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# Using UX design principles for comprehensive data visualisation

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## **Tillämpning av UX designprinciper för omfattande datavisualisering**

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## **Abstract**

Workplace safety, particularly in manual handling tasks, is a critical concern that has been increasingly addressed using advanced risk assessment tools. However, presenting the complex results of these assessments in an easily digestible format remains a challenge. This thesis focused on designing and developing a user-friendly web application to visualise risk assessment data effectively. Grounded in a robust theoretical framework that combines user experience principles, and data visualisation techniques. The study employed an iterative, user-centric design process to develop the web application. Multiple visualisation methods, such as pie charts for visualising risk distribution, bar chart, and line chart for time-based analysis, were evaluated for their effectiveness through usability testing. The application's primary contribution lies in its efficient data visualisation techniques, aimed at simplifying complex datasets into actionable insights. This work lays the groundwork enabling future development by pinpointing areas for improvement like enhanced interactivity and accessibility.

## **Keywords**

data visualisation, user experience, user interface design, usability testing, interactive charts, RAMP, ergonomic risk assessment, workplace safety, manual handling, risk management



## Sammanfattning

Belastningsergonomiska risker i arbetsmiljön, särskilt i uppgifter som involverar manuell hantering, är en kritisk fråga som alltmer har adresserats med hjälp av avancerade riskhanteringsverktyg. Men att presentera de komplexa resultaten av dessa bedömningar i ett lättillgängligt format kvarstår som en utmaning. Denna avhandling fokuserade på att designa och utveckla en användarvänlig webbapplikation för att effektivt visualisera riskbedömningsdata. Studien bygger på en robust teoretisk ram och kombinerar principer för användarupplevelse med datavisualiseringstekniker. Webbapplikationen har utvecklats med hjälp av en iterativ och användarcentrerad designprocess. Flera visualiseringsmetoder, såsom cirkeldiagram för att visualisera riskfördelning, stapeldiagram och linjediagram för tidsbaserad analys, utvärderades för deras effektivitet genom användningstester och utvärderingsformulär. Applikationens primära bidrag ligger i dess effektiva datavisualiseringstekniker, som syftar till att förenkla komplex information till handlingsbara insikter. Detta arbete lägger grunden och möjliggör framtida utveckling genom att peka ut områden för förbättring, som förbättrad interaktivitet och tillgänglighet.

### Nyckelord

datavisualisering, användarupplevelse, användargränssnittsdesign, användbarhetstestning, interaktiva diagram, RAMP, ergonomisk riskbedömning, arbetsplatssäkerhet, manuell hantering, riskhantering





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# 1 Introduction

This introductory chapter aims to explain the scope of the thesis as well as the problem definition upon which this work will be based. This thesis has been conducted on behalf of the Division of Ergonomics at the KTH Royal Institute of Technology (Kungliga Tekniska Högskolan) as part of the RAMP initiative. RAMP (Risk Assessment Management tool for Manual Handling Proactively) is a research-based assessment tool developed in Sweden in close cooperation between researchers at KTH and practitioners at companies. The project is financed mainly by AFA (Arbetsmarknadens Försäkringsaktiebolag) and the participating companies. The purpose of this tool is to identify and assess physical ergonomic risk factors when working with manual handling, which may increase the risk of developing musculoskeletal disorders (MSDs). The tool can be used to assess work, work tasks, or workstations during an average working day.

The work presented in this thesis involves ergonomics as both a practical aspect in the form of UX design and its principles, as well as the material and resources provided by RAMP. Ergonomics, derived from the Greek words "ergo" (work) and "nomos" (law), is understood by laymen as the principles or laws of design and engineering in relation to the human factor. The guiding principles are based on the psychological and physiological aspects and form of the human body and mind. Ergonomics as a field of study has its place in the development and formulation of both physical and virtual products and systems.

## 1.1 Problem statement

Organisations and companies that use the RAMP tool has a need to better compile, visualise and understand the results from the survey tool. The results are, as of now, presented in the form of a simple excel sheet with a colour-coded assessment, score, and comments field. The assessment colour can either be red, yellow, and green, where red represents high risk and green low risk. At the bottom of the sheet, one can find a summary of the results with a total risk score.

The way the results are presented today are not satisfactory for the organisations and companies that use RAMP. Visualisation and presentation of result data should be apprehensible and be presented in such a way that the user can quickly and efficiently take in the information. The results need to be shown to managers, suborganisation or others that may not clearly understand the results in its current form. With the visualisation, the data can be transformed and better understood by more people. The user also needs to have a way to choose which data to present and how to present it. There needs to be a way for the user to filter the result data by choosing which aspects to focus on. Examples of what aspects to filter the results by can be to be able to choose based on time, by organisation and specific risk areas. There also need to be an authentication system where the user only has access to data, they are permitted to have access to.

## 1.2 Goals

The main goal of this thesis is to develop an application that can efficiently, quickly and in a good way present the result data from the RAMP surveys to the user. The design of the implementation needs to easily provide the user with the most essential information. A filter system needs to be implemented where the user can filter the results based on different aspects. Such aspects might include organisation, suborganization, risk areas, risk levels and/or time. The user needs to easily understand what filtering options exist and how they are used. The use cases include workstation, department, site, country, and company. All these use cases need to have a time aspect. An example is that the application also needs to have the functionality to compare results for a workstation by date. For example, compare the results from different dates for a specific workstation with a comparison tool. Different ways to show the results also needs to present and the user can then choose what is best for them. The user needs to easily understand how to make these choices. The application needs to have a way to authenticate users and only show them data that they are allowed to have access to.

A pre-study/literature study with the goal of gaining insight and understanding of how data visualisation is done in the most optimal way will be performed. Further studies on UX design and principles and how it can be implemented to fulfil the goals will also be done.

The application will also be evaluated by the intended users. Different aspects of the application, like the visualisation method(s), UX design and presentation, will each be evaluated. The intent is to get feedback from people participating in surveys with questions pertaining to the design principles of UX. The goal here is to gain insight into how the solutions are perceived by real users.

## 1.3 Authors' contributions

This implementation is a part of a larger system developed by the CBH school at KTH, where users can generate and study RAMP-data.

## 2 Theory and background

The current chapter aims to provide both general extensive understanding of the sciences involved in this work/thesis. Through examination of previous bodies of work retaining to the field of ergonomics and user experience, the goal is to set a relevant foundation to support the rationale, analysis and methods used in practice.

### 2.1 RAMP

“Division of ergonomics – KTH” [1] explains that the main goal of the field of ergonomics is to improve comfort and user experience and minimise harm and inaccessibility where there exists human interaction with designed systems and products. The science behind ergonomics involves the study of the human body and can be broken down into three design intents: improved health, better experience, and productivity.

Ergonomics as a field of research is carried out in CBH (School of Engineering Sciences in Chemistry, Biotechnology and Health) which is one of the five schools at KTH (Royal Institute of Technology). The division of ergonomics is a department of CBH that conducts research on the relation and interaction between humans and technology and companies such as factory labour and construction. The goal of this division is, through applying science of ergonomics and engineering, to develop ideas and methods that will benefit and improve working conditions in different environments with consideration to human health and efficiency. Studies conducted in the division of ergonomics are mainly focused on work systems in industry and health-related settings. One of the ongoing research projects in the division of ergonomics is RAMP [2].

#### 2.1.1 RAMP II

RAMP consists of four modules. The first module is RAMP I, a checklist assessment tool for screening of MSD risks. The second module is RAMP II which is intended for use for a more in-depth analysis of MSD risks. The third module is the results model. This module is used to present, visualise, and communicate the results of the assessments. The fourth module is the action module. The purpose is to support risk reducing measures [3][4].

RAMP I is intended to be used as a screening tool to identify and assess ergonomic risk factors during manual work that may increase the risk of Musculoskeletal disorders (MSD). Examples of manual handling include lifting, holding, pushing, or pulling of loads. High or sustained exposure to these risk factors can increase the risk of developing MSDs or worsening existing disorders. RAMP II is a developed version of RAMP I that allows for a more in-depth analysis and assessment of MSD risks and is what this thesis will focus on.

RAMP II is a score-based tool and in the user manual for RAMP, Rose L [5] explains that RAMP II, compared to RAMP I, is a more in-depth analysis of potential risk factors during manual labour. The assessment performer goes through seven different sheets. These sheets are divided into different categories relating to ergonomic,

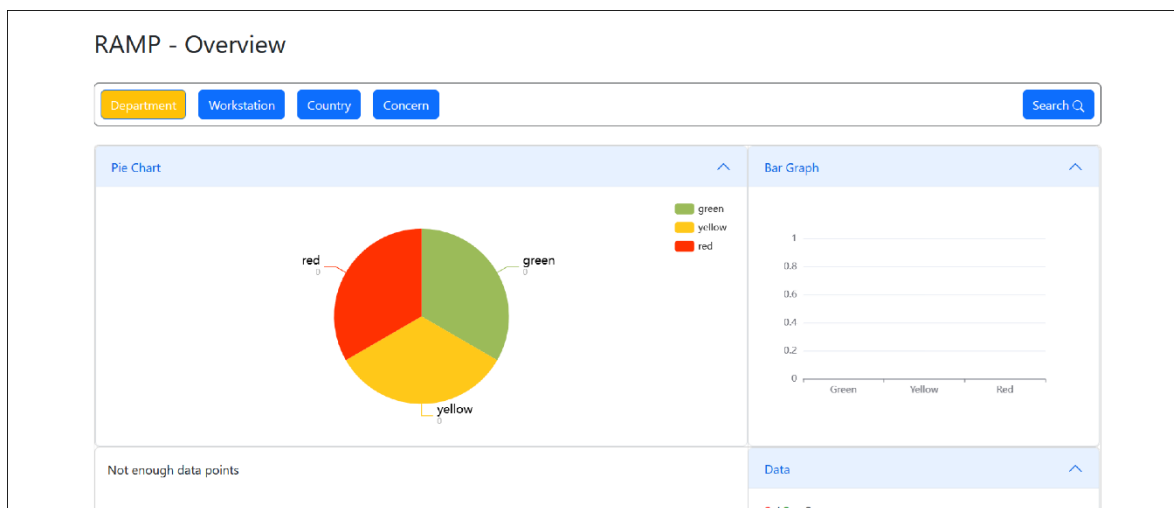
for example posture and lifting work. The assessment performer picks a score after answering the question in the sheet and fills it in a corresponding item in the results sheet.

The results sheet gives a colour-based assessment score based on the score the assessment performer chose. Red means that there is a high risk of developing or worsening existing MSDs, yellow means that there is a risk while green shows a low risk. There is also a comments field if the performer wished to add additional information. Figure 2.1 shows a typical risk assessment of one category.

RAMP II assessment		Assessment	Score
<b>1. Postures</b>			
1.1 Posture of the head - forwards and to the side		Red	5
1.2 Posture of the head - backwards		Red	10
1.3 Back posture - moderate bending		Green	1
1.4 Back posture - considerable bending and twisting		Yellow	2
1.5 Upper arm posture - hand in or above shoulder height*		Green	1
1.6 Upper arm posture - hand in or outside the outer work area*		Red	7
1.7 Wrist posture*		Red	7
1.8 Leg and foot space and surface		Green	0,5

**Figure 2.1:** Typical risk assessment of category “Postures” with scores.

RAMP II has an existing web application that is used for simple presentation of the results. The web application uses the same colours as the RAMP result sheet. An example is shown in figure 2.2.



**Figure 2.2:** Typical view of the existing web application

### 2.1.2 Results module

The results module enables compilation and presentation of the results of the assessments. Multiple assessments can be entered and displayed at three different levels of scope: Detailed, Risk category & Overview. Detailed displays the results for each assessed risk factor. It is on a single department level, meaning that the results of multiple workstations in a single department is shown. Risk category displays the



results for the seven different categories (sheets), and not each assessed risk factor. Overview shows the results on a department level. Each department gets a results summary and multiple department results can be seen and compared. Figure 2.3 shows the results at the category level. The results of two workstations are filled in and at the bottom a summary of the results can be seen. This is the current way to compare multiple workstations [5].

Results of the RAMP II analysis at risk category level		Date:
Country		
Site		
Department		
Work station ID	WS001	WS002
1. Postures	2	2
2. Work movements and repetitive work	1	1
3. Lifting work		
4. Pushing and pulling work		
5. Influencing factors	1	9
6. Reports on physically strenuous work	1	
7. Perceived physical discomfort		1
Results summary:		
Number of red assessments (high risk)	4	3
Number of yellow assessments (risk)	17	15
Number of green assessments (low risk)	14	17

Figure 2.3: Results at category level

### 2.1.3 Action plan and action suggestions

The action plan and the associated action suggestions allows the assessment performer to write out a plan to lower or eliminate the risk. Actions suggestion has suggested actions for each assessment item. The assessment performer picks one of the suggestions from the action suggestions and enters it in the action plan, along with some other information, as shown in figure 2.4. The action plan is the current way to present the result. The problem with how to results are presented today is that they are difficult to understand and not intuitive. If the reader is not familiar with RAMP, it will be hard to understand what the action plan is showing [5].

Action plan based on RAMP II assessment			
Date of assessment:	Work/Employee load:		
Work/Work task:	Site:		
Ordered by:	Formed by:		
Risk factor	Assessment	Score	User comments
1. Postures			
1.1 Posture of the head - forwards and to the side		5	
1.2 Posture of the head - backwards		10	
1.3 Back posture - moderate bending		1	
1.4 Back posture - considerable bending and twisting		2	
1.5 Upper arm posture - hand in or above shoulder height*		1	
1.6 Upper arm posture - hand in or outside the outer work area*		7	
1.7 Wrist posture*		7	
1.8 Leg and foot space and surface		0,5	

Figure 2.4: Action plan with some scores inputted

## 2.2 User experience

User experience is an umbrella term that refers to all aspects of how human interaction with products and systems. The International Organisation for Standardisation [6] defines user experience as the perception and response of a user's emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviours, and accomplishments. The exact definition of UX is often debated and not fully agreed upon explains Law et al. [7] following their research on how UX is scoped and defined. In their conference paper Law et al. set out to formulate the most generally agreed upon definition of UX as well as its delimitations, through conducting surveys and collecting views from researchers and professionals in academia and the industry. Law et al.'s findings showed that most participants agreed on UX being context-dependent, dynamic, and subjective. A good user experience is therefore individual and emerges from user interaction with a product or system. The paper reached a conclusion that reinforces the definition provided by the ISO standard.

### User Experience and design fundamentals

Looking at the fundamentals of UX design, there is difficulty in coming to a consensus on the topic of design principles regarding UX. Law et al. [7] aimed to tackle the problem of describing UX, however, the complexity of trying to define the principles that UX is comprised poses a greater challenge. As explained by Stull [8], when defining UX principles there is no possible way to create an exhaustive list that satisfies everyone. Stull does emphasise that his approach to defining UX principles focuses on principles that represent shared concepts in user experience and design regardless of background and approach. In his book, Stull presents eleven principles and concepts that every UX practitioner should take into consideration.

#### 1. The user in UX

Stull [8] points out that there exists a balance between the user needs and business goals and how it is a responsibility that falls on the creator or developer. In UX and design, a developer or creator must balance the needs and goals of their employer with the needs of the user. The convergence between business goals and user needs is where the UX designer should aim to operate. The focus being on the user, according to Stull, is a common denominator between all practices of UX design.

#### 2. Avoid biases and unfounded preferences

Stull [8] points out that there exists a balance between the user needs and business goals and how it is a responsibility that falls on the creator or developer. In UX and design, a developer or creator must balance the needs and goals of their employer with the needs of the user. The convergence between business goals and user needs is where the UX designer should aim to operate. The focus being on the user, according to Stull, is a common denominator between all practices of UX design.

### **3. The product is a small part of the user's live**

Creating a good user experience means creating a solution to a problem that users embrace. The product or software being developed falls into a small portion of a user's daily activities and workload. One should therefore aim to create a solution that users embrace and functions efficiently. Creating an embraced solution follows a structured approach: first, identifying and understanding the core problem; then, evaluating current user solutions and identifying any ongoing user concerns. Stull [8] also highlights the need to examine similar services and products as well as recognise the impact it has on the user's life.

### **4. Create effective and simple navigation**

One key aspect of designing a website or online service is the way users traverse the different pages. The role that UX professionals play here is ensuring an easy comprehensive way for the user to reach their end goal. Stull [8] explains in more practical terms, to ensure that navigation is simple and fluid one must plan out all tasks and tools the system will provide to the end-user. After planning what task can and should be accomplished in the service, the next step is to design how the user will journey through the pages and steps to reach their end-goal.

### **5. Reduce complexity**

One of the many pitfalls when designing a website or online service is trying to cram many features and accessories that may not be essential to complete a given task. Stull [8] recommends that, when designing an application, one should seek to limit distraction and the number of actions a user can make and instead focusing in on what is necessary and beneficial to the experience. Creating delimitations means more time focusing on fewer features resulting in a higher quality product.

### **6. Consider the users' past, present, and future experiences**

Stull [8] continues about user-centered design where he encourages designers to consider the past, present, and future in the context of the user's experience. How people perceive a certain design is highly influenced by what they've encountered before. Therefore, the designer needs to take into consideration the user's past experiences and what they have become familiar with. The designer needs also to take account for the user's current experience, one should ask "how does the user currently facilitate their needs?" and in what context (professional, entertainment etc.) will they use the application. Stull explains that user context represents the culmination of past and current experiences which then shape future experiences.

### **7. Consider the users' past, present, and future experiences**

The end-user should not have to spend time to decipher the different choices that were made when creating the application. In Stull's [8] seventh point "Speak the user's language" he emphasises the importance of designing appli-

cations that are contemporary and caters to the persons that will use the application. Users come from a variety of backgrounds and may not have knowledge that seem obvious for the designer. Therefore, a designer should ask if an experience requires any special knowledge to be used effectively. The answer to this question will then dictate if further clarification is necessary for a design.

## **8. Favour the familiar**

Stull [8] says that there is value in designing features that are familiar to the user. Users should immediately be able to understand a design based on previous experience. In practical terms, this means to look at common solutions to a problem and implementing these solutions. Human interface guidelines are documents to be used as reference points by application developers and designers. The intent with interface guides is to create an experience that is familiar across different applications. Examples such as Google Material Design or Apple Human Interface Guidelines are a system of guidelines, components and tools that support best practises for user interface design by relying on what has been proven to work and is widespread.

## **9. Stability, reliability and security**

With giving users a good experience there should be focus on making that experience safe and secure. The stability of a product bleeds into its perception by a user. Not only should the application look and feel good, but it should also function effectively and not be riddled with bugs. Reliability also comes alongside creating a stable product. With reliability, as explained by Stull [8], is stability over time. An application developer should plan for when issues arise. This can be dealing with user frustration by letting users know a problem is being worked on. Ensuring that an application is secure as well as connotes security is key in gaining user trust. While designing an application there should be deliberation whether certain content is sensitive or confidential. Stull explains that one should not give out more information than needed, but also not asking for more information than needed.

## **10. Performance**

An experience should not be slow. There is importance, when creating an experience, that it allows for efficiency. In this point Stull [8], references to Hick's law, which says that the more choices presented to the user, the longer for that user to make a choice. This is solved by reducing the number of choices available, also by only showing them until specifically asked for by the user. Users need the possibility of practice. Meaning that for a user to learn to use an application efficiently, there should be consistency in the design and many changes. Stull's last note on performance deals with not high complex task under the false pretence that it is simple, Stull explains that how users perceive efficiency is expectation minus actual duration.

## 11. Usefulness

A satisfying experience is one that fulfils users' needs, according to Stull [8]. By making usefulness the cornerstone of an application or design it ensures a good user experience. All features and aspects of a design should fulfil a need in terms of providing information or even entertain.

### 2.3 Data and information visualization

Data and information visualisation, as a field of study, deals with the way data and information is visually represented. The main goal of a graphical representation is to transform the data and information into a form that is easily understood and perceived by humans. The user needs to be able to make sense of the information that is presented in a way that provides new insight. Raw data and information are often high in volume and complexity and effective visualisation is more than just plotting the data points onto a graph, as explained by Gershon et al. [9]. When visualising data, one should aim to convey information in a story-like fashion, where recorded information is communicated in a way that exposes meaningful patterns for an organisation or user.

The visualisation needs to enable the user to thoroughly understand the information. Achieving this means that the information needs to be displayed efficiently and coherently. The information also needs to be presented in a compelling and appealing way to make it comfortable for the user. Gershon et al. [9] write about how storytelling can be a valuable component in information visualisation. A single image or chart may not clearly inform the user of all the needed information. Declarative statements and explanations are used to add additional information to make it clearer for the user.

Scientific visualisation, for example RAMP in its current form, is meant for highly trained personal that have a deep knowledge of the subject. The problem is that the other users that the information needs to be conveyed to come with all types and levels of personal skills, education, and knowledge. This means that there cannot be a universal visualisation method. The answer to choosing the correct methods depends on the context in which the visualisation is being used. The designers also need to understand how humans interact both visually and non-visually with data. They also need to understand how the human mind works when searching for known and unknown information. This knowledge allows the designer to create flexible user interfaces and search methods appropriate for each type of user, according to Borkin et al. [10] and Stephen [11].

#### 2.3.1 Interactive data visualization

Interactive data visualisation refers to the utilization of modern data analysis software. This enables users to directly manipulate, explore and filter graphical representations of data. It also enables the user to see more detail, create new insights and capture the full value of the data.

Ward et al. [12] explain that there are three basic attributes of a successful data visualisation interaction design – available, accessible, and actionable. There are three questions one needs to ask when creating an interactive data visualisation:

1. Is there sufficient source data to meet the data visualisation goals?
2. Can this data be presented in an accessible manner so that it is intuitive and comprehensible way?
3. Do the data visualisation interactions provide meaningful actionable insights?

Provided that the designers can answer these questions, a user interface with an interactive design can be achieved.

The advantages that interactive data visualisation provide are many. When dealing with large amounts of data, interactive data visualisation allows the user to identify, isolate, and visualize information. Another advantage is the ability to identify relationships more effectively, explains Janvrin et al. [13]. The user can narrowly focus on specific metrics, aspects and dimensions which then allows the user to for example identify overlooked cause-and-effect relationships through defined timeframes. Dealing with complex, big data can be perceived as a chaotic and incomprehensible. Filtering and choosing the data the user wants to focus on allows for the data to be more accessible and help the user gain better insights.

### 2.3.2 Data visualization tools

There exist multiple tools that can be used in data visualisation. Different types of charts, diagrams, and maps. Some of these are more suitable than others depending on which type of data the designers are dealing with. The designers need to carefully analyse and choose the right types to best fit the needs of the data. Below are some examples of such tools.

- A bar chart is used when the user needs be shown a distribution of data points or perform a comparison of metric values across different subgroups of the data, according to Bikakis [14]. The user can see which groups are the highest or most common and can easily compare them to other groups. There exist best practices for using bar charts. One of them is to use a common zero-valued baseline. This enables the user to easier read and compare bare lengths. Another important factor is that it promotes the truthfulness of the data visualisation. A non-zero baseline will misrepresent the comparison between groups since the lengths will not match the ratio in actual value. More best practices are to maintain rectangular forms for the bars and avoid using 3-d effects. Doing the opposite may make the chart harder to read. The order of which the data is to be plot should also be taken into consideration as it makes it easier to compare the bar lengths no matter the order.
- Bikakis [14] further explains that pie charts are better suited when the proportion of different representations needs to be shown and compared. It is useful when one only have a small group series that needs to be represented

but as the number of series increases, each pie slice becomes smaller, and it is then not clear and concise.

- When taking time into consideration, line charts are a great way to show the change of data over a continuous period. Adding multiple data records allows for comparison between different data over time. This allows for easier analysis of trends and variation. Line charts are not useful when single points of data need to be visualised, says Bikakis [14].

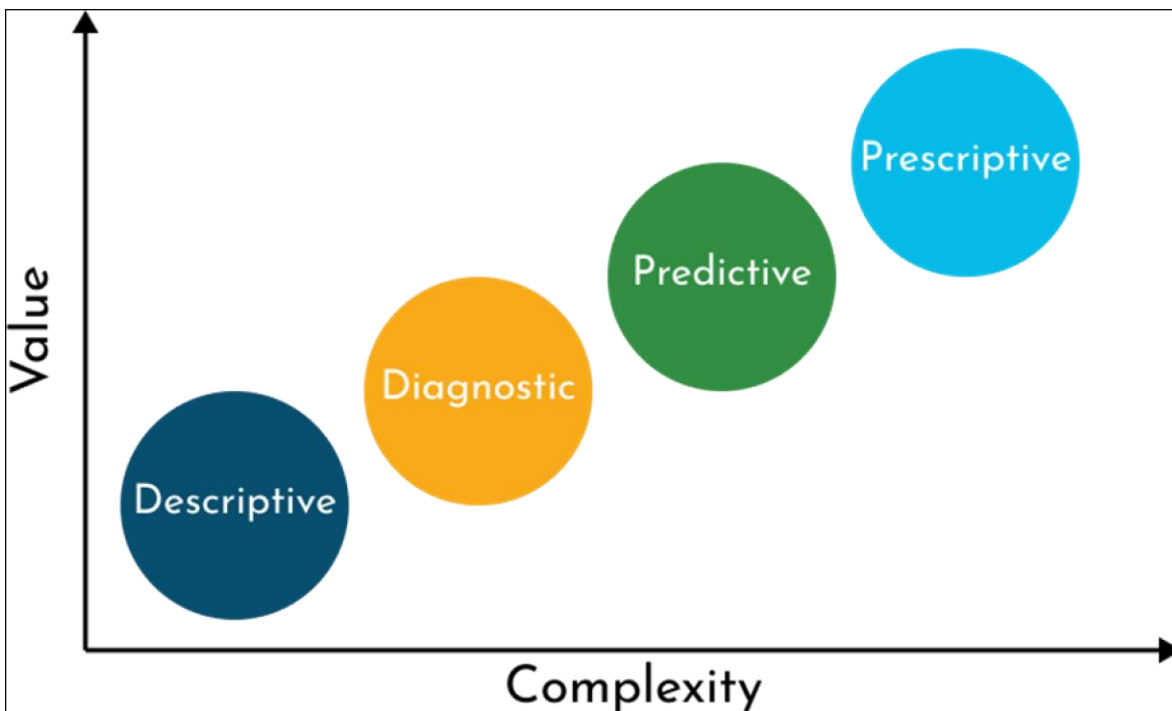
Visualisations techniques encode the data into visual shapes and colours. The user then decodes the data when using the data visualisation tools. But it is not entirely that simple, according to Kosara [15]. The encoding part is when the program draws a bar chart, pie chart or a diagram for example. The decoding part is the user looking at the drawn shapes and colours and then tries to understand it in their own mind. For example, when users are looking at bar charts, then rarely look at individual bars but instead compare them to each other. In pie charts, the angle of the slice can change the information the user takes away from the data. In scatter plots, the user does not compare two data points but instead looks at the overall shape to give an overview of the plot. This provides the user with correlation. The main point of how users decode data is that the way data is visualized and shown to the user will change the information the user get out of the visualisation and the designer needs to strive to limit the effect on the decoding of the data.

## 2.4 Analytics

Knafllic [16] explains that when creating effective visualisations of data and information, there must be a process where data is analysed and where decisions are made regarding how data is handled. Data analytics is the process of applying systematic analysis to data with the goal of uncovering trends, communicating patterns and answer questions of interest for a business or organisation. The field of analytics can be split into four areas. They are visualised in figure 2.5. These areas can be ordered by their complexity and subsequent value they provide to an analytics process:

- **Descriptive:** Descriptive analytics aims to answer the question of “what happened?”. It is the most common type of analytical initiative that organisations take to better understand historical trends and performance, according to Knafllic [16]. The process of descriptive analytics can be broken down into three steps: collection of data, processing and analysing the data and data visualisation.
- **Diagnostic:** Diagnostic analytics expands on descriptive analytics with the purpose of answering the question “why did X happened?”. The compiled data and information that results from descriptive analytics are further analysed in hopes of uncovering root causes to potential trends or patterns. As with descriptive analytics, this process conducted by identifying outliers or inconsistencies in the data. These outliers are then compiled into a dataset and by applying. From this dataset, one can employ statistical models or machine learning techniques to find relationships and patters that explain the outliers.

- **Predictive:** Making predictions about future trends and developments for a business or organisation is the third part of the analytical process. Predictive analytics utilizes machine learning models and statistics to produce insight into how future development will unfold, the goal with predictive analytics is to answer the question “what is most likely to happen?”.
- **Prescriptive:** After going through the four areas of analytics the last question of interest for a business or organisation is the question of “what should be done?”. For the prescriptive part of an analytics initiative, it is about the decisions made, decisions that have their basis on the preceding areas. The goal here is to analyse and conclude the best and most profitable course of action going forward. As in the previous areas, prescriptive analytics relies on pattern finding through statistics and machine learning and by analysing past decisions.



**Figure 2.5:** The different types of analysis processes according to Knafllic [16]

#### 2.4.1 Data analysis

Knafllic [16] writes about the importance of context when trying to successfully visualise data, time and attention needs to be devoted to understanding and analysing the data and in what context the need for communication exists. Knafllic also draws an important distinction between exploratory and explanatory analysis.

- **Exploratory analysis:** The process of exploring a subject. In the case of analytics and data visualisation an exploratory approach means to analyse the data with the goal of finding points of interest, according to Knafllic [16]. In this phase, the aim is to figure out what is noteworthy for the end user.



- **Explanatory analysis:** The next step in the analysis is the explanatory part. Here the focus lies on showcasing the findings that resulted from the exploratory analysis. Knafllic [16] explains it as taking time to turn data into information that will be used to communicate with an audience.

Which type of analysis one wish to utilise depends on the audience to whom one wish to communicate the data to. Knafllic [16] explains further that data visualisation, when used as a medium, has a bigger emphasis on the exploratory analysis.

Nambiar [17] explains that focusing on an exploratory data visualisation approach means that the end user or business is left to draw their own conclusions based on the visualisations and graphics provided, given that a comprehensive visual has been provided to the business or user.

## 2.5 Evaluation

Evaluating the user interface is an important step in the development of an application. Stufflebeam et al. [18] explain that an evaluation can help the designers in understanding the effectiveness and usability of a user interface. It provides valuable information on eventual problems and improvement suggestions.

There are two main approaches when it comes to evaluating a user interface: an empirical evaluation and a heuristic evaluation. Empirical evaluation is where results are derived by observation or experiments. When evaluating a user interface with the empirical evaluation approach, a set of users are asked to evaluate by answering pre-determined questions, explained by Chin [19]. The main goal of this kind of evaluation is to gather and evaluate the user's opinion on certain crucial aspects of the user aspects.

A heuristic evaluation is when a set of established rules and methods are followed to evaluate a user interface. This approach to evaluating is helpful when designers need to decide or solve problems quickly and practically. The most-used and widespread heuristics for usability is the Nielsen-Molich heuristics for user interface design, according to Gallardo et al. [20].

Jakob Nielsen and Rolf Molichs heuristics were first introduced in two papers by Molich and Nielsen with a revised set of heuristics published in 2005 by Nielsen [21]. The set of heuristics includes ten principles for user interface design. Nielsen does however note in his publication that the set should be used as a rule of thumb more so than firm guidelines.

### 1. Visibility of system status

Visibility of system status refers to user feedback in that a user should always be informed about what is going on. Systems should have a visual reaction to user input, for example loading a page with placeholders until data is fetched and shown or having user friendly error messages. This principle is about conveying the system status to the user.

**2. Match between system and the real world**

A design should not be foreign to a user. When designing a user interface, one should opt to incorporate language, icons and concepts that adhere to real-world conventions. A design should conform to how things are usually done. Using a magnifying glass icon next to a search bar, or a chevron “>” to indicate a next slide or a dropdown list helps to create a design that is intuitive to the user.

**3. User control and freedom**

A system should not lock a user in a state without options to exit. A well-designed system needs to allow the user to back out of a process as well as allow the user to undo or redo an action. Nielsen argues that giving the user control of their actions will promote confidence to a design.

**4. Consistency and standards**

User’s perception towards a system is influenced by all systems the user has experienced beforehand. In the principle that retains to consistency and standards Nielsen highlights that a design should try to follow industry conventions and guidelines that are already widespread and established. Failing to create consistency with other systems in a user’s life will only create confusion and a mental load. A system should therefore try to meet users design expectations and preconceptions.

**5. Error prevention**

A good system design tries to remedy errors that occur. Nielsen however highlights the importance of creating designs that prevent errors from ever happening. Error prone conditions such as forms should have constraints that only allow valid input. Another example of error prevention could be confirmation dialogs for high stakes actions.

**6. Recognition rather than recall**

The user should not have to rely on memory to carry information between actions. Users should be presented with options to choose from rather than having to recall them by their own accord. An example of this is user search history or autocompletion in a search bar.

**7. Flexibility and efficiency of use**

A design should be flexible and able to adapt to different users based on their experience and expertise. Nielsen provides an example which are keyboard shortcuts that when learned can speed up a task.

**8. Aesthetics and minimalist design**

Regarding the aesthetics of a design, Nielsen champions the use of minimalism. The visual aspect of the design should convey essential

information and forego any bells and whistles such as to not draw the user's attention from their primary goals.

#### 9. **Help users recognize, diagnose, and recover from errors**

When errors do occur, it is not only important that the user is alerted but, if possible, be presented with a solution. Nielsen also emphasises the importance of expressing an error message in plain language that the user will understand as well as using visuals such as bold text, icons and red colours that convey that a problem has occurred.

#### 10. **Help and documentation**

Nielsen explains that a good system should always aim to be self-explanatory through its design and not through exposition. However, there may exist a need for documentation when dealing with complex systems. Documentations should help the user understand how they can complete their task. Documentation should be easy to understand with concrete steps and be accessible in the right context.

##### 2.5.1 Surveys

Empirical evaluation often involves conducting surveys, which are designed to yield reliable and valid measures of the intended aspects of interest through well-crafted questions. The effectiveness of a question hinges on its consistent and clear understanding by respondents, aligning with the intended meaning of the researcher. Surveys encompass closed-ended and open-ended questions, each serving distinct purposes, according to Fowler [22].

Fowler [22] further explains that **closed-ended questions** typically present a limited set of response options, often in the form of multiple-choice questions. These questions provide quantifiable data, allowing for the calculation of percentages and frequencies to enable comparative analysis.

In contrast, **open-ended questions** prompt respondents to provide free-text responses that require reflective insights or opinions. While these responses are more challenging to quantify due to their diversity, they offer nuanced perspectives that closed-ended questions might not capture, according to Fowler [22]. Strategically incorporating both question types yields comprehensive insights into the aspects of interest, resulting in a well-rounded understanding of user experiences and system effectiveness.

##### 2.5.2 Usability testing

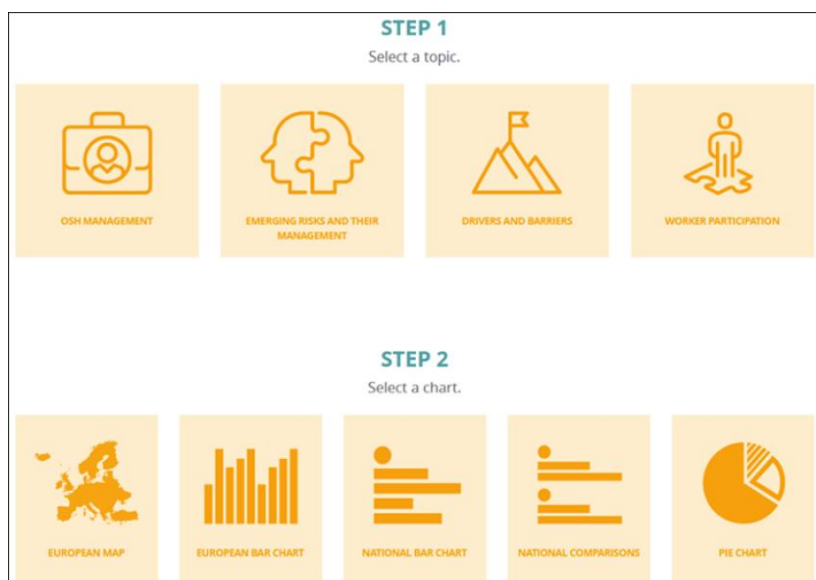
Usability testing aims to evaluate the extent to which an application or service fulfils its intended purpose. It is a valuable method for assessing an application because it provides direct feedback from real users. Nielsen [23] explains that usability testing is the most fundamental aspect of creating usability. To test usability, a scenario must be created for the user. When given an application, the user can be prompted to perform a series of tasks under observation to assess the effectiveness of various solutions.

## 2.6 Related works

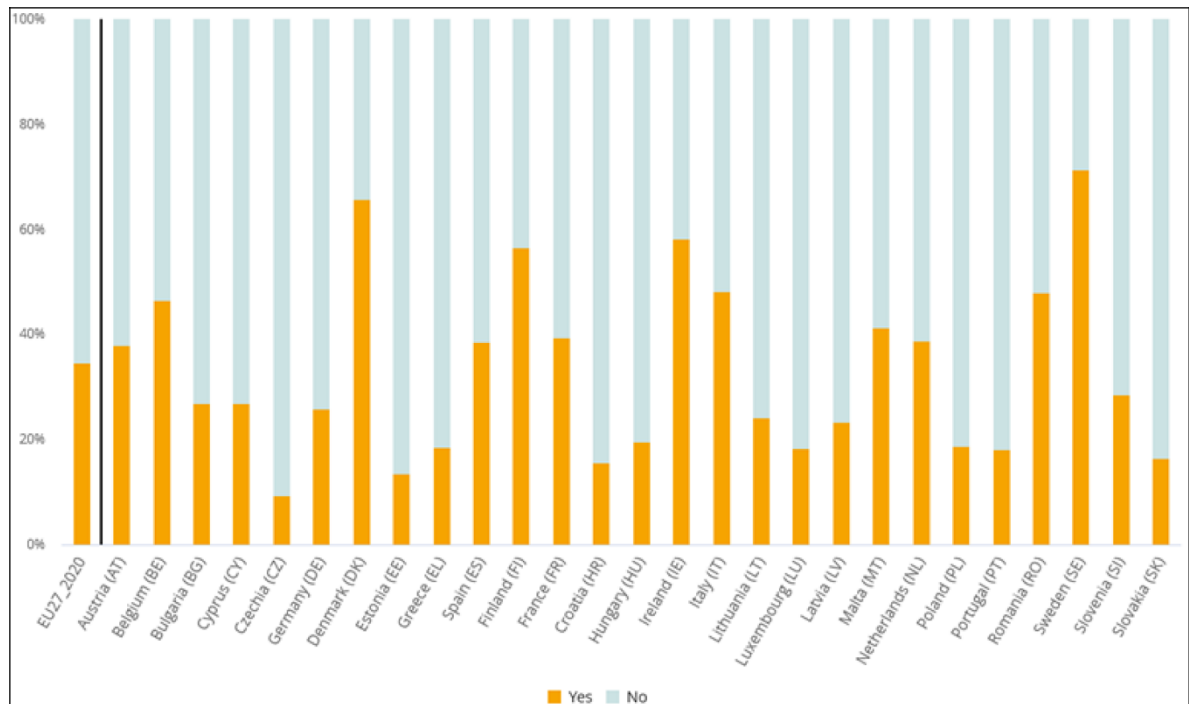
The European Agency for Safety and Health at work (EU-OSHA) [24] is the European Union's agency for occupational safety and health and is responsible for making European workplaces safer, healthier, and more productive. Their main goal is to improve working conditions in Europe. EU-OSHA have developed three different data visualisation tools that present facts and figures about a range of occupational safety and health issues across Europe. The tools display key data and findings that can be filtered by variables like country, sector and more.

One of the tools is an interactive dashboard used to visualize the European Survey of Enterprises on New and Emerging Risks (ESENER) [25] carried out in 2019. The survey was performed by 45 000 establishments across different business sizes and sectors in the EU. The questionnaire focused on, among others, general safety, and health risk in the workplace and how they are managed and psychosocial risks like stress, bullying and harassment.

The survey results are presented with a data visualisation tool [26]. The user starts by choosing a topic of interest then choosing how the related data will be presented, as shown in figure 2.6. This gives the user some liberty in choosing a visual that is best suited for them. There are explanations for how the data will be represented depending on the graph chosen. Looking at the topic emerging risks and their management with data displayed as a bar chart gives an illustration showing how the question “Does your establishment have an action plan to prevent work-related stress?” is answered throughout the European countries. For the bar chart it is explained that the values of all answers are provided for each country but also alongside the EU average, as shown in figure 2.7. This comparison is not possible when viewing the data in a pie chart or through a map visualisation.



**Figure 2.6:** Landing page of the data visualization tool



**Figure 2.7:** Answer distribution to the question “Does your establishment have an action plan to prevent work-related stress?” displayed in a bar chart

The design follows the principle from Nielsen’s heuristics of allowing user control and freedom. When initially choosing a topic and chart the user is still able to change them through a navigation drawer. Essentially the user is never locked into their choice of topic and chart. Analysing the aesthetics of the tool, it follows a simple colour scheme since most of the questions in the surveys are polar questions where affirmative answers are given a more positive colour in orange and negative answers are contrasted with a more negative colour, grey. The tool is easy to navigate with a simple hierarchical navigation drawer as well as providing filtering options for the data this is in line with both Nielsen’s [21] heuristics and how Law et al. [7] scoped UX. The user is also able to filter the results by sector, establishment size and answer, where the chosen answer will be highlighted.



### 3 Methodology

This chapter aims to present how the literature and information provided in chapter 2 will be put into practice and implemented to accomplish the goals presented in chapter 1.2. The methodology encompasses methods and solutions used as well as how the solutions are evaluated.

#### 3.1 Pre-study

The pre-study was divided into two phases. First, a literature study was conducted where the goal was to gather information and knowledge about data visualisation, web design and user experience. The aim was to compile different aspects and opinions on the subject which provides the basis for decision making. Additionally, this phase involved an analysis of the current implementation of RAMP II in terms of how results are displayed. This analysis aimed to identify existing deficiencies and establish a clear vision of the desired end-product.

The second phase of the pre-study was to learn and study the already developed backend of the service as well as learn about the different ramp services developed. In this phase the goal was to uncover any possible constraints that may be present for the front-end application which may present themselves in different aspects, such as established theming and colour-scheme for other RAMP services which would influence decisions for creating the data visualisation tool. Another aspect is simply what data is accessible and how the data is modelled, key points being relationships between entities in the data as well as what types of queries the backend exposes.

#### 3.2 Integration of UX principles

The theoretical foundations laid out in Chapter 2.6 serve as the guide for implementing UX principles in the RAMP business application. This chapter specifies how these principles: simplicity, familiarity, and reduced complexity are integrated into the design, with a focus on enabling quick and efficient decision-making in a business context.

##### 3.2.1 Prioritization of UX principles

- **Simplicity and Straightforwardness:** Given the primary goal of aiding personnel in data driven decision-making, the application eliminates unnecessary elements and functions. The interface prioritizes effective and simple navigation, so users can locate relevant data quickly. This approach aligns with Stull's [8] guidance on reducing complexity. The two-step approach used by EU-OSHA to let users first choose a topic and then view the corresponding data visualization also inspired this focus on straightforward navigation.
- **Familiarity:** Consistent with Stull's [8] principle to "favour the familiar," the application's user interface and language choices are in harmony with the broader RAMP framework. This consistency creates a cohesive user experience and minimizes the learning curve.

- **Reducing Complexity:** The design aims to present essential information in an easily digestible format. By doing so, the design addresses the problem statement and Stull's principles, enabling users to understand the data with less cognitive effort.

### 3.2.2 Methodological exclusions

- **Performance, reliability, and security:** These elements, while foundational, serve as basic standards and are integrated across the application, such as in user authentication features. However, they are not the main focus of the overall thesis work.
- **Non-Competition for user attention:** Considering the application's specific role in a work environment, the principle of becoming a small yet embraceable part of a user's life is not relevant here. Unlike entertainment platforms, the application doesn't compete for users' leisure time or attention.

The user experience design of this business application directly correlates with its overall functionality and usability. By emphasizing simplicity, familiarity, and reduced complexity, the design aims to provide a tool that both serves its purpose and enhances decision-making processes. These UX principles are particularly suitable for a business environment where rapid, informed decision-making is critical. Design choices aim to remove unnecessary steps and to integrate smoothly into existing workflows, leveraging the look and feel of other RAMP systems to enhance the application's accessibility and user-friendliness.

## 3.3 Charts

In the field of data and information visualization, the choice of chart or diagram plays a pivotal role in effective communication. As per Gershon et al. [9], the goal is not merely to plot data points but to transform complex information into a human-understandable form, creating a compelling "story." This storytelling approach is closely aligned with the pre-study phase, where understanding the nature of the data, the objectives of the visualization, and the intended audience guides chart selection.

The variables such as scale, distribution, and data type (categorical or numerical) are keenly considered, aligning with the principles of data analytics outlined by Knaflitz [16]. Achieving effective visualisation also involves exploratory and explanatory analysis, focusing first on identifying noteworthy patterns and then on communicating them to the audience.

### 3.3.1 Pie chart for RAMP evaluation

For representing the RAMP evaluation data, a pie chart effectively communicates the proportionality among categories: high risk (red), medium risk (yellow), and low risk (green). This chart type is particularly advantageous when the data comprise distinct, fewer categories, conforming to the guidelines posited by Bikakis [14]. Here, the pie chart functions as a visual storytelling tool, allowing users to swiftly grasp risk distributions, thus adhering to Gershon et al's. [9] criteria of efficient and coherent display.



### 3.3.2 Bar chart for time progression

The use of a bar chart aligns with the need to present survey data in a chronological progression. Bar charts are particularly useful for showcasing data points across different time subgroups, as noted by Bikakis [14]. Our choice was further validated by the EU-OSHA tool's effective use of bar charts for similar purposes. Additionally, they adhere to best practices such as a zero-valued baseline, promoting the "truthfulness" of the visualization. This design choice also aligns with the principle of 'accessible and actionable' interactive data visualization as described by Ward et al. The bar chart not only presents the data in an accessible format but also offers actionable insights into shifts and developments over time.

### 3.3.3 Methodological exclusions

In line with Bikakis' [14] recommendations, other chart types like scatter plots and 3D bar charts were deliberately excluded due to their potential for misinterpretation or complexity, which would contravene our goals of accessible and actionable data presentation. The absence of such complex visualizations in the EU-OSHA tool further reaffirmed our decision to focus on more straightforward chart types. While these methods have their utility, they were found to be less aligned with the design principles articulated by Gershon et al. and Ward et al., particularly in serving a diverse user base and in conveying actionable insights.

## 3.4 Mock-ups

In the design process, mock-ups serve as important tools for effective communication between product owners and developers. They play a crucial role in ensuring alignment among stakeholders and promoting an iterative design approach that actively gathers valuable feedback and initiates early improvements. Notably, this iterative process leads to the refinement of visual elements and layout, ensuring that the product aligns precisely with stakeholder expectations.

### 3.4.1 User-centered design

As described by Stull [8], a key aspect of UX design is to create solutions that users embrace and find efficient. Mock-ups facilitate this by allowing stakeholders to visualize and interact with the proposed design, promoting a shared understanding of the user experience.

### 3.4.2 Iterative approach

The iterative nature of mock-up development aligns with the UX design fundamentals outlined by Stull. UX design emphasizes the importance of continuous improvement and user feedback. Mock-ups enable an iterative approach by facilitating periodic feedback sessions with stakeholders. This ongoing dialogue helps fine-tune various aspects of the design, including the placement of charts and other data visualization elements, as discussed in the theory chapter.

### 3.4.3 Design-tool choice

In the design process, the selection of appropriate design tools is critical to ensure efficient communication and collaboration among stakeholders. Figma has been chosen as the primary design tool due to its real-time collaboration features. These features enable quick adjustments based on stakeholder input, contributing to a more efficient design process, and ensuring that the final product aligns closely with stakeholder expectations.

## 3.5 Evaluation

This section outlines the evaluation methodology used to comprehensively assess both the user interface and user experience of the developed application. The evaluation process aims to gather insights into the application's usability, effectiveness, design quality, and user preferences. The approach integrates usability testing within a user survey to efficiently collect both quantitative and qualitative data.

### 3.5.1 Evaluation method rationale

Building upon the theoretical framework presented in Chapter 2, two principal evaluation methods were considered: Empirical and heuristic, as outlined by Stufflebeam et al. [18] and Chin [19]. The chosen method integrates empirical evaluation in the form of usability testing within a user survey, aligning with Nielsen's [23] assertion that usability testing is a fundamental aspect of achieving usability. This integrated approach efficiently captures both qualitative and quantitative data on usability, user feedback, and design preferences.

### 3.5.2 Integrated usability testing and user survey

The evaluation process streamlined usability testing and user feedback collection through a single user survey. This design aligns with the considerations discussed in Chapter 2.5 and 2.5.2 regarding the importance of using both closed and open-ended questions to obtain a well-rounded understanding of user experiences and system effectiveness.

The survey encompassed three main sections:

- **Usability testing and feedback:** Participants were provided access to the application and instructed to perform specific tasks. These tasks were carefully crafted to cover various application functionalities. Participants' interactions were observed to assess task completion, navigation, and potential difficulties. Subsequently, participants provided feedback on their task outcomes.
- **General design and UX feedback:** In this section, participants evaluated the design quality, information presentation, and overall user experience of the application. Questions focused on visual aesthetics, clarity of information, and participants' satisfaction with their interactions.
- **Preference comparison:** Participants were presented with two versions of the application, each featuring a distinct data visualisation component. They

were instructed to explore both versions and provide their preference along with the reasons for their choice.

### 3.5.3 Methodological exclusions

While the integrated usability testing and user survey method was chosen for its comprehensive approach to gathering both qualitative and quantitative data, other methods were considered and subsequently excluded for specific reasons:

- **Heuristic evaluation:** This approach, based on Nielsen-Molich's [21] heuristics, was initially considered. However, it was excluded due to its focus on expert evaluation rather than direct feedback from the application's user base. The primary goal was to gather data that would offer a well-rounded understanding of the actual users' experiences and preferences, which heuristic evaluation could not fully provide.
- **Field studies:** Observing users in their natural setting could offer valuable insights but would be too time-consuming and could introduce numerous variables that might be difficult to control for in the study.

## 3.6 Implementation

The creation of the application followed some web design approaches to create a good quality application. Some industry standard framework was also used.

### 3.6.1 Responsive web design

Responsive web design is a transformative approach to web development aimed at ensuring optimal viewing experiences across different devices and screen sizes. This can be done by utilizing flexible layouts, media queries and other information to dynamically adapt the content and design of the web application. This allows for better and more fluid navigation and better usability for the user. They may normally use the application on a computer but may need to quickly look up some information on their smartphone or their tablet, and the applications needs to be able to handle the different screen sizes to give an optimal user experience.

To allow for a familiar look and feel, the application was designed using Bootstrap. Bootstrap is a front-end framework for responsive design. It simplifies and standardises web components to allow for a smoother user experience. Components like buttons, text fields and others are predesigned and ready-made to be used in the application.

### 3.6.2 Dynamic application

As the application uses data that is constantly updated and new data is introduced after RAMP evaluations are done, the new data needs to be available in the application for the user to filter etc. This approach is called a dynamic application. A dynamic application can handle data real-time updates. Unlike static web pages, a dynamic application is connected to a server that then gets data from a database which contains the up-to-date data and constantly sends it back to the application. This allows for an interactive application which aligns with the mentioned principles.

### 3.6.3 React.js

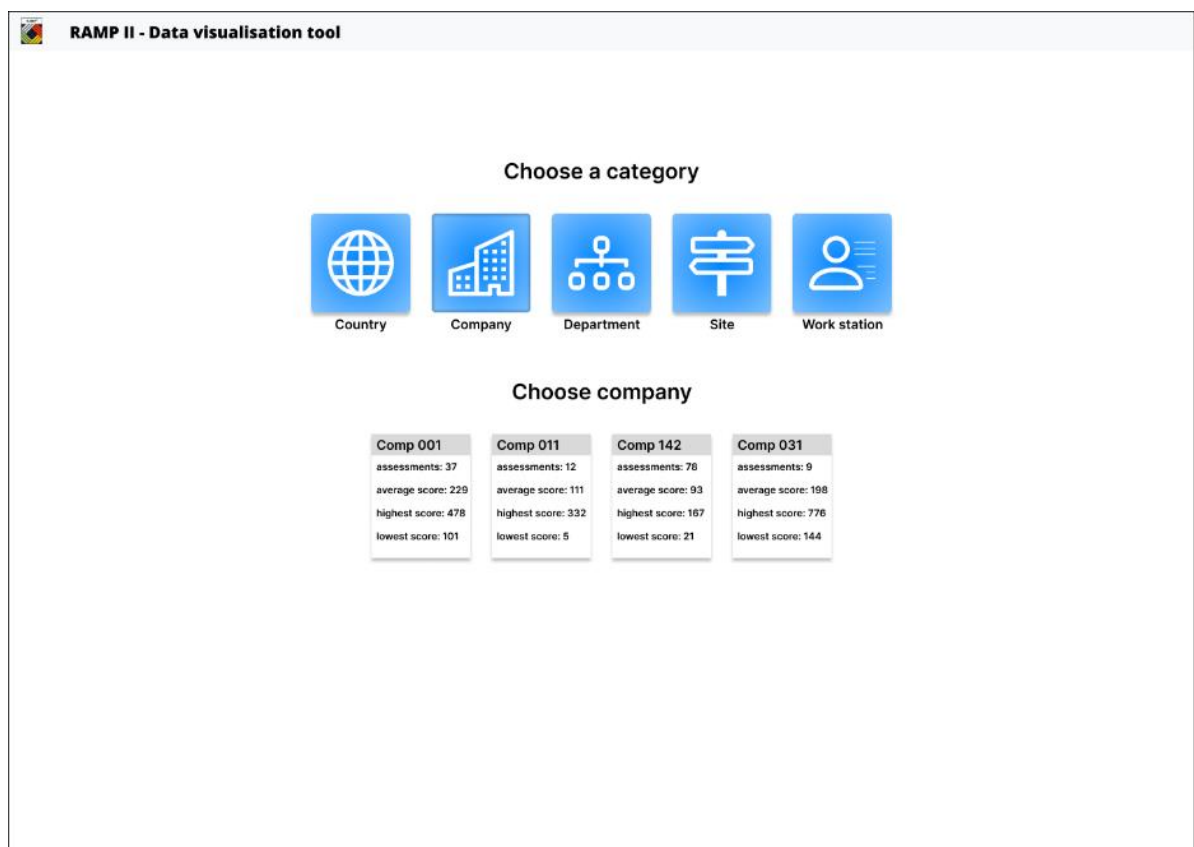
React.js is a JavaScript framework developed to solve challenges when developing user interfaces. The framework allows for a dynamic and interactive user interface and helps with developing the different pages and allowing them to be connected, and this was the reason this framework was chosen for this work, as it follows the principles described in the theory.

## 4 Results

In this section, the outcomes of the applied methodology are presented, encompassing both the resulting mock-ups, a comprehensive overview of the users' experiences and perceptions, offering valuable insights into the usability, effectiveness, and design of the developed web application and insights derived from the user survey findings and the results of the conducted usability testing.

### 4.1 Mock-ups

Aiming for easy navigation resulted in two mock-ups in total for the web application. The first mock-up is the landing page, where a user inputs the desired area or category they wish to observe, shown in figure 4.1. The second mock-up is for the dashboard, housing all central functionality, shown in figure 4.2.



**Figure 4.1:** Landing page mock-up

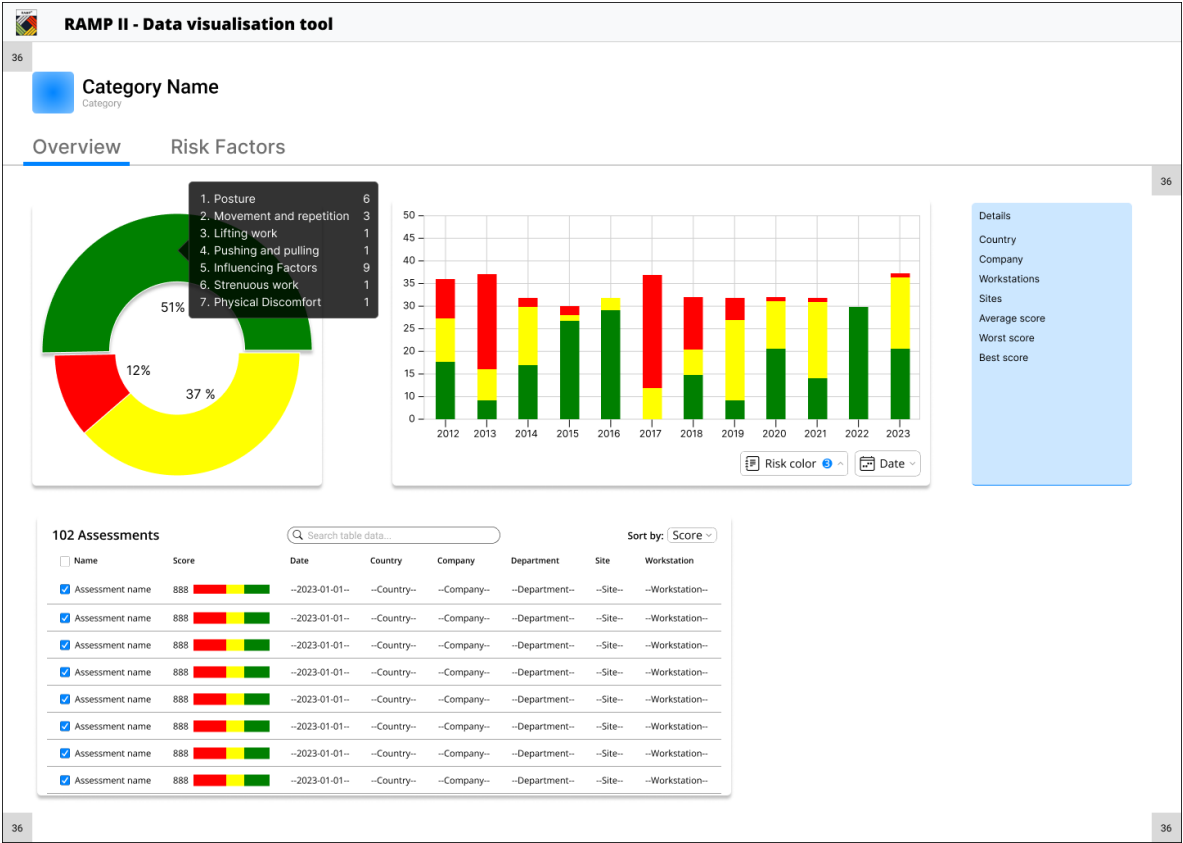


Figure 4.2: Dashboard mock-up

## 4.2 Application overview and features

### 4.2.1 Landing page

The landing page, as shown in figure 4.3, serves as the entry point for users. It presents five categories: Representative, Department, Workstation, Site, and Country. Users can select a category of interest, leading them to the dashboard data for data visualisation.

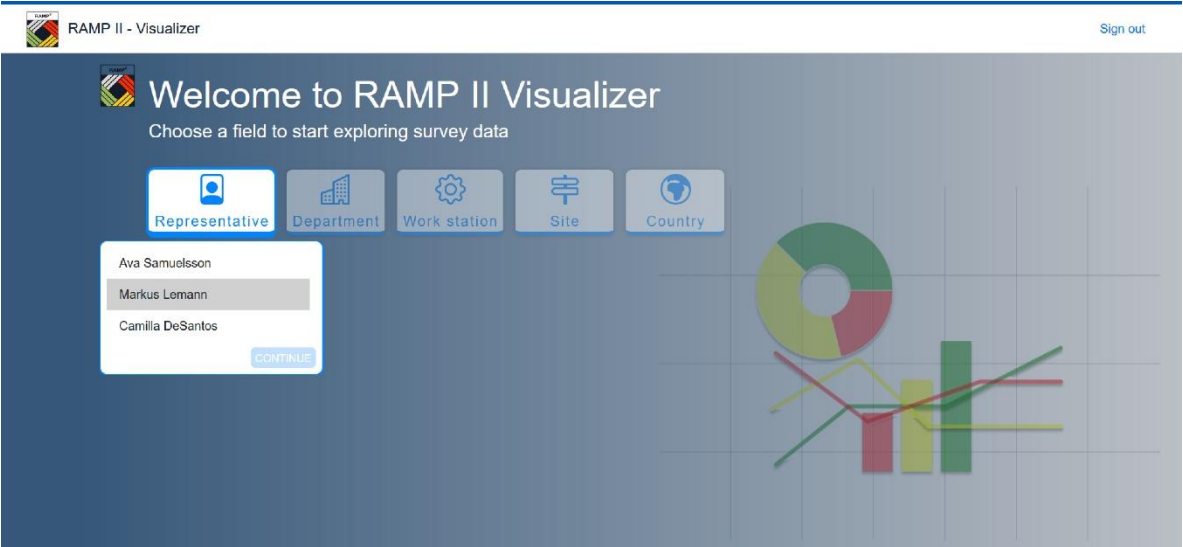


Figure 4.3: Resulting landing page

### 4.2.2 Dashboard

Upon selecting a category on the landing page, users are directed to the dashboard. The dashboard is the central hub of the web application, offering various components to explore and visualize data. The resulting dashboard is shown in figure 4.4.

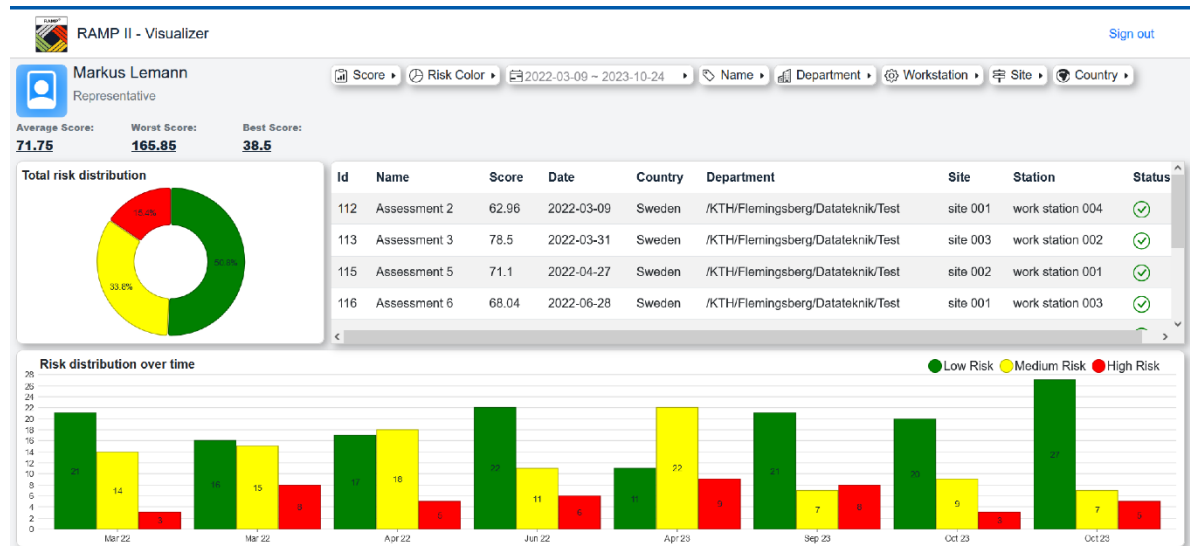


Figure 4.4: Resulting dashboard

### Logo and stats

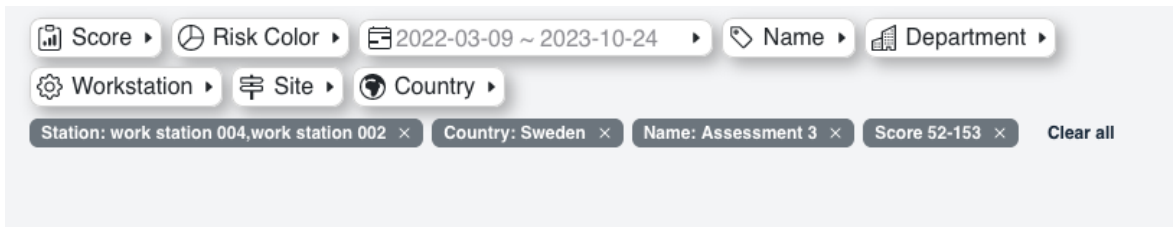
The Dashboard's top section features an icon that represents the chosen category (e.g., representative, site, department) along with the name of the selected item and what category it belongs to. Under the logo, users find statistics that display the average, best, and worst scores for the assessments belonging to the chosen item. It is shown in figure 4.5.



Figure 4.5: The logo with assessment statistics

## Filters

Positioned to the right of the logo and statistics section, the filter component enables the user to refine the data. As shown in figure 4.6, found here are dropdown buttons to modify the data according to specific criteria: assessment score, risk levels, date, assessment name, department, workstation, site, and country. This section also displays the currently active filters.



**Figure 4.6:** Filter component with some filters chosen

- Range sliders filters:** The score and risk colour filters allow users to specify a minimum and maximum value for respective search criteria using range sliders or numbers inputs. It is shown in figure 4.7.



**Figure 4.7:** Score range filter and risk colour range filter

- Date filter:** Filtering the date is accomplished through a ranged date picker or text input. The user picks a start and end date from the calendar or enters the date values manually. It is shown in figure 4.8.



2022-03-09 ~ 2023-10-24 ▶ Name ▶ Department ▶ ⚙️

2022-03-10 ~ 2022-08-25

Mar 2022							Aug 2022						
Su	Mo	Tu	We	Th	Fr	Sa	Su	Mo	Tu	We	Th	Fr	Sa
27	28	1	2	3	4	5	31	1	2	3	4	5	6
6	7	8	9	10	11	12	7	8	9	10	11	12	13
13	14	15	16	17	18	19	14	15	16	17	18	19	20
20	21	22	23	24	25	26	21	22	23	24	25	26	27
27	28	29	30	31	1	2	28	29	30	31	1	2	3
3	4	5	6	7	8	9	4	5	6	7	8	9	10

OK

**Figure 4.8:** Date filter with a start and end date choose

- **Selection Filters:** Filtering on assessment name, department, workstation, site, and country involves selecting specific values from a dropdown list associated with the category. Additionally, a text search functionality allows users to locate and choose items within the dropdown lists based on their preferences. It is shown in figure 4.9.

Name ▶ Department ▶ ⚙️

Search name 🔍

- ☐ Assessment 2
- ☐ Assessment 3
- ☐ Assessment 5
- ☐ Assessment 6
- ☐ Assessment 14

OK

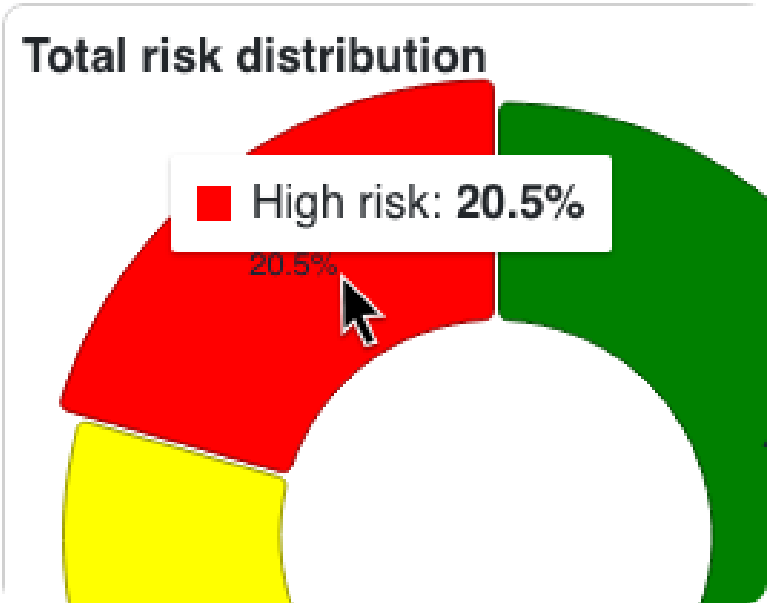
**Figure 4.9:** Selections filters, name

**Filter chips**

Filter chips are generated below the filter section as users apply filters, providing a visual representation of active filter criteria. Users can remove specific filters by clicking the corresponding chips.

**Pie chart**

Positioned below the filter component, the Pie Chart visually represents the distribution of risk levels (Low, Medium, High) among the assessments associated with the selected item. Hovering over the slices reveals the corresponding risk level and its percentage representation. The pie chart is shown in figure 4.10.



**Figure 4.10:** Pie Chart component showing total risk distribution

**Data table**

The Data Table occupies the space next to the Pie Chart, providing a structured view of the assessment data associated with the selected item. The columns include assessment ID, name, score, date, country, department, site, workstation, and status (completed or unfinished). Additionally, users can sort the table by clicking on the headers of each column. The table is shown in figure 4.11.

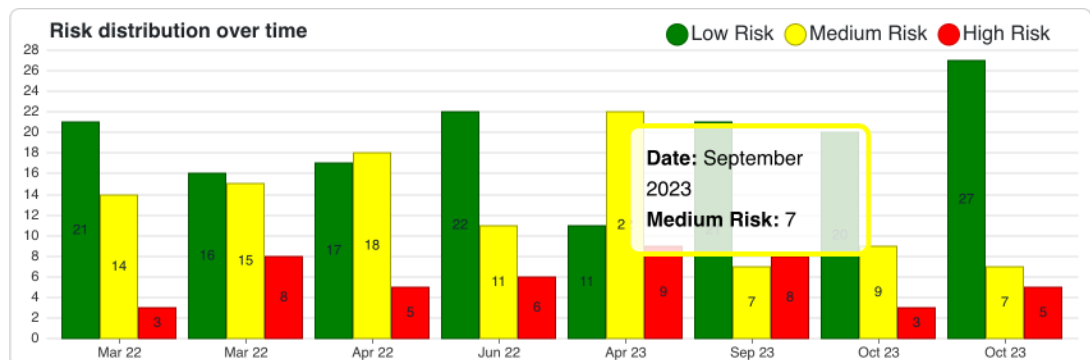
Id	Name	Score	Date	Country	Department	Site	Station	Status
112	Assessment 2	61.96	2022-03-09	Sweden	/KTH/Flemingsberg/Datateknik/Test	site 001	work station 004	✓
113	Assessment 3	77.5	2022-03-31	Sweden	/KTH/Flemingsberg/Datateknik/Test	site 003	work station 002	✓
115	Assessment 5	70.1	2022-04-27	Sweden	/KTH/Flemingsberg/Datateknik/Test	site 002	work station 001	✓
116	Assessment 6	67.04	2022-06-28	Sweden	/KTH/Flemingsberg/Datateknik/Test	site 001	work station 003	✓
124	Assessment 14	164.85	2023-04-18	Sweden	/KTH/Flemingsberg/Datateknik/Test	site 006	work station 004	✓
129	Assessment 19	45	2023-09-26	Sweden	/KTH/Flemingsberg/Datateknik/Test	site 001	work station 001	✓
130	Assessment 20	42.08	2023-10-03	Sweden	/KTH/Flemingsberg/Datateknik/Test	site 002	work station 004	✗

**Figure 4.11:** Table showing information about assessments

## Bar chart versus line chart

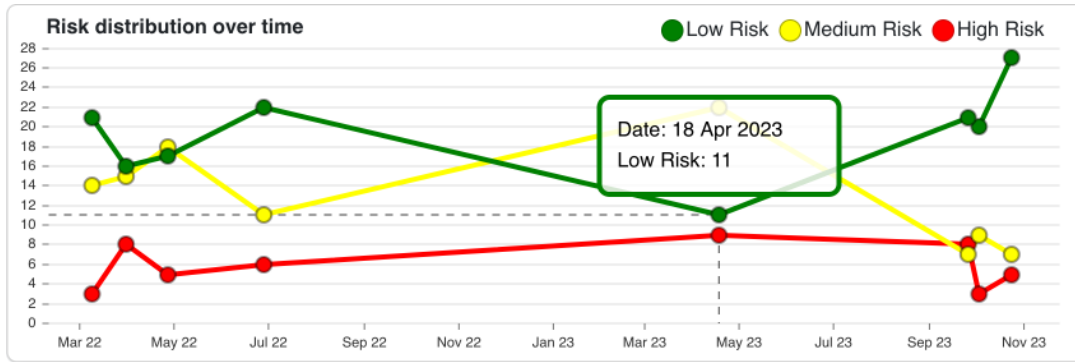
The lowermost component within the dashboard displays either a bar chart or a line chart, based on the version the user is engaged with. These two versions enable users to compare and provide feedback regarding data visualisation methods. Both types of charts share the common goal of illustrating the distribution of risk levels over time.

- Bar chart:** This chart visually represents the assessment data in relation to time. Assessments are organized by their respective month and year. For months with multiple assessments, an average is computed. Each month features grouped segments categorized by risk level, providing segmented visualisations for low, medium, and high-risk levels. It is shown in figure 4.12.



**Figure 4.12:** Bar Chart component showing risk distribution over time

- Line chart:** The line chart plots three lines, each representing a distinct risk level (green, yellow, red). The chart plots connected data points along each line, signifying the assessment creation date and the corresponding values for low, medium, and high-risk levels. It is shown in figure 4.13.



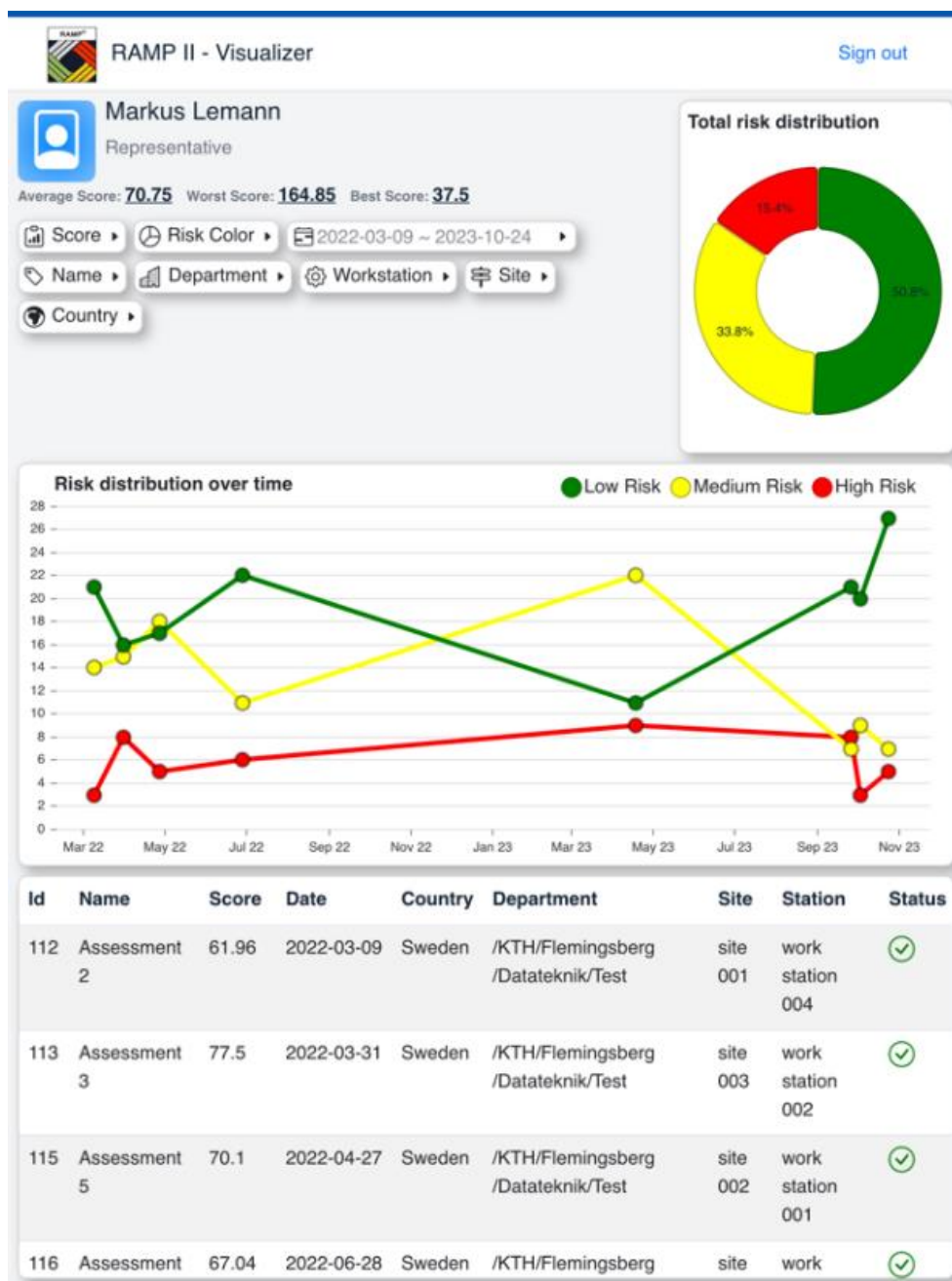
**Figure 4.13:** Line chart component showing risk distribution over time

#### 4.2.3 Responsiveness

The web application has been designed with responsiveness in mind, ensuring usability across various devices. The responsive design primarily caters to tablets and devices with viewport widths larger than 1090px. However, devices smaller than tablets, such as phones, were not considered within the responsive design framework.

For devices with a viewport width smaller than 1090px, the layout adjusts to optimize the available screen space. The layout changes to a 4-row, 3-column grid arrangement. The top row features the logo,

spanning two columns. The second row contains the filter component, also spanning two columns. The pie chart is positioned in the third column, spanning from the first row to the second row. This tablet layout has the line and bar-chart in the third row and the data table at the bottom row. Figure 4.14 shows the layout for smaller screens.



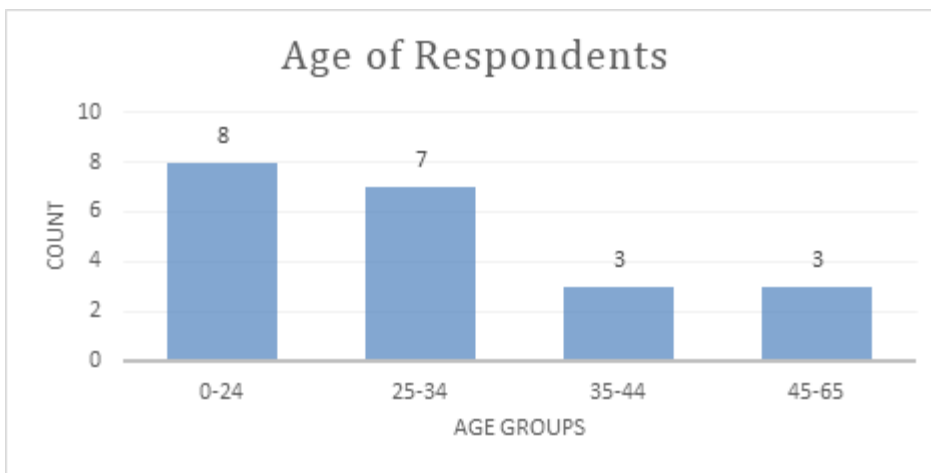
**Figure 4.14:** Layout adjusted to available space on a smaller screen

### 4.3 User survey findings and usability testing results

This section unveils user feedback collected through a comprehensive survey evaluating the web application in terms of the UI, design, and user-friendliness. The analysis delves into user experiences, highlighting strengths, areas for improvement, and growth opportunities. All the questions included in the survey is presented in appendix A.1.

#### 4.3.1 Demographic information

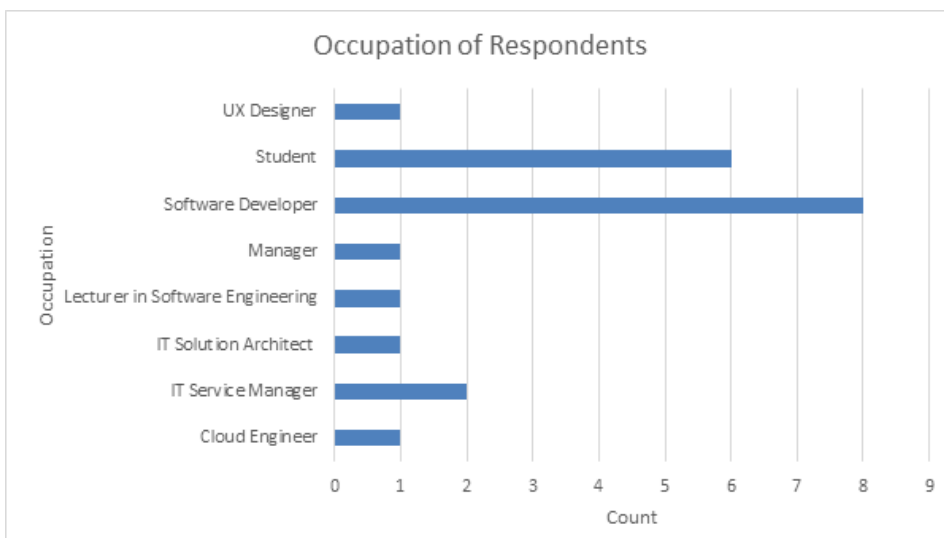
In total, there were 21 participants in the user survey. 15 of the respondents were male, and 6 were female. The gender split of the respondents was therefore about 71% male and 28% female. Only 2 of the 21 respondents, about 10%, had any previous experience with RAMP. The age of the respondents is divided into categories and presented in a chart, figure 4.15.



**Figure 4.15:** Age of the respondents divided into categories

#### Occupation

The occupation of the respondents is presented in a bar chart, figure 4.16.



**Figure 4.16:** Occupation distribution of the respondents

### 4.3.2 Usability tests

To get respondents familiarized with the web application, they were asked to perform two usability test scenarios. This involves you going through the whole flow of the web application to find specific information. They needed to filter the data based on some criteria. The criteria for the tests are presented in appendix A.2. After completing the scenarios, the respondents were asked to answer questions on what they found in the web application.

#### Usability test 1

What is the average score of the filtered data? There were three answers to choose from, with 56.45 being the correct answer. The distribution of the answers by the respondents is shown in figure 4.17.

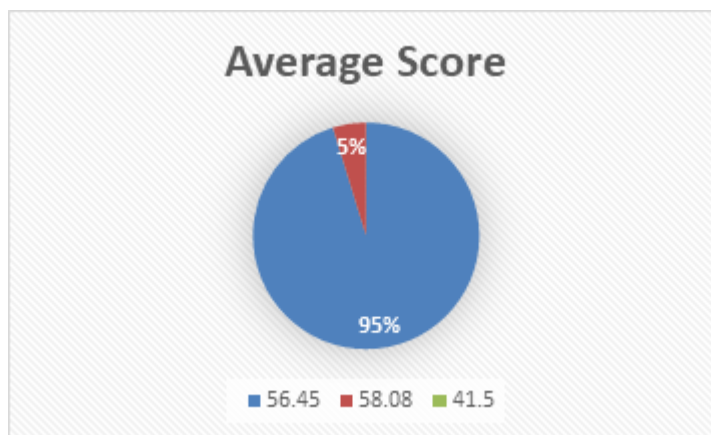


Figure 4.17: Answer distribution of the respondents

**Between Aug 2022 and Mar 2023, how would you describe the change of green, yellow, and red assessment?** There were two different answers to choose from, with Green ↓ Yellow ↓ Red ↑ being the correct answer. The distribution of the answers chosen by the respondents is shown in figure 4.18.

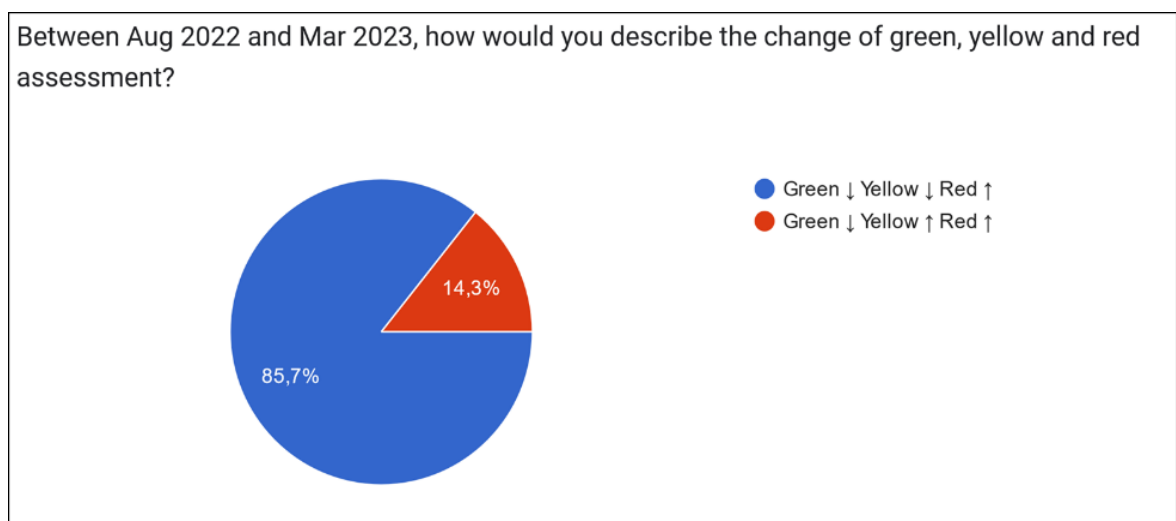
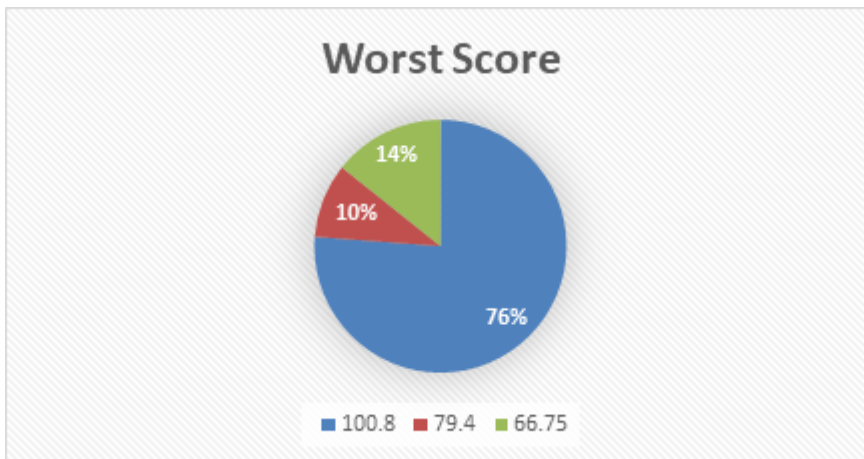


Figure 4.18: Answer distribution of the respondents

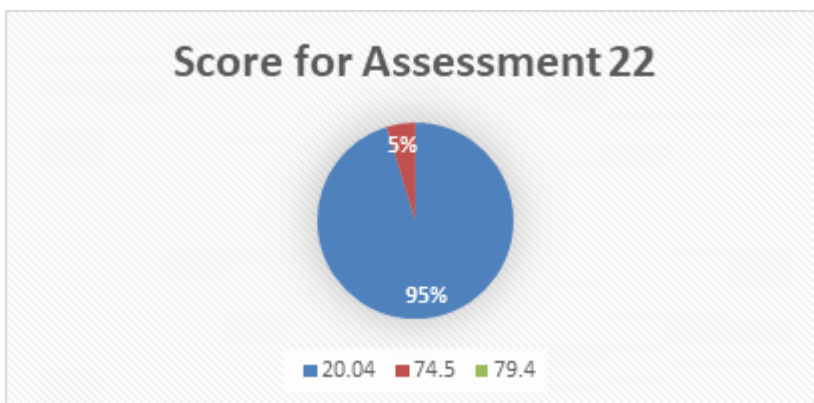
## Usability test 2

**What is the worst score of the filtered data?** There were three different answers to choose from, with 100.8 being the correct answer. The distribution of the answers chose by the respondents is shown in figure 4.19.



**Figure 4.19:** Answer distribution of the respondents

**What is the score for assessment 22?** There were three different answers to choose from, with 20.4 being the correct answer. The distribution of the answers chose by the respondents is shown in figure 4.20.



**Figure 4.20:** Answer distribution of the respondents

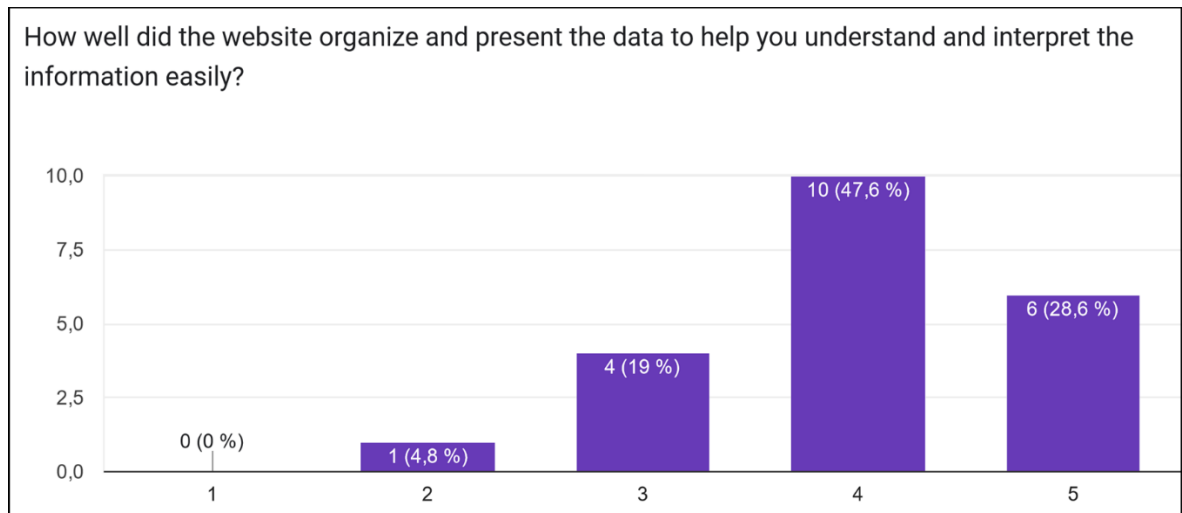
### 4.3.3 General questions – Usability and user friendliness

After completing the test, the respondents were asked a series of questions on the tests they performed.

**How well did the web application organise and present the data to help you understand and interpret the information easily?**

The respondents were presented with a linear scale to answer with 1 representing “not well” and 5 representing “well”. The answer distribution is shown in figure 4.21.





**Figure 4.21:** Answer distribution of the question “How well did the web application organize and present the data to help you understand and interpret the information easily?”

### **Were you able to accomplish your tasks efficiently and effectively on the web application? Please elaborate.**

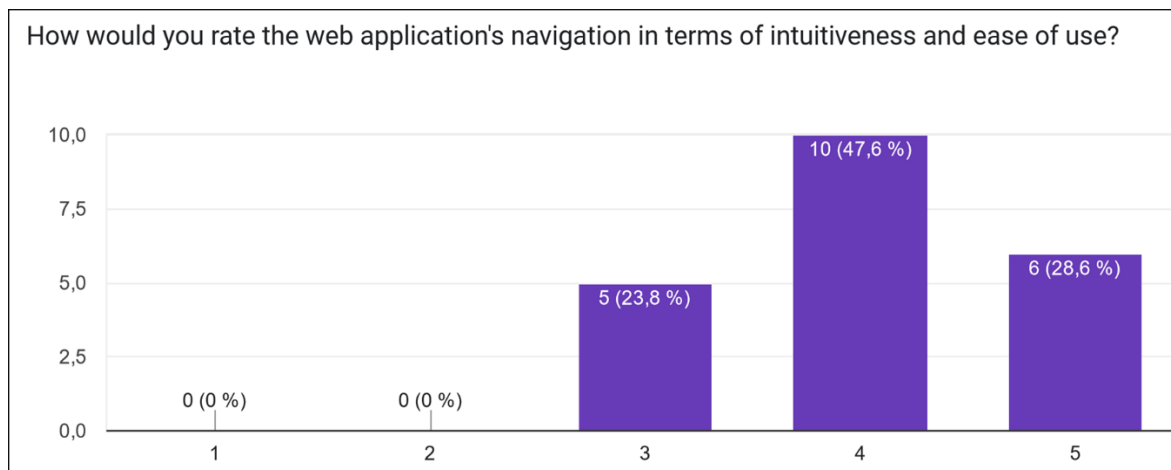
This question was a free-form question. The responses are summarized. All the answers can be viewed in full in Appendix B.1.

The participants' feedback regarding their ability to accomplish tasks efficiently and effectively on the web application can be summarized as follows:

Overall, the responses suggest that most users were able to accomplish their tasks on the web application efficiently and effectively. Users generally found the web application easy to navigate, with clear instructions and descriptions. However, there were a few minor issues mentioned, such as difficulties with the date-picker, the need for clearer labelling in some cases, and suggestions for improving font size in certain data visualisations. Despite these minor challenges, the majority of users found the web application user-friendly and were able to complete their tasks successfully.

### **How would you rate the web application's navigation in terms of intuitiveness and ease of use?**

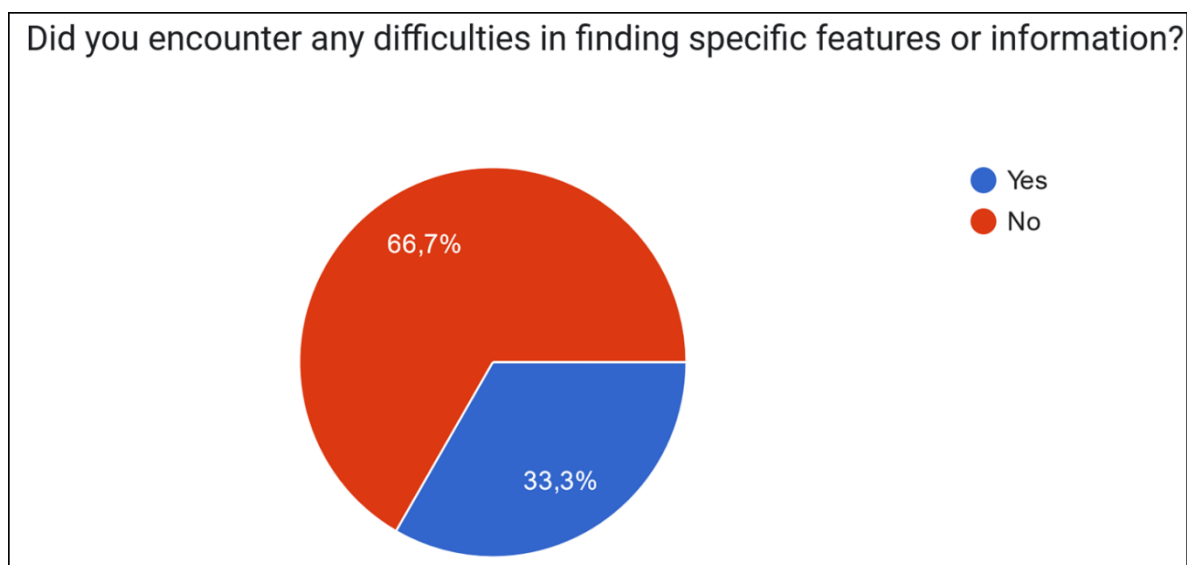
The respondents were presented with a linear scale to answer with 1 representing “bad” and 5 representing “good”. The answer distribution is shown in figure 4.22.



**Figure 4.22:** Answer distribution of the question “How would you rate the web application’s navigation in terms of intuitiveness and ease of use?”

### Did you encounter any difficulties in finding specific features or information?

A question if the respondents had any difficulties in finding specific features or information was asked. The result is presented in figure 4.23.



**Figure 4.23:** Yes or No distribution if the respondents have had previous experience with RAMP

### Were the interactive elements, such as charts and filters, clearly distinguishable and easy to use and understand? Please elaborate.

This question was a free-form question. The responses are summarized. All the answers can be viewed in full in appendix B.2.

The participants' feedback regarding the clarity and usability of interactive elements, such as charts and filters, can be summarized as follows:

Overall, users generally found the interactive elements on the web application, including charts and filters, to be reasonably distinguishable and user-friendly. They appreciated the clear colour distinctions in charts representing different risk levels and the straightforward functionality of the filters. However, there were notable concerns raised. Some users felt that the charts took up too much space and suggested inputting values before generating them to reduce clutter. There were also calls for better colour choices to accommodate individuals with colour blindness and requests for clearer labels on elements to enhance accessibility. Users identified issues with the date-picker, including difficulties in understanding the selected options and the need for more testing. Some users suggested the option to reset only one of the selected dates. Additionally, there were calls for explanatory text for sliders and better visibility for the "Clear All" option.

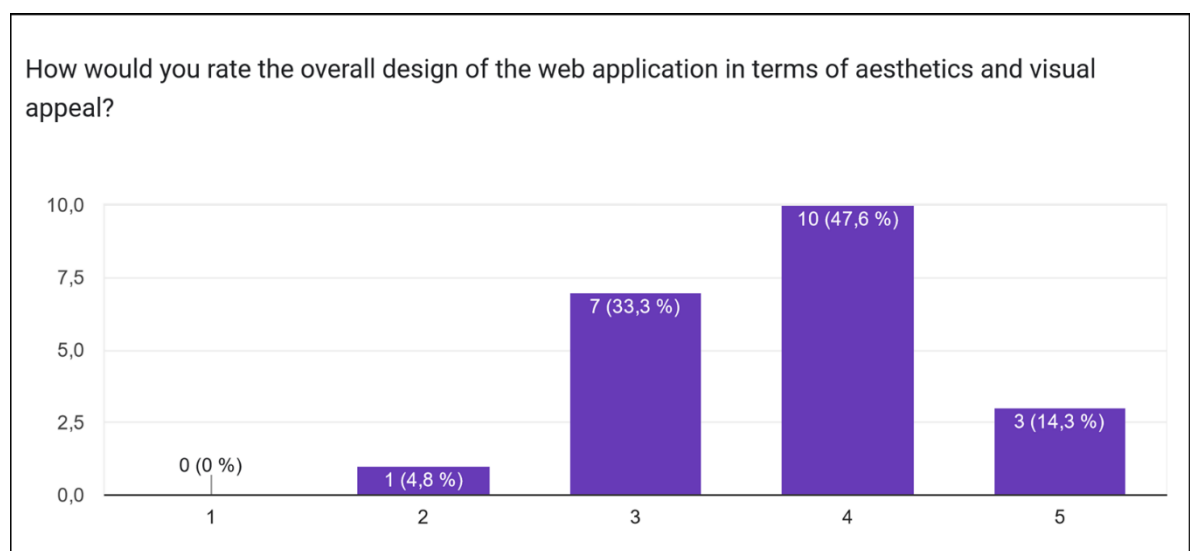
Despite these concerns and suggestions for improvement, users generally appreciated the web application's usability and functionality, highlighting the ease of access to filters and the overall user-friendliness of the interface. While there were minor issues, such as layout and labelling, most users were able to navigate and utilize the interactive elements effectively once they became familiar with the system.

#### 4.3.4 General questions - Design

The respondents were asked to form opinions about the design and user-friendliness of the web application. They then answered general questions regarding the topic.

#### **How would you rate the overall design of the web application in terms of aesthetics and visual appeal?**

The respondents were presented with a linear scale to answer with 1 representing "bad" and 5 representing "good". The answers are shown in figure 4.24



**Figure 4.24:** Answer distribution of the question "How would you rate the overall design of the web application in terms of aesthetics and visual appeal?"

**Do you think the design reflects the purpose of the web application effectively? Please elaborate.**

This question was a free-form question. The responses are summarized. All the answers can be viewed in full in appendix B.3.

The responses suggest that the design of the web application generally aligns with its purpose, although there are nuanced observations and suggestions made. It is summarized as follows:

The majority of users believe that the web application's design effectively reflects its purpose. They appreciate the clean and sleek design, noting that it conveys a sense of efficiency and functionality. Users also acknowledge that once they become familiar with the interface, they can maximize their efficiency in using the web application. However, some users expressed initial concerns about the web application feeling overwhelming or needing clearer information about selected filters and user interactions. They suggested adding explanatory sections and improving colour choices for better readability. Despite these minor issues, most users found the design to be straightforward and suitable for its purpose, particularly for administrative use, as it effectively presents risk assessment data and allows users to select fields and access relevant information.

**Did you find the use of colours, typography, and charts on the web application visually pleasing and suitable for the content? Please elaborate.**

This question was a free-form question. The responses are summarized. All the answers can be viewed in full in appendix B.4.

The participants' feedback regarding the use of colours, typography, and charts in the web application can be summarized as follows:

Users generally found the use of colours, typography, and charts on the web application to be visually pleasing and suitable for the content. The colour choices, particularly red, yellow, and green, were seen as intuitive for indicating different risk levels. Many users appreciated the use of common chart types like pie and bar charts, which are easy to read and understand. The visual design was generally described as effective in conveying information.

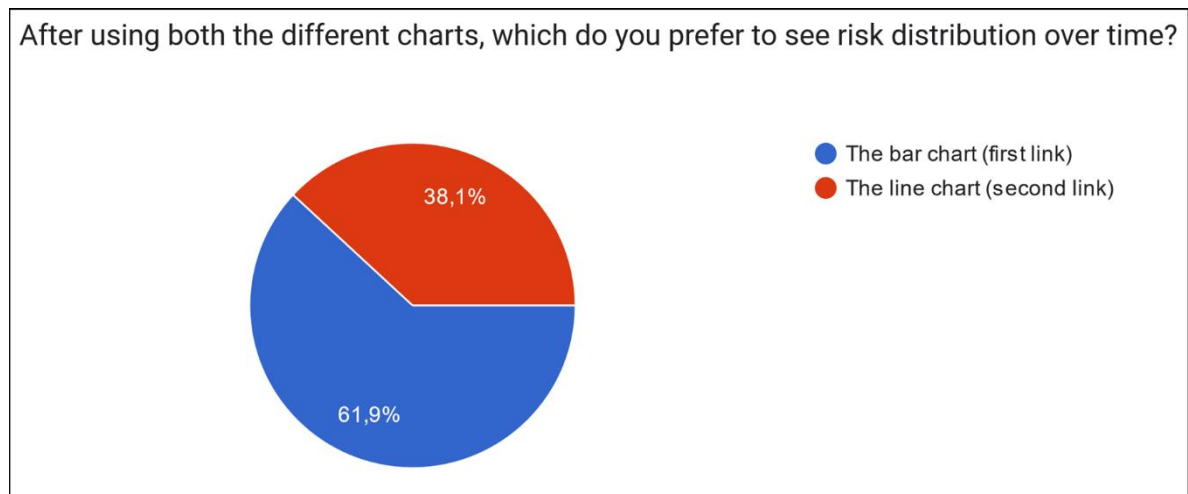
However, some users raised concerns about colour choices, particularly regarding red and green, which may pose difficulties for individuals with colour blindness. Additionally, a few users suggested reducing colour saturation for a more visually appealing experience. Overall, the majority of users found the visual design to be suitable and effective for presenting the content of the web application.

#### 4.3.5 Preference comparison

The last part of the survey was to share their opinion on which chart they preferred of two. They were asked to visit another version of the web application where a line chart was presented instead of a bar chart for risk distribution over time.

#### **After using both the different charts, which do you prefer to see risk distribution over time?**

A question if the respondents preferred the bar chart or the line chart was asked. The result is presented in figure 4.25.



**Figure 4.25:** Distribution of answers if the respondents preferred the bar chart or the line chart

#### **Please elaborate why you prefer one over the other.**

This question was a free form question. The responses are summarized. All the answers can be viewed in full in appendix B.5.

The participants' preferences between the bar chart and the line chart can be summarized as follows:

Users' preferences for bar charts vs. line charts varied based on their specific needs and perceptions. Some users favoured bar charts because they found them cleaner, more readable, and easier to follow, especially for shorter time spans. Bar charts were seen as suitable for providing an overview of data and making it easier to detect values quickly. Users appreciated the specific numbers displayed on bar charts for precise information.

On the other hand, some users preferred line charts, especially when the goal was to visualize changes over time. Line charts were considered more effective for tracking trends and understanding how different risk zones evolved over time. Users valued the clarity of the x-axis in line charts for time comparisons. However, some suggested that line charts could appear messy when multiple lines overlapped and recommended adding filtering options for better customization.

Overall, users' preferences depended on their data interpretation needs, with bar charts being favoured for clarity and immediate value detection, while line charts were preferred for tracking trends and changes over time. Some participants also suggested having both chart options available for different use cases.

## 5 Analysis and discussion

In previous chapters, the focus was on the theoretical framework, research methodology, and the presentation of results. This chapter shifts the focus toward a comprehensive analysis and discussion of the project's outcomes. It aims to critically examine these outcomes in the context of the set objectives, research, and methodology.

For a well-rounded analysis, the chapter will explore the following key aspects:

- **Evaluation of user interface design:** The interface design and user experience are subject to evaluation based on established heuristics and usability principles.
- **Analysis of user testing results:** This segment explores the data, statistics, and trends from usability tests. The analysis aims to reveal successes, challenges, and unexpected findings encountered during the project.
- **Societal, economic, environmental, and ethical considerations:** Beyond technical analysis, this section delves into the broader societal, economic, and environmental implications of the project.

By addressing these aspects, the chapter aims to offer a comprehensive evaluation of the project's outcomes and their wider implications.

### 5.1 Evaluation of user interface design

The user interface design of the web application played a pivotal role in achieving the project's objectives of providing an efficient and user-friendly platform for presenting RAMP survey results. The design approach was centered around simplicity and usability, guided by established UX principles and heuristics.

**Simplicity as a core principle:** Simplicity in design emerged as a critical factor in achieving the project's objectives, closely adhering to Stull's UX principles. An evenly distributed content layout and well-structured elements contributed to a fine balance between providing essential information and avoiding clutter. This focus on simplicity served as a cornerstone for the project. Replacing existing complex Excel sheets with a streamlined interface was a significant but necessary challenge. The result indicates that the focus on simplicity was a key driver in meeting project goals, reinforcing its position as a vital UX principle.

**Maintaining design continuity with RAMP:** Incorporating a colour-coding system that aligns with RAMP's risk levels of low, medium, and high aimed to reduce the learning curve for existing users. The strategy of maintaining design continuity with pre-existing elements did more than just ease the transition; it validated the underlying decision to leverage user familiarity for quicker adoption. This not only preserved the integrity of the RAMP framework but also expedited user onboarding.

It raises a point for future reflection: while leveraging pre-existing familiarity facilitates initial adoption, it might inadvertently create limitations for users who are unfamiliar with RAMP, a consideration that holds significance for the system's future scalability and inclusivity.

**Interactivity and filtering:** Limited interactivity was deliberately implemented in the interface, primarily through a filtering system designed to be intuitive and categorized by relevant criteria. This approach successfully contributes to a streamlined user experience and offers valuable insights into managing interface complexity.

Reflecting on the introduction of filters, it becomes apparent how this focused interactivity strikes a balance between functionality and usability. The effectiveness of the filtering system affirms that well-planned, targeted interactivity can enhance user experience significantly, even when overall interface interactions are kept to a minimum. The choice to divide filters into intuitive categories also reflects positively on user engagement and satisfaction.

In summary, the limited but effective interactivity through filtering not only meets the current user requirements, but also serves as an interesting point of consideration for future iterations of the web application.

**Adaptation for responsiveness:** The challenges in ensuring responsive design initiated a re-evaluation of component placement and feature prioritization. Prioritizing data visualisations for smaller screens while enhancing data tables for larger displays was a calculated approach to make the interface scalable.

Upon reflection, an alternative "mobile-first" approach could have been considered. This approach usually starts with the smallest screen sizes as the design foundation and scales up, focusing on essentials due to limited screen real estate. Although the current design strategy was effective, pondering the benefits of a "mobile-first" philosophy raises questions about whether a more streamlined and focused user interface could have been achieved, and how that might affect user engagement across various devices.

## 5.2 Data visualisation methods

This section serves as a reflection on the data visualisation methods employed in the project, each chosen to optimally display risk assessments over various dimensions. The effectiveness and limitations of these methods are examined, providing insights for future work in this area.

**Pie chart for Risk distribution overview:** The pie chart proved to be an effective tool for quickly conveying a holistic view of risk distribution across all assessments. Its intuitiveness enabled users to grasp the relative risk levels without significant cognitive load. Confirming its enduring relevance in data visualisation, the pie chart met its intended goal effectively. However, it also emphasized the principle that the right tool must be chosen for the specific need, in this case, a broad overview rather than a detailed analysis.



**Bar chart for time-based analysis:** The bar chart was particularly effective for capturing shifts in risk across different time periods. It provided clear separation between individual data points, allowing for trends to become easily observable. A deliberate decision was made to average closely spaced data points to maintain clarity and legibility. This approach emphasized that, in certain contexts, the need for simplicity and readability outweighs high granularity, a lesson that will inform future data visualisation choices.

**Multiline chart for time-based analysis:** In contrast to the bar chart, the multiline chart offered greater granularity, enabling a more detailed examination of risk trends. However, this granularity sometimes led to visual clutter when data points were closely spaced in time. This experience served as a reminder of the ongoing trade-off between detail and clarity, and this tension will need to be carefully balanced in any future iteration of this project.

The variety of visualisation techniques used in this project demonstrated the complexities and trade-offs inherent in representing multifaceted data. This experience underscores the need for a flexible and nuanced approach to data visualisation, a lesson that will undoubtedly inform future projects.

### 5.3 Analysis of user testing results

**Usability and task completion:** Most participants found the web application to be efficient and user-friendly. Clear instructions were particularly appreciated, aiding in successful task completion. Although some challenges were noted, such as difficulty with date inputs, overall feedback suggested that participants were able to navigate the web application and complete tasks effectively.

Most participants recognizing the efficiency and user-friendliness of the web application validates the design goals. While the feedback was largely positive, acknowledging that there's always room for improvement is encouraging. The suggestion for clearer instructions resonates with the intention to create a seamless user experience. The issue with the date picker's usability and lack of clarity regarding manual input is noted. Investing time to explore better solutions and providing more transparent functionality guidance represents a step forward.

**Design assessment:** Participants expressed a range of views on the web application's design and information presentation. While some found the design helpful, a few indicated the need for clearer labels and more prominent help functions. Specific design elements, such as font size on charts and histograms, were mentioned as areas for improvement. Inconsistencies in labelling affected initial understanding for some participants.

Acknowledging the range of views on design is an essential aspect of understanding user perspectives. The proposal for incorporating a walk-through of the web application or an about section aligns with the approach to enhancing user guidance. Creating an interface that not only communicates its functions but also provides a brief introduction for new users is a strategy we're considering. Additionally, addressing

clarity issues with labelling, especially in the statistics section, is a valid concern that we're committed to resolving.

**Accessibility:** Participants generally found the elements in the web application, such as charts and filters, to be distinguishable and relatively easy to use. While many appreciated the accessibility of these elements, suggestions were made to enhance colour choices for colourblind users and to improve the display of charts after applying filters. The usability of filters received positive feedback, but some participants highlighted the need for clearer visual indicators for selected items.

Balancing colour choices based on user preferences and consistency with RAMP's design was a thoughtful decision. The suggestion to incorporate a small delay for filtering and updates is well-received, as it can provide smoother transitions and mitigate sudden changes. The emphasis on clearer indicators and accessibility considerations aligns with the commitment to ensuring the web application is user-friendly and inclusive.

**Design alignment:** Most participants perceived that the design effectively reflected the purpose of the web application. The clean, minimalistic design was noted for promoting efficiency and risk assessment information dissemination. Some initial impressions were that design was overwhelming but diminished with usage, leading to better understanding and navigation.

The observation regarding the potential design being overwhelming could stem from aiming to fit all elements into the viewport. However, letting the page to flow and providing breathing room is a solution that resonates with the goal of enhancing user comfort and navigation. The insight on the learning curve but users' quick adaptation shows that user familiarity with the design and functionality will develop over time.

**Comparison of bar and line charts:** In exploring participant preferences for bar and line charts, it became evident that these choices were influenced by a range of factors, including specific use cases, the nature of the data, and the timeframe being considered. During the research, participants showcased differing preferences based on their individual needs and requirements.

Bar charts emerged as the preferred option overall, mainly due to their inherent simplicity that allows for quick and intuitive data comparison. These charts were particularly favoured for scenarios where immediate insights and comparisons were paramount. On the other hand, line charts were embraced by participants who valued their ability to track trends over time and discern changes between data points. This preference underscored the significance of line charts for situations demanding a deeper understanding of data evolution.

The feedback gathered from participants provided valuable insights into the varied contexts in which these visualisation methods excel. Some participants even suggested the possibility of offering both chart options to cater to diverse user needs.

Overall, participants provided valuable insights into usability, design, interactive elements, and chart preferences. This analysis guides the enhancement of the web application to improve user experience and align with user preferences.

#### 5.4 Economic, societal, ethical and environmental considerations

In addition to the technical and usability aspects, it's important to consider the broader impact of the web application on society, the economy, the environment, and ethical considerations. The analysis explores these dimensions to ensure a holistic understanding of the implications of the degree project.

**Economic implications:** From an economic perspective, the web application can result in increased productivity and reduced costs associated with workplace injuries and absenteeism due to MSDs. By facilitating more informed risk assessment and proactive mitigation strategies, companies can potentially save on medical expenses, compensation claims, and operational disruptions. Additionally, the improved efficiency in analysing survey results can lead to streamlined processes and faster decision-making, enhancing overall productivity within organizations.

**Societal impact:** The introduction of the new web application has the potential to impact various societal aspects. By simplifying the presentation of RAMP survey results, the web application can contribute to improved ergonomics in workplaces by enabling better-informed decisions for risk mitigation. Organizations can use the web application to promote safer working conditions, enhancing the well-being of employees and reducing the occurrence of Musculoskeletal Disorders (MSDs). Furthermore, the intuitive interface design and effective data visualisation methods can empower users of varying technical backgrounds to engage meaningfully with the assessment results, fostering a culture of data-driven decision-making.

In the realm of accessibility, the efforts were comprehensive, but certain areas for enhancements are acknowledged. Notably, the absence of a dark mode feature for addressing light sensitivity and the lack of a colour-blind mode catering to those with colour vision deficiencies might have added to the web application's inclusivity.

However, a significant aspect that received priority was the proper utilization of HTML tags. This approach is important for enhancing the web application's usability for users who rely on assistive technologies like screen readers or keyboard navigation. Through effective implementation of these tags, not only is content organized coherently, but a seamless experience for users accessing the web application through alternative methods is also ensured.

**Ethical implications:** The application plays a crucial role in presenting risk assessment data that will inform decisions related to workplace safety. As such, it has an ethical responsibility to ensure that this data is presented accurately and without bias. The design elements such as language, scale, and colour should be carefully chosen to avoid skewing the interpretation of risk levels. For instance, leading language or colour choices that make certain data points stand out more than others

can introduce bias, affecting the integrity of safety measures implemented based on that data.

The consequences of misrepresentation are high. Incorrect or misleading visualizations could lead to inadequate safety measures, putting employees at risk, or conversely, could lead to an over-allocation of resources to areas that don't need it. Given these stakes, there is a strong ethical responsibility to be both accurate and impartial in the presentation of this data. Failing to uphold these principles could not only affect the well-being of employees but also lead to a range of consequences from minor inconveniences to severe safety hazards.

**Environmental impact:** While the primary focus of this project is on data visualization and user experience, environmental considerations are also relevant. The digital nature of the application has the potential to reduce the need for printed materials and physical meetings, which could offer some environmental benefits. However, it's also important to note that web applications inevitably have a carbon footprint associated with server usage and energy consumption for end-users. After consideration, there were no pressing environmental impact concerns that warranted comprehensive exploration in this analysis.

## 6 Conclusions

The journey undertaken to develop the RAMP visualisation tool culminates with this conclusion. Through research, design, development and evaluation, a comprehensive exploration has been conducted, yielding insights and accomplishments aligned with the project's objectives.

### 6.1 Summarizing the journey

The endeavour started with the intention of enhancing the capabilities of the RAMP ecosystem in ergonomic risk assessment. The focus was the development of a web application that effectively presents survey results and enables the aggregation of data from multiple assessments. Throughout this pursuit, the trajectory encompassed theoretical understanding and practical implementation.

### 6.2 Key contributions

The main objective of this thesis was to develop a web application capable of making RAMP survey data accessible, understandable, and actionable for users. This endeavour has been largely successful through the design and development of a RAMP visualization web application that prioritized intuitive user experiences and the effective communication of complex information.

The application begins with a landing page where users select a category and then an item within that category for in-depth visualization. This efficient, streamlined process directs users to the main dashboard, which serves as the core of the application.

Visualizations play a central role in achieving the goal of making complex ergonomic risk data comprehensible. The pie chart offers a complete view of risk distribution, while the bar- and line charts provide a way to track risk over time. The data table not only arranges all assessments in a structured manner, but also includes sorting functionality, allowing for more effective data interaction, and understanding.

Functionality-wise, the application offers extensive filtering options. This feature directly aligns with the objective of providing users a way to tailor their data view based on a variety of aspects such as organizational divisions, risk parameters, or time frames. Active filters are displayed as 'chips' on the dashboard, each representing a specific filter criterion. These chips allow for easy identification and removal, adding a layer of interactivity and clarity.

However, not all objectives were met. While basic tools for data comparison are provided, a comprehensive comparison tool as initially envisioned was not incorporated. Similarly, the current state of the application does not allow for user-customized visualizations, limiting user control over how data is displayed.

The evaluation phase added significant value to the project. User testing and surveys were conducted, involving participants from diverse backgrounds such as software development, UX design, and people familiar with RAMP. This multi-faceted evaluation provided critical insights into the application's user interface, functionality, and overall experience, serving to understand its strengths and weaknesses from various perspectives. This process not only affirmed that many of the initial goals were met but also offered a roadmap for future refinements.

### 6.3 Future work

As this thesis concludes, it signifies a point of completion while also indicating avenues for potential future exploration. The iterative nature of user-centered design suggests ongoing refinements based on user feedback and user testing conducted. Potential enhancements to visualisation methods, interactivity, and accessibility may contribute to a more refined user experience.

**Enhancing user instructions:** The feedback from user testing emphasized the need for clearer instructions on how to use and navigate the web application. Incorporating an "About" section with detailed instructions and explanations about the various components and pages can provide newcomers with a comprehensive overview. Additionally, implementing a guided walkthrough overlay with step-by-step instructions for new users could significantly enhance the onboarding experience.

**Addressing accessibility concerns:** The concerns raised about accessibility, including colour blindness, eye strain, and cognitive load, underscore the importance of making the web application user-friendly for a diverse audience. To address these concerns, consider implementing a colourblind option to ensure that users with colour vision deficiencies can effectively interact with the visualisations. Introducing a dark mode option can help reduce eye strain, and refining transitions and animations can create a smoother and less overwhelming user experience. For example, incorporating a filtering delay can prevent abrupt visual updates and make the transitions more seamless.

**Implementing export functionality:** An essential enhancement is providing users with the ability to export visualisations and data points, along with their chosen filter options. To achieve this, consider implementing a modal functionality that allows users to customize their export preferences. This feature can facilitate seamless integration of data into presentations, reports, and other contexts, enhancing the practical utility of the tool.

### 6.4 Parting reflections

In conclusion, this thesis has been dedicated to the advancement of ergonomic risk assessment and user experience through a focused web application design and data visualisation. The work completed demonstrates how effective design can make complex data more understandable and actionable. The project represents not just a conclusion but also a foundation for future work aimed at enhancing work environments through better design and technology.

## References

1. KTH. Divisions of ergonomics [Internet]. 2021 [cited 2022 Jun 6]. Available from: <https://www.kth.se/mth/ergonomi>
2. KTH. RAMP – a risk management tool for manual handling [Internet]. 2019 [cited 2022 Jun 6]. Available from: <https://www.kth.se/mth/ergonomi/forskning/ramp-utveckling-implementering-och-spridning-av-belastningsergonomiskt-bedomnings-verktyg-och-atga-1.60371>
3. KTH. RAMP - The programs [Internet]. 2017 [cited 2022 Jun 6]. Available from: <https://www.ramp.proj.kth.se/about-ramp/the-programs-1.726550>
4. KTH. RAMP - The modules [Internet]. 2017 [cited 2022 Jun 6]. Available from: <https://www.ramp.proj.kth.se/about-ramp/the-modules-1.726551>
5. Lina R, Carl L. User Manual for the Risk Management Tool RAMP© [Internet]. KTH Royal Institute of Technology, Unit of Ergonomics; 2017 [cited 2022 Jun 6]. Available from: [https://www.ramp.proj.kth.se/po-lopoly\\_fs/1.1132795.1641815918!/User%20Manual%20for%20the%20RAMP%20tool%20%28v1.02\\_2%29.pdf](https://www.ramp.proj.kth.se/po-lopoly_fs/1.1132795.1641815918!/User%20Manual%20for%20the%20RAMP%20tool%20%28v1.02_2%29.pdf)
6. ISO. ISO 9241-210:2019 Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems [Internet]. 2019 [cited 2022 Jun 7]. Available from: <https://www.iso.org>; International Organization for Standardization; 2019. Available from: <https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-2:v1:en>
7. Law EL-C, Roto V, Hassenzahl M, Vermeeren APOS, Kort J. Understanding, Scoping and Defining User Experience: A Survey Approach. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. Association for Computing Machinery; 2009. p. 719–28.
8. Stull E. UX Fundamentals for Non-UX Professionals: User Experience Principles for Managers, Writers, Designers, and Developers. Berkeley, CA: APress; 2018.
9. Gershon N, Page W. What storytelling can do for information visualization. Communications of the ACM. 2001;44(8):31–7.
10. Borkin M, Vo A, Bylinskii Z, Isola P, Sunkavalli S, Oliva A, et al. What Makes a Visualization Memorable? IEEE Transactions on Visualization and Computer Graphics. 2013;19(22):2306–15.

11. Stephen F. Data Visualization: Past, Present, and Future [Internet]. 2007 [cited 2022 Jun 15]. Available from: [https://www.perceptualedge.com/articles/Whitepapers/Data\\_Visualization.pdf](https://www.perceptualedge.com/articles/Whitepapers/Data_Visualization.pdf)
12. Ward MO, Grinstein G, Keim D. Interactive Data Visualization. Boca Raton, Florida: CRC Press; 2015.
13. Janvrin DJ, Raschke RL, Dilla WN. Making sense of complex data using interactive data visualization. *Journal of Accounting Education*. 2014;32(4):31–48.
14. Bikakis N. Big Data Visualization Tools [Internet]. 2018 [cited 2022 Jun 15]. Available from: <https://arxiv.org/abs/1801.08336>
15. Kosara R. Encoding vs. Decoding [Internet]. 2017 [cited 2022 Jun 15]. Available from: <https://eagereyes.org/blog/2017/encoding-vs-decoding>
16. Knafllic CN. *Storytelling with Data: A Data Visualization Guide for Business Professionals*. New York, NY: John Wiley and Sons (WIE); 2015.
17. Nambiar R. *Transforming Industry Through Data Analytics*. Sebastopol, CA: O'Reilly Media; 2017.
18. Stufflebeam DL, Coryn CLS. *Evaluation Theory, Models, and Applications*. New York, NY: John Wiley and Sons (WIE); 2014.
19. Chin DN. Empirical Evaluation of User Models and User-Adapted Systems. *User Modeling and User-Adapted Interaction*. 2001;11(1–2):181–94.
20. Gallardo J, Molina AI, Bravo C, Redondo MÁ, Collazos CA. Empirical and Heuristic-Based Evaluation of Collaborative Modeling Systems: An Evaluation Framework. *Group Decis Negot*. 2011;20(5):535–62.
21. Nielsen J. Ten usability heuristics [Internet]. 2005 [cited 2022 May 5]. Available from: <https://www.nngroup.com/articles/ten-usability-heuristics/>
22. Fowler FJ. *Improving survey questions: Design and evaluation*. Thousand Oaks, CA: SAGE Publications; 1995.
23. Nielsen J. *Usability Engineering*. San Francisco, CA: Morgan Kaufmann; 1994.
24. EU-OSHA. About EU-OSHA [Internet]. 2019 [cited 2022 Jun 22]. Available from: <https://osha.europa.eu/en/about-eu-osha>



25. EU-OSHA. ESENER 2019 [Internet]. 2019 [cited 2022 Jun 22]. Available from: <https://visualisation.osha.europa.eu/esener/en/survey/overview/2019>
26. EU-OSHA. ESENER 2019 Data Visualisation [Internet]. 2019 [cited 2022 Jun 22]. Available from: <https://visualisation.osha.europa.eu/esener/en/survey/datavisualisation/2019>



## Appendix

### Appendix A – Survey questions & usability test criteria

#### Appendix A.1

The following questions were used in the evaluation form of the resulting web applications.

#### Evaluation form questions

1. Age?
2. Gender?
3. Occupation?
4. Have you had any previous experience with RAMP?
5. What is the average score of the filtered data?
6. Between Aug 2022 and Mar 2023, how would you describe the change of green, yellow, and red assessment?
7. What is the worst score of the filtered data?
8. What is the score for assessment 22?
9. How well did the web application organize and present the data to help you understand and interpret the information easily?
10. Were you able to accomplish your tasks efficiently and effectively on the website? Please elaborate.
11. How would you rate the web application's navigation in terms of intuitiveness and ease of use?
12. Did you encounter any difficulties in finding specific features or information?
13. Were the interactive elements, such as charts and filters, clearly distinguishable and easy to use and understand? Please elaborate.
14. How would you rate the overall design of the web application in terms of aesthetics and visual appeal?
15. Do you think the design reflects the purpose of the web application effectively? Please elaborate.

16. Did you find the use of colours, typography, and charts on the web application visually pleasing and suitable for the content? Please elaborate.
17. After using both the different charts, which do you prefer to see risk distribution over time?
18. Please elaborate why you prefer one over the other.

**Appendix A.2**

The respondents were asked to navigate the web application from the landing page to the dashboard and chose filters based on criteria presented to them. The criteria they were shown is shown below.

**Usability test 1**

Choose the field and filter the data based on the below criteria.

- The data is represented by the work station field, with the work station 004 option.
- The data is from 2022-08-23 to 2023-12-27.
- The data is from site 001 and site 004.

**Usability test 2**

Choose the field and filter the data based on the below criteria.

- The data is represented by the Representative field, Camilla DeSantos.
- Assessment Name 10, 13, 17, 22
- The data is only from 2023.

## Appendix B – Full answers from the free-form survey questions

This section contains the full answers for the free-form questions in the survey.

### Appendix B.1

Were you able to accomplish your tasks efficiently and effectively on the web application? Please elaborate.

#### Evaluation free form answers

- Yes, I was.
- It went quite well. I struggled a bit to locate all the prompts I was supposed to find at the front page at the start since I didn't realize the fields had similar options as to what I saw when I was assessing a random representative. When I realized this, it was pretty easy to navigate but the only real issue I had was inputting the dates since I needed to alt+tab to read the instructions and find the correct dates, it was a bit of a hassle to say the least.
- Yes. The time spent learning the website on question 1 made it so question 2 could be answered faster. Information is easy to find on the website when you understand where different options are located. Although at first glance it might look like the website gives away too much information at one time.
- Yup, with the help of the descriptions given in this form.
- Yes, the descriptions within each category were clear and intuitive.
- It was complicated and hard to understand.
- Mostly, but the date-picker seemed to change from value when to was selected, and the other way around.
- I'm missing some Labels and Help functions to help me understand more deeply, but I understand that it might be something added later on.
- Assessment X, the title of the column is "Name", but I thought name was Camilla DeSantos, so this was confusing at first.
- yes, but the calendar widget was a bit confusing to interact with. If you move the start date and end date also needs to be select again so you have to go back and choose the end date.
- Very user-friendly, however the numeric font size on the pie chart & the histogram could be helpful if a bit bigger.
- Yes, there were some difficulties. The calendar accepts typing but forgets the typed numbers meaning that you need to remember all dates exactly.

- it was easy to execute and understand how to use it.
- The instructions were clear and easy to follow. Otherwise, it would have been quite difficult to navigate since I have not been familiar with this interface or the processes it depicts.
- I was able to accomplish all tasks. It was easy to get the grasp of it.
- Yes, the filters were easy to use, and I had no problem to accomplish the tasks without any prior experience with the website.
- For the most part so was it easy to perform set task except the positioning of "Average Score, Worst Score and Best Score" as they feel a bit "hidden" to make room for the other objects on the webpage.
- Yes, it was clear, except part of the document for the first filter I didn't get to choose workstation 004 from the landing page.
- It was very clear to follow the instructions and filter the results accordingly.
- For some fields, such as date and scores, they were not clear to find them. they need to be highlighted.
- Yes

## Appendix B.2

Were the interactive elements, such as charts and filters, clearly distinguishable and easy to use and understand? Please elaborate.

### Evaluation free form answers

- Yes although maybe change colours for colourblind.
- They were distinguishable but I felt that they took up a bit too much space compared to all the filters I had to navigate at first in order for the chart to be what was requested. Maybe the buttons can have some colour in them as well to make them pop more. I felt that the graphs were a bit overwhelming with their size. Maybe not having the chart appear right away would help, make the user put in the values first instead of handing them everything filled in since that means nothing to me because I have not read the filters applied yet.
- The ease of access to the filter and the speed of the website made it very easy to use and understand. For smaller screens such as on a laptop, the absence of a scroll wheel made it so you manually had to zoom out in the web browser, which will affect users.
- Yes but on the landing page the chosen item in the dropdown menus should be marked somehow so the user knows that they have clicked the intended item.
- Yes
- Yeah it was fairly easy to understand and use the filters and charts
- On a medium sized laptop display, the dashboard ui is hard to grasp, too much info in one view. It's difficult to see the selected values (upper part of view). Info on buttons and other choices needed (e.g. hover -> info).
- The Datepicker needs more testing (buggy) and perhaps some additional features. But I guess you used some out of the box component. But either way, data is not getting updated when expecting so, and date selection sequence is, I think a bit confusing.
- All worked well, but I can imagine if you do this frequently, sorting by date, then you'd want to be able to actually enter date rather than clicking it. Entering a YYYY-MM-DD date is usually much faster than clicking many times to select the right year, month, etc.
- yes
- Pretty good, once again, the proportion of the font size to the histogram & pie chart could be improved.



- Yes, though it struck me that there was no labelling of the red, yellow, green columns which may cause accessibility problems for people with red, green colour-blindness.
- it was easy to understand and something i'm use to seeing in the context, and that was nice
- Somewhat easy, took a bit of time to familiarise with the information presented, but once I understood where everything was, finding the information to answer questions was easy.
- Yes. The search elements were based on name, risk, location, and date. Easy to use and understand.
- Yes, the chosen colours made it easy to distinguish between the low, medium and high-risk charts. The filters were also easy to use and to see which filter was chosen.
- "Date picker was hard to understand what option you have selected, picked date do look the same as the one already set and therefore hard to follow. Date picker allows user to enter text in already set filter.
- Inconsistency on the filter ""Name"" versus how it was mentioned in the test script. In the test script it says that you shall filter on ""Assessment name"" and not ""Name"" as it is displayed on the page.
- Sliders for "Score" and "Risk Color" for a new user are strange as the sliders can move in both directions. A short explanation text would improve understanding of how they are used and work.
- "Clear all" option in my opinion should be displayed as a button to high light it better same for the removal "X" for each filter."
- Yes
- Yes. Filters were easy to use and there was an indication below the filters which indicated the filters in use. The charts were very straight forward. However, a line chart would represent change over time better.
- Some of them such as the date filter were not clearly distinguishable.
- Whenever we want to change dates in the filter, we always have to set the both starting and ending dates again. It would be good if we had the option to reset just one of them. For example, let's say I had set a time period from Jan 22 - Oct 23, but then I changed my mind and want to filter from Jan 22 - Dec 23. It would be nice if I could reset just the ending date from Oct 23 to Dec 23, and had no need to set the starting date to Jan 22 again.

- In the main page, when we select a department/country/representative/site/workstation, there is a continue button that we need to hit in order to proceed with the flow. It felt that button was unnecessary, since multiselection is not allowed. So, clicking on the department/country/representative/site/workstation only should be enough."

### Appendix B.3

Do you think the design reflects the purpose of the web application effectively? Please elaborate.

#### Evaluation free form answers

- Yes.
- Yes, it does.
- It does well, there is still some learning room to be had when I first encountered this site. But by now I know which button does what and can easily navigate myself. In my opinion it felt a bit "harsh" to tread at the start, but it would be overcome by a couple of minutes of usage. The problem with this is that most people won't give it the benefit of the doubt if they have this issue. Most will click off.
- The design being very sleek and straight forward I think reflects the purpose, as in it shows that the application is supposed to promote efficiency. First impression of the site may be for many users that it is over encumbering, however once you understand where everything is and how it works, I believe users will be able to maximize their efficiency.
- Yes, clean, and neat design :)
- Yes, it seems like all the necessary activities within RAMP are presented in the dashboard.
- The design for when you chose filters and look at the charts feels a bit overwhelming.
- I think clearer info on what's selected/filtered and info on what the user can do with the ui is needed.
- The purpose is hard to understand. Adding some explanatory "About" section on the start page would help. Some users might not understand if they have arrived at the correct web site.
- On the front page, the logo appears twice, in the header and on the page. It only needs to be in one of the places. When you select e.g., Representative, it's not shown (no tick box or otherwise) which representative you've selected.
- looks perfect for admin use and the layout is well thought out.
- Precise & Minimal.
- Yes:)

- it is basic but reflects the purpose good enough.
- I think so. It is easy to detect different risk levels, all charts have titles, axes names and the legend. Not so clear what different statuses mean, perhaps having a possibility to see what "pass / fail" status implies or caused by, would increase understanding. However, it might be obsolete if the user is already familiar with the context.
- Yes
- Yes, the application is simple yet effective in its design, without unnecessary visual elements that might confuse the user.
- "Start page is good gives you all you need but there are dominant colours making the UI hard to look at. Using the 60-30-10 rule for UI is a good practice.
- Data page feels "crowded"" and "boxy"" it gives you all the data but almost too much so that data like "Average Score"... feels hidden. Again, colours need to be improved as there are many different colours dominating the screen making long session hard on the eye.
- The section of average score, worse score,... is not clear and they look like a help text maybe because of the text colour(pale) or the section is not divided clearly.
- I don't not know being responsive is important or not, but charts are not clear in the mobile view, table is responsive and handled in a good way.
- The web application is a risk assessment visualizer which it does a great job of showing. You chose a field and get the data for the chosen field; nothing less nothing more.
- yes, it will affect the user experiences.
- Yes.

## Appendix B.4

Did you find the use of colours, typography, and charts on the web application visually pleasing and suitable for the content? Please elaborate.

### Evaluation free form answers

- Yes
- Pretty easy for the eyes font choices which is good, I feel that the colours may be changed. a colourblind person would struggle with the red and green for example. I also felt that the percentages on the graphs were a bit too tiny, so I had to strain myself a little to see, especially on the green ones.
- Yes, they were very helpful and made the different stats very distinguishable, the use of colours like red, yellow and green is very good.
- I believe so, green is often associated with good, yellow medium and red = bad, so the colour scheme is something people are used with, which makes it more intuitive. And the types of charts are very common so most people would be used to read them already.
- Yes, the different colours made it easier to distinguish each chart etc, (visually pleasant)
- Yes
- Ok.
- The colours are a bit "too red", "too green" and "too yellow". The RGB values are `rgb(255, 0, 0)`, `rgb(0, 128, 0)` and `rgb(255, 255, 0)`. Normally, the clients brand manual should be used, or if there is not a client yet, use an online Colour Palette Generator. The site seems to work good responsivly (on a mobile) but the table could have switched to a Condensed Font version when viewport is narrow.
- Just a little confusing that high score = bad, rather than the opposite as I would've expected.
- Yes, the colours charts and spacing between elements is visually appealing.
- It was a good fit.
- The layout of the website suits the purpose well. I would suggest redesigning the worst, average and best scores as the underline suggests that the values are clickable. As previously mentioned, the colours/patterns of the graphs might be interesting to reconsider for accessibility reasons.

- it was following something I am used to seeing and that made it easy to understand the visualisation.
- The colour scheme, although not my favourite, allows clear distinction between risk levels making it easy to navigate and follow the trends in the data.
- Yes, the colours and typography were pleasant for the eye.
- Yes, the application is visually appealing yet effective which in my opinion suits the content very well.
- Too many dominating colours making the UI hard to look at for longer periods.
- Selected colours for the chart are great.
- I don't know is good or not but maybe consider average score,... in the card(like other parts) and combine it with Total risk distribution chart in the one row. Then display table and other chart into specific rows."
- Yes. The colours red/yellow/green are universally known to mean bad/neutral/good which helps with interpreting the results. Pie and bar charts are also very easy to read and understand.
- yes
- While the colours theme chosen for displaying graphs convey the information effectively, it would be more visually appealing if the colour saturation were not so high.

## Appendix B.5

Please elaborate why you prefer one over the other.

### Evaluation free form answers

- Easier to keep track of the chart.
- I feel that the bars are easier to read but that the line chart makes it easier to see the trends in real time better. If I was an economist or something, I would have probably preferred that over the other.
- I do find the bar chart a bit more visually appealing, however the purpose to see the change over time is to understand how the different risk zones have changed. And I believe the line chart makes comparing a lot better. You can easily see how singular risks (e.g., high risk) changes over time and at the same time compared to the others. While on the bar chart it is very hard to understand exactly how they changed between datapoints instead you are looking more at each datapoint separately.
- Cleaner, more readable, I think it looks messy with the lines overlapping each other. Linear charts are in my opinion better used when singular lines are showed one at the time. If you were to use the line chart you should provide a filtering option to filter out and in the different lines, for a more customizable view.
- It was more pleasant to see the overall risk distribution in a bar chart than in a line chart.
- It feels easier to see how it changes with time.
- If the purpose is the present changes over time the line chart version is better.
- Easier to understand the development of the values, as well as comparing individual dates that is not possible with the bar chars. Well done!
- Easier to follow the trend on the bar chart, but I'm missing a fourth line, the average, or something similar. I'd like to weigh the risks together, so I get a more prominent line showing the average trend, while perhaps having the red/green/yellow a little bit more in the background for context.
- No preference as such but will be good to have both charts as it depends on the data and the time frame. Maybe line chart is better when time frame is bigger.
- A bar chart is more user-friendly, and a Line chart reminds us about the financials, and the stock market, which could be perceived as overwhelming which in turn won't get the user engaged.

- The first version presented the overview of the information well, though the second one provided better detailed information.
- my first impression as that the line chart looked messy, but then I think it gave a better view over time than the bar chart.
- Bar charts having specific numbers on them allow to detect the values quicker. Line chart as it is looks a bit messier and more difficult to follow. The distinct advantage of line chart is its possibility to observe trends quicker. So, it depends on what user needs are.
- First one was more pleasant.
- Over a larger span of time like 10 years or so the line chart would be a better fit in my opinion. But for data over the span of 2 years the bar chart shows the data much clearer.
- If I cannot choose what type of chart to use, then bar chart is the best for this level of data but if I want to follow a particular risk then line chart is best.
- First chart was more clear to me.
- For me personally, a line chart represents change over time a lot better than a bar chart. There's a reason why it is commonly used in visualizing e.g., stock prices.
- The bar chart gives a glance of overall view for me.
- The line chart is easier to understand because we have a clearer view of the time slot (x-axis in the graph) being used in the comparison. In the bar chart representation, that axis is very confusing at first glance.





