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University of Applied Sciences

Impact of User Research on Product Design and Functionalities; Case: An Accident Detection System

Zubair Tariq

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Abstract

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Author(s)
Zubair Tariq

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This thesis puts an emphasis on the importance of User Research and User-centered design. The main aim of this study is to find out if user research really impacts the potential application's concept and if it does impact then what are those impacts and what is the extent of those impacts. An automatic accident detection system has been used as a case study.

This research utilizes a mixed methodology for data collection. Semi-structured interviews were conducted, and requirements were collected after the analysis of those interviews. Also, an online survey was conducted to gather data from a bigger user group.

Using the task matrix of list of features and results from the survey, a prototype of the potential application was then developed using Adobe XD and it was tested against the old interface of same application. Users were asked to use both old and new version of the application and provide their feedback on both.

Results of usability testing were then recorded and users' comments for a specific feature in both versions of application were compared to each other for analysis of tests and draw up results.

Overall, it is seen that user research plays an important part in design and development of an application's concept. It has been proved from the comparison of mobile application for accident detection system.

Keywords
User Research, user-centered design, usability testing, accident detection system, concept design

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List of Abbreviations

Following abbreviations have been used in this research. Here are their full forms:

UI:	User Interface
UX:	User Experience
UCD:	User-Centered Design
AI:	Artificial Intelligence

1 Introduction to User Research & its Importance

Design is an easy yet strong factor to find the differences between products and their position and it also determines the success of a product (Veryzer & Mozota, 2005). Design plays a very important role in capturing the users' attention which ultimately make the product succeed. When we understand the needs of the users correctly, and if we accomplish those needs by providing them with an excellent design, the product is an absolute success. To understand the needs of the users, we need to conduct some sort of research, which in this context, is often called as 'User Research' or 'User Studies'.

User Research plays an important role in the overall development process of a product, specially the user experience design stage. That's why it is recommended to do it in the start of the project. User Studies are typically comprised of various research methodologies and techniques to gather desired data and feedback to be used to improve the design process and finally the design of the product. Therefore, we can say that User Research means the difference between designing a product based on guesswork and assumptions and designing a product that solves the users' problems and fulfils the needs.

If we dive into User Experience Research, we'll ultimately know that it is a very thoughtful investigation of knowing your users to inform your design process. And with the help of various methodologies, you'll know the behaviour, attitude, psychology, and mind-set of the users of the product you are going to design. (Luca, 2019)

There is always a time in the career of a user's researcher where one needs to convince the client or the team to add user experience research in the project. You can always do that by stating the necessity and importance of research. Also, you can state how the product can fail if there is not good amount of user research done in the beginning. It is obvious that research makes design better. It also gives you a holistic approach towards designing and developing your solution in a better way. We know that the end goal is to come up with something that users want to use.

It can actually save a lot of money and time needed to develop the solution. (Luca, 2019) When we have very specific requirements and needs, we will not need more resources later in making modifications in the design and development. User research is not very expensive itself. It can be done in a very short time with a very less budget. The resources which are needed for User research are far less that the actual development. Therefore, companies need to understand that it is very important to conduct it because of its affects

it's going to have on final design and functionalities. It also helps you identify the initial users of your product or help you find out that who are going to buy your product initially.

User research provides you with valuable data and stats to develop your product. It can also help you in defining your design strategy for a product and make decisions. (Luca, 2019). Without conducting User Research, it is very difficult to find out the exact problems and needs of the users. It is almost impossible to figure out what pain-points the solution should provide answers to. There is or at least there used to be a misunderstanding or a bad practice of conducting very little to none level of user experience research. It is often considered enough to do a little bit of research on the problem, developing the solution and testing the product at the end. This approach is very wrong, and a good User Experience researcher will never recommend it. It is very important to conduct the User Studies at the very beginning of the project followed by Usability Testing (Luca, 2019) Without conducting the research in the start, you will basically be designing your product based on your own assumption which can lead to project failure in many cases. (Luca, 2019)

1.1 Scope of this Research

The main purpose of this thesis is to highlight the importance of User Research. Author will underline this issue by finding the key differences and impacts of User Research on a product's design and functionalities. This will be done by comparison of design and usability of the same application with and without conducting user research. The process will be explained in the later part of this research.

The main purpose and goal of conducting User Research, understanding the User Experience Design Process and User Studies is to put your design into context. It will give you a better understanding of the problem you are trying to solve. It will also underline the key issues related to that very specific problem. It will give you useful insight into your user; who they are? What they need from you as a designer? How will they be using the product actually? Etc. (Luca, 2019) Answer to all these questions are very important and combined with the techniques of user research, it ensures that you are designing the product keeping your users in mind which eventually leads to the development of a successful product.

The main aim of this research will be to find out if user research and user study impacts the final design and functionalities of the potential application's concept and if they do then what are the impacts and how does it impact. Hence the main research question is:

RQ1: Does user study and user research impact the design of the potential application concept?

Furthermore, the study also pursuits to answer the following question:

RQ2: What is the impact of the user research and user study from the usability and user experience perspective?

Answers to these will be used to conclude and make recommendations for future studies.

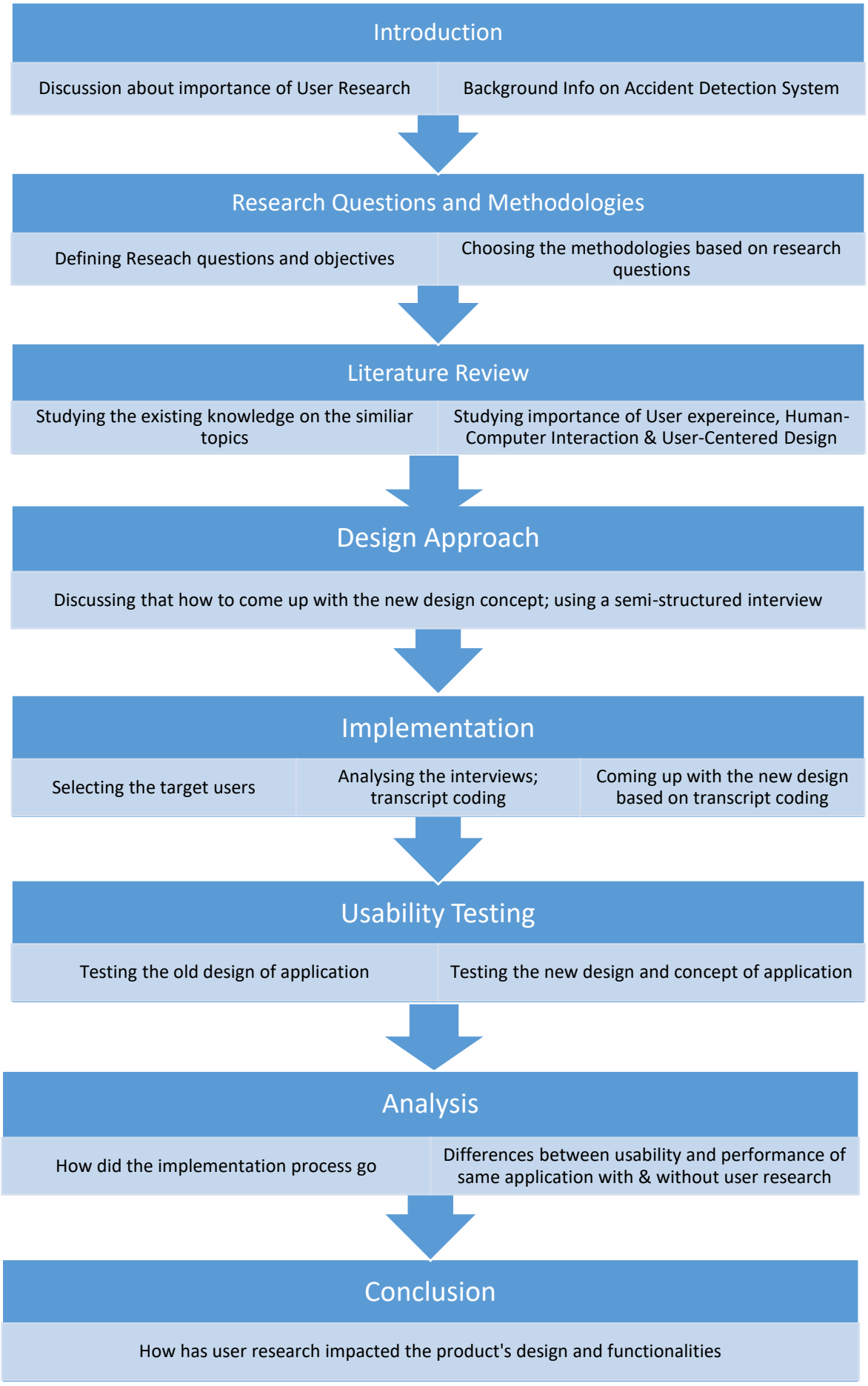
1.2 Case Information: Accident Detection System

Back et al. 2019, author combined with other fellows, published a conference paper titled as: '*An Automatic Accident Detection System – A Hybrid Solution'.* During that research, an automatic accident detection hardware device has been designed and implemented using Bluetooth technology connected with a mobile application to send accident information to emergency services. The proposed model of accident detection system can be an important aid in building smart transport systems in future. The system can also be used by the transport companies to monitor the vehicle speed, its location in real time and vehicle theft. (Ali, et al., 2019).

The initial idea of the project was to create a mobile application model. The application will connect automatically to a small hardware device called Accident Detection System via Bluetooth which fits in the car of a user. If the driver hits a road accident especially in suburban area or village then the application will collect the data in real time and contact the emergency services through a notification containing the actual location of the accident and general information about the user so that emergency services respond at the earliest possible time and saves the lives of users. (Ali, et al., 2019).

1.3 Structure of Thesis

Since this thesis is somehow different than the normal thesis in terms of its structure and layout, therefore an overall thesis diagram is presented in Figure 1 for better understanding of the reader:


Introduction
Discussion about importance of User Research
Background Info on Accident Detection System
Research Questions and Methodologies
Defining Reseach questions and objectives
Choosing the methodologies based on research questions
Literature Review
Studying the existing knowledge on the similiar topics
Studying importance of User expereince, Human-Computer Interaction & User-Centered Design
Design Approach
Discussing that how to come up with the new design concept; using a semi-structured interview
Implementation
Selecting the target users
Analysing the interviews; transcript coding
Coming up with the new design based on transcript coding
Usability Testing
Testing the old design of application
Testing the new design and concept of application
Analysis
How did the implementation process go
Differences between usability and performance of same application with & without user research
Conclusion
How has user research impacted the product's design and functionalities

The flowchart drawn above describes how the thesis has been divided into different stages and what each stage is about. The chart gives an overall view of the research to the reader.

2 Research Methodologies

2.1 Mixed Methodology

In this study, author will use a mixed methodology to collect data and then come up with results. Knowledge from case study, user-centered design methodology and usability testing methods will be combined to conduct a reliable research. In such cases where researchers need to conduct various kinds of experiments or tests, it is good to use a mixed methodology. Whenever planning a user research, it is good to have a mix of both qualitative and quantitative methods. (Wisdom & Creswell, 2013)

Data Collection is also divided in two main parts. At first, semi-structured interviews will be conducted in Design Approach phase to gather the requirements and information from the user. Then, based on that Concept, a prototype will be developed and tested. The results from usability testing will then be used for comparison and finding the answers to actual research questions. More details on why interview has been chosen as a method, are described in Design Approach (Chapter 4).

Since this research is based on the previous one by the author himself, therefore the existing knowledge of the system and the results obtained will be used to proceed further in this research. Moreover, the design of the application developed during existing research will also be used for comparison with the design of prototype of new application based on user research.

2.2 User Centered Design Methodology

The second method which will be used is using the principles of User Centred Design to come up with the new design for the application and then later using these principles to evaluate and compare the new design.

Conventional Design Process or Traditional Design Approach is not very successful and has often been blamed for not engaging with the users during design process. (Wilkinson & Angeli, 2014). Alternatively, a User-centred design approach was introduced which keeps users in mind during the early stages of product design. Designer steps into the

shoes of users and keeps the users' needs in mind before proceeding further with the design and development cycle. This methodology has been used and implemented in various projects and results were quite good. One of those projects was a European Project to develop a mobility aid for disabled people. (Wilkinson & Angeli, 2014).

Since the nature of our project and research is very similar to this one I-e: developing an emergency solution for people who hit a road accident, therefore, author has chosen this method as well for research.

2.3 **Usability Testing in the Lab**

The third and the last method which will be used is Usability Testing in the Usability Lab of Haaga-Helia University of Applied Sciences. This testing will comprise 5-7 users who will first use the old version of the product and give their feedback on the design. Then, they will use the new version (version developed during this research) and then provide their feedback on this.

Comments and User behaviour will then be analysed to answer the research question and make any recommendations.

3 Literature Review

Different literature related to the topic material has been studied and considered while proceeding. Background knowledge on user research has been utilized. Various topics that fall into the domain of design and user experience has been studied and used for research. Moreover, literature related to Accident Detection Systems has been studied too.

3.1 Topics under the umbrella of 'Design'

HCI (Human-Computer Interaction)

The term HCI stands for 'Human Computer Interaction'. It is commonly used by interchanging with the similar names like 'Man-Machine Interaction' or 'Human-Technology Interaction'. We can simply define it as *the study of Interaction between humans and computers.* (Booth, 1989).

HCI lies at the convergence between the social and behavioural sciences on one hand, and computer and technology on the other. HCI is basically one of the most rapidly growing field of computer science. HCI experts dissect and structure UIs and new UI technologies. They additionally coordinate and assess utilizations of innovation to help human exercises. (Carroll, 2003)

Human-Computer Interaction (HCI) is the examination and practice of ease of use of technology. It manages the design, execution and appraisal of technology frameworks that are for human use. HCI can be utilized in any place where there is a plausibility of computer establishment. The point of this subject is to gain proficiency with the methods for designing easy to understand interfaces or communications. (Issack, 2017)

HCI design utilizes different fields' information, for example, brain research, psychological science, humanism, or computational hypothesis. The design principles exist to keep a designer from seeking after a design choice that would be likely lead to an unusable product (Issack, 2017).

Great utilization of HCI standards and methods isn't significant for the end client, yet additionally is a high need for Software organizations. If a product item is unusable and causes disappointment, no individual will utilize the product by decision, and accordingly sales will be adversely influenced. (Fitzpatrick, 2017)

User centered Design

UCD or User-Centered Design is an elaborative and iterative process in which designers keep users in mind and keep their need in mind throughout the design process (Interaction Design Foundation, 2019).

The term 'User-Centered Design' was first introduced in Donald Norman's examination lab at the College of California San Diego (UCSD) during the 1980s and turned out to be generally utilized after the publication of a co-composed book entitled: User-Centered System Design: New Perspectives on Human-Computer Interaction. Norman fabricated further on the UCD idea in his book 'The Psychology of Everyday Things (POET)'. (Abras, et al., 2004).

In UCD, you base your ventures upon an express comprehension of the users, tasks and conditions. The point of the procedure is to catch and address the holistic user experience. In this manner, your design group ought to incorporate experts from over various controls (e.g., ethnographers, analysts, programming and equipment engineers) (Interaction Design Foundation, 2019).

As per (Usability.gov, 2019), there are various rules that underlie user-centered design. Design depends on an unequivocal comprehension of users, errands, and situations; is driven and refined by user-centered assessment; and addresses the entire client experience. The procedure includes users all through the structure and improvement procedure and it is iterative.

At the point when your UX Team brings the clients into each phase of the design procedure, you put your exertion and different assets into a ground-breaking method for discovering what functions work, what doesn't and why. Your users are an early-cautioning framework you can use to course-right and calibrate your structure (Interaction Design Foundation, 2019).

Placing designers in close contact with clients implies a more profound feeling of compassion rises. This is fundamental in making ethical designs that respect security and the personal satisfaction (Interaction Design Foundation, 2019).

User Experience

According to Don Norman and Jakob Nielsen, “User Experience is an umbrella term that covers all the aspects of user’s interaction with a product or service” (Nielsen Norman Group, 2019).

UX was also defined as, “The holistic or overall journey the users go through, not only it describes their direct interaction with a product but also how a product serves in the task completion process” (Product Plan, 2019).

User experience is significant on the grounds that it attempts to satisfy the client's needs. It expects to give positive encounters that keep a user faithful to the product or brand. Furthermore, a significant UX enables you to characterize user’s journey on your service that are most helpful for business achievement (Gangadharan, 2019).

User experience is diverse for everybody. The most significant thing to remember when planning a service is that however you have designed the product, you probably won't be a potential client who may be utilizing the item. Thus, we can't determine what a client needs or How they need (Gangadharan, 2019).

In context of design, UX is similarly as important as a visual personality. Truly. It doesn't make a difference what your site or application resembles if individuals don't have the foggiest idea of how to use it. In addition, they have to appreciate that communication (Ceros Resources, 2019).

Concept Design

Concept Design is the underlying enormous picture or large-scale design. It gives us what issues the product will tackle, how it will unravel them, and what it will feel like as it is fathoming them. Seemingly the most inventive phase of product development. It approaches us to think about clearing thoughts and all the different potential outcomes. The more the better. In this stage, you have a much clearer picture of what your product is going to look like (Hedges, 2017).

Concept Design sounds straightforward and it ought to do, as well. Concepts ought to be basic enough for everybody to comprehend – yourself included. Concepts are the central column for advancement. Numerous creative organizations we know these days – Apple,

Tesla, and Facebook – became effective not on the grounds that they are notable innovators, but since they are experts of concept structures. Advancement isn't constantly about making new things, it's tied in with moving toward an issue with an inventive concept (Park, 2016).

Concept Design Methods

In a nutshell, concept-design methodology is a synopsis and recognizable proof of the essential research. Design and research are joined ahead of schedule through idea structure, in this way the current issues in the essential research can be discovered before and fathomed in a convenient way. Concept-Design is helpful for utilizing specialized and monetary perspectives to control the pilot study, giving precise data to process advancement. As concept-design guarantees the uprightness of essential research, it is useful to anticipate blunders in the pilot test. In this way, concept-design can abbreviate the advancement cycle and improve improvement quality. (HongzhangChen, 2015)

Concept Design usually involves these steps:

- Identify problems
- Set System Objectives
- Identify constraints (both internal & external)
- Find out information needs
- Develop various designs
- Reporting

In concept design methodology, the feasibility of meeting the objectives and broader picture of a concept is analysed (Thakur, 2017).

Usability and UX Evaluations

Usability evaluation alludes to assessing a product or administration by testing it with delegate clients. Normally, during a test, users will attempt to finish regular undertakings while observers watch, tune in and take notes. The objective is to recognize any ease of use issues, gather subjective and quantitative information and decide the users' fulfilment with the service. (Usability.gov, 2019)

Ease of use or in other words usability is a significant factor for all product quality models. It is the key factor in the advancement of effective intelligent software applications. Ease

of use is the most generally utilized idea in the product building field and characterizes the product framework's request and use. (Madan & Kumar, 2012).

It was originally introduced by Jakob Nielsen in 1990. The main aspects of heuristic evaluation are:

- Visibility of System Status
- User control and freedom
- Error Prevention
- Recognition rather than recall
- Flexibility and efficiency of use
- Consistency
- Help and Support

These were further refined in by Jakob Nielsen in 1994. (Interaction Design Foundation, 2019).

What is Design Thinking?

Design Thinking is a critical-thinking condition that was grown fundamentally by Stanford University's Institute of Design and IDEO during the mid-1990s with an end goal to feature the human component that is available inside design. This technique or process was created dependent on an examination of how products are for all intents and purposes utilized and the waste that happens because of over-planning. General approach is divided into three main phases: “Inspiration”, which involves the identification of the root cause or problem, “Ideation”, which includes generation or proposition of broad solutions, “Implementation”, which involves manufacturing and release of a product. The Figure 2 below explains the process in detail that how each main phase is divided into sub-phases.

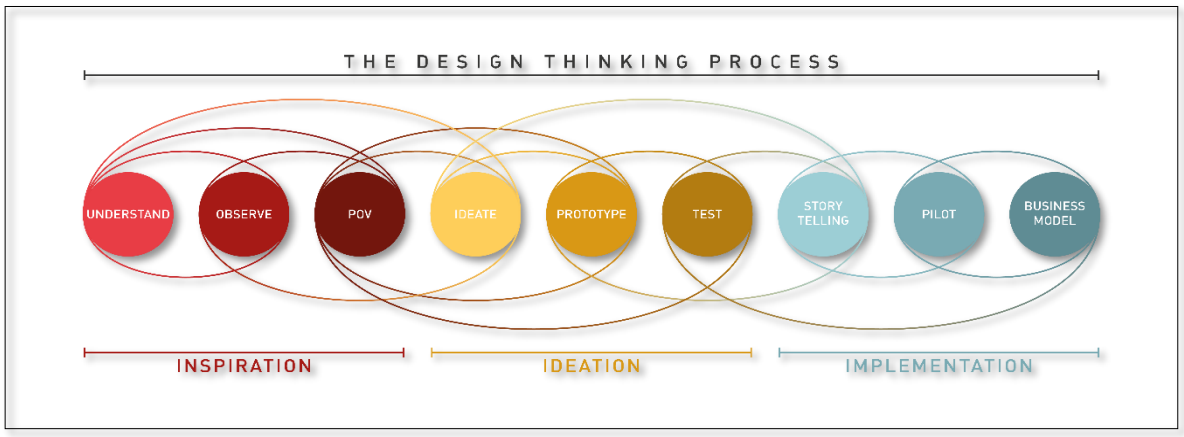


Figure 2: Design Thinking Process

It is obvious that each phase is divided into sub-phases and carries it own value. We must first understand the problem, observe others with the same pain point and then set our point-of-view. Secondly, we need to ideate a broader solution, develop a prototype and test it with the users bearing the pain we observed. If the tests pass, and the solution is ready to solve the problem, we then implement it by creating scenarios and piloting it using a business model (Hoffenson, 2017).

3.2 Accident Detection Systems and Applications

In present days the pace of mishaps is expanding quickly because of excessive use of vehicles like autos, bicycles- Individuals are going under chance due to their over speed, because of inaccessibility of propelled procedures, the pace of accidents can't be diminished. To reduce the accident rate, an accident detection system can be helpful.
The principle objective is to control the accidents by sending alert to registered contacts or services using different communication techniques. At the point when a mishap happens at a city, the message is sent to the enlisted contacts through GSM module in less time. Arduino is the core of the framework which helps in moving the message to various gadgets in the framework. Vibration sensor will be initiated when the accident takes place and data is moved to the enrolled number through GSM module. GPS framework will help in finding the area of the crash spot. (Kalyani, et al., 2019)

The greater part of the mishap passing that happens are because of the absence of quick medicinal help, on the ways like express highways. A facility for giving quick therapeutic help to the mishap territory can diminish the casualty to a more noteworthy extent. Subsequently comes the possibility of a system that detects the mishap and its earnestness to alarm the close by hospital for giving emergency vehicle or restorative guide to the mishap region (Kattukaran, et al., 2017).

When the mishap is recognized and its reality is affirmed the mobile application will alarm the therapeutic help focus with the essential data, for example, name, age and blood group together with the area of the mishap. The mobile application will likewise advise the injured individual's companions and family members about the occurrence and the area of the mishap (Kattukaran, et al., 2017).

It is normal that the correspondence between vehicles can give drivers more data about their environment, enabling them to settle on better choices, bringing about an expansion

of their security and efficiency. Very good quality autos, today, offer a few ITS administrations, for example, turn-by-turn GPS route frameworks, mishap identification framework, just as traffic, climate, and entertainment applications worked in on vehicle's ready-made PCs. On older and lower-end vehicles, smart phones are now already being utilized, to bring those propelled highlights and administrations. Cell phones these days are an important answer for push ITS and are incredible gadgets that can be incorporated with vehicles. (Fernandes, et al., 2015)

A survey has shown that both Android and iOS applications that promote road safety are very popular and have received very positive feedback. This itself is a sign that it is a serious matter and this sort of product is really helpful. (Fernandes, et al., 2015).

Some of the most popular road safety applications are described briefly below.

Avertino

It is basically a mobile application that increases the safety by getting inputs directly from its users. So, if someone who is using this application, finds a danger on the road, will upload the information in the app, others will confirm it. Then, when someone drives near to that location, this application will alert the driver both giving visual and audio alarm. This application is available for Android and iOS. However, no other special feature has been seen in this application. It doesn't detect if the car is in the accident. (Fernandes, et al., 2015). A screenshot of this application is attached in Figure 3.

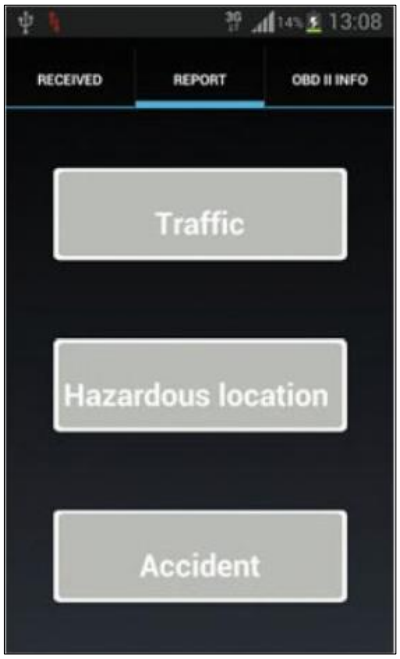


Figure 3: Avertino Home Screen

It is evident from the screenshot of Figure 3 that one manually needs to input traffic data, accident data and other dangerous locations and then other drivers would be able to read those. Therefore, it arises a need for more digital and automatic solution.

iOnRoad Augmented Driving

It is another safety increase mobile application. Typically, there would be a camera installed in the vehicle which will use the augmented reality to prevent the accident. It detects the objects and surroundings etc. It also notifies the driver if the car is too close to another car and is about to crash into it. (Fernandes, et al., 2015). Main screen of this application is attached in the form of screenshot in Figure 4.

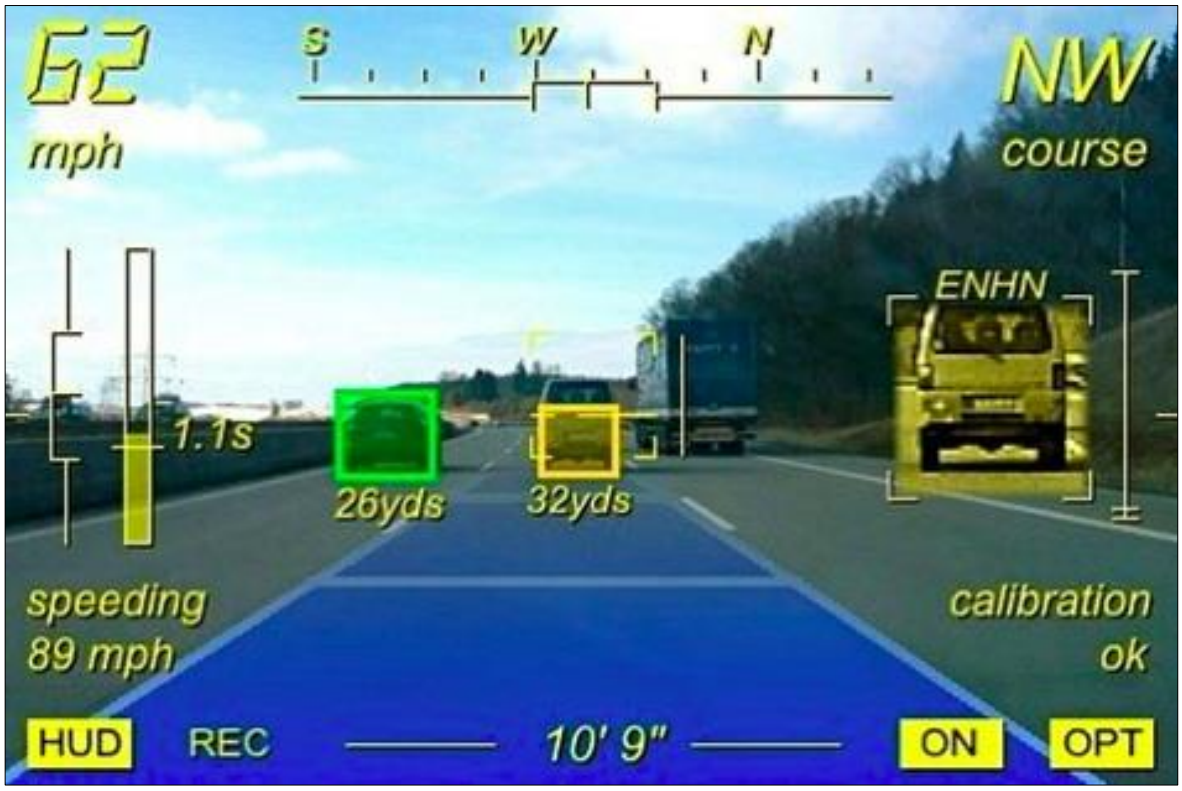


Figure 4: iOnRoad Main Screen- Source: Fernandes, et al., 2015

This is quite advance application which uses image recognition to detect distance etc. A camera is installed in the front screen of the car and it uses laser technology to calculate the distance from another object. It also uses a library of images to match the objects with certain objects from databases. (Fernandes, et al., 2015).

SOSmart

This is another application which is considered a top-notch so far. It utilizes the internal resources of your phones and sends the location and notification to your pre-selected contacts. It can be configured both automatically and manually. However, when it comes to alerting the emergency services, this application doesn't send a message if the receiving party doesn't have SOSmart installed. (SOSmart, 2015)

One of the features that this application has, is the web version of this application which is mainly used by hospitals to track a car or ambulance after it is carrying an injured person back to hospital. It provides them with the real time traffic data and everything which is required to make sure that ambulance gets to the hospital as quick as possible. A screenshot of the web version is attached below in Figure 5.

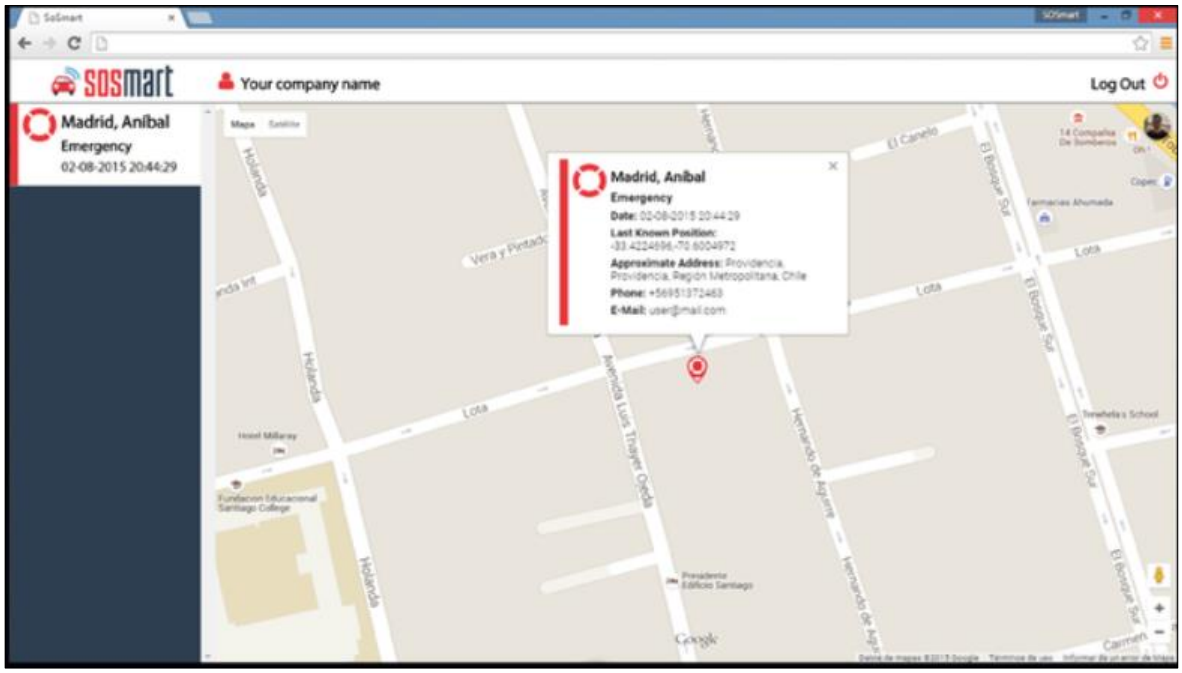


Figure 5: SOSmart hospitals dashboard- Source: sosmartapp.com

4 Design Approach

Design Approach is basically the methodology which author is going to use to come up with a new design. Data is gathered here by using different methods of User-Centered design. However the most popular one is conducting user interviews. (Thornton, 2019)

Semi-Structured Interviews

To involve the users and to gather the requirements from them, author is going to conduct semi-structured interviews with 4-7 users. Interview is supposed to last for 15-20 minutes. If interviewees would allow, interviews will be recorded for assessment later. Otherwise, notes will be taken and then expanded. User profiles are described in the later part of this research.

But before proceeding further, it is needed to understand that why interviews have been chosen and how would they be conducted.

User Interviews has always remained the foundational UCD method. It is always best to conduct them early in the process before you have any prototype or even an idea (Thornton, 2019). User Interviews are not about asking the users what they want or what they want you to develop. It's about understanding their needs by observing what a user is trying to do and understanding that what isn't working for them. (Thornton, 2019)

Author is going to conduct interviews in which some questions related to use of smartphone will be asked and then more focus would be on gathering the requirements for potential application concept if interviewees would like to have one. Some of the questions which will be asked are:

Q1: Are you a smartphone user? If yes, then which phone do you have? Are you an advanced user or just a normal user?
Q2: How many apps do you have in your phone? How many of them do you use on daily basis?
Q3: Do you own a car? If yes, then which one? Where do you live and how much do you drive on average in a day?
Q4: have you ever been in a road accident? If yes, then how did it happen?
Q5: Were you injured? If yes, what was the severity?
Q6: Were you able to receive medical assistance in time? If not, can you explain why?
Q7: Would you like to have an automatic accident detection system?

Q8: What according to you is important when someone is in a road accident?
Q9: Do you think this system can be helpful? Any thoughts?
Q10: How would you like this system to work?
Q11: What are your favourite colours?
Q12: Is privacy an issue for you if you decide to have this system in your car and phone?

These are just open-ended questions where there is room for discussion. Answers to these questions will then undergo transcript coding to extract useful information related to potential application concept.

All the ethics on conducting user interviews are kept in mind before conducting the interviews.

5 Implementation

5.1 User Profile

Target users of this potential application is the general public who own automobiles and drive. Frequency of driving doesn't really matter. However, the country where you live, the city, the area, car itself, healthcare system and environmental factors are all those aspects which count towards the concept design of this application and really matter a lot. Therefore, focus group of the interviews was broad. Most of them were professional drivers (truck driver, bus drivers, taxi drivers etc). Also, study included people of different age groups to understand the requirements better and to come up with a solution that will suit almost everyone. User profiles are explained below in Table 1.

Table 1: User Profiles

User Profile					
User No.	Gender	Age	Occupation	Country	Owns a car?
U1	M	38	Taxi Driver	Finland	Yes
U2	F	28	Housewife	Finland	Yes
U3	M	22	Student	USA	No
U4	M	45	Bus Driver	Finland	Yes
U5	F	31	Banker	Pakistan	Yes
U6	F	55	Principal	Pakistan	Yes

Some of the users were contacted directly while others were contacted via phone call. A general introduction to the research was given and the purpose of the interview was somehow defined. A time slot was booked for interview. Author tried to do his best to choose a balanced user group so that results would be more generalized rather than inclined.

5.2 Analysis

Interview Analysis

A very common technique which is called as 'Transcript Coding' was used to analyse the results of interview.

According to (Cope, 2009), Deciphering or Transcribing is normally utilized in qualitative research ventures when analysts need a composed rendition of their connections with users, or from other sound sources, for example, radio reports, promoting, addresses, network shows, for the motivations behind examination. Basic qualitative research collaborations that loan themselves to recording and translation incorporate focus gatherings, interviews, oral narratives, participatory mapping sessions, photovoice, and whatever other system which includes sound substance that may be recorded and transformed into content.

There are numerous ways to examine and get translations and deliberate methods for arranging and understanding the crude material. One common approach to understanding transcripts which will be the principal centre here is to build a system of codes as an approach to fathom data. Codes are contained classifications of information and themes that the scientist is keen on. For categorization, information is inspected and grouped based on similitudes (e.g., all notices of "location" or all encounters related to map), and every classification is allocated a code. For thematic coding, the information is doled out codes based on examples identified with subjects that are important to the research (e.g., themes of business or transnational identities). Beyond simply considering codes "categories “or "subjects," there are numerous different ways to structure a coding framework, for example, distinguishing between spellbinding and explanatory codes, "latent “and "show" codes, and contemplations about how codes identify with one another (would they say they are hierarchical, arranged, or parallel?) (Cope, 2009).

Based on the interviews conducted, transcript coding was carried out. Some of the code words for this research were, “crash”, “health”, “drive”, “emergency”, “location”, “map”, “help”, “automatic”, “connection” etc. Then each of the transcript was coded and common words in all the transcripts were picked up. Also, overall analysis of sentences and answers were carried out too.

After that a task matrix was prepared. Purpose of task matrix is to identify the key features and functionalities of potential application concept. These features can be related to both design and development. The code words which appeared the most can mean that it has high importance. Or it is some feature which everyone wants to have. Therefore, a task matrix plays an important role in identifying the key role of the application or a product. On the basis if questions asked in the interviews, author came up with a task matrix which

then will be utilized in concept design and prototype. Task matrix is given below in Table 2.

Table 2: Task Matrix based on Transcript Coding

Feature	U1	U2	U3	U4	U5	U6
Exact Location	Yes	Yes	Yes	Yes	Yes	Yes
Health Data	Yes	Yes	Yes	Yes	Yes	Yes
Automatic Connection	Yes	Yes	Yes	Maybe	Yes	Maybe
Digitally Safe	Yes	Yes	Maybe	Maybe	Yes	Yes
Simple UI	Yes	Yes	Doesn't matter	Yes	Maybe	Maybe
Local map	Maybe	Maybe	Maybe	Doesn't matter	Yes	Yes
Local Language	Yes	Yes	Yes	Yes	Maybe	Maybe

Based on the task matrix, it is certain that almost everyone wants the application to send the exact location to the contacts or to emergency services. Moreover, interviewees who were health conscious, they also wanted us to send the health data like their allergies or if they are on special medications etc. They think that it will help the medics to provide them with better healthcare treatment.

Then, some users wanted the application to connect to the system in the car automatically. They mentioned that sometimes they are in a hurry and might forget to connect it manually. So, application should somehow detect the device and make an automatic connection. Plus, it is not very practical to repeat the same step every day.

Since there is a lot of personal information in the app, users wanted it to be secure so that their data is not publicly available to everyone. Other than that, they mentioned about simple UI and area of local map. Also, they wished that it will be good if the application or at least some of its services are in local language.

Survey Results

Author also sent a survey questionnaire to different users using social media platforms like Facebook and WhatsApp. Questions for the survey were same as for the interview. However, number of responses were 25. When results of survey were analysed, it almost gave the same result as the interviews. Exact results are shown here in Figure 6.

	1	2	3	4	5	TOTAL	WEIGHTED AVERAGE
Health Data	12.00% 3	8.00% 2	16.00% 4	12.00% 3	52.00% 13	25	3.96
Local Area Map	16.67% 4	8.33% 2	16.67% 4	8.33% 2	50.00% 12	24	3.83
Location	36.00% 9	0.00% 0	0.00% 0	12.00% 3	52.00% 13	25	3.80
Personal Information	12.50% 3	8.33% 2	33.33% 8	8.33% 2	37.50% 9	24	3.63
Automatic connection with car	38.46% 10	0.00% 0	3.85% 1	23.08% 6	34.62% 9	26	3.54
Access to contacts	20.00% 5	12.00% 3	12.00% 3	28.00% 7	28.00% 7	25	3.52
Towing Service	19.23% 5	7.69% 2	34.62% 9	11.54% 3	26.92% 7	26	3.38

Figure 6: Survey Results from research

Participants were asked to mark the importance of specific feature on a scale of 1 to 5 where 1 means least important and 5 means most important. When all the results were collected, they were sorted in descending order on the basis of weighted average. It is clearly obvious that users want to have ‘Health Data’, ‘Local Area Map, and ‘Location’ as the most important features of the application.

5.3 Prototype Development

Based on the design approach, task matrix and concept design, a prototype of the application is developed – named as ‘Savior’. Main features of the potential application are as follow:

- Sending precise location to emergency services and contacts using live GPS tracking
- Storing most of the health data like medications and allergies and forwarding them as well
- Automatic connection with the car once it is paired manually
- Digitally Safe: GDPR compliances are followed
- Simple and easy to use UI with minimum text
- Extra services like towing and taxi
- Map of local area if the driver is on an adventure in a remote town
- Option to use application as a Navigation application

Adobe XD was used as a prototyping tool to come up with a prototype. **Error! Reference source not found.** and **Error! Reference source not found.** show User profile screen and Sign-up screen of the potential application's prototype.

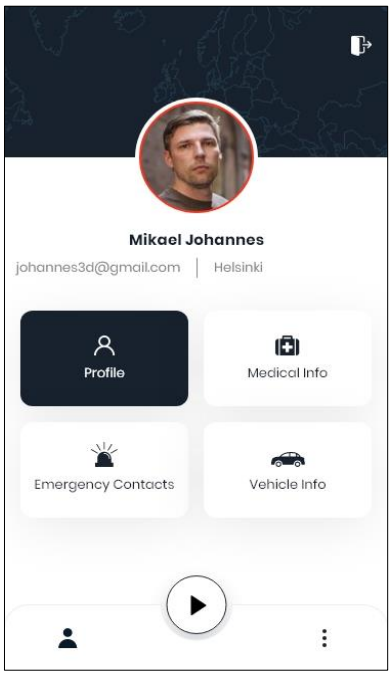


Figure 7: User Profile Screen

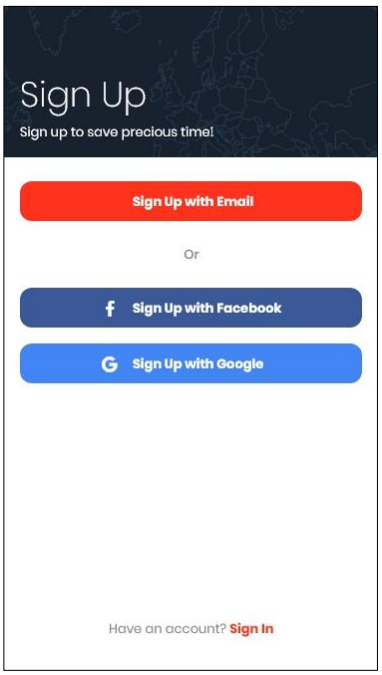


Figure 8: Sign-Up screen

In Figure 7, it can be seen that this screen includes various options like Medical Info, Vehicle info etc. These requirements came from user research and interviews. Features of the application are based on task matrix and users' expectations from the said product.

6 Testing

Usability Testing has always been considered an important part of a Product's Design and development. It plays a key role in determining if the product is going to be successful in the market or not based on the data gathered from users during testing phase. (Usability.gov, 2019).

6.1 Test Plan

(Thornton, 2019) described that in order to conduct Usability testing, one needs to have a Test plan in order. Generally, test plan includes the following:

- Users to test the application or prototype
- Usability Lab / testing environment
- Test Cases

Users Profile for Testing Purposes

In this research, the focus group is very diverse as the potential application serves the needs of general public. Anyone who knows how to drive a car, or who drives on a regular basis, can be a user of this application. Therefore, users selected for testing purposes are random people. User profiles are described below in Table 3. Users have been provided with both of the interfaces (old and new) turn by turn and readings have recorded for test cases.

Table 3: User Profiles for Testing Purposes

User No	Occupation	Age	Gender
U1	Student	22-24	Male
U2	Taxi Driver	30-32	Male
U3	Student	20-22	Female
U4	Housewife	30-34	Female
U5	Fast Food Worker	26-28	Male

All of the users were those who own a car and drive on regular basis either from their work to home or from school to home and vice versa. U1, U2 and U4 also had international driving experience. Therefore, their inclusion in the usability testing and then their feedback provided a lot of new ideas.

Testing Environment

All of the tests were conducted in the participants' premises. However, they were carried out in a controlled manner. Participants were asked if it is okay to record them. Those who agreed were recorded and the rest of them were observed and notes were taken.

For recording purposes, two different camera angles were used. One of used to capture the face expression and body language of the user while other was focused more on the mobile screen to observe how the user is using the application and if he is having any sort of issues with that.

Test Cases

Test cases determine if your product or parts of your products are satisfying the users' needs or if they need to be removed or modified. Every feature is tested separately in a step by step manner and users' moves are recorded using a test case. Results of test cases are then used to further change or modify the application.

In this research, test cases were prepared separately for both old and new interfaces and were tested with the same users. Results were then used for comparison and analysis. A sample test case is given below in **Error! Reference source not found.**.

Test case must display the information about the feature to be tested. Furthermore, information about who has designed the feature and who is going to execute the test must be indicated in the top section of the test case.

Preconditions define what a user needs to have in order before one undergoes the testing process. It may include testing tools required, or the environment. Sometimes, pre-training is required as well to give the user an overall idea of what this test is about.

Table 4 describes the step by step actions a user needs to take in order to successfully execute a task. Post-Conditions then describe the expected result of these actions.

Test Case No. 1	Test case name: Bluetooth Connection
System: Old Interface of Application	Sub-System: Automatic pairing
Designed by: Author	Designing Date: 20.11 2019
Executed by: Author	Execution Date: 26.11.2019

Objective: Users can successfully and easily make a Bluetooth connection between mobile and car

Pre-Conditions: User has a smartphone, internet connection & the application installed.

Table 4: Test case step by step

Actions	Expected Response	Pass / Fail	Comments
Start the application	Shows an activity indicator	Pass	
Click on 'Connections'	Displays Bluetooth devices	Pass	
Select 'specific device'	Displays success prompt	Pass	
Select ' Continue'	Displays profile screen	Pass	

Post-Conditions: User has successfully established a Bluetooth connection between hardware and mobile application.

Figure 9: A sample test case file

6.2 Usability Testing with the Old interface

Old interface of the application was presented in the form a developed mobile application and users have been asked to use it freely. They were first given an overall idea of the application and then were provided with a mobile device which already had a working version of application.

Users were recorded and then later were asked for the feedback and comments for the following functionalities and features:

- Ease of Use
- UI and Colours
- Setting up an account
- Setting up a Bluetooth connection with hardware device
- Adding emergency contacts to the application
- Notification settings
- Overall working of the application

Overall comments which the users provided are as follow:

“I think the application is useful, but it still requires a lot of work. It was hard for me to make a Bluetooth connection because application doesn’t show the name of the device”. U4

“Colours and UI can be improved. It looks old. Text fields are not very clear and easy to type in.” U2

“I would recommend adding more functionalities into the application and make it automatic to connect with the car.” U3

6.3 Usability Testing with the New interface

New interface was tested in the form of prototype which has been developed by author based on user research and design approach. This interface was also tested by the same users who tested the old interface. New interface was tested for the same features and test cases as the old interface. However, some new features have been added so there were some extra test cases. Comments of the users about the new interface are as follow:

“It looks really nice. It is clean and easy to navigate. I really like all the features it has.” U3

“I like the idea how you can add your medical information into the app. I think it can help old people in getting better treatment.” U4

Overall, users were satisfied and comfortable using the new interface. According to them, it is modern and very easy to use. Application serves their needs quite brilliantly. A complete analysis between old and new interface is provided in the chapter 7.2 of the report.

7 Analysis

7.1 Implementation Analysis

Implementation process in a nutshell went smoothly. There were some difficulties in conducting the interviews and gathering the data. It was very hard to make the users express their opinions and collect more information for the concept design. However, there was no difficulty in selecting the users for the interview. If a comparison would be made for implementation process of old interface and the process for new application concept, it will be obvious that User Research and its methodologies play an important role and are very helpful in making a product undergo a successful implementation phase.

From contacting the potential users to prototype development, the timeline was very short, but it was very efficient and problems-free. All the users cooperated to their best. They expressed their opinions about the concept and then the interfaces freely and according to best of their knowledge. Users highlighted many important aspects of the application concept of an Automatic Accident Detection System. The requirements that came up were totally fascinating. There requirements have been then considered in the further development of the application and the prototype which has been developed contains most of these features and requirements.

A small comparison has been made between two screens of the same application concept but with different implementation approach. Old interface was developed without any User research and Implementation plan. However, the new interface was developed after conducting the User Research and with proper implementation of User-centered design principles.

Figure 10 reflects the new interface whereas Figure 11 reflects the old interface. These are the screenshots of Bluetooth connection screens. It is clearly obvious that the new interface is much user friendly and it displays the name of the car the user is trying to connect to. On the other side, old interface is not user-centered. It displays the hardware id only and therefore the user must know that in order to connect to the application.

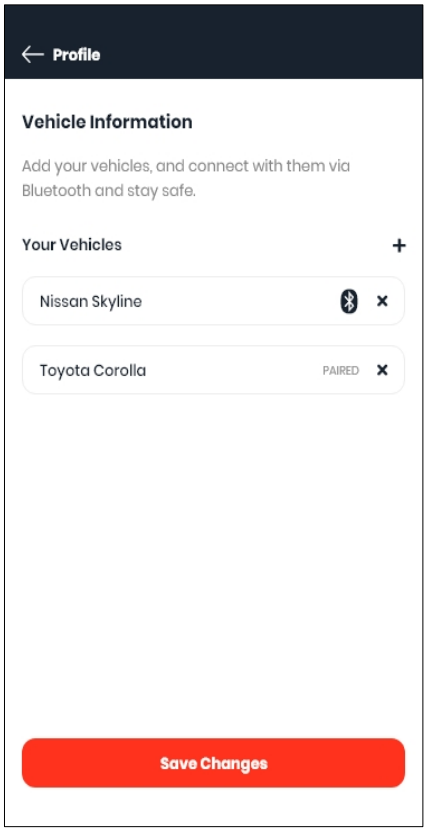


Figure 10: New Interface

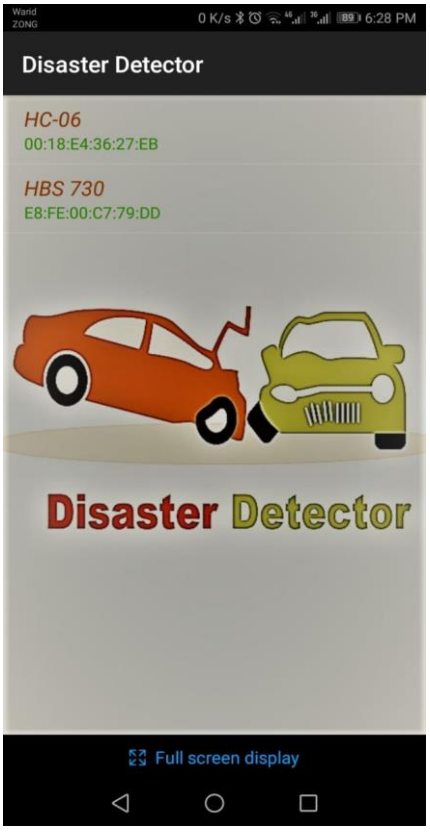


Figure 11: Old Interface

This analysis clearly gives us the answer to our first research question. User research definitely impacts the potential application's concept and design.

7.2 Usability Testing Analysis

For the analysis of Usability Testing, test cases for both interfaces were compared to each other to check whether the new interface satisfied the users' needs. Also, each user gave feedback on both interfaces after usability testing was done. Comparison was made based on the requirements gathered from users as the results of conducting interviews. Each of the feature was then considered for both new and old interface. For example, how easy it was to establish a Bluetooth connection in both interfaces? What were the good aspects and what were the bad aspects?

Comments of the users were recorded, and a generalized version is presented below in Table 5. It is crystal clear from the table and users' feedback that new application concept is far better than the old one and it satisfy their needs to a greater extent.

Table 5: Comparison of Users' comments on Both Interfaces

Feature	Users comments in old interface	Users Comments in new interface
Profile Setup	"Short but bad layout", "Very bad UI and colours", "Why not add email address?", "Should have more personal details options"	"Really nice UI and colours", "I like the layout of the profile page", "Everything is clear and easy to add"
Bluetooth Connection	"It should connect automatically", "It should display the name of device", "How do I know which car is mine if there are no names?"	"I like that it detects the car automatically", "wow, it knows the name of car by itself",
Adding Vehicle Info	Old interface lacks this feature	"It's good that I can add more than one car", "It's easy to add and delete cars from here"
Adding Medical Info	Old interface lacks this feature	"I think this is really important and nice feature", "I like the idea of sending medical information to hospitals"
Sending Location	"Why does it send only the coordinates?" "It should have GPS tracking"	"It's good that there is a navigator inside the application" "If it sends the location on map, it's very useful then"
Data Privacy	Old interface lacks data privacy feature.	"App asks for permissions which is good", "It contains a Data Protection option"
Ease of Use	"It's messy and it has bad UI", "It should be automatic and save my profile"	"This is fast and easy to navigate", "All options are clear",

8 Conclusion

8.1 Conclusion in a Nutshell

User research plays an important role in a product's design and development which in turn contributes towards success of a product. It has been proved from this research that user studies and usability evaluation impact the concept of potential application.

(Nielsen Norman Group, 2019) writes that many researchers in the field of Design has repeatedly mentioned that Designer is not the user. This statement means that the one who is designing the application might not see it the way its users are going to see. Designer might think that the product is beautiful and usable. However, this is not always true. Sometimes, a product which is a very useful one, doesn't stand a day in the real world. One of the reasons for its failure is the lack of user studies done before and during the product's design and development phases. Therefore, one can argue that Design is for the users, and not for the Designers.

In case of an Automatic Accident Detection System, it has clearly been seen and proved that how user studies have impacted and changed the whole concept of the application. When the application was first developed without conducting any user studies and without considering the principles of user-centered design, the application only had one feature and that was sending location coordinates. Application had a very bad UI and colour schemas. None of the design theory was considered before development of that application. However, as a part of this research, when author started to work on the designing and development of new application concept, user studies were conducted. Principles of user-centered design were considered before the concept design. Results of this research were self-explanatory. Users highlighted many of the features and requirements that author cold never have thought of as a designer alone. One the basis of these results, it can be said that users are the actual designers of the application.

After conducting the user research, the new application is a much better looking, better functioning and properly designed application. The health data feature of the application was lacking in the old version but now as per users' requirements it has been added and users appreciated it a lot. In fact, this feature was ranked as the most important one by the users in the survey. As far as other changes are concerned, the potential application now has a navigation option which users can use as a live map and navigator. Bluetooth connection is now automatic, and users don't need to worry about connecting their device to

the correct car because in the old version is was the device code but now it's the car's name.

In the light of above facts, author can conclude that user research greatly impacts what is being designed and for whom it is being designed. It increases the designer's overall understanding of users' need and product's functionalities. Talking, about the extent of these impacts, it can be stated that it depends on what is the product and who are the users. But in a nutshell, author can say this with full confidence that, "Product designed after conducting the user research will definitely going to be better than the product designed without user research".

8.2 Recommendations

In this research, the focus was on utilizing the results of user research to come up with a new design of a product which was earlier designed without user research. Also, the product was inclined more towards Accident Detection and Notification. Author can recommend working on an application which will notify the driver before an accident is going to happen or in other words, "Accident Prevention System". Also, how would that application function? Or what can be the important design aspects of that system?

Moreover, it should also be researched in future that if user research has any negative impacts? Or how user research will impact different products in different regions of the world? Answer to these question will really help other who are conducting user researches for their products.

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Appendices

Appendix 1: Application Screens (Both Interfaces)

Figure 13: Profile Setup - Old Interface

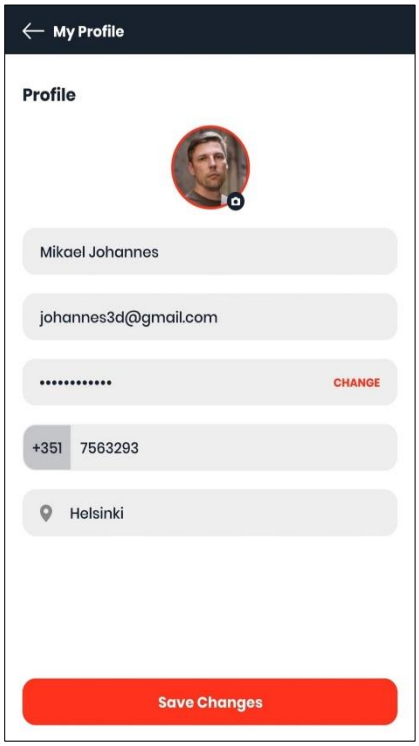

Figure 12: Profile Setup Screen

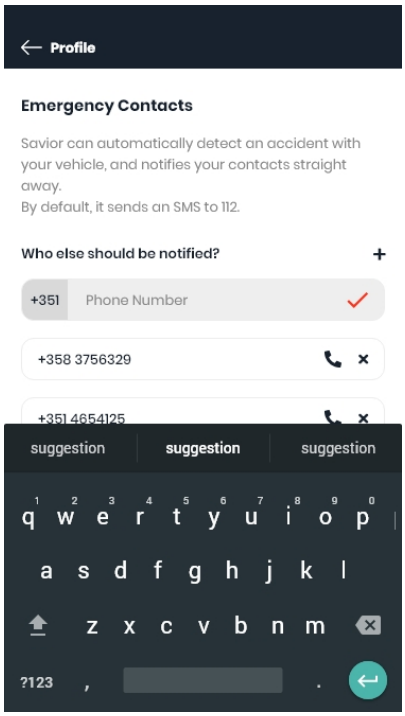

Figure 14: Add contacts - New interface

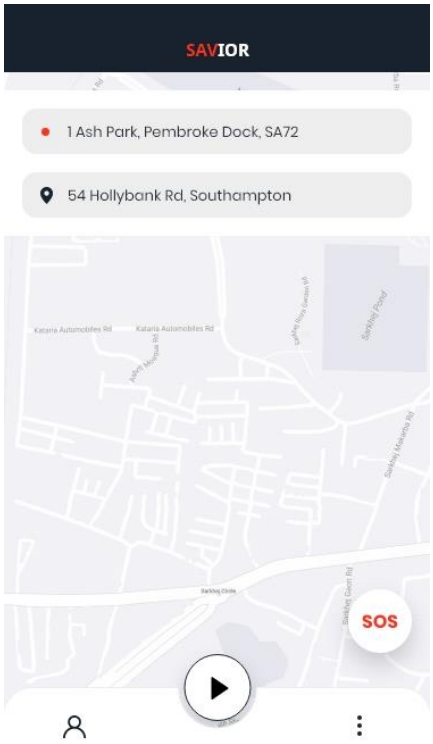

Figure 15: Home Screen-New interface

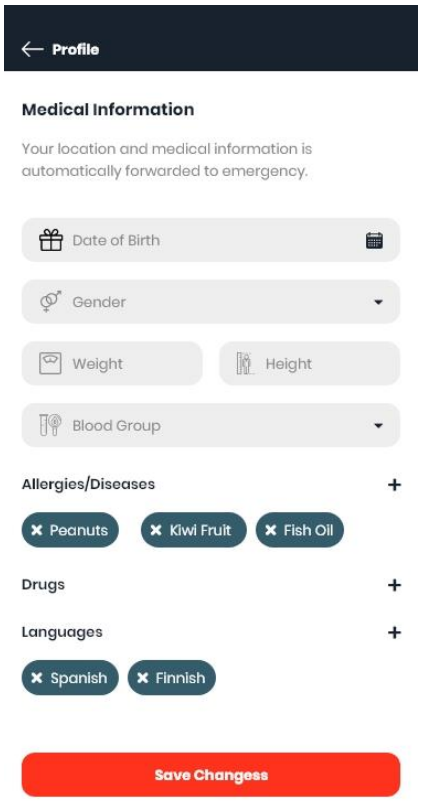

Figure 16: Add Medical Information

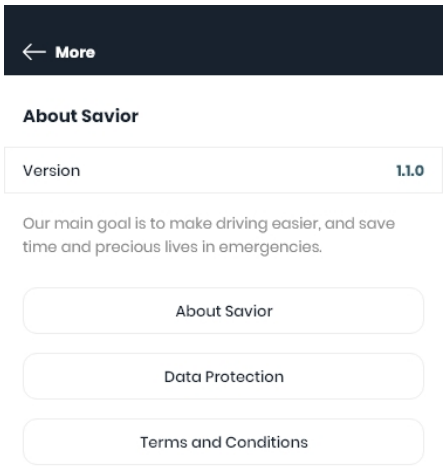

Figure 17: More Options

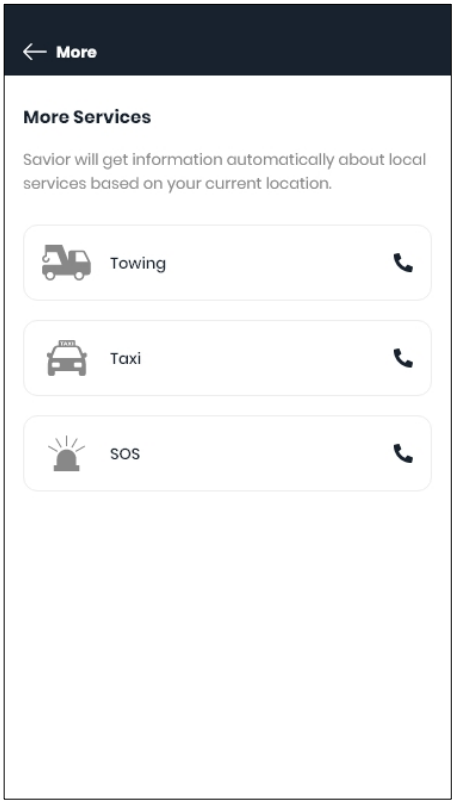

Figure 18: More Services

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