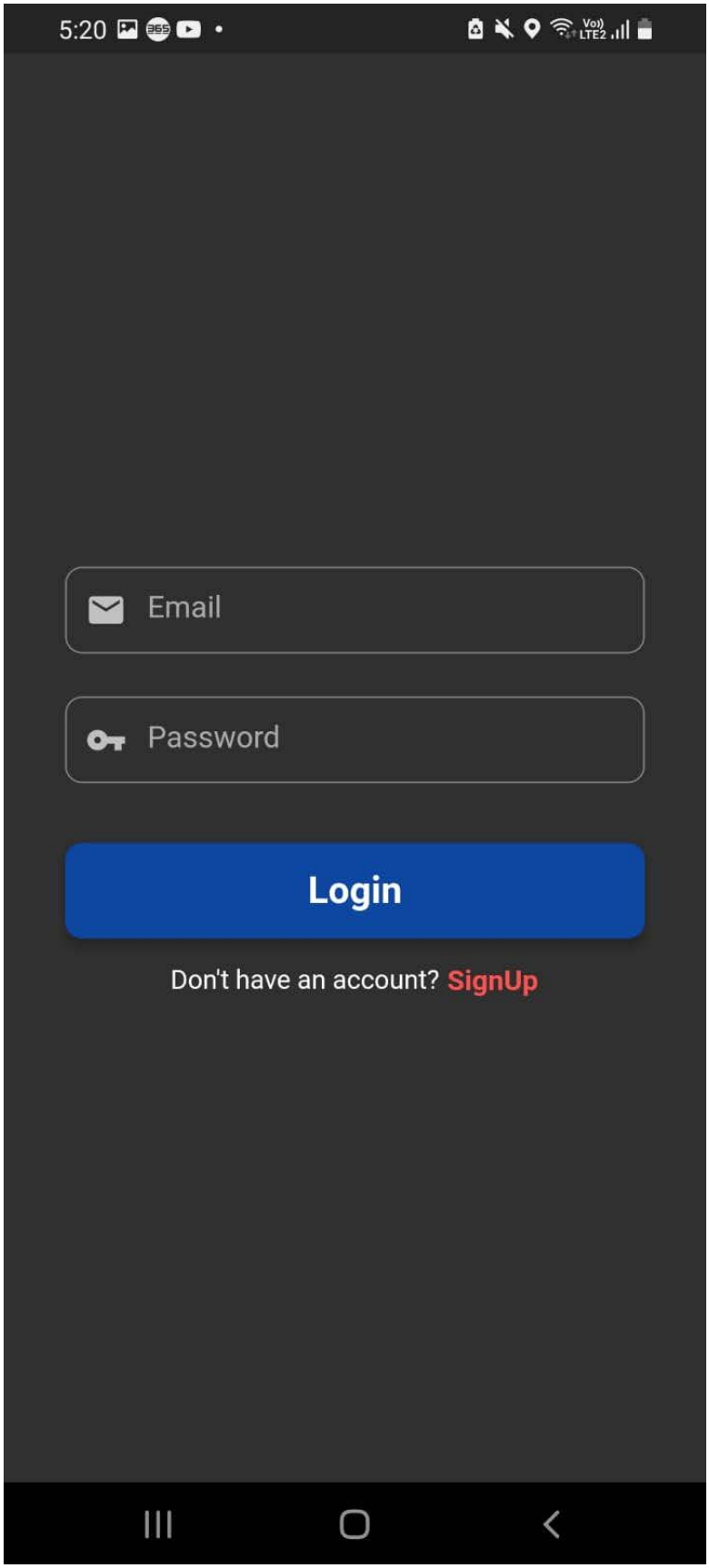

Figure 30 Login Screen

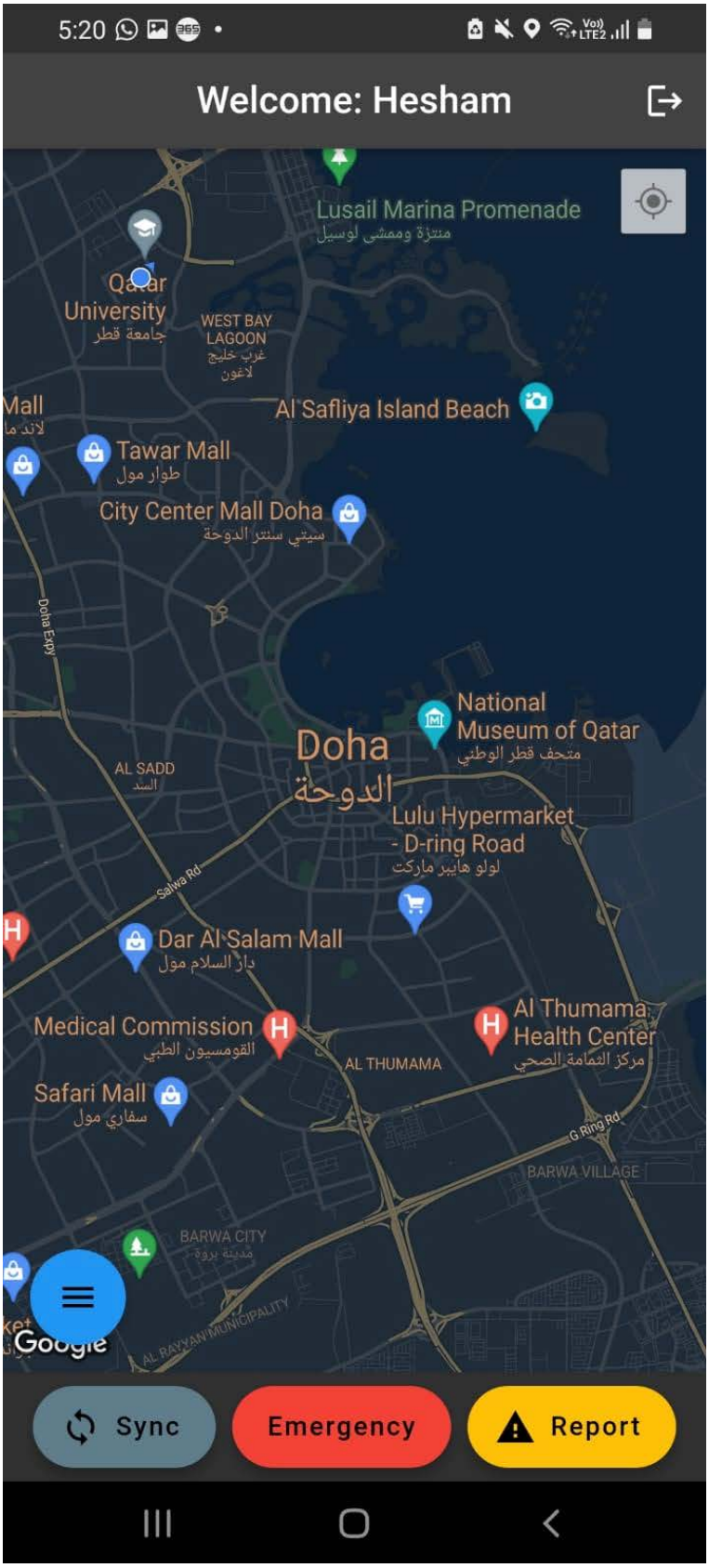

Figure 31 Main Window

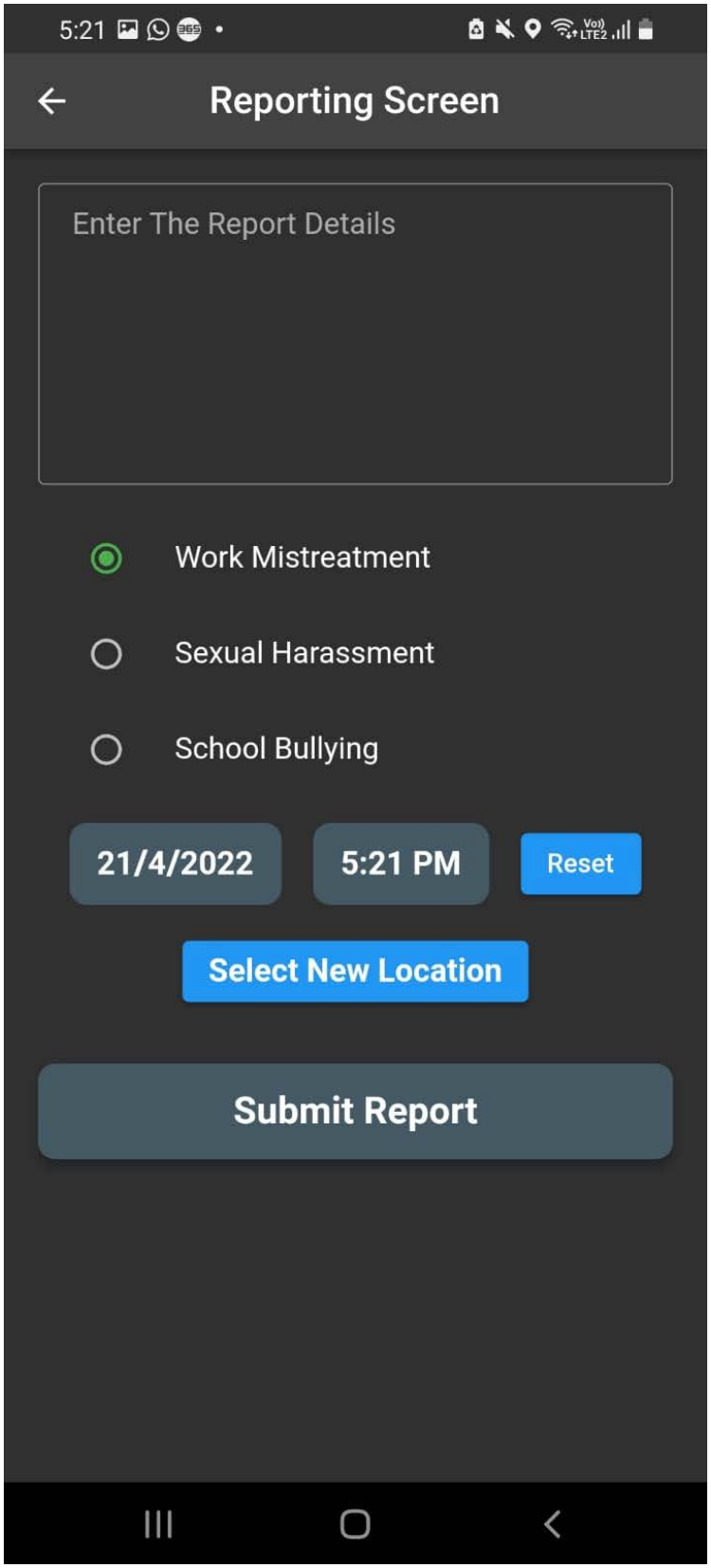

Figure 32 Reporting Screen

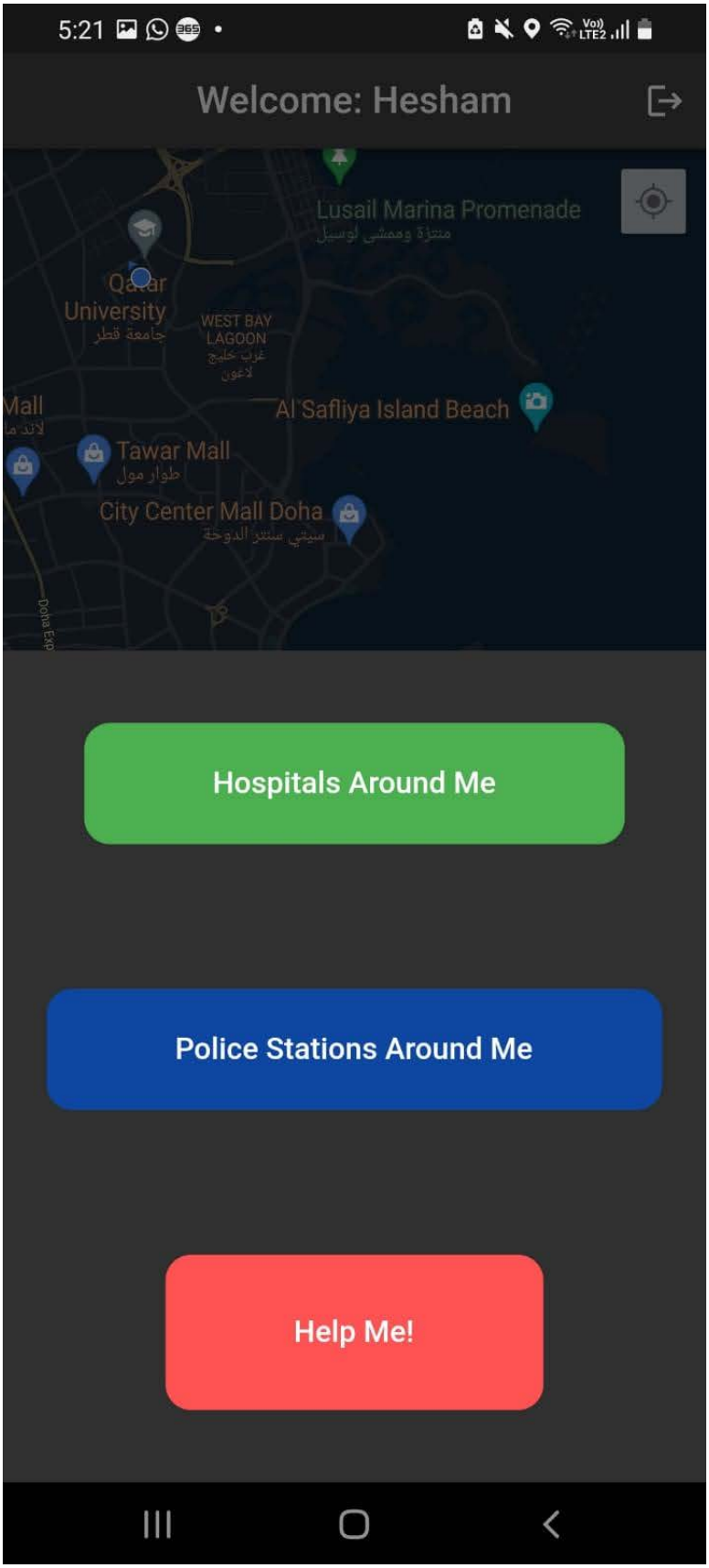

Figure 33 Ask for Emergency

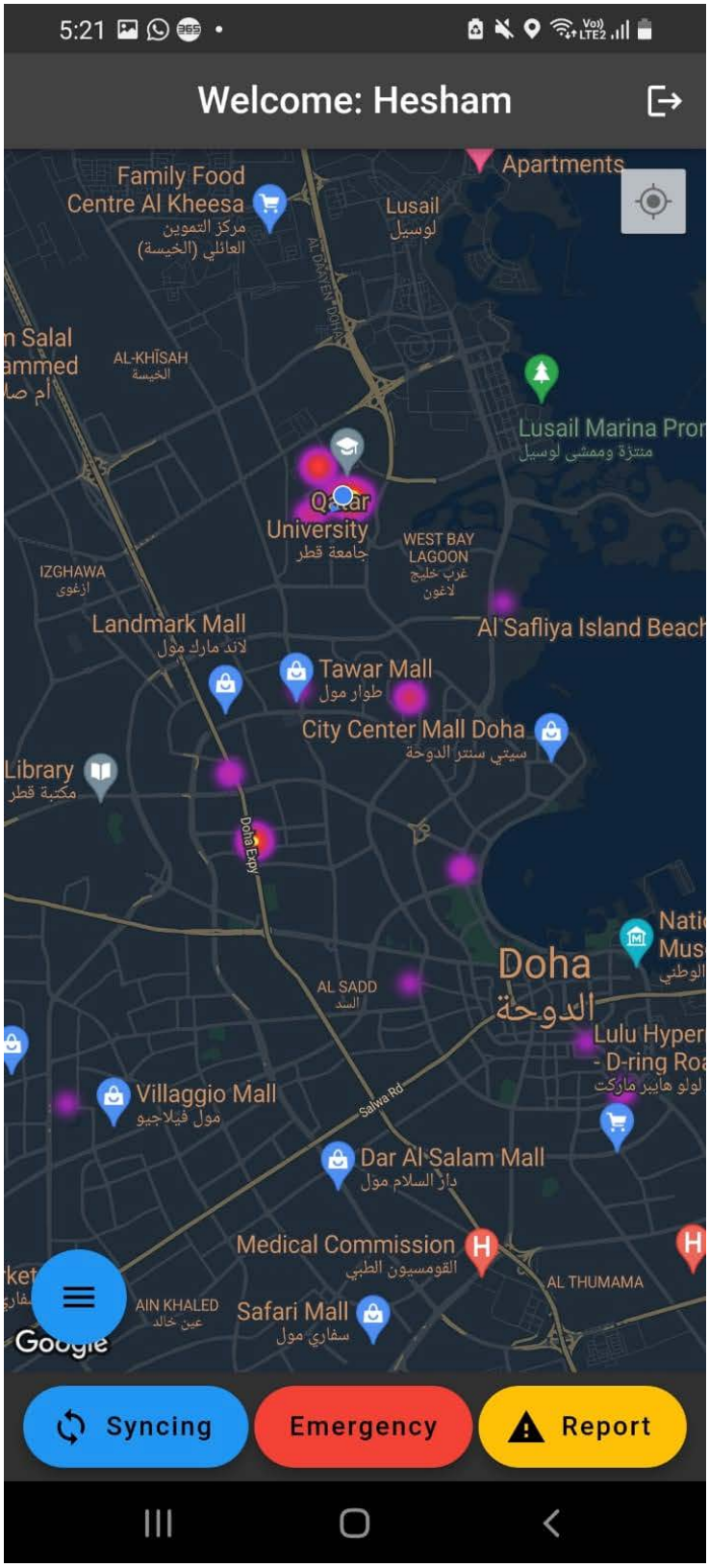

Figure 34 Heat Map

4.7.Design patterns

MVVM

The model, view, view model architecture helped us immensely when scaling the application. Modulating the project was one of the main tasks that we had to put much effort into since we planned to include several widgets that depend on the user and report data. Accordingly, we had to centralize and control how each widget could access these data efficiently and effectively. Hence, we chose to use the MVVM architecture.

We prepared a primary User Model that holds the attributes related to the user that gets read from firebase, as well as using some existing models that were included with the packages imported into the project, such as the Weighted Point and the Lat Lang models, which were key into fleshing out the Heatmap in a concise manner.

The view model is the essential part of this pattern since it dictates how the data will be curated from any API using the models and presenting it to the view without requiring the view to process it more. We used GetX to structure our view model, a famous package used in many real-life flutter-based applications to handle state management, besides other valuable utilities.

The view is mainly presented as widgets that interact with the data presented by the view model using methods. The view model, in our case, is presented as a GetX controller, which is injected into the widgets to allow them to access the data and the methods implemented in these controllers.

Factory

A factory pattern is an approach that utilizes generalized components/classes, and in our case, widgets, that take in parameters to specify their looks and their behavior. One leading example of this pattern in our application is the floating speed dials on the main screen; each dial is an instantiation of a generalized class called Speed Dial that takes in the icon, the background color, and the specification of the expected action when it is pressed. Additionally, the graph used in the application is mainly a very generalized widget that took in many specifying parameters to produce this line graph; these parameters are the name, background color, data presented, scaling on both axes, title, and most importantly, the graph type (line graph).

Singleton

A singleton pattern is implemented using one instantiation of a specific class, where this specific instance can be accessed anywhere in the application without being duplicated or cloned. The most important implementation of this pattern in our app is the authentication service. The firebase authentication package provides a singleton class that gives the widgets access to the different functionalities and attributes linked to logging in, registering, and querying logged-in user data. Accordingly, we created an authentication GetX controller that utilized this singleton

class and built the various authentication functions around it, such as signing in, up, and out.

Moreover, one of the crucial Singleton pattern implementations in our application was how we managed the injection of the GetX controllers or view models; we made each controller a singleton object that then gets injected into the context of the application so that we can call onto this specific instance when we query for that controller's instance, this injection happens when you first load the application.

Publish / Subscribe

The publisher Subscribe pattern grants users access to the data being broadcasted by a publisher, where these users are subscribers. Subscribers can be categorized and fed different types of data according to their category; for example, in our application, we have two types of subscribers, the average user and the guardian. Typical users are allowed to see the macro information of the reports, which are the location of all of the reports and the information presented in the graph. Guardians are allowed to consume the micro details of the reports, for example, who submitted the report and when, the body of the report, and the distance between the guardian and the report. Also, The publisher in our application is firebase, which provides the subscribers the data according to some set rules. For example, users have to be authenticated to receive the data stored in the database. Accordingly, we set some filters on the client-side to deny clients from withholding micro information of the reports while allowing guardians to inspect and track the reports' details and location. The firestore package provides the subscription mechanism in Snapshots and Widget Builders' image, allowing the data stream to be continuous and not discrete.

4.8.Hardware/software used.

Software	Description	Usage justification
Android studio 	Android studio is a powerful IDE that is used worldwide. It is mainly used to develop android apps via Kotlin and can accept other SDKs to develop apps using different languages and frameworks.	We used android studio as our primary developing IDE. We added flutter SDK to it so we would be able to code on it in flutter, as it is one of the most recommended IDEs to use for flutter implementation.
GitHub	GitHub is software used mainly to store source code of projects	GitHub was used to enhance our teamwork so we could all be up to date

GitHub	online that can be viewed and modified by multiple parties. The source project can be set as public, private, or custom; these statuses are for viewing constraints.	with everything done by any group member. We used it also to document everything and every modification done. We also used it for any future jobs to be included in our C.V.s.
Firebase 	Firebase is online database software that Google builds. It is considered a NoSQL database, as it stores data JSON.	We used firebase as our primary database for every database call. It is a google platform that provides security to the data in it. Also, it is free for a certain number of calls per day, so we thought it was the perfect fit for our project as it provides the database with the needed security and storage and ease of use.
Lucid Chart 	Lucid Chart is an online outlining application that permits clients to team up and cooperate continuously to make flowcharts, hierarchical graphs, site wireframes, Unified Modeling Language (UML) plans, mind maps, programming models, and numerous different sorts of charts.	Lucid Chart was used because we were already used to it from past projects. It is easy and free to use and provides clean and clear charts and diagrams. It was used to create the charts of the projects, like the MVVM diagram.
Visual paradigm 	Plan and the board instrument for I.T. frameworks. It gives programming designers a state-of-the-art advancement stage to assemble quality applications quicker and better. It upholds industry demonstrating dialects like UML, SoaML, XML, and BPMN.	We used a visual paradigm for the use case diagram and the software development as suggested and introduced to us in the software development course at Qatar University. It was effortless to use and one of the best software for the task.

Flutter 	Flutter is a cross-platform U.I. toolkit designed to help developers create apps that can run multiple operating systems like IOS and Android.	We used flutter as it was one of the most popular and best frameworks in the market at the time. As we plan to publish the application in both operating systems IOS and Android, we found that flutter is the best choice for us. It is a hybrid, straightforward, efficient, and has a strong developer community.

5. Implementation

We used flutter framework and dart language for coding and implementation. Many libraries were used as well so we can achieve what we have now; the used libraries are:

- firebase core
- firebase auth
- cloud firestore
- firebase analytics
- google_sign_in
- geolocator
- get
- google maps flutter Heatmap
- f1 Chart
- flutter speed dial

As reviewed before in the comparison table (Table #), we have some features in common with most applications and features that no one thought of before. Heatmap is one of the main features of our project. It was not found in any other application or project related to the problem. It is a handy feature that allows users to find the safest places. It makes people's lives safer and better as they do not have to deal with bullies, harassers, or bad workplaces. The Heatmap does not only serve the users but the authorities as well, as it provides the enforcer with a notification if there is any incident near them so they can act quickly. Also, it shows them the locations for where are the most dangerous places so they can act on that information.

Moreover, the gathered information from the reports, like what happened and how it will ease the way for future models that would expect the next moves of the harassers and bullies and how to avoid them. The guardian can also monitor the reports and assign himself an incident to act on it, so the user can feel safer that someone will be there for them very soon. The authorities can review what happened and how they handled it from

the enforcer. More on the information, our application provides graphs that show the data in more superficial ways for both users and authorities, as it will help the user to indicate when to avoid someplace and when not, and it will provide the authorities with data to study and figure out solutions for the raised problems in the society given from the app. to add up, the harassment-heatmap application does not accept the users to sign up until it checks that they are not bots, by verifying their email addresses with verification code that will be sent to the provided email and wait for the response before allowing them to access anything in the application. It helps with avoiding scammers. Going back to the user's safety and helping the guardian, the application has proximity notification, as it will send a notification to the nearest guardian to the victim. Then the guardian, as was said, can choose to act on it and queue it to himself, and when it is done, he writes feedback. The application is not static, and victims can report an incident whenever they need and assign the time of the incident, so they are not obligated to report at the same time of the incident and add more stress on them than they already have.

Of course, we faced many challenges during the implementation phase, but we could address them correctly and solve and move past them. One of the earliest challenges we faced was the choice of working with flutter; as the three of us had no previous experience with it, we had to learn it from scratch and master it to be able to provide the best user experience we could give. One of the worst parts was the community of flutter, as flutter is still trying to get on track with other languages already in the market and have their reputation in the programming community. Hence, whenever we met an error in the code, it was not easy to find the solution for it directly. We had to read similar problems and figure out something for our work. To add up, as the community was no the best thing for flutter, also the libraries and resources were poor; in order to find what we needed for the application, we had to go through a lot of useless libraries and try them until we found the optimal on, as well as altering some libraries to be compatible with what we need. That takes us to the next challenge, which is the Heatmap. It was frustrating to find anyone who used heatmaps with flutter and documented it before us, and we found it did not work correctly, and we had to alter some lines to make it usable in our project. Even though we could optimize the Heatmap to work on Android, the library's author did not work enough to make it usable on the iOS devices. We could not find where the error was precisely to try and solve it, so we kept brainstorming until we found an alternative solution. We decided to have two versions of the application, one for iOS and one for Android. The android version will have the Heatmap, but the iOS will have a cluster map instead; it serves the same purpose but in a different style and look.

6. Testing

6.1.Unit Testing

In this part of the testing, we want to test the functionalities specified in the table below

Functionality	Test case
user Registration system	Case1: user can Register an account successfully
user Login system	Case2: user can log in successfully and gain permission
View heat map	Case3: User can view heat map, and heat points must be generated successfully
Submit Report	Case4: The user can submit a report and appear on the map and in the database
Ask for emergency	Case5: The emergency help button must be working
Proximity notification	Case6: If there is an incident near a police officer, a notification will be sent to him.

Table 6 Test Cases for Functionalities

6.1.1. User Registration system

To test this functionality, we tested the functions related to this functionality by interacting with the user interface to see if it is working correctly. When a user does not enter any data or wrong data, an error message should appear, and if he entered the correct data, the username should be saved in Firestore, and the user can then log in, which will be held in the next test case. The result of the test can be shown below in the following figures.

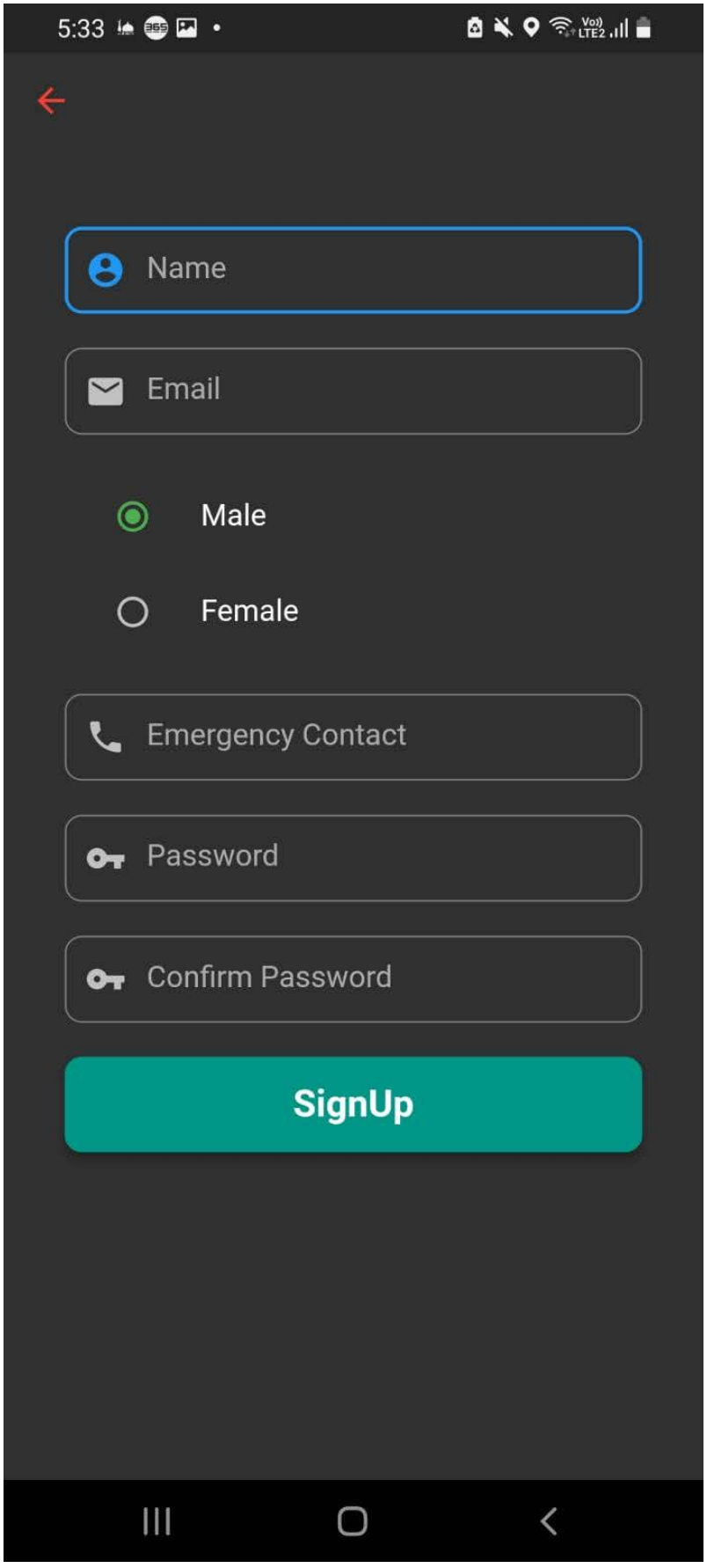

Figure 35 Registration Window

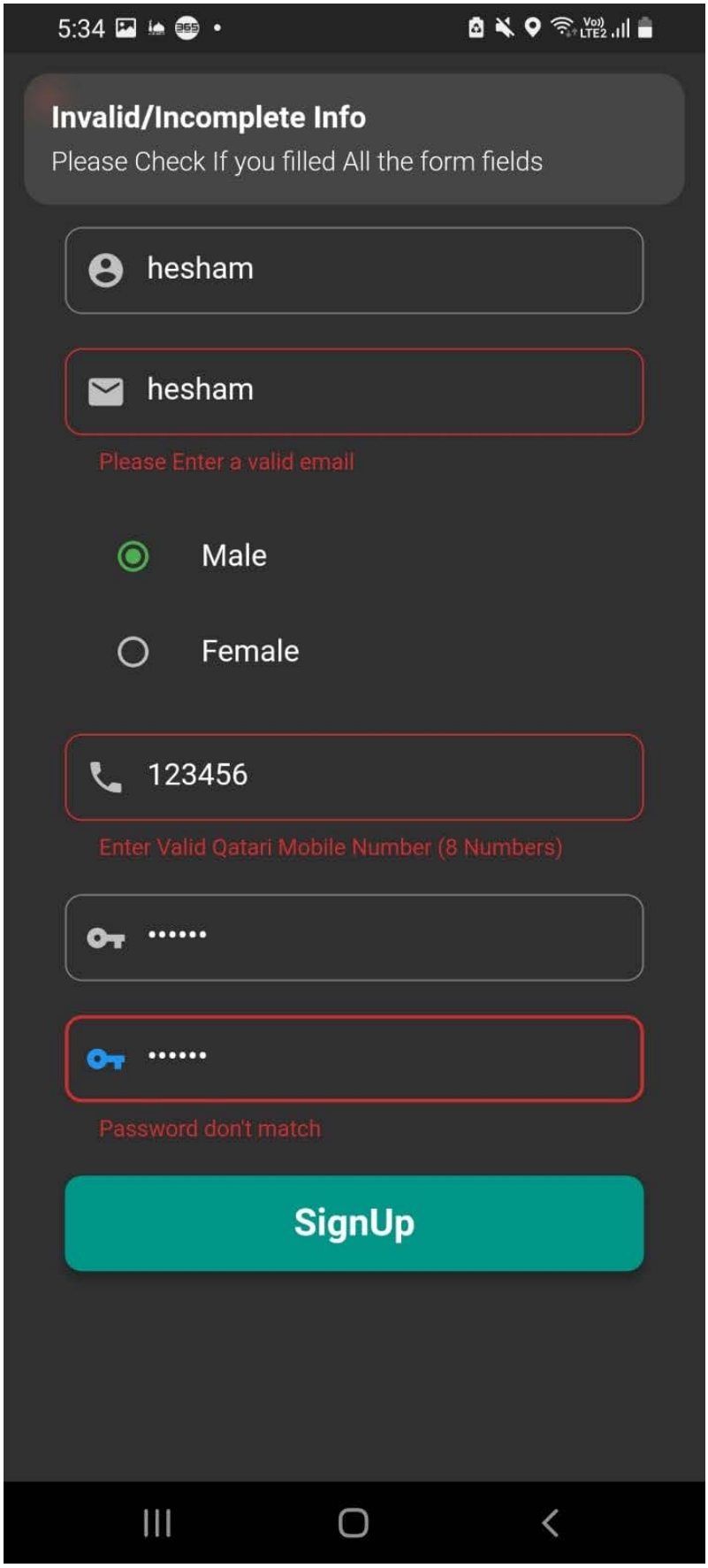

Figure 36 Invalid Data

Figure 37 Success Data

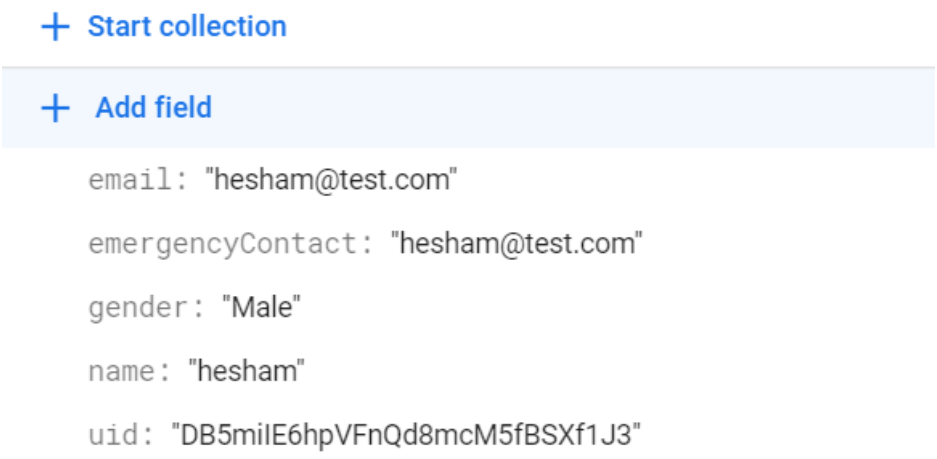

Figure 38 User Created

6.1.2. User Login system

When the user does not enter any data or wrong credentials, an error message should appear, and if he entered the proper credentials, the username should be retrieved from Firestore. The user should gain permission and be logged in to the system. We interacted with the user interface to test this functionality to see if it worked properly. The result of the test can be shown below in the following figures.

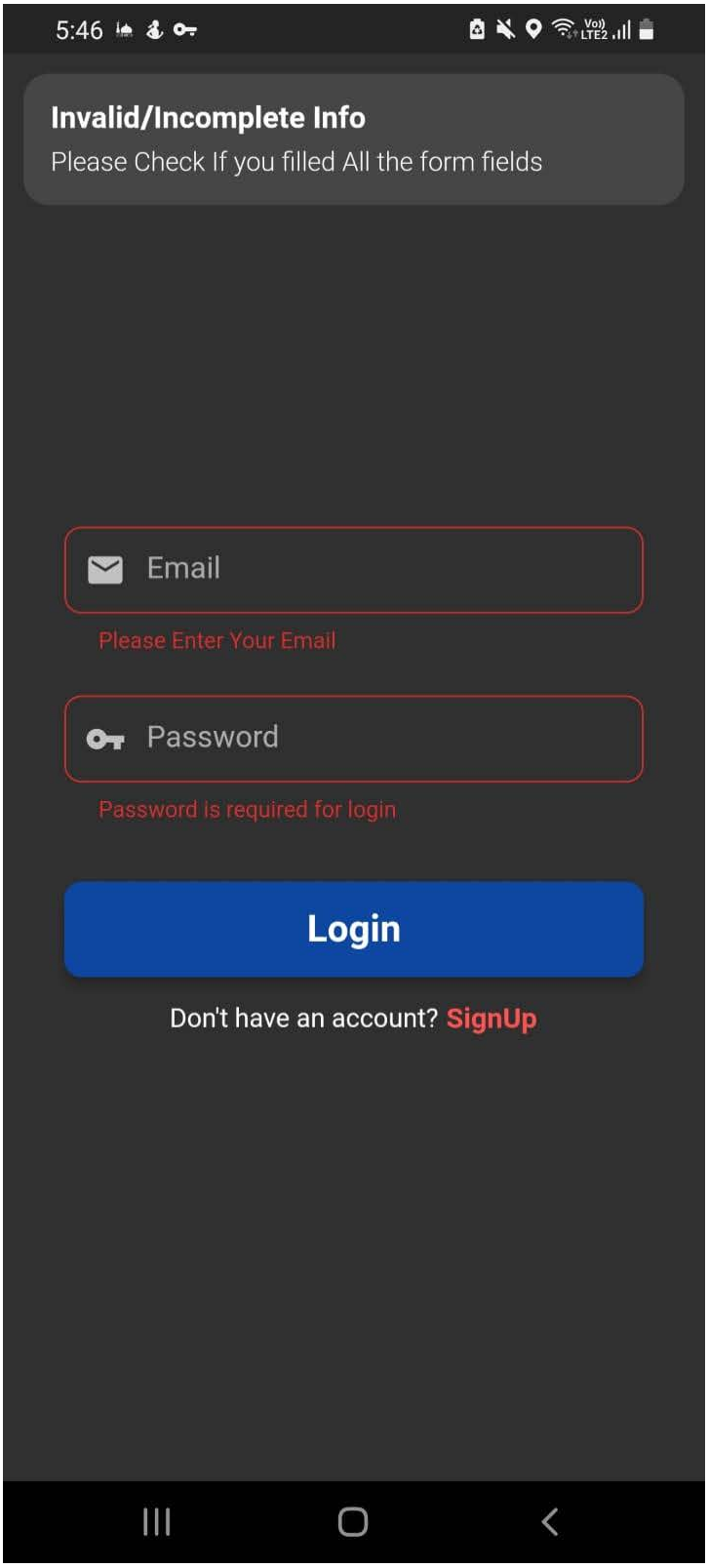

Figure 39 Fail to log in.

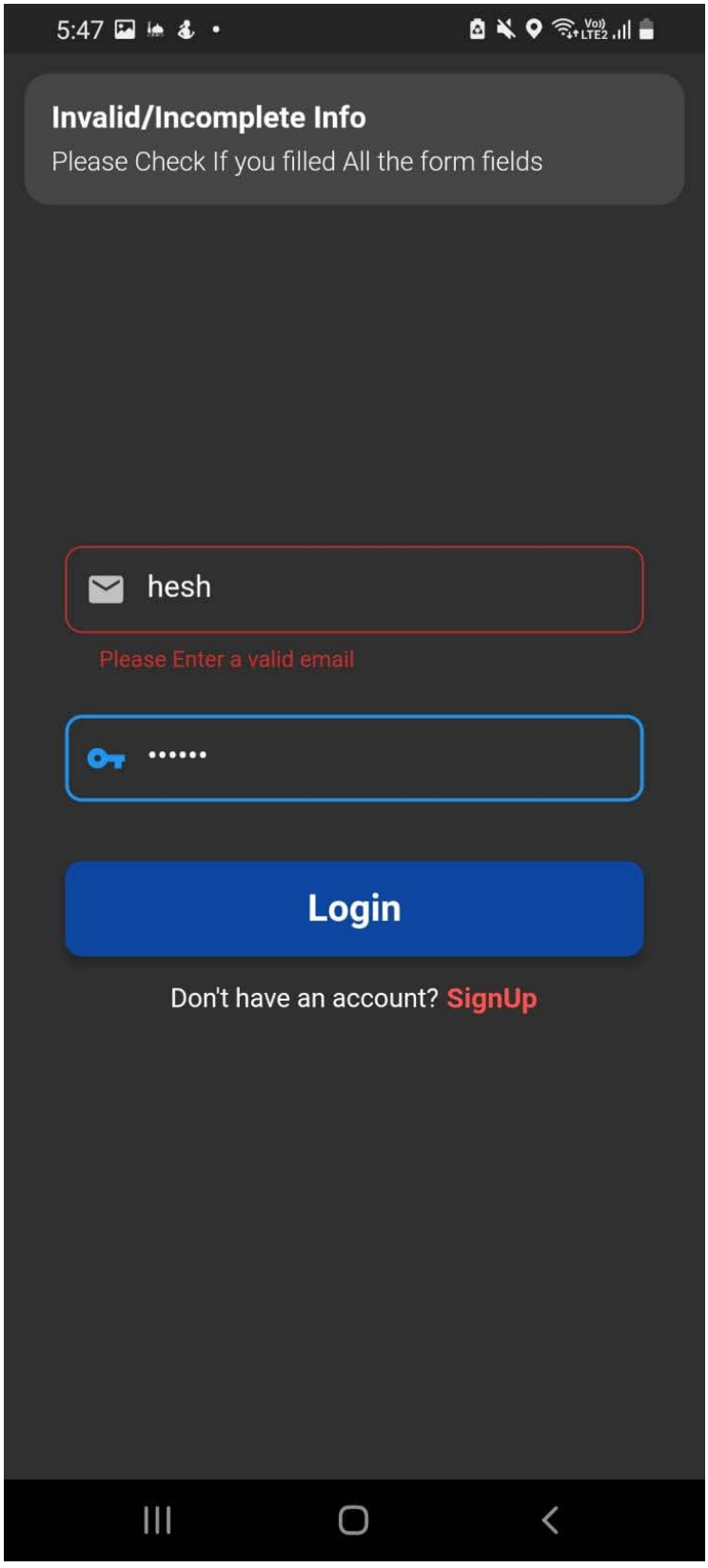

Figure 40 False Credentials

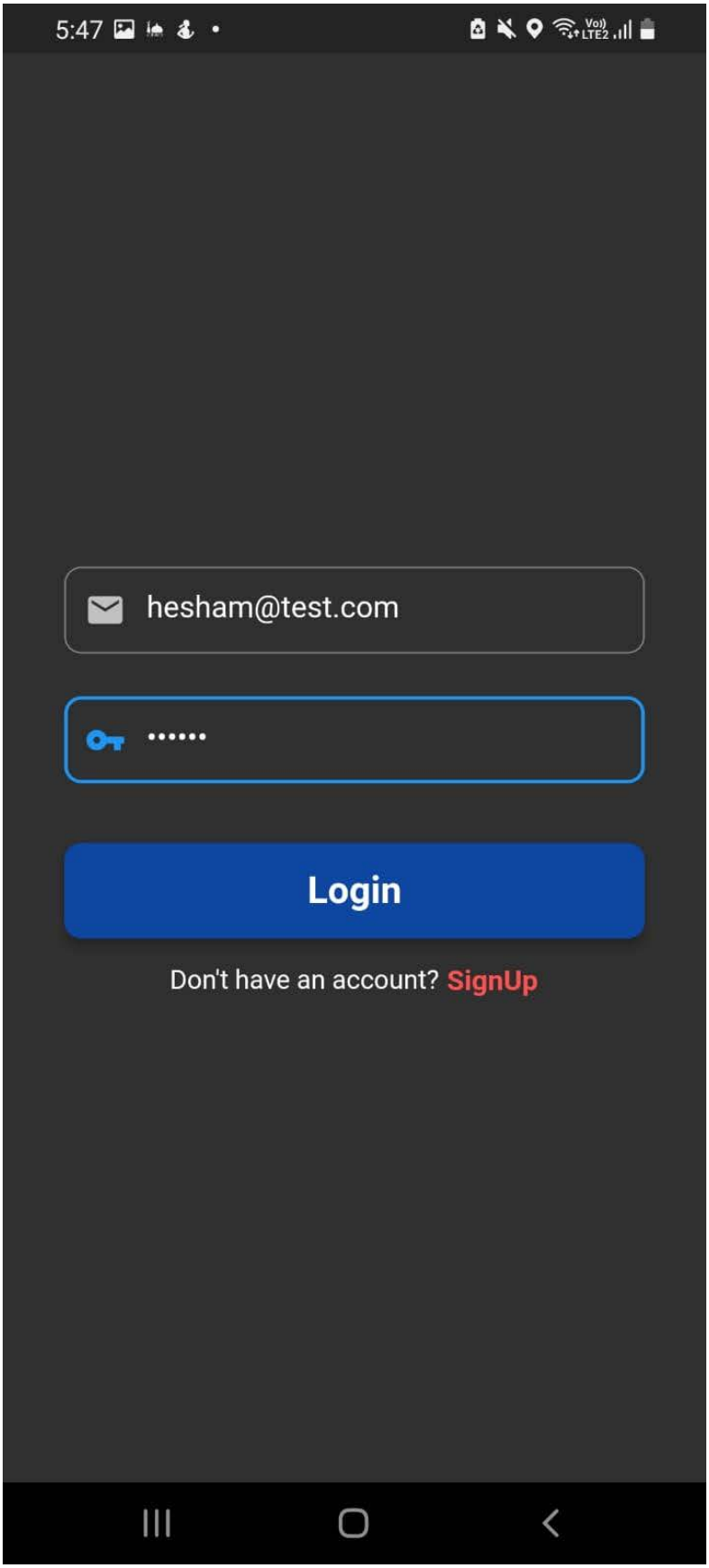

Figure 41 Log in

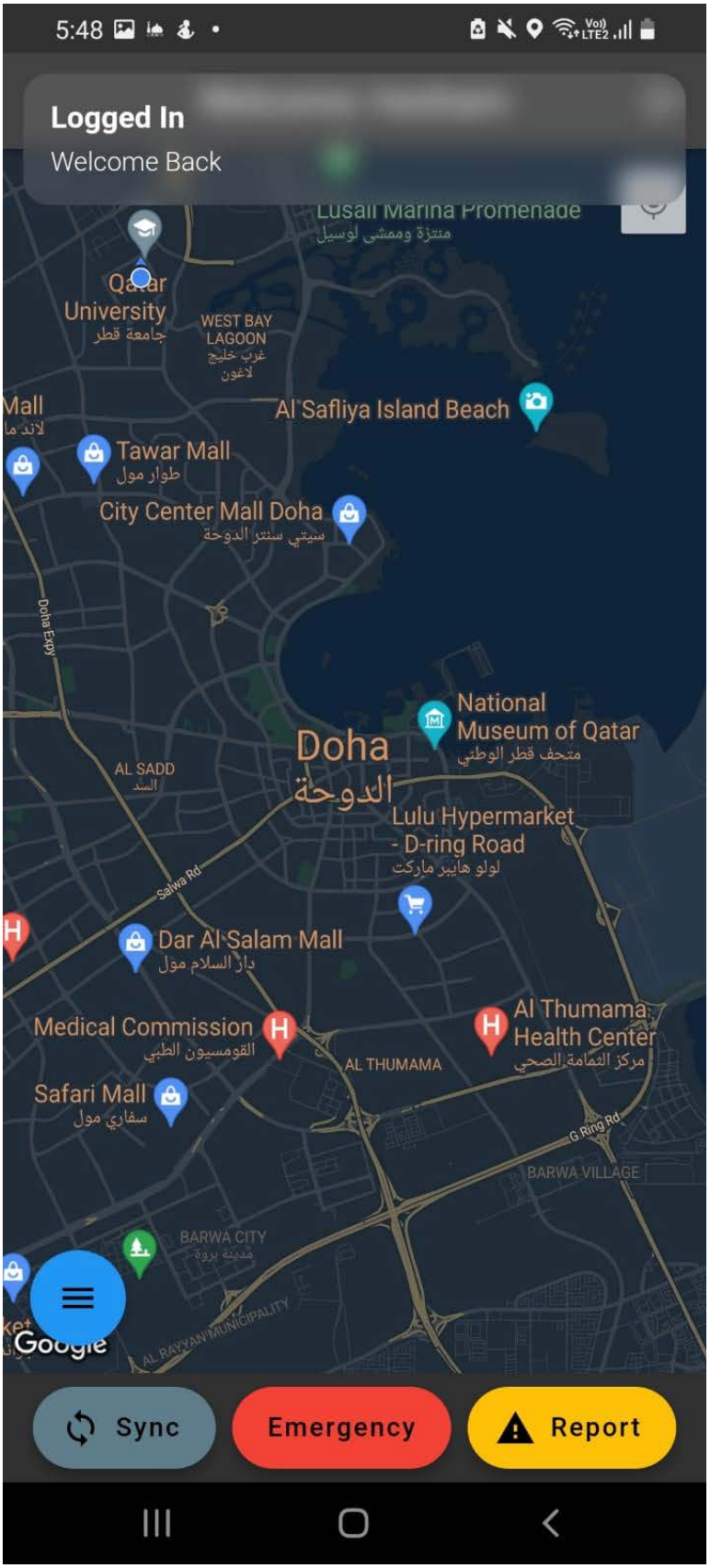

Figure 42 Login Success

6.1.3. View heat map

If the user is logged in successfully, the map should appear; many options should appear if he interacts with the user interface buttons. In this test case, we will test the heat map, so if the user interacts with the Sync button, data should be retrieved from Firestore and appear as a heat point on the map. The following figures show the result of this test case.

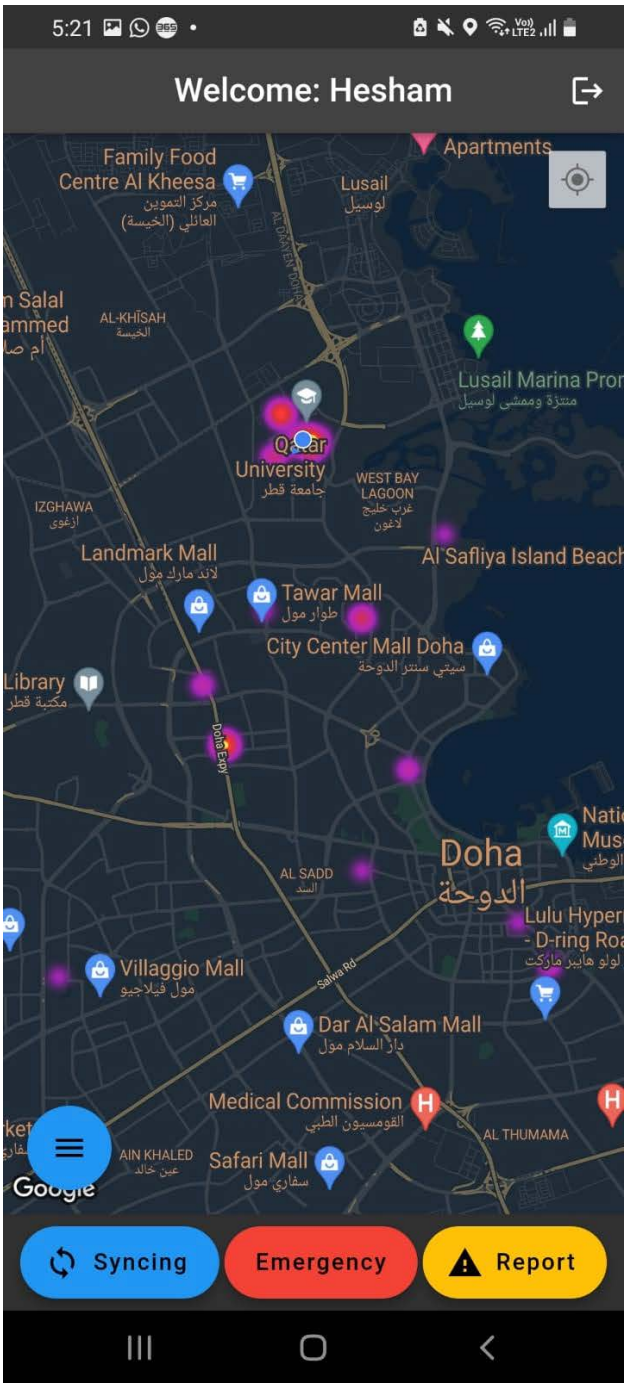

Figure 43 Heat Map

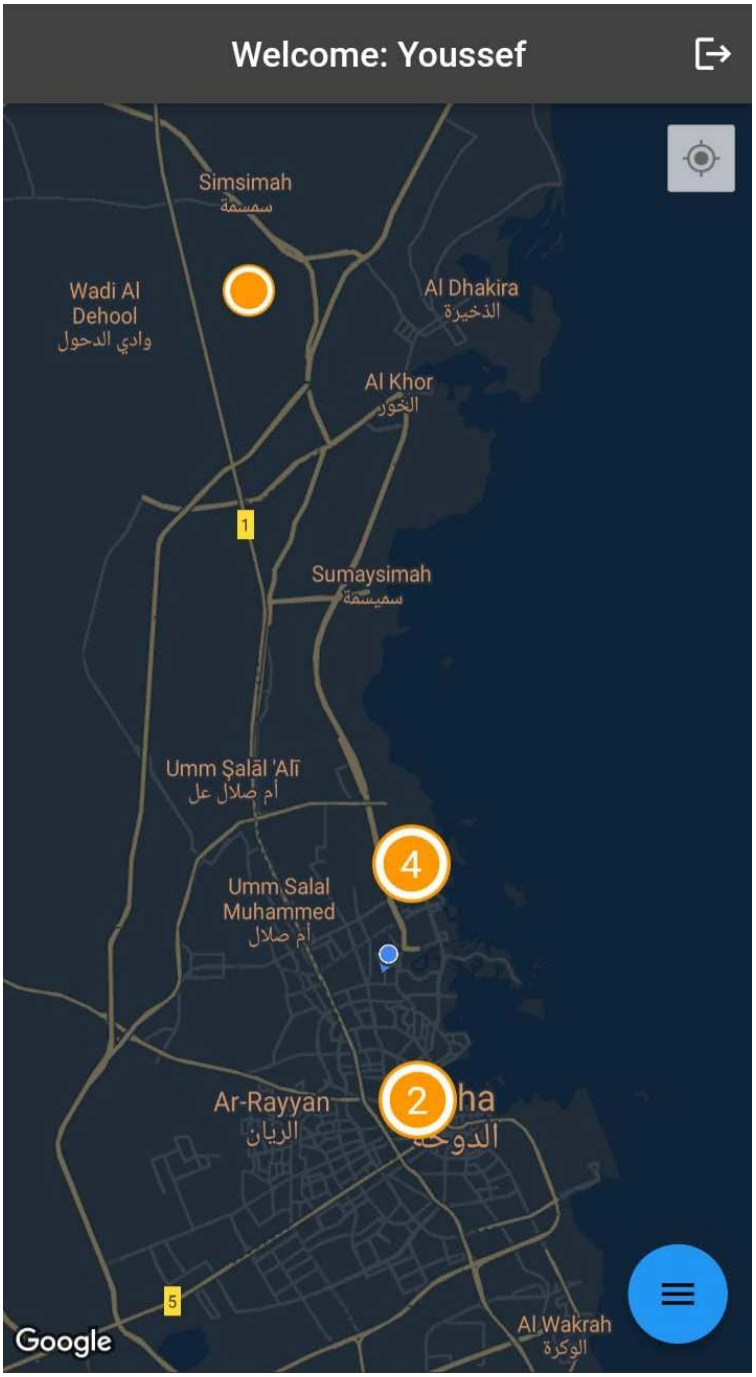

Figure 44 Cluster Map

6.1.4. Submit Report

This functionality is about submitting a report; after the report is submitted, the report will be saved in the database, and the heat map will be updated. We used the user interface to test this functionality to interact with the button related to this functionality. The results of this test case will be shown in the following figures.

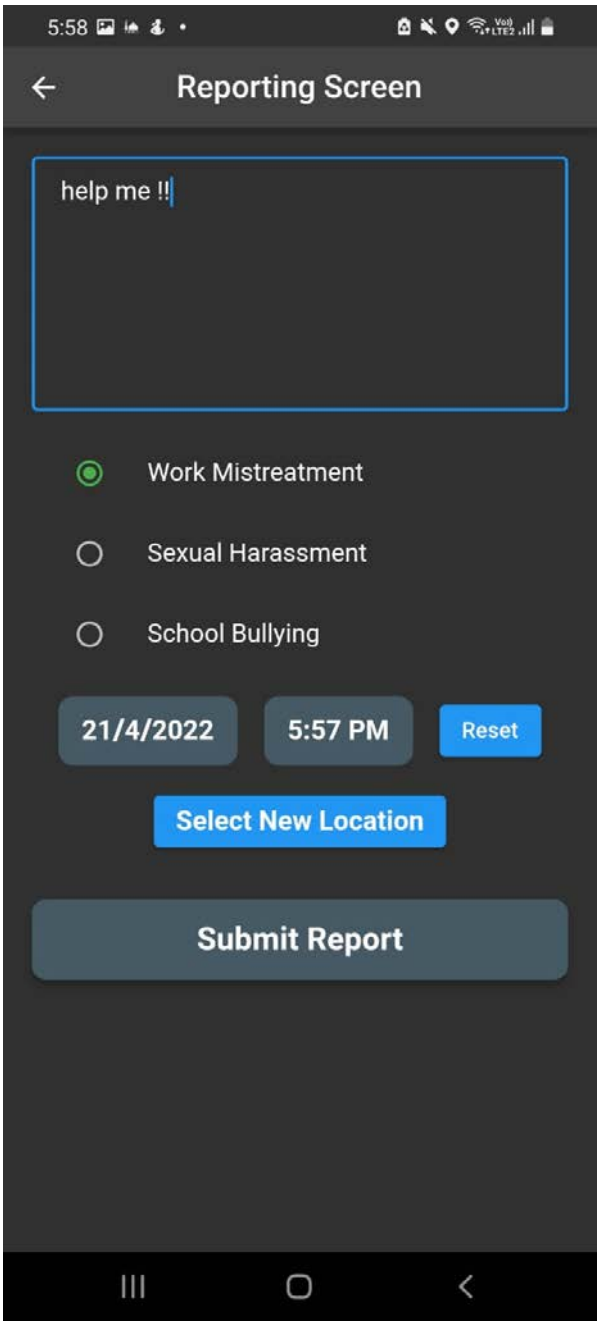

Figure 45 Reporting

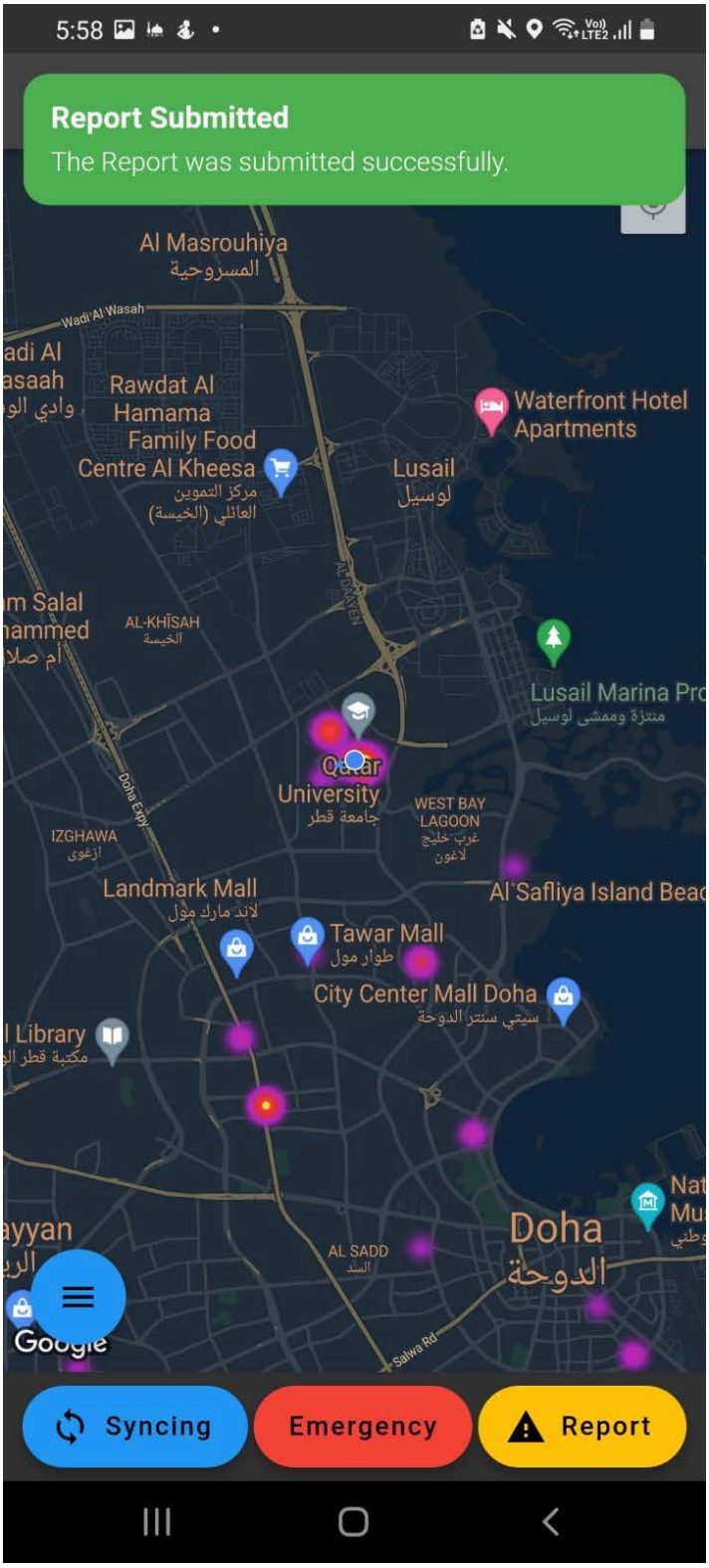

Figure 46 Report Submitted

```
    latitude: 25.3745337
    longitude: 51.4903913
    speed: 0.4645399749279022
    speed_accuracy: 0
    timestamp: 1650553020000
officerId: ""
report: "help me !!"
reportType: "Work Mistreatment"
status: "limbo"
timeOfResponse: ""
```

Figure 47 Report in Database

6.1.5. Ask for emergency

When the user interacts with the emergency help button, the mobile should automatically call 911 and automatically write a message including the user's locations to a specified number that the user early wrote while he/she was registering an account. The result of this case study is shown in the figures below.

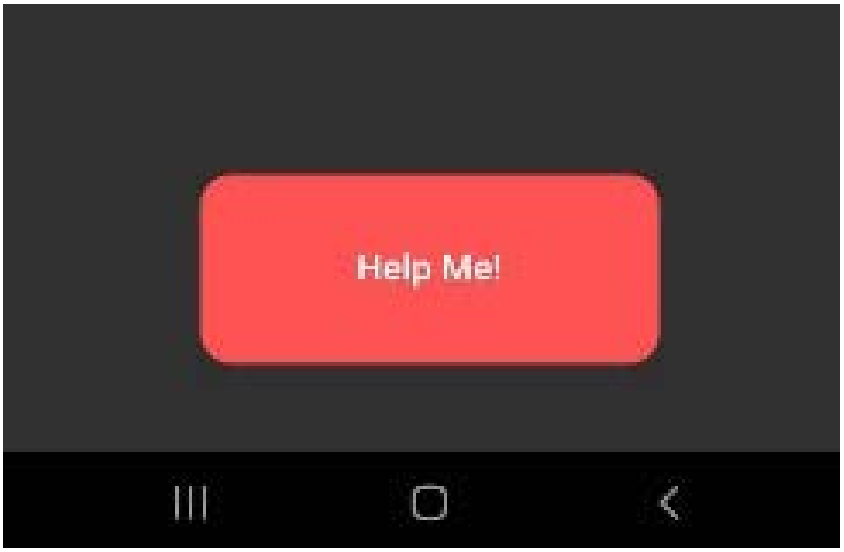

Figure 48 Help Me Button

6.1.6. Proximity notification

These test cases are about sending notifications to the police officers when a user is submitting a report; this function is not internally within the code. The following figures will show the test case results.

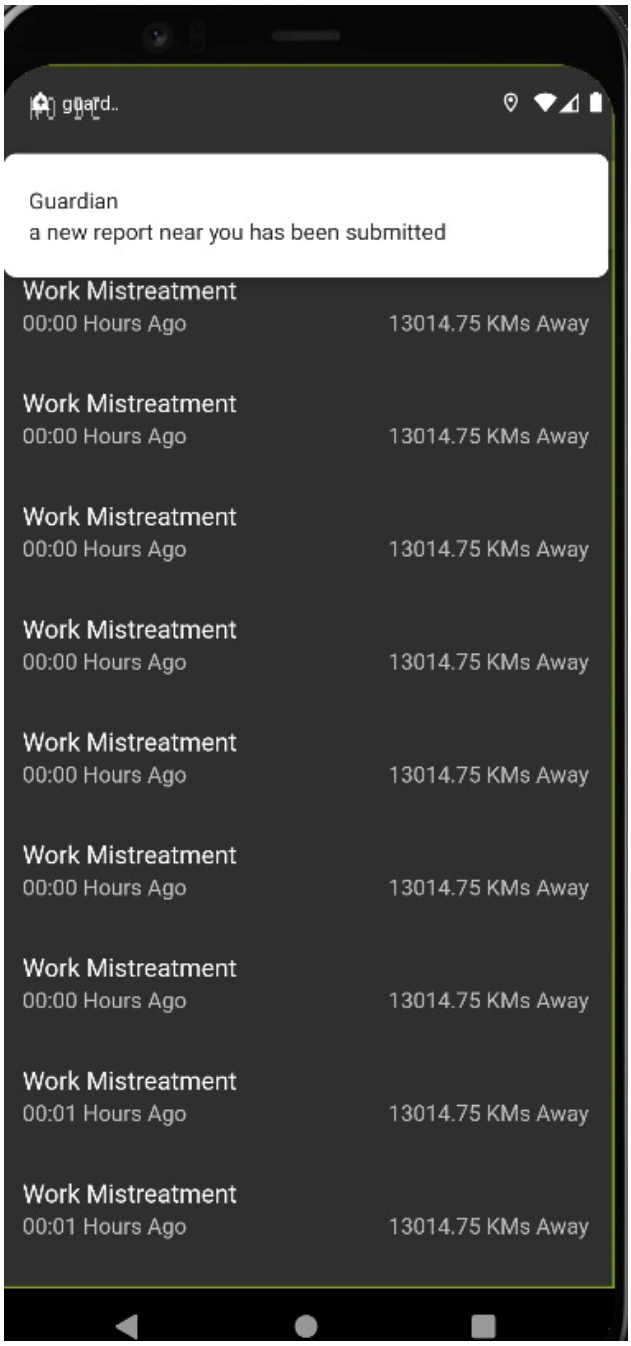

Figure 49 Proximity Notification

6.2.Integration Testing

In integration testing, we tested the full functionality of the application, ensuring that all the previous functionalities were working together efficiently.

6.3.Non-Functional Requirements Testing

Test case 1:

For this test case, we will test the portability of our application by testing the application on different software/hardware platforms. Expected devices: smartphones, tablets, P.C.s. Actual devices after testing: smartphones, tablets, P.C.s. The testing results show that the application can work smoothly on all platforms related to the expected devices for this use case.

Test case 2:

In this test case, we will measure the performance of our application. Expected performance must provide 5 seconds response time for 99% of requests. Actual performance for the requests: 4 seconds. For this use case, the time between response time and Request should not exceed 5 seconds for 99% of the requests. In this test case, we measured the time between syncing the data from firebase and showing it on the heat map, and the result came with a response time of 3.7 seconds. Also, we measured the time between reporting an incident and reflecting it on the heat map, and the result came with a response time of 4 seconds.

Test case 3:

This test case tests the application's security to give the user a secure experience. Firestore comes with a built-in security system that provides data encryption and protection. Also, no one can send or retrieve data without being authenticated in our application.

Test Case 4:

Making our application accessible in multiple ways is the goal of this test case. We did not implement a way to reach this requirement in our application. However, it will not affect reaching our application or making it respond fast.

Test Case 5:

To test the non-functional requirement that needed the application to be user-friendly, we developed a ‘stay logged in’ feature that allows the user to access his account faster and start using the application.

Test Case 6, 7, and 8:

To test the application's availability, Reliability, and Scalability of the application, we published a prototype and conducted 30 users; through their testing phase, the application was available 24x7 with reliability scaled to 100%. Also, the application did not crash while the number of users was high, showing that the non-functional requirements were met.

Test Case 9:

To test the modifiability of the application, in the prototyping phase, we gathered reviews from testers about the User interface, and it was easy to modify. For example, making snack bars look more good-looking, we were able to modify that quickly because we used the Model view-view model technique that separated between backend and frontend.

Test Case 10:

To test the maintainability, we changed the database server to another server with a different path and id. We could easily maintain it in our application because it is organized and well structured.

Non – functional requirement	Level of Requirements
The application could be efficiently executed on a different soft-ware/hardware platform.	We met this requirement since we could test the application on different software/hardware platforms such as smartphones, tablets, and P.C.s. We made sure that the main features were working.
Application performance must pro-vide 5 seconds response time for 99% of requests.	We met this requirement because we were able to make a response time for reporting a harassment incident and how the data in the entire application is changed due to it, not exceeding the decided time, which was 5 seconds.
Stat of the art technologies will be used for data storage and transmis-sion to provide maximum security.	We met this requirement since we have a built-in security system provided by the firebase database.
The application will be accessible in multiple ways.	We did not meet this requirement since our application is not accessible in any situation, for example, in lock screen mode. However, this will not affect the usability and reach of our application.

The application interface is friendly and will help users access the application easily.	We met this requirement by conducting surveys focused on the Ease-of-use points in the project and measuring the user-friendly part.
The application will be available all the time.	We met this requirement since our application can run 24x7, with an overall availability of 100%.
User's reports and connections will be granted anywhere, anytime.	We met this requirement since our application is not causing data or message loss, with 2 second response time.
The application must be able to scale up with the spike of users and scale down when the number of active users is low.	We met this requirement using the firebase database service, which allowed us to use scalability features.
The application will be easily modifiable.	We met this requirement since we managed to separate data and the user interface. Furthermore, we used the technology of the MVVM model.
The application will be maintainable and upgradable in the future.	We met this requirement because extra features can be added in future development after getting user rates for the application.

Table 7 Testing Summary

6.4.Acceptance Testing

We collected a survey from 30 people of different ages and genders who participated in the prototyping part of this testing phase. The percentages of males and females were slightly big, the percentage of females was 76.7% and males 23.3%. Most of the participants were between 18 to 25 years old, and most of them were still students, as shown in the figure below.

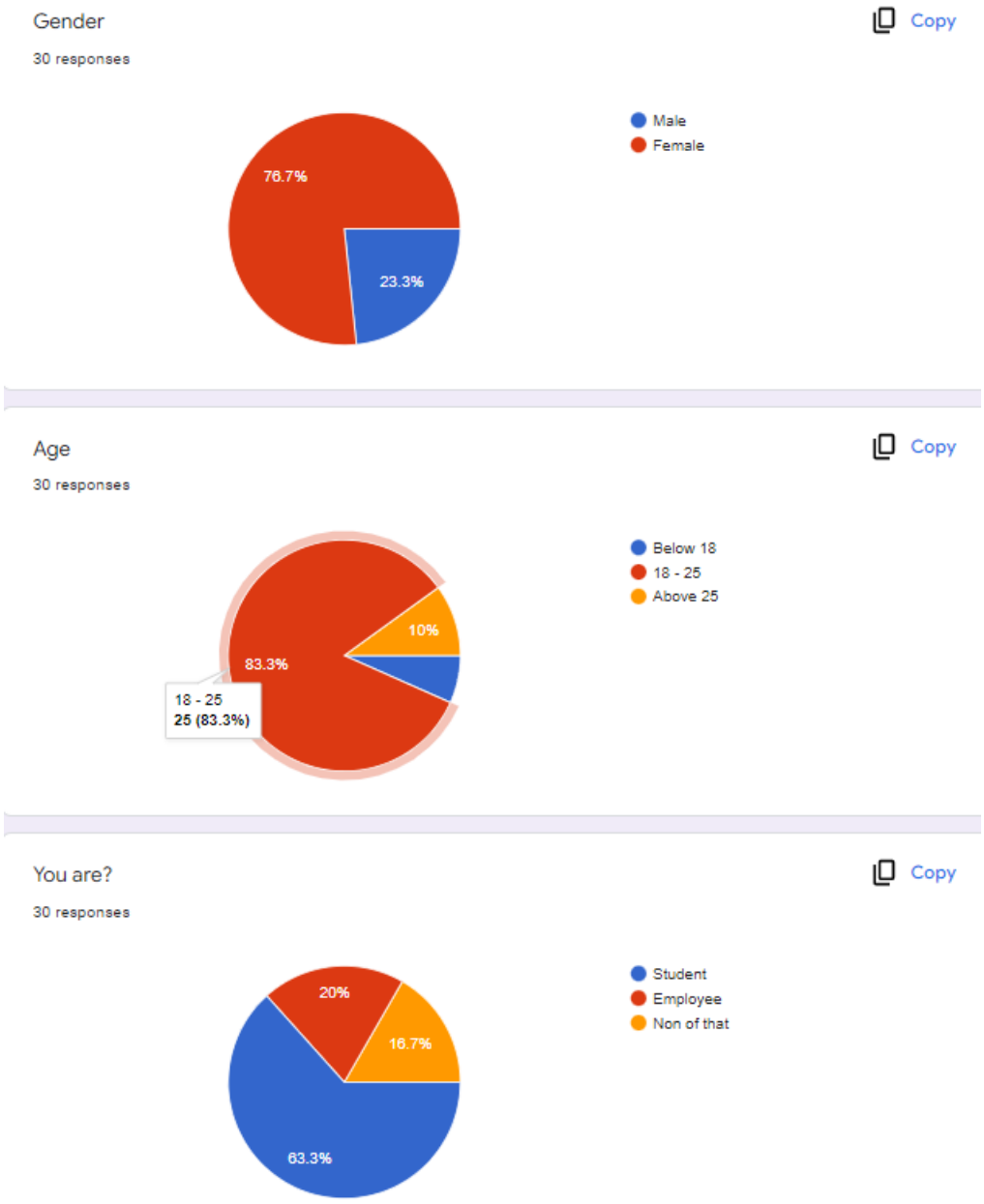

Figure 50 Questions Result

In figure 50, we asked them if they found any difficulties accessing the application. The percentages are as shown in the figure below.

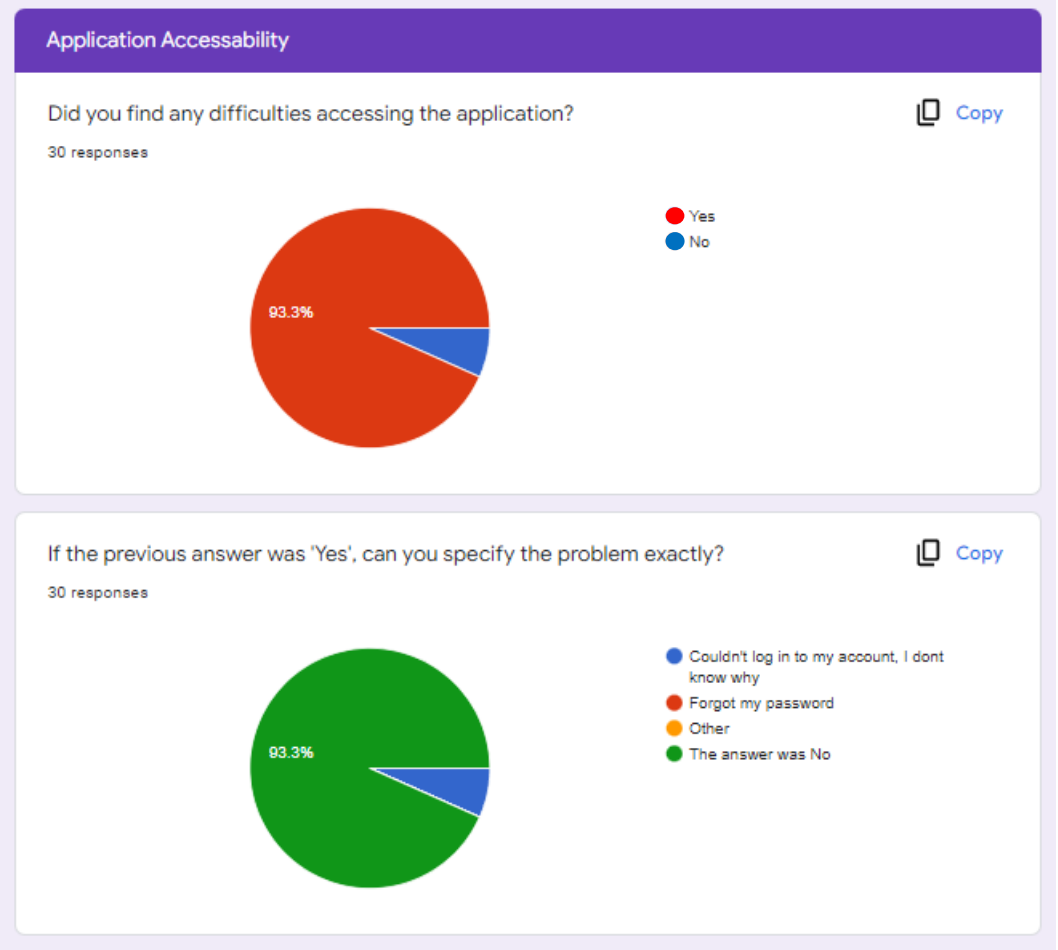

Figure 51 Accessibility Questions and Result

in figure 51; we asked them if they found any difficulties using the application. The percentages are as shown in the figure below.

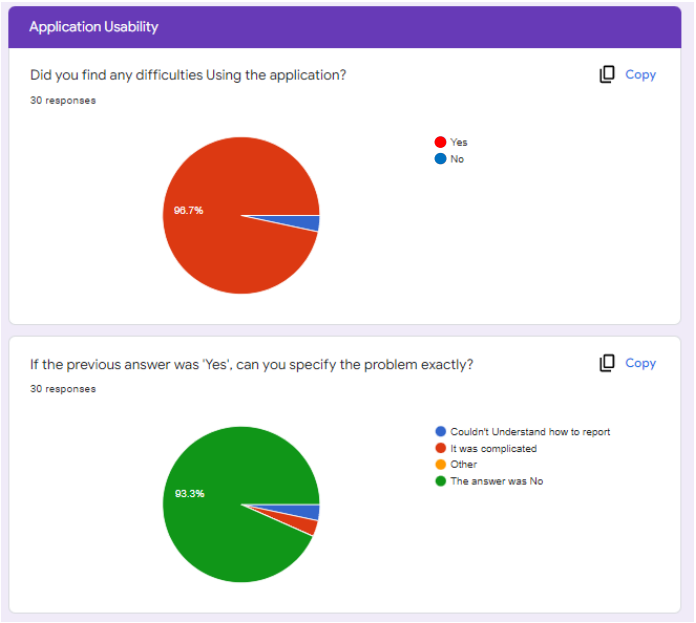

Figure 52 Application Usability

in figures 52 and 51, we asked about application response time; we found that it satisfied the user and was smooth. The percentages are as shown in the figures below.

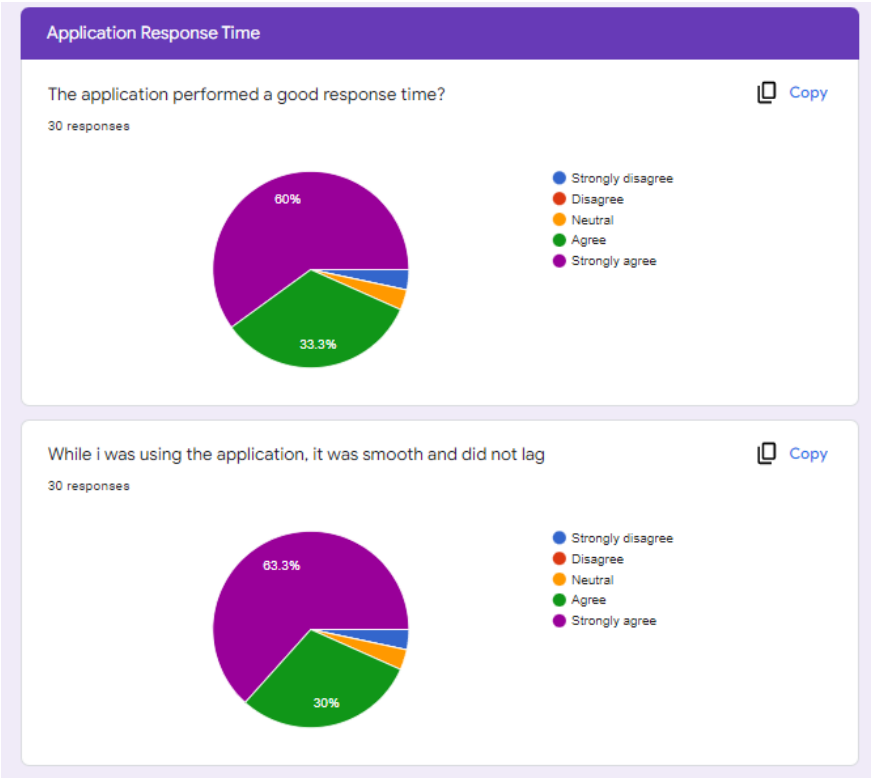

Figure 53 Response Time

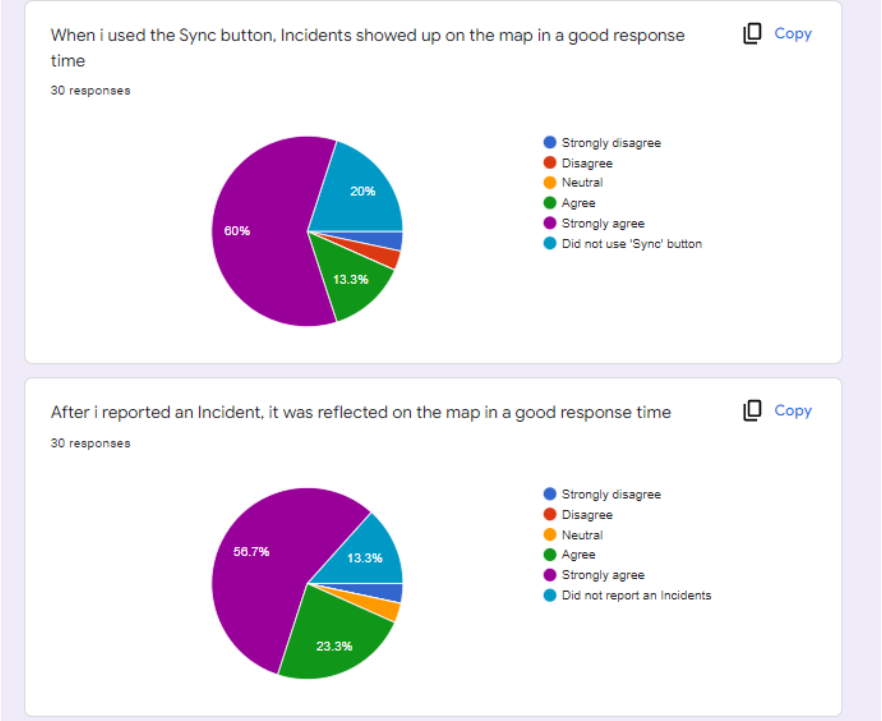

Figure 54 Response Time Cont

in figures 55, 56, and 57, we tested the User interface by asking the participants about their experience; users loved the User interface, thus satisfying their needs. The percentages are as shown in the figures below.

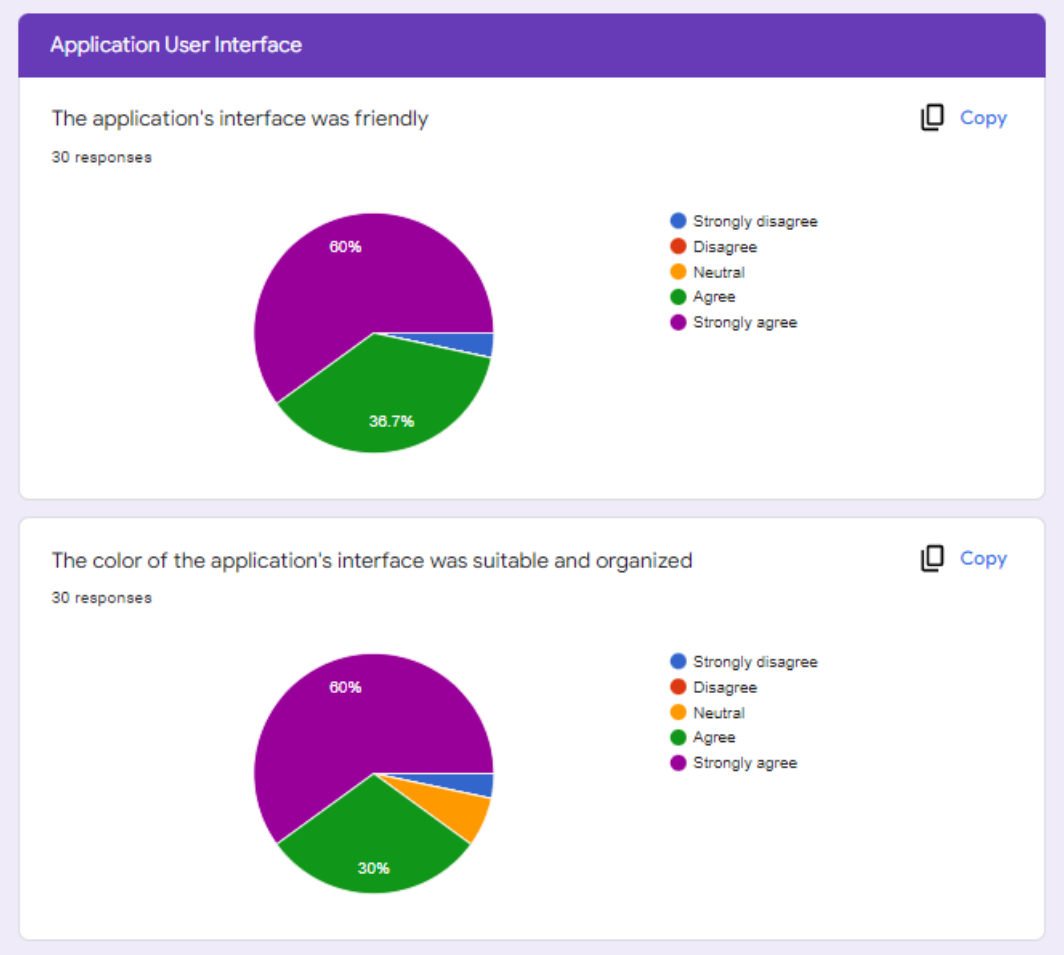

Figure 55 User Interface Survey

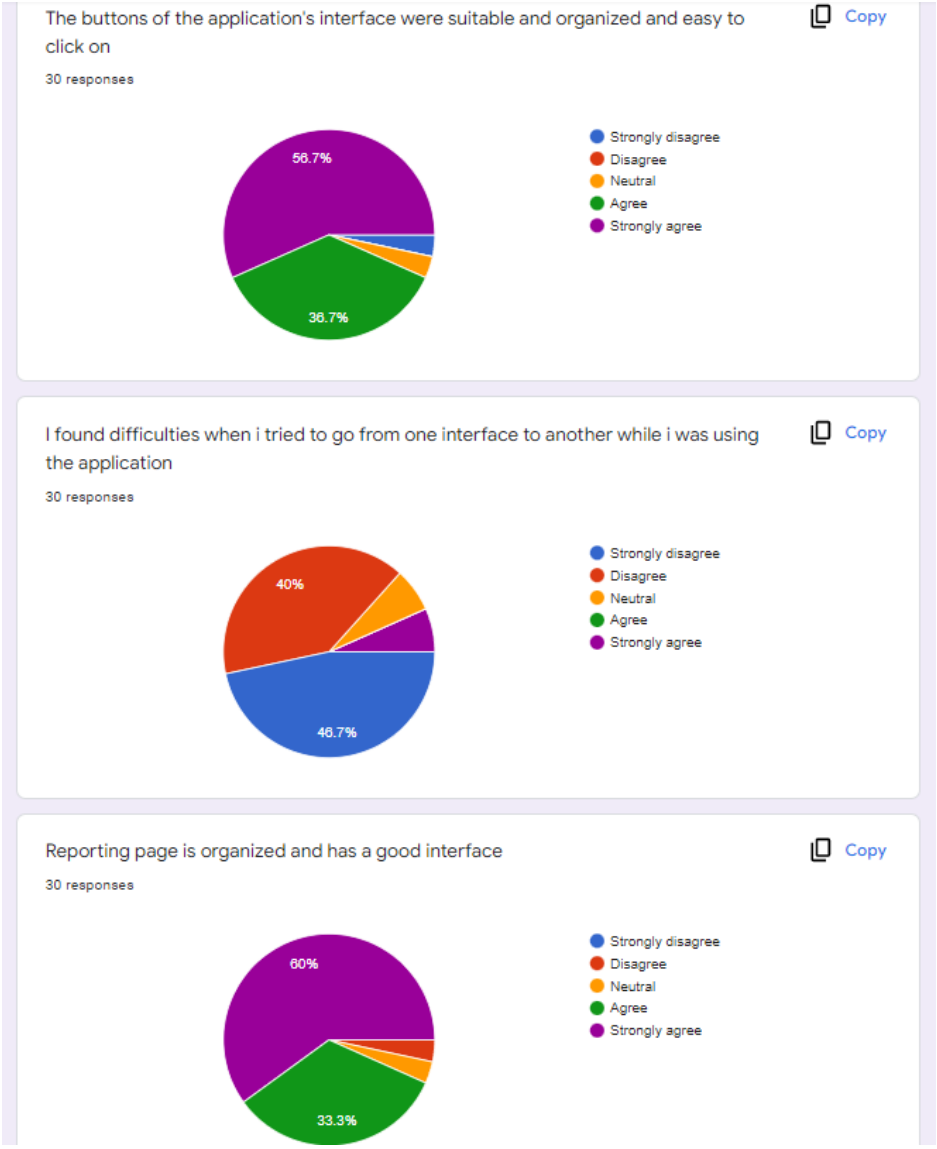

Figure 56 User Interface Cont

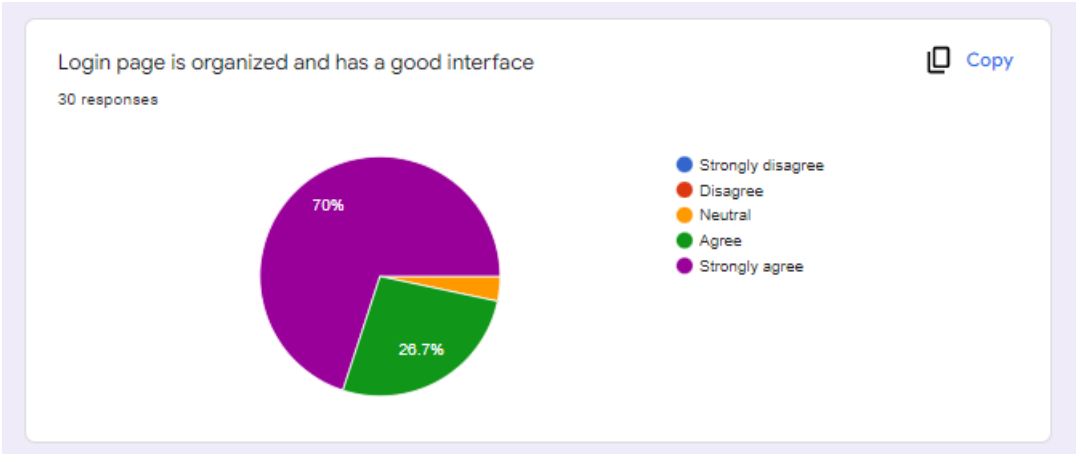

Figure 57 User Interface Cont

6.5. Applying the Software Development Process

According to the V-shaped software development process, four main steps are required before developing a feature: the requirement analysis, the system design, the architecture design, and the module design.

First of all, our requirement analysis was mainly based on the ideas we had and documented during SDP 1, which can be shown in the use case diagram <figure 8> and the appendix <Appendix B>. Moreover, some changes and additions were implemented due to compatibility issues on IOS and the moderating website that comes with the harassment heatmap suit. The website fulfilled the need to handle spammers and has a macro visualization of the reporting and the user usage accompanied by the ability to download the data after filtering.

Moreover, the system design we followed is documented in the behavioral models in chapter 4.4, along with the discussion of each sequence and the actors involved in it. Additionally, the architecture design can be observed in chapter 4.2, where the tiers are signified along with the main processes in each tier. Finally, the module design was documented in the structural class diagram mentioned in figure 10. The main modules of the applications can be seen along with the discussions of each one and the reasoning behind their separation and structure.

For the testing part of the V-shaped model, we had each component tested on its own, as signified in chapter 6.1, to finalize the unit testing requirement; then, we tested these units in parallel to verify the functionality of them being integrated fulfill the Integration testing requirement. Additionally, we used the application in parallel for the system testing while monitoring the expected results and how they reflect on the database and our application, which can be previewed in figure 39, which shows the successful case of registering a user. Finally, the acceptance testing was held in the surveys concluded with the testers, as shown in chapter 6.4. We took the users' responses after using the application and how satisfied they were.

The v-shaped model proved robust with consistent progression when we needed to implement a new feature or fix an already implemented one. We also had a clear plan for testing the application, so we did not face many deadlocks when trying to resolve a bug or change a feature according to the users' needs/comments. On the other hand, since there are four steps before developing the planned feature, sometimes we had to rush through some steps when implementing some features due to time constraints or breaking bugs. The testing phase was sometimes tedious to follow too, where we had to implement several features and test them together at once, instead of doing the 4-steps test for each of the new features, because these features were not big enough to invest much time to test them.

7. Impact of project solution

Our project aims to generalize how people approach and treat harassment cases in all shapes and forms without going through tedious protocols that might negatively impact them by sabotaging their anonymity. Accordingly, our project will have to address the three pillars of customers: individuals, organizations, and Societies.

Individually

On an individual basis, our application will help the user be as safe as possible without experiencing any incidents beforehand before building the general knowledge of how safe a place is. This method will help prevent these accidents by only utilizing people's collective efforts. Consequently, the sense of internal safety will be boosted by the knowledge of having watchers and reports all around you ready to give in reports whenever an incident of this sort happens to you.

In conclusion, adopting this mechanism, where there is a consistent live feed from and to the individual, will boost their sense of safety and make any criminal very hesitant, if not terrified, of practicing these harmful actions naturally.

Organizations

By utilizing this application, organizations will have a valuable heuristic to prevent any toxic tendencies occurring in their internal or external environments. To elaborate, Internal toxic tendencies can be represented by the "Work Mistreatment" category that workers/whistleblowers report under. According to the reported magnitude, the organization will take action to survey and gauge their work environment. Moreover, an organization specializing in defense or incident prevention, such as the police force, will focus more on the external toxic tendencies outside its organization. These external tendencies could be in the picture of verbal/sexual harassment in public areas and public property damage.

Society

Building and kick-starting this application in a society that experiences these negative phenomena will revive and aid the community's sense of self-sufficiency in public security and image instead of relying on external forces such as the police. Moreover, it will help erode the negative stigma surrounding people who experience these incidents, since not only will they be witnessing and reporting these incidents instead of entirely relying on the victim to come out and report what happened themselves.

8. Conclusion

The project was successfully done most of, except for some parts planned to be in the project's future work. Hence, in terms of objectives, all of our expectations for the project were met. We now have the application up and running with testers and feedback, and most

of the feedback was positive we did not encounter a lot of negative feedback features. We can proudly say that

we have done three different platforms, two mobile apps, and one website. The mobile applications are working very fine without any bugs on both operating systems, iOS and Android. We have done the Heatmap successfully on Android. For some technical issues in the used library for the Heatmap, as the Heatmap has issues regarding iOS, it did not work; we switched to cluster map, which does the same job but with another look. Also, the emergency help is working exactly as expected by sending messages to the user's emergency contacts and calling the country's emergency number. Moreover, heat spots are shown on the map successfully. The user can see the dangerous areas and filter among the received data on what type of incidents they want to avoid and when they happened. The app can show the user the nearest facility to them. If they need help, they will not have to go and search for them and waste their valuable time finding things already easily accessed throughout our application. We have the reporting functioning as well as it can get; when the report is done, it reflects directly on the Heatmap and the guardian app. That takes us to the next platform, which is the guardian app.

We are happy to say that society now has an app like this to ease ways for the enforcers to help the civilians. The guardian app gets every new report in a real-time way, which gives us approximately ZERO delays. The app also provides the enforcers with a notification whenever a report near them is submitted, so the nearest enforcer can act and help the victims as fast as it can get. Also, the enforcer will assign themselves to the incident so the authorities can refer to them later.

Enforcers can view the resolved cases and the queued cases to them. Moving on to our third platform, the admin’s webpage. It is a beautiful, user-friendly, and smooth interface where admins can do multiple things. On the website, they can visualize the data in an organized and easy-to-understand way; we reached that by using pie charts and metrics on the report’s types, statuses, and categories. In this way, they can efficiently study the data, and it will help them come up with statistics and solutions. In Addition, they can filter the queried data according to the report's status, category, and when it was submitted. The website also shows a cluster map to visualize the places and how big the problem is. Like our other platforms, the website provides a real-time update of the data for when the reports occurred, got queued, or was resolved. Admins can inspect the report's details, including the time of submission, location, and which officer is assigned to this incident.

The admin can view spammers throughout the website, as it determines when the user spamming is and highlights this user, and the admin can then view the users’ reporting rate and decide whether this user needs to get banned. The next great feature is banning users, admins can ban spammers using the website, so the reports stay accurate to the users and not get faked by some spammers. Banning a spammer will delete the account and their reports, which will also be deleted from the maps across the three platforms. We can safely say now that we met our objectives of building a helping tool for the people to lower the rate of these

types of incidents in our society, and according to the received surveys, we did a pretty good job on that.

9. Future work

Firstly, we will try to find a client to sponsor the project and have a professional project. Secondly, the application is good for now, but it needs improvements in some parts. The Heatmap in the iOS devices is not there yet because of the library issue, so we are planning in the future to give more time to the iOS development part and resolve the problem that we faced. We are sure we can come over it and provide the iOS users with the best experience. Moreover, we have some features to add to the application, like having more reporting categories and spreading the app to help on different levels, not only harassment. We are also planning to collaborate with the authorities to have full support.

10. Student reflection

Mohanad:

This was one of the best experiences I have had on a project, as I learned a lot from my teammates. First of all, I learned how to code using dart and flutter framework, which was a big step in my professional life. Now I can quickly build hybrid apps with no issues. Also, it gave me many experiences with dealing with errors and bugs and how to design a project from scratch. I got used to teamwork even more now. I can say I can work with a team and solve conflicts without any grudges between my teammates and me. I learned that I should avoid sticking to my opinion without listening to others.

Youssef:

This was a very new experience for me, and I enjoyed it through and through. As we brainstormed the idea of our senior project last summer, I would not have guessed how fun this would be, starting from learning app development in flutter, going through fleshing out this idea we had on a small piece of paper to this multiplatform project that incorporates many technologies in it, which at the same time, is ready for real-life usage. I also now enjoy the maturity I gained from working in a team. I learned a lot from interacting, conflicting, and resolving the problems we faced along the way. I learned to be bolder and more courageous when it comes to collaborating with others and when it comes to the tools I use to develop applications.

Hesham:

It was not just a passing experience; we can say that it was a milestone in my life. The tremendous amount of knowledge and experience I have gained is immeasurable. I learned many experiences along the way. Starting with learning Dart Language that will help me in my professional life in an indescribable way, passing through learning how to overcome the challenges that one can face while working, and learning how to be with the team and work with them to reach a great goal that we can be proud of. My practical experiences developed, I learned how to work on different tools at one time, and I also learned how to build programs on more than one operating system, such as iOS and Android, which gave me a great experience that will help me a lot when I start my working career.

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Appendix A – Project Plan

A.1. Project milestones

Milestone 1: Gathering information about the topic and researching how big the problem is.

Milestone 2: Finding the best approach and features to reduce the problem as much as possible.

Milestone 3: Studying the idea more to come up with the most suitable steps for us to finish the project (software process)

Milestone 4: Implementing 20% of the whole project as a proof of concept

Milestone 5: Prototyping

Milestone 6: Collecting feedback and analyzing it

Milestone 7: Developing the full project

A.2. Project timeline

Task	Start Date	End Date	Duration
Deciding the topic and the idea of the project	19-08-2021	31-08-2021	12 Days
Researching the idea	31-08-2021	07-09-2021	6 Days
studying the pre-existing solutions to do better	07-09-2021	25-09-2021	18 Days
Writing and reporting everything we reached	25-09-2021	05-10-2021	10 Days
Implementing 20% of the project	05-10-2021	19-10-2021	14 Days
Studying the market and creating a business model	19-10-2021	30-10-2021	11 Days
Filling the report with the rime line of the whole process	30-10-2021	04-11-2021	5 Days
Publishing the prototype as a beta for a limited number of users	09-01-2022	12-01-2022	3 Days
Users testing the application	12-01-2022	12-02-2022	1 Month

Surveying the users about their experience and gathering feedback and recommendations	12-02-2022	19-02-2022	1 Week
Studying the needs of the society in our app	19-02-2022	26-02-2022	1 Week
Deciding the remaining features for the application	26-02-2022	28-02-2022	2 Days
Start implementing the features	01-03-2022	05-04-2022	5 Weeks
Finalizing the application into its last form	05-04-2022	19-04-2022	2 Weeks

A.3. Anticipated risks

Anticipated Risks	Description	Minimizing approach
Schedule risk	The risk of not having the same free time to meet and decide.	We gathered before the semester so we could have the lecture timing
Potential legal risks	As the app might require some sensitive information like I.D.	We decided to go with the phone number so we could create our database without going into any legal issues.
Lack of government collaboration	Because our project might require some collaboration with some government institutions	We decided to make it a standalone project
Multiplatform	As the app will be needed on both platforms IOS and Android	We decided to go hybrid and use flutter instead of Kotlin and Xcode

Appendix B – Use cases specification

Use case Id: UC**01**	Register

Brief Description	User registers a unique account using their mobile number and other information about the person, which is then stored in the D.B. An OTP is sent after that to verify the user
Primary actors	User
Preconditions: • The user must not have an account already	
Post-conditions: • A new user account will be created	
Main Success Scenario: the user will gain an account in the application	
Actor Action	**System Response**
1. the user will click on the signup button	2. the system will show the signup window
3. the user will provide their needed information	4. the system will create a new user account
Alternative flows: 4.a. if the provided user key information already exists, the application will not create a new account, and a warning message will appear on the screen	
Special Requirements: Portability, Performance, Security, Usability, User Friendly, Availability, Reliability, Scalability, Modifiability, Maintainability	

Use case Id: UC**02**	Login
Brief Description	The user logs in into the system using their credentials
Primary actors	User
Preconditions: The user must already have a registered account	
Post-conditions:	
Main Success Scenario: The user will sign in successfully and be able to use the features of the application	
Actor Action	**System Response**
1. user will provide the username and password of their account	2. the system will log them into the app
Alternative flows: 1.a. the user will provide the wrong username or password, then a warning message will appear	
Special Requirements: Portability, Performance, Security, Usability, User Friendly, Availability, Reliability, Scalability, Modifiability, Maintainability	

Use case Id: UC**03**	Submit Report
Brief Description	The user opens the Report Forum, fills in the needed information, and then submits the report.

Primary actors	User
Preconditions: • The user must have an account • The user must be logged into the application	
Post-conditions: • It must not be a scam	
Main Success Scenario: the user will submit a report, and it will be stored in the database so authorities can look at it.	
Actor Action	**System Response**
1. user will log in to the application	2. the system will open the app and provide the features
3. user will click on the report button	4. the system will direct the user to the report window
5. user will provide the needed information in the report window	6. the system will submit the report to the database
Alternative flows: 5.a. the user is a scammer, in this case, the user will be banned, and the report will not be submitted.	
Special Requirements: Portability, Performance, Security, Usability, User Friendly, Availability, Reliability, Scalability, Modifiability, Maintainability	

Use case Id: UC**04**	View heatmap
Brief Description	Users Navigate to the home screen and observe the Heatmap, which contains different views according to the category they want to analyze
Primary actors	User, system
Preconditions: • The user must be logged in	
Post-conditions:	
Main Success Scenario: The user will log in and be able to avoid the dangerous places via the Heatmap provided by the application	
Actor Action	**System Response**
1. user will log in	2. the system will route the user to the heatmap window as it is the starting window of the application
3. user will be able to avoid the places with the most unwanted behavior	
Alternative flows: 1.a. the user is not able to log in for some reason, as shown in UC02	
Special Requirements: Portability, Performance, Usability, User Friendly, Availability, Reliability, Scalability, Modifiability, Maintainability	

Use case Id: UC**05**	Ask for emergency
Brief Description	The user presses the Ask for Emergency Button, which then alerts the intended parties along with the user's emergency contacts
Primary actors	User, system, intended parties
Preconditions: • The user must be logged in	
Post-conditions:	
Main Success Scenario: The user will log in and be able to ask for emergency	
Actor Action	**System Response**
1. user will log in	2. The system will route the user to the heatmap window, which also contains all the buttons
3. user will press the emergency button	4. the system will alert the intended parties with the user's contact
Alternative flows: 1.a. the user is not able to log in for some reason, as shown in UC02	
Special Requirements: Portability, Performance, Usability, User Friendly, Availability, Reliability, Scalability, Modifiability, Maintainability	

Use case Id: UC**06**	View Closest Facilities Map
Brief Description	Users Navigate to the home screen and press the View Closest Facilities button, which shows various facilities on the map view
Primary actors	User, system
Preconditions: • The user must be logged in	
Post-conditions:	
Main Success Scenario: The user will log in and be able to press the button and view the nearest facilities to them	
Actor Action	**System Response**
1. user will log in	2. the system will route the user to the heatmap window, which also contains all the buttons
3. user will press on nearest facilities button	4. the system will then show the nearest facilities on the map so users can view them
Alternative flows: 1.a. the user is not able to log in for some reason, as shown in UC02	
Special Requirements: Portability, Performance, Usability, User Friendly, Availability, Reliability, Scalability, Modifiability, Maintainability	

Use case Id: UC**07**	Proximity Notification
Brief Description	When a superuser/admin is near a place where an incident just got reported, they will get notified to simplify quick interference
Primary actors	User, system, enforcer
Preconditions: • The user must be logged in • Enforcer/s must be near the incident	
Post-conditions:	
Main Success Scenario: The user will log in and be able to report, so whenever a report happens with an enforcer in a specific range of the incident, the enforcer will get notified about it and interfere quickly to avoid any possible harm.	
Actor Action	**System Response**
1. user will log in	2. the system will route the user to the heatmap window as it is the starting window of the application
3. user will click on the report button	4. the system will submit the report and inform the close enforcers with it
	5. application will notify enforcers nearby the incident
Alternative flows: 7. the user is not able to log in for some reason, as shown in UC02 7. b there is not any enforcer close enough to the incident to get the notification	
Special Requirements: Portability, Performance, Usability, User Friendly, Availability, Reliability, Scalability, Modifiability, Maintainability	

Use case Id: UC**08**	Block User
Brief Description	If Admins Suspect a user spamming false reports, they can block the user from further using the application / from giving reports
Primary actors	User, system, admin
Preconditions: • The user must be spamming • Admin monitors the user	
Post-conditions:	
Main Success Scenario: The user will keep on false reporting (spamming), and the admin will notice this and block the user so there will be no user affected by this spamming	
Actor Action	**System Response**
1. user will log in and start spamming	2. the system will notify the admin about the spammer
3. admin will block this user	
Alternative flows: 8.a the user is not able to log in for some reason, as shown in UC02 8.b User will be a decent person and will not spam	
Special Requirements:	

Portability, Performance, Usability, User Friendly, Availability, Reliability, Scalability, Modifiability, Maintainability

Use case Id: UC**09**	Donate
Brief Description	Users can donate to us through a link that will be provided on the account screen
Primary actors	User, system
Preconditions: • The user must be logged in	
Post-conditions:	
Main Success Scenario: The user will log in and navigate to the account screen and press on donate button, and donate	
Actor Action	**System Response**
1. user will log in and press on account scree	2. the system will route the user to the account screen
3. the user will press on donate button and donate to the app	
Alternative flows: 9.a the user is not able to log in for some reason, as shown in UC02	
Special Requirements: Portability, Performance, Usability, User Friendly, Availability, Reliability, Scalability, Modifiability, Maintainability	

Use case Id: UC**10**	Contact us
Brief Description	Users can send emails and inquiries/complaints when it comes to their experience with the system.
Primary actors	User, system
Preconditions:	
Post-conditions:	
Main Success Scenario: Users will reach to our contact details and choose one of them to start and reach us	
Actor Action	**System Response**
1. User will reach our contact detail	
2. Users will choose one of the contacting options and send their inquiry	
Alternative flows: 1.a. user will use wrong contact details	
Special Requirements:	

<table>
<tr><td>Use case Id:
UC11</td><td colspan="2">Enforcer Register</td></tr>
<tr><td>Brief Description</td><td colspan="2">Third-party partners such as the police and the emergency teams can sign up as admins to get the admin privileges</td></tr>
<tr><td>Primary actors</td><td colspan="2">enforcer, system</td></tr>
<tr><td colspan="3">Preconditions:
• The user must be from a third-party partner</td></tr>
<tr><td colspan="3">Post-conditions:</td></tr>
<tr><td colspan="3">Main Success Scenario:
The user will be an enforcer from one of the third-party</td></tr>
<tr><td>Actor Action</td><td colspan="2">System Response</td></tr>
<tr><td>1. Enforcer’s organization will contact us to register</td><td colspan="2">2. The organizations’ accounts will update the system</td></tr>
<tr><td>3. Enforcer logs in using the registered accounts</td><td colspan="2"></td></tr>
<tr><td colspan="3">Alternative flows:
2.a. The Request will be rejected, and the organization will get informed</td></tr>
<tr><td colspan="3">Special Requirements:
Availability, Reliability</td></tr>
</table>

Appendix C – The Surveys Conducted

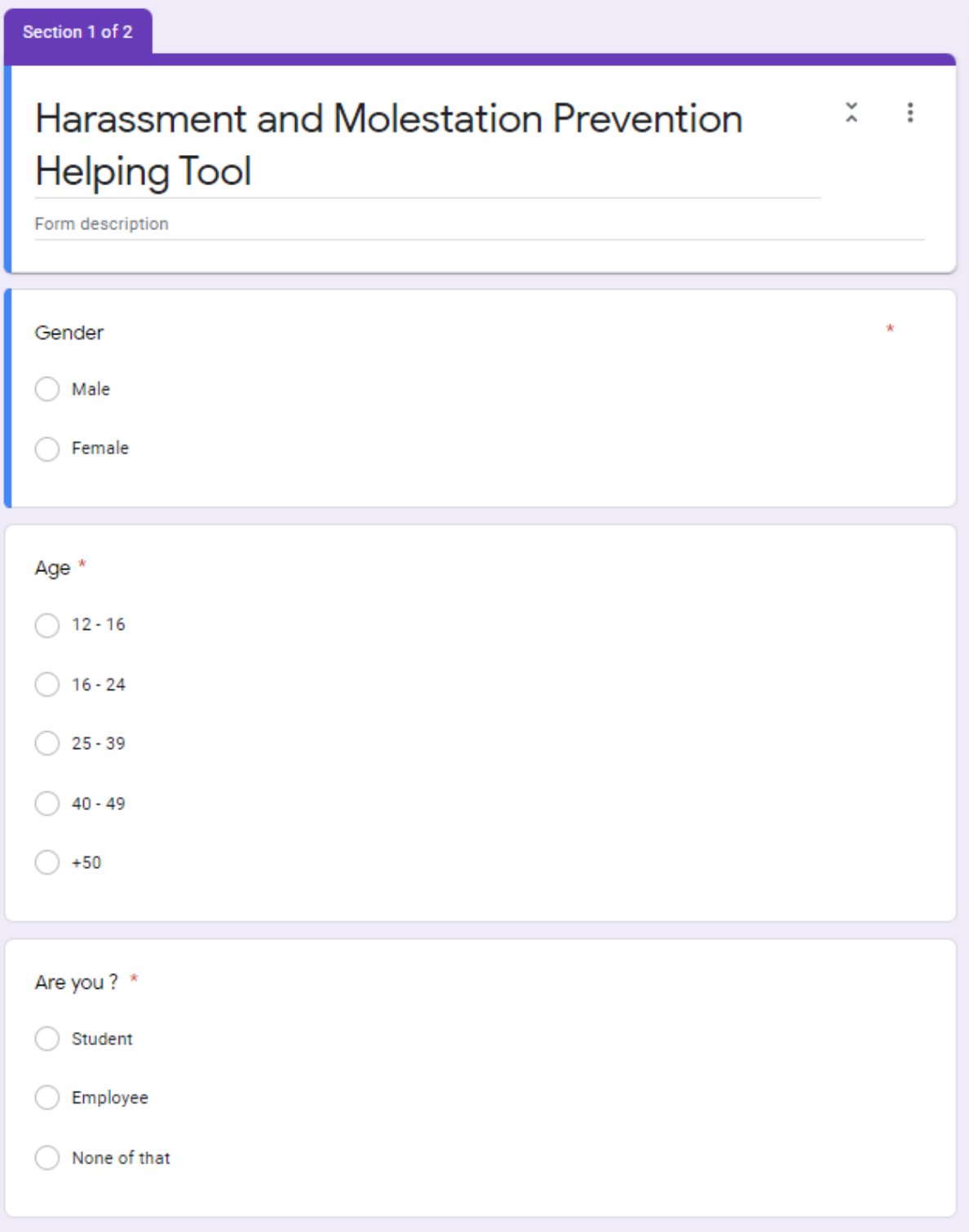

Figure 58: first survey questions

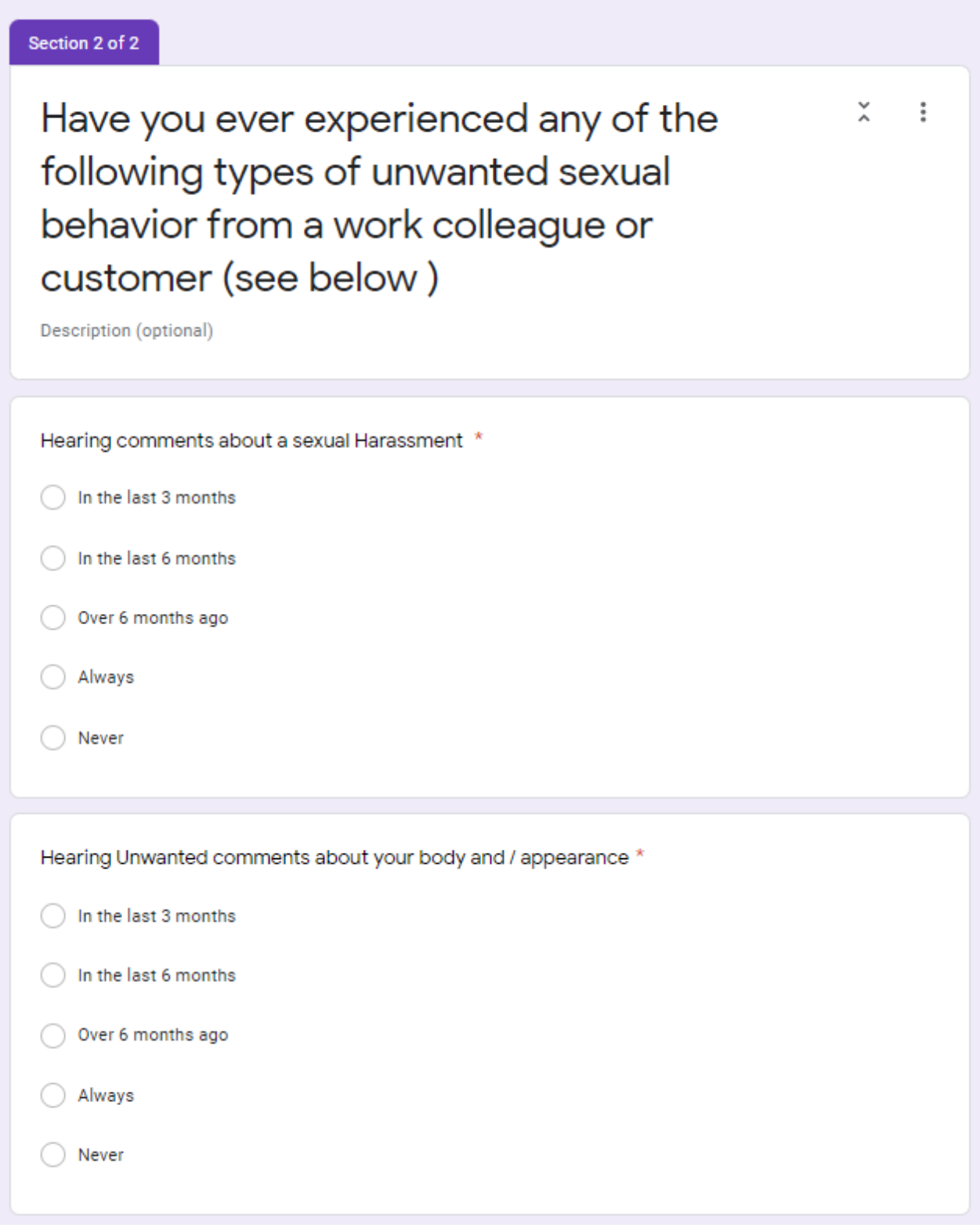

Figure 59: first survey questions

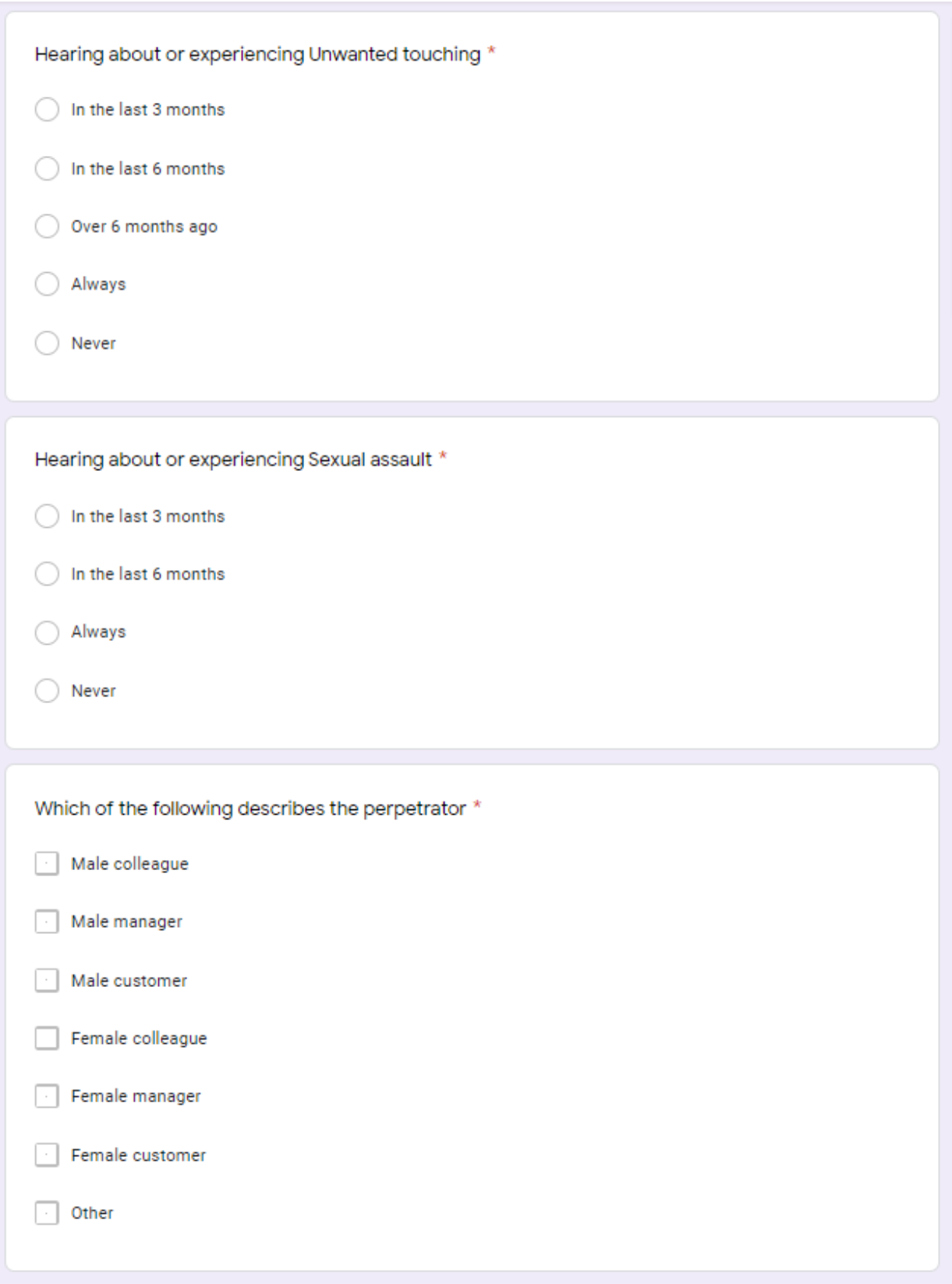

Figure 60: first survey questions

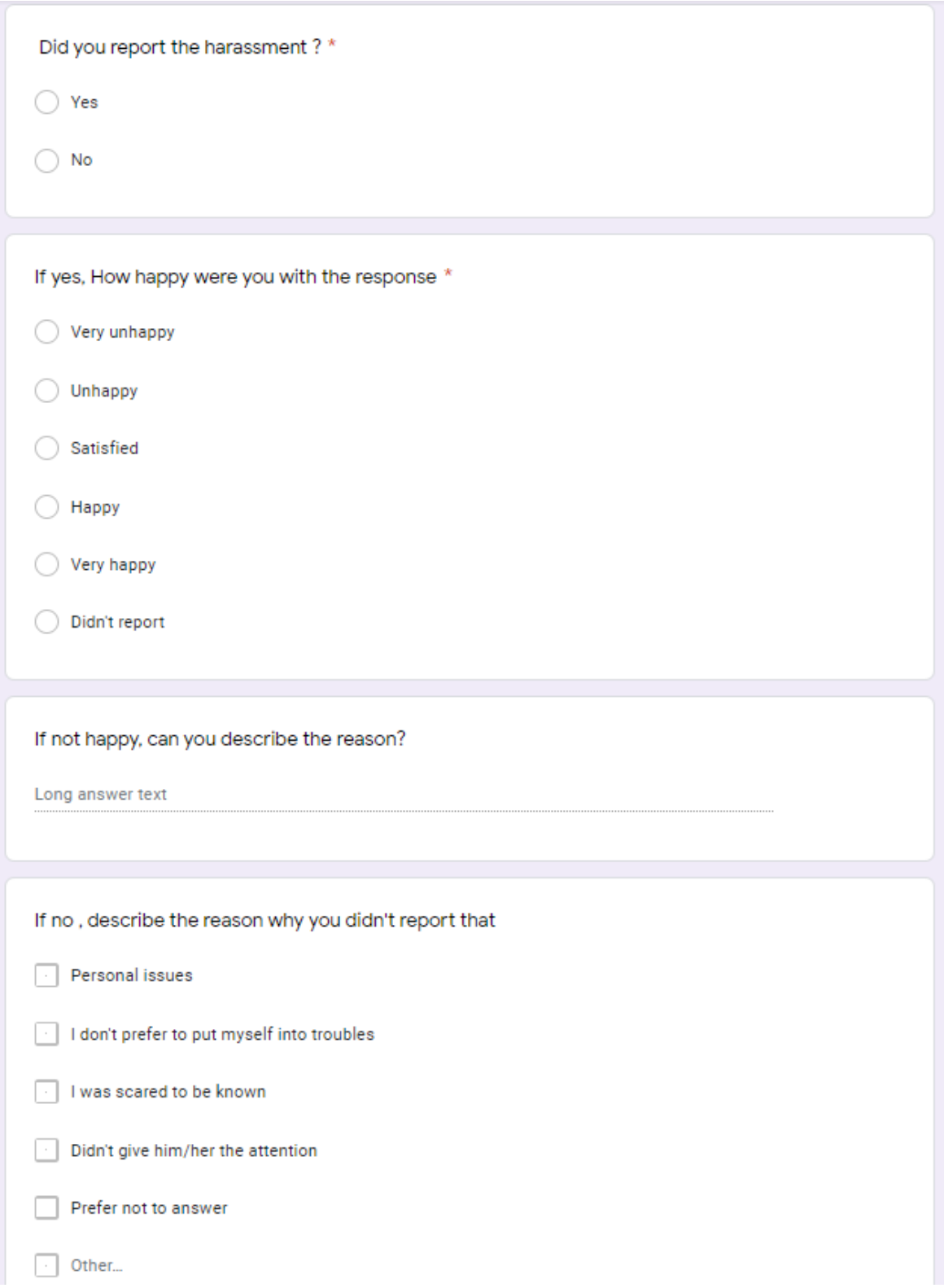

Figure 61: first survey questions

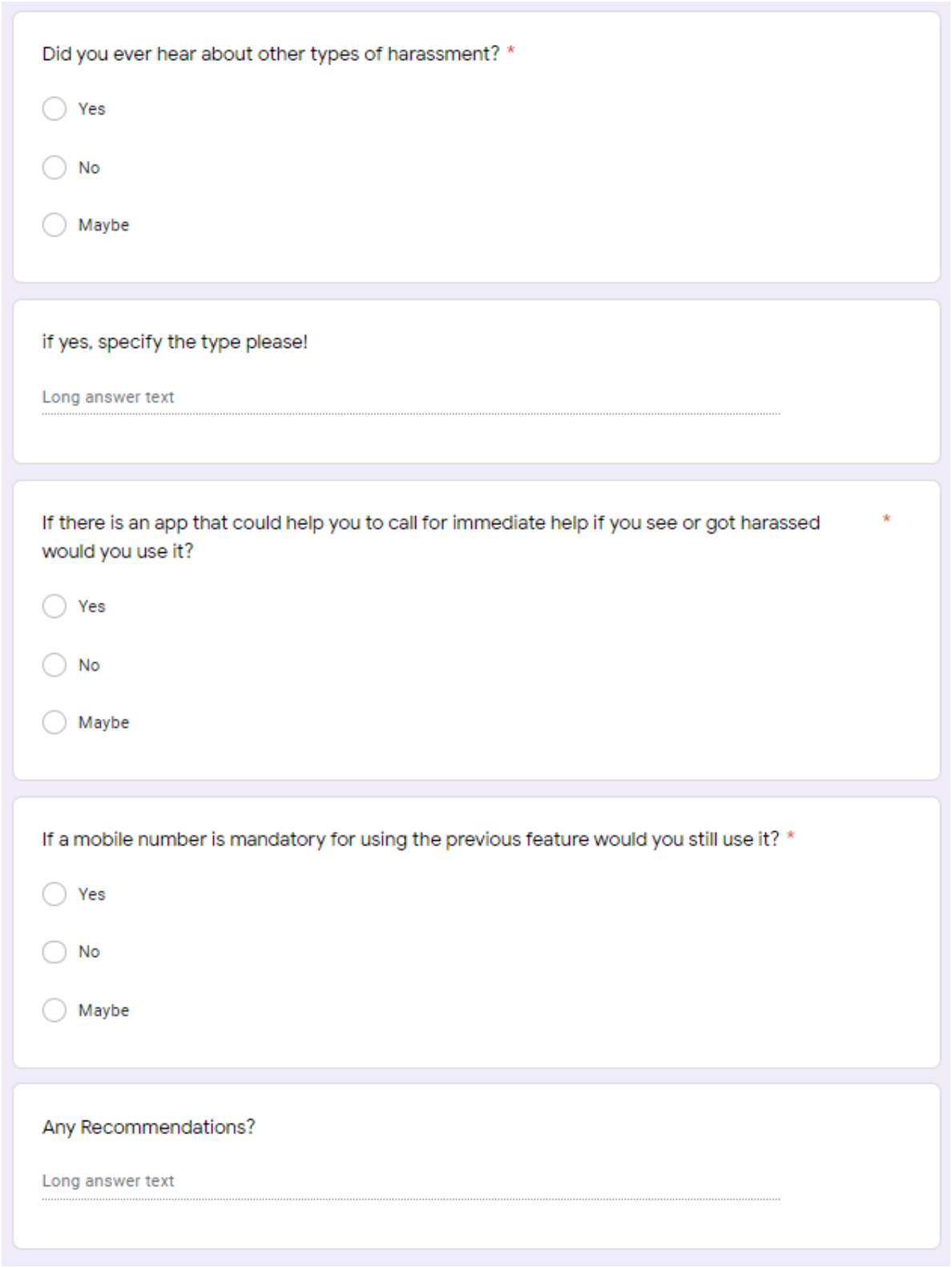

Figure 62: first survey questions

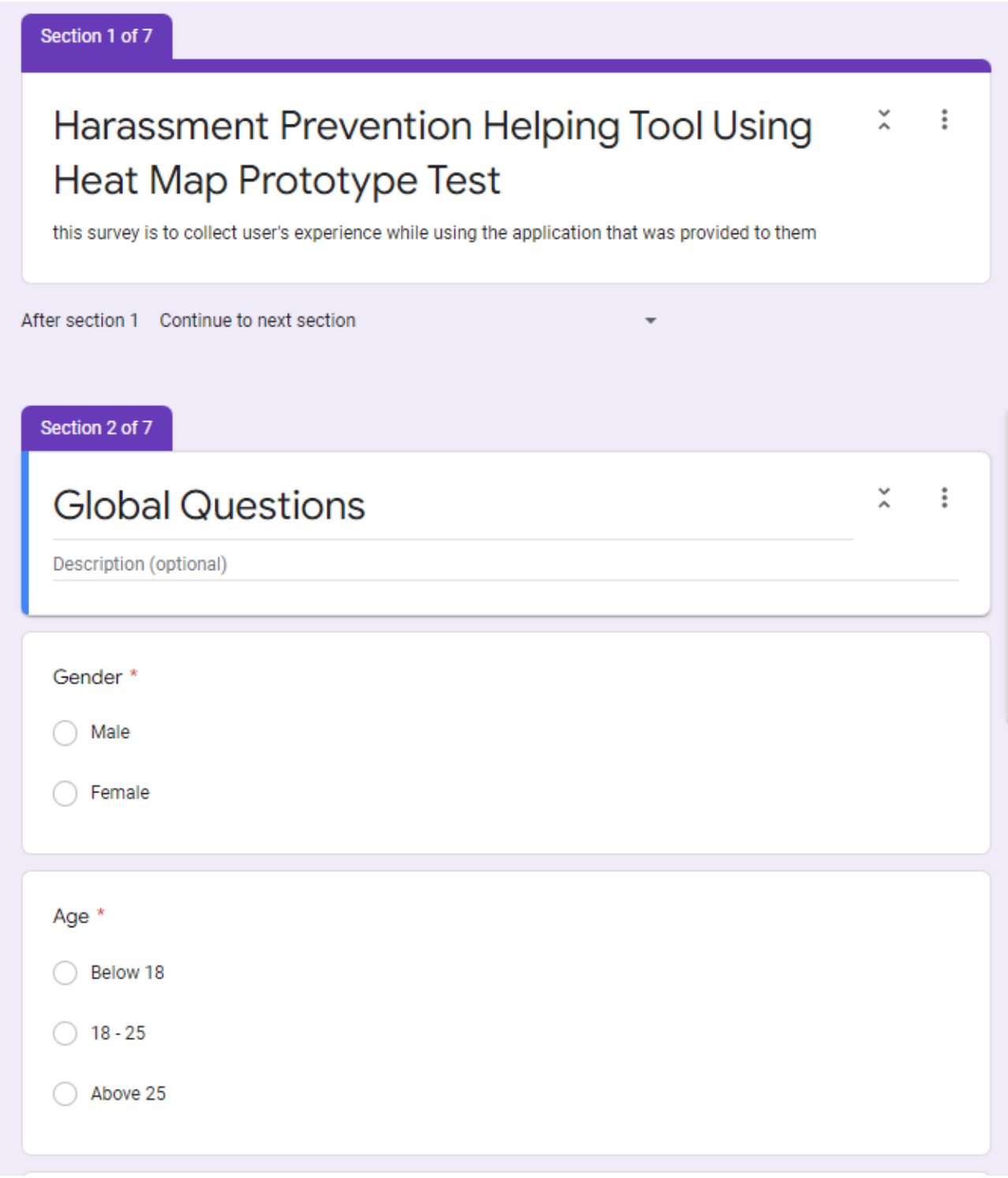

Figure 63 Second survey questions

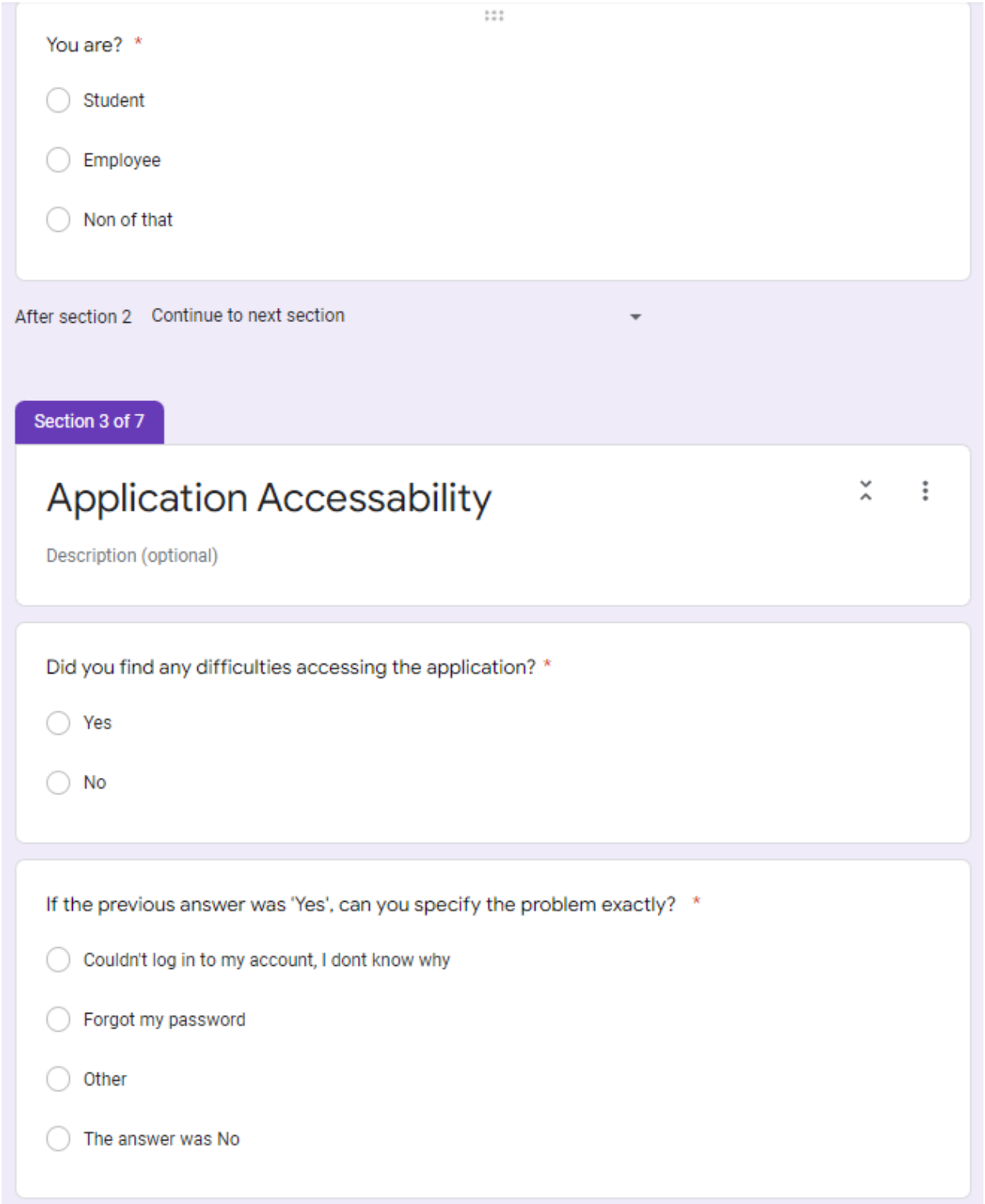

Figure 64 Second survey questions

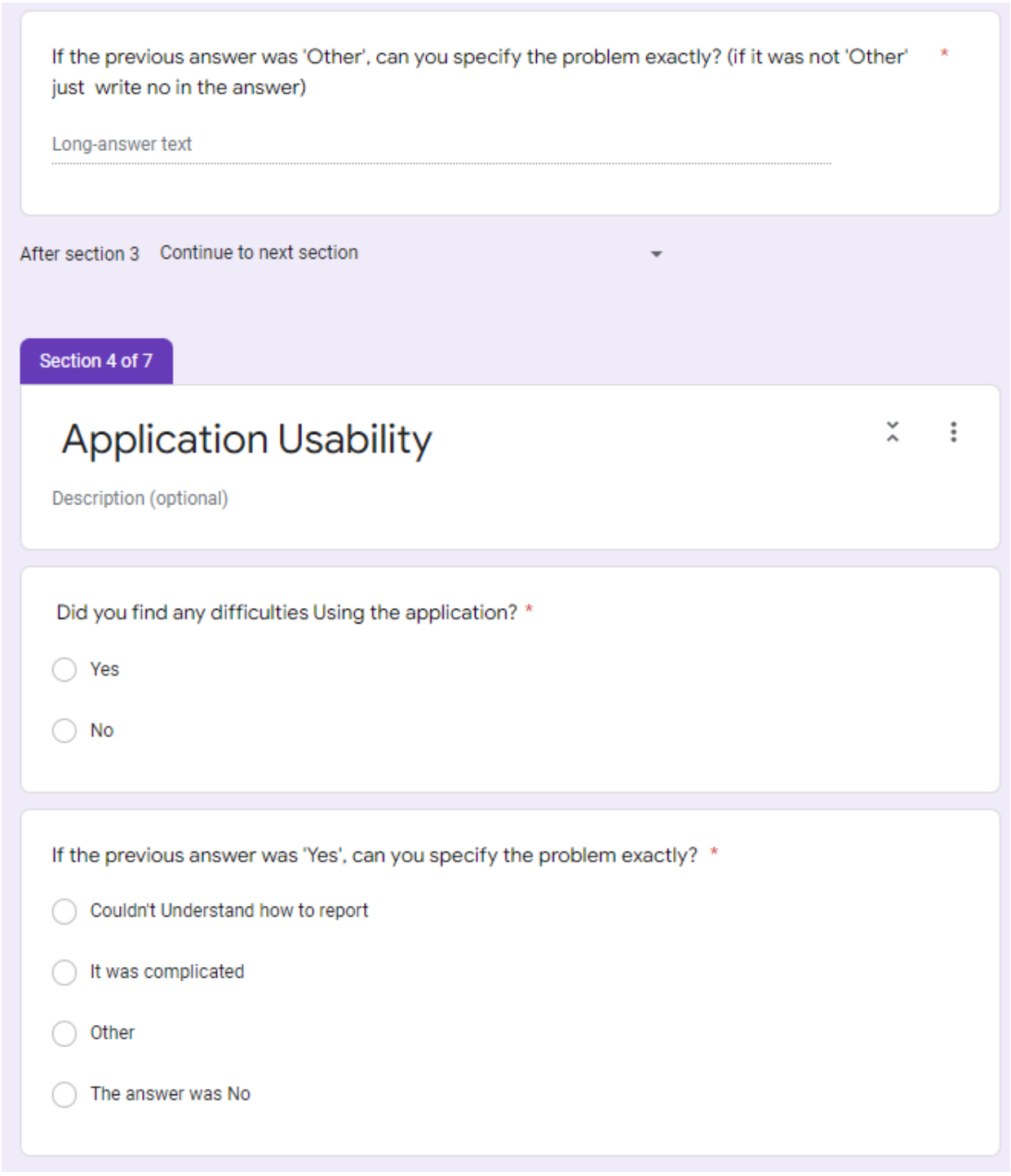

Figure 65 Second survey questions

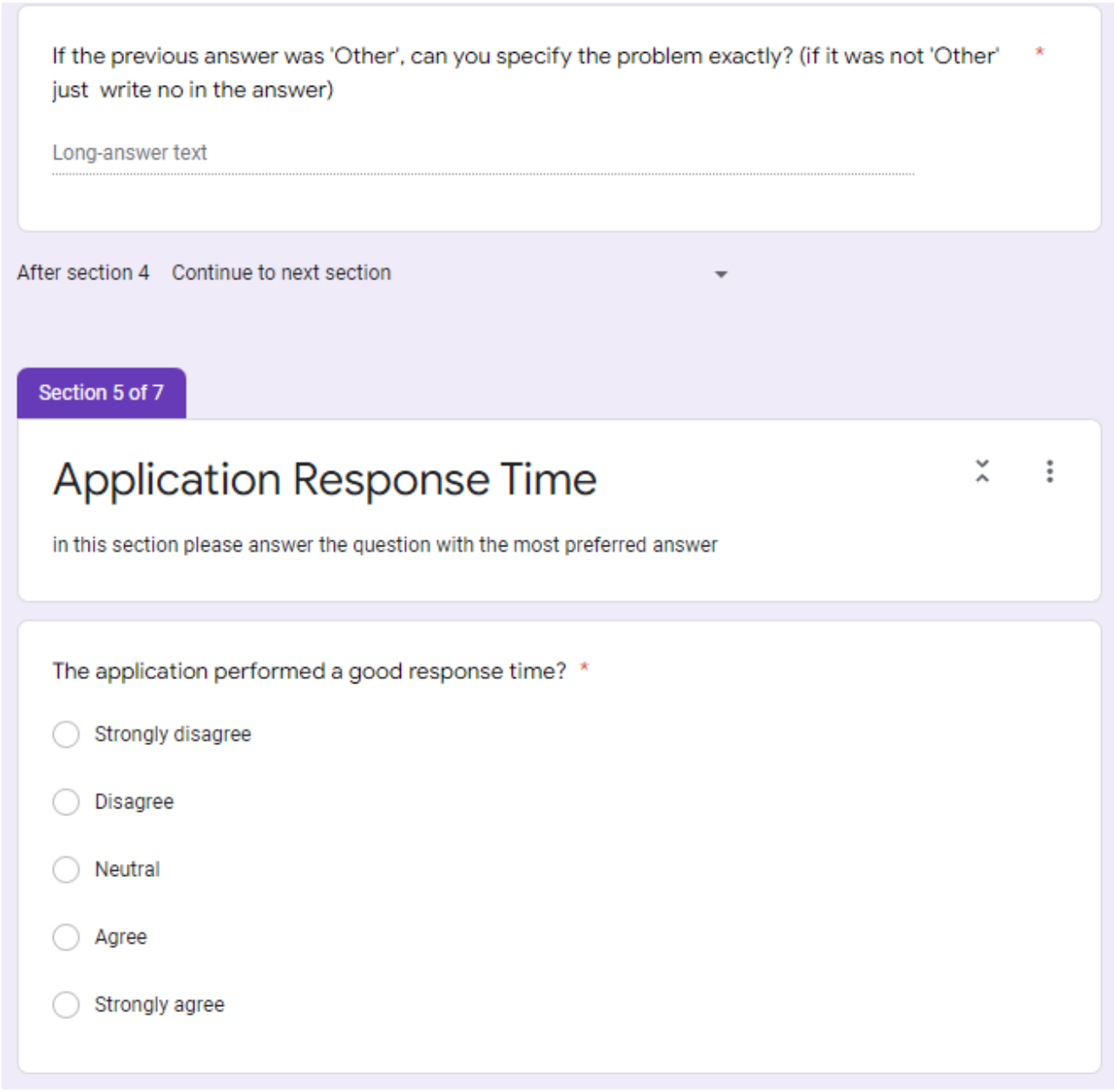

Figure 66 Second survey questions

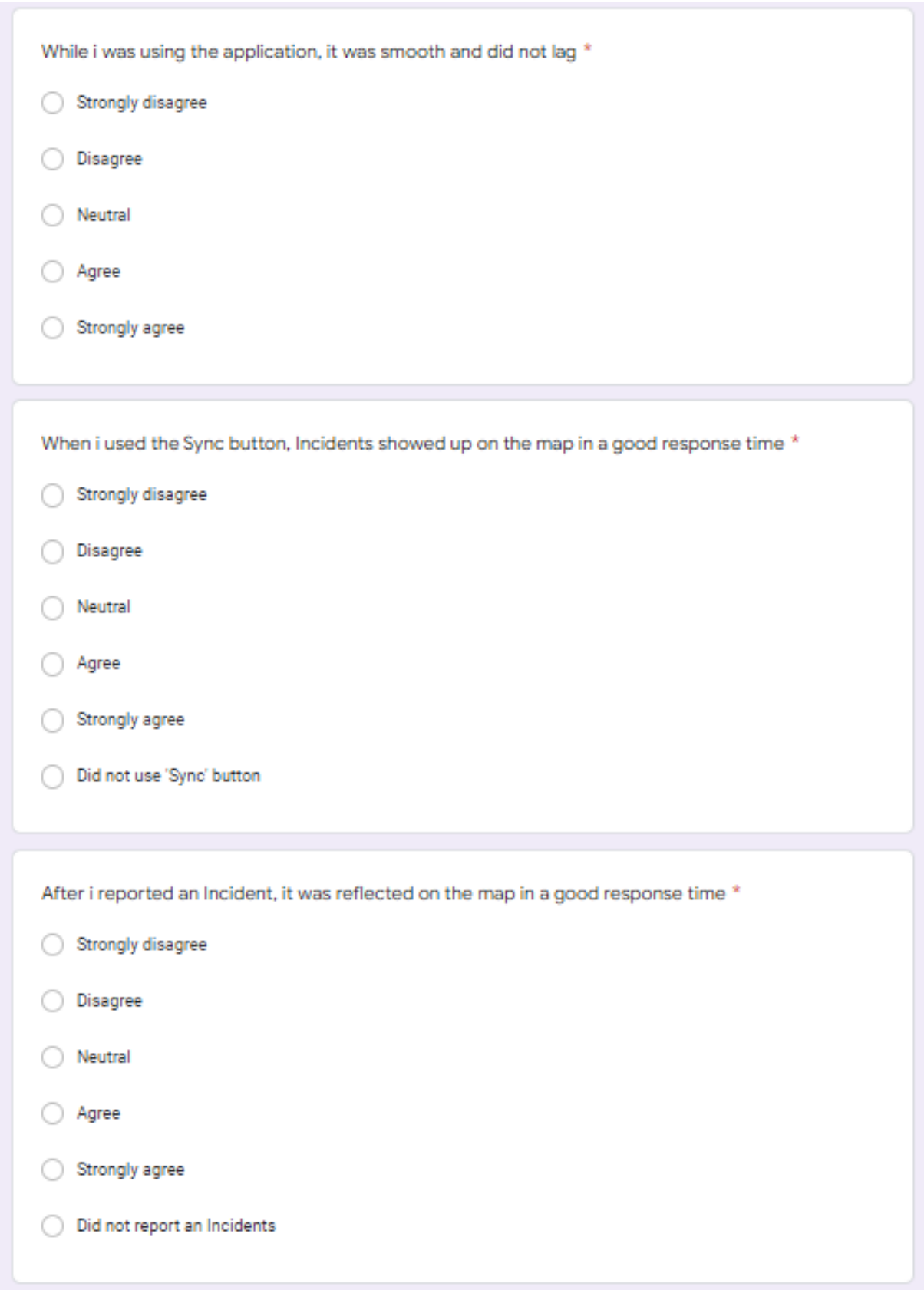

Figure 67 Second survey questions

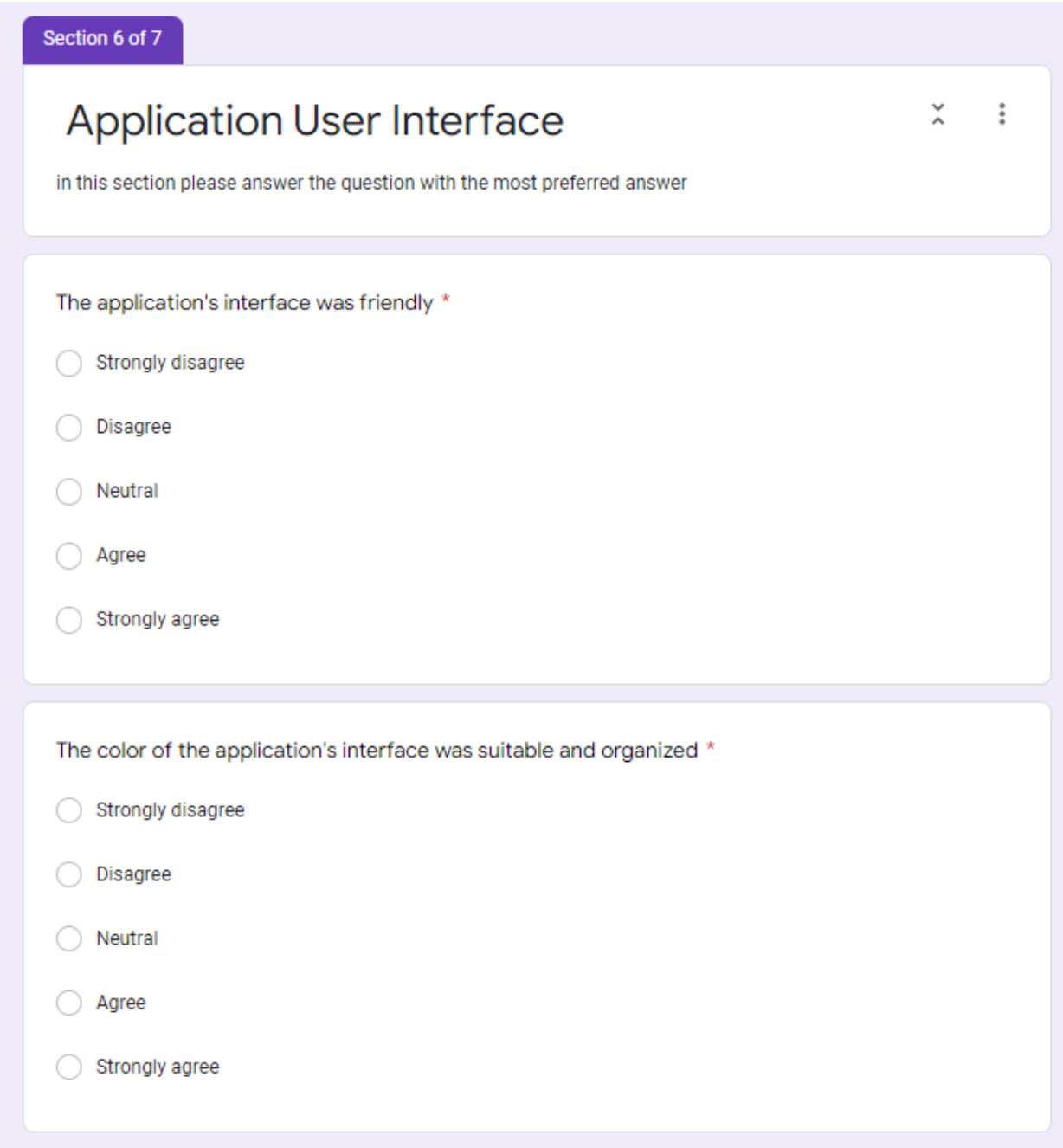

Figure 68 Second survey questions

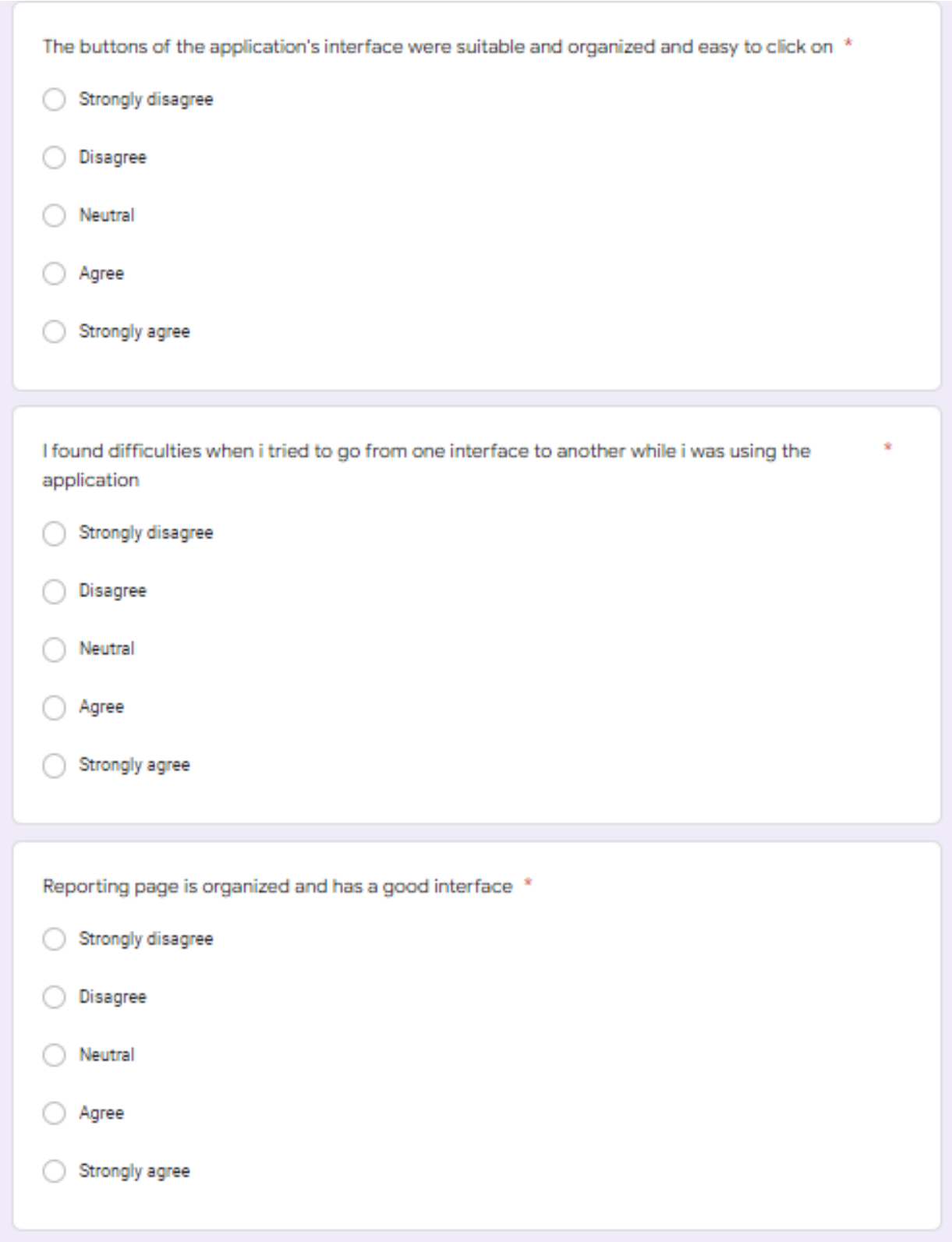

Figure 69 Second survey questions

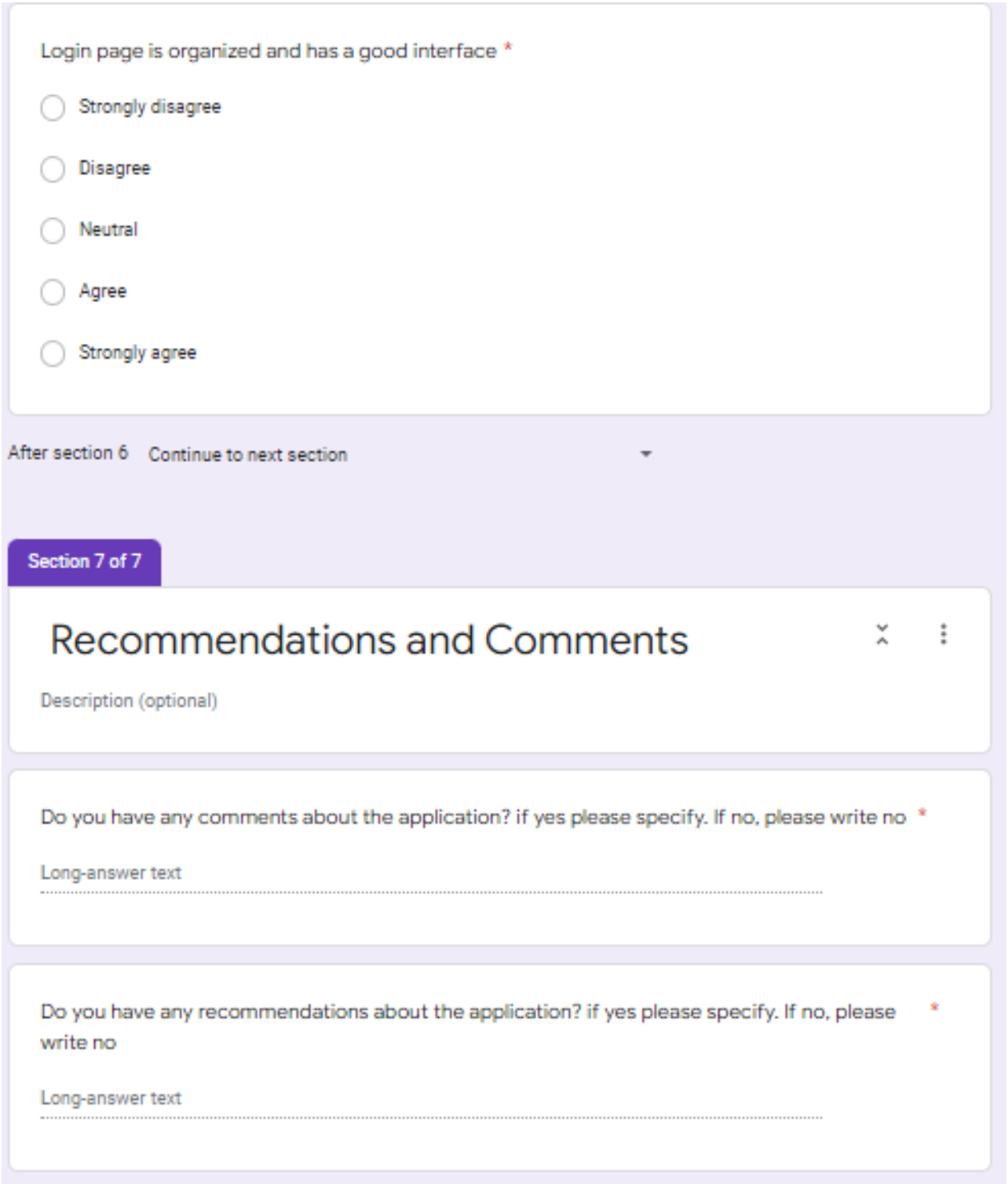

Figure 70 Second survey questions