Design and development of a web application for skills' Gap analysis

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Laurea University of Applied Sciences **Abstract**
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Digitalization is completely transforming the world and society, as well as how we work. The need to gain and develop digital skills has significantly increased in order to keep up with this new social and labor reality. Cybersecurity risks, as one of the many challenges of digitalization, need therefore to be addressed and tackled. For this very reason, the necessity to gain and develop digital skills is of paramount importance. But to reduce these security risks, it is essential to first identify digital skills levels amongst the population. The purpose of this thesis, as well as the project's ultimate objective, was to design and implement a tool capable of identifying and measuring these digital skills in order to assess and address cybersecurity weaknesses. This tool, a web application, was ordered and developed for Laurea University of Applied Sciences, which is a Finnish higher-education organization that operates in the south of Finland.

The research and development process of this project prompted, through the use of qualitative approaches and combined with the adoption of an agile development method, a comprehensive solution. A number of technologies such as client & server side tools, web programming languages, and cloud hosting resources were employed to accomplish this goal. The project was successfully implemented, and all its objectives were achieved.

Keywords: Gap analysis, radar graph, ECHO Project, web development, e-skills

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1 Introduction

Digitalization presents a huge opportunity and challenge for our generation. It is completely transforming business and market structures, how we work, and it is increasing innovation as a whole. Digital technology is vital for many types of businesses and sectors like healthcare, retail, manufacturing, and education (European Investment Bank, 2022, para. 1). Concepts like the 4th industrial revolution, the internet of things (IoT), smart society, or the omnipresence of the internet are well known to most of us, or at least we have heard about them in some form or another.

The necessity to gain and develop digital skills during COVID19 might have increased in order to keep up with social and labor transformations during this period, but this need has already existed for quite some time now, which was aiming to better prepare workers for a digital future labor market. This necessity to educate and reeducate the population impacts the present workforce in addition to the population currently in school. This health crisis may have speeded up digital transformation, but it may have also further increased the digital divide among the population (Milanesi, 2020, para.4).

This increase in the need to acquire digital skills can also be represented using economic terms. There are benefits to society when investing in *human capital*. Refusing to do so, creates an *opportunity cost*. This could be manifested as social and economic costs of having a part of society not able to produce output for lack of skills (Blöndal et al. 2002, 27).

Unfortunately, and not surprisingly, with great possibilities also come great risks. Namely, cybersecurity risks as one of its many challenges. Therefore, the necessity to gain and develop digital skills should also be the focus to achieve a reduction of these security risks together with encompassing awareness among the general public.

As a consequence, and related to this increase of cybersecurity issues, public awareness appears to have also increased due to this perceived or real threat. Figure 1 represents a visual illustration obtained using Google Trends. It depicts how active the general public has been searching for information related to this phenomenon over the last 18 years. The reader will observe a tenfold increase since 2014, which is quite remarkable and goes to show how public consciousness and awareness have dramatically increased during the last 8 years (from 2014 to 2022).

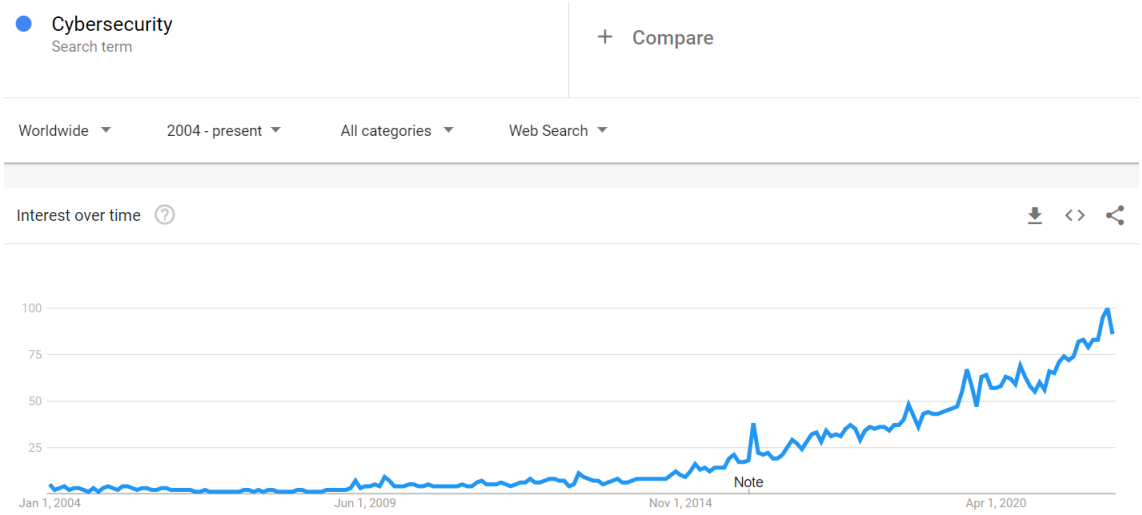

Figure 1: Google Trends result on the search term "cybersecurity".

According to a research report conducted by IBM (IBM Security Services 2014 Cyber Security Intelligence Index, 2014, 3), “over 95 percent of all incidents investigated recognize ‘human error’ as a contributing factor”. This seemingly trivial piece of information is vital to understand the objective and significance of this project. It is in fact its *raison d'être*.

Keeping ahead of these real or perceived threats is paramount to fight cybercrime. One obvious solution, among others, is to update IT skills in the general population as a whole in order to reduce this “human error” factor to a minimum. But to reduce this human error, it is imperative to identify IT skills levels, or related skills, in the population in the first place, hence some sort of measurement methods and tools are needed.

1.1 The organization

Laurea University of Applied Sciences is a Finnish higher-education organization that operates in the Uusimaa region at six different campuses: Hyvinkää, Leppävaara, Lohja, Otaniemi, Porvoo and Tikkurila. Its fields of study are Business Management, Social Services, Health Care, and Hospitality Management. It offers 18 degree programs, six of which six are taught in English. Laurea was established in 1992 and its education is based on the Learning by Developing (LbD) operational model.

Laurea is also a partner of the *European Network of Cybersecurity Centres and Competence Hub for Innovation and Operations* (ECHO). This ECHO project is one of four pilot projects that the European Commission has launched with the objective of connecting and sharing knowledge across multiple domains to develop a common cybersecurity strategy for Europe (Echonetwork, no date). The relation between Laurea, the ECHO project, and this project will be shortly established.

1.2 The project

The organization in question (Laurea UAS), was interested in promoting awareness about cyber security risks and challenges. For this reason, it was looking for ways to identify and quantify readiness in order to assess and address cybersecurity weaknesses, be that of individuals or organizations as a whole. A solution to this challenge was required, and a way to achieve this goal in a concrete manner was needed in order to produce, gather, and convey such information.

The task for this project was to create and deliver a web app, toolkit, or artifact (Let the reader know that from this point onwards, these terms will be used interchangeably and will come to have the same meaning) that would help the interested part (managers, team leaders, etc.) gather quantitative data in order to measure, quantify, and assess a certain set of skills from potential users. The clients also left the door open to the possibility of future improvements, corrections, and additions from future developers that would take on this same project, as this is an ongoing project that will be refined, improved, and further develop over time. The timeframe for the development process was originally agreed to last three months but the clients offered ample leeway to accommodate for possible additions, improvements, delays, or obstacles. At the end of this timeframe, certain parts, if not all of the objectives, would have to be achieved and ready to be deployed as a fully working solution. At the end of the day, this flexibility proved to be of the essence as not all went as straightforward as expected. A final product was successfully delivered but it took longer than expected due to various technical reasons that will be further explained down the line.

1.3 Project goals

The main objective of this project was to create and deliver a toolkit in the form of a web app that would gather data and later produce and convey such data in the form of a *GAP-analysis* of said skills and values. This Gap analysis would be visually represented as a *radar graph*. In chapter 2.1.2, the reader will find a graphical representation of a radar graph.

According to Weller (2018, para. 2) “A gap analysis is [a] process that compares actual performance or results with what was expected or desired”. It is because of this, that the clients wanted a tool to identify actual and desired or expected level of skills to assess readiness to meet certain cybersecurity challenges. In other words, a tool to identify skill gaps.

Skill gaps are portrayed as deficient, or not enough skill levels, among workers to meet the needs and requirements of their present job (McGuinness & Ortiz, 2016, 1).

In order to identify skill gaps, this toolkit would have to:

1) gather actual (or perceived) data from individuals according to the perception they have of their own skills,

2) gather desired data (target data) from the organizer of the survey, and

3) contrast both data with each other.

It would also need to compare the target data with the average of all individuals taking the survey according to group or team they have been assigned to. Figure 2 *(Giannosa, 2020)* represents a visual illustration of the steps needed to identify skill gaps.

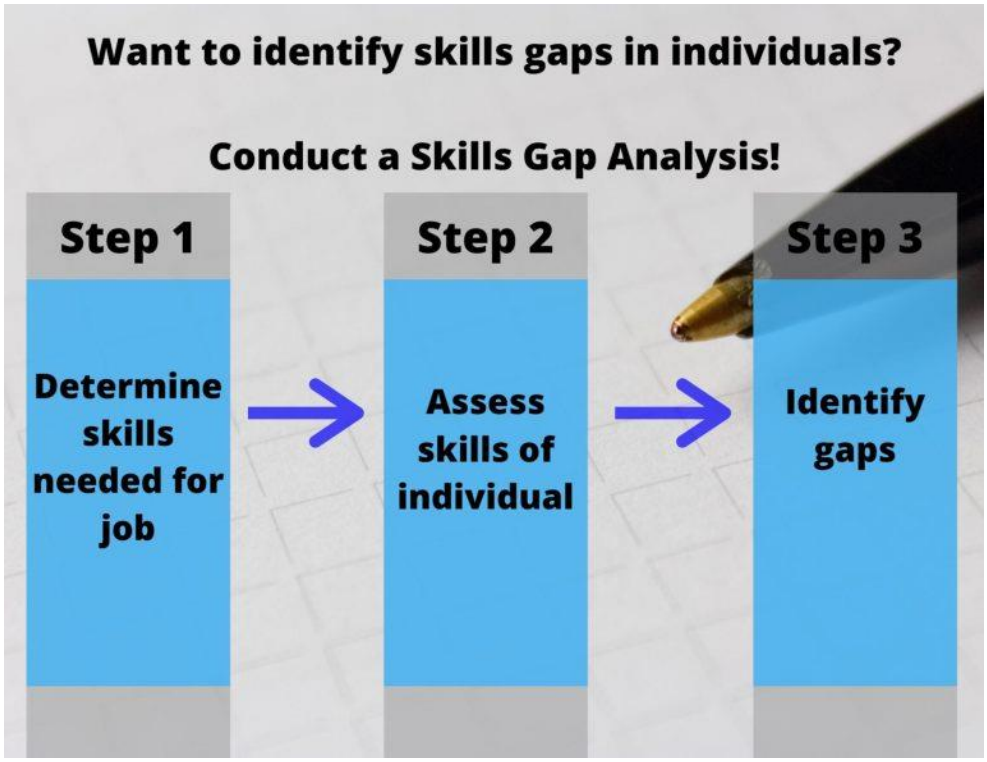

Figure 2: Skill Gap Analysis three-step process.

This can also be mathematically explained with a formula whereby negative numbers would mean lacking needed skills or too much emphasis on those same skills, and positive numbers would mean fulfilling the skill requirements. Figure 3 illustrates this formula. There is a caveat or explanation to prevent misinterpretation about the figure. Where it says "stuperception - refers to student perception on the importance of skills", it should say for the sake of our own purposes "an individual's own perception of his/her skills". That way, it would properly reflect what we are looking for in this project. This is of no importance as this formula can be implemented in different ways so the wording of the numerator variables can accommodate the data we intent to use depending on what kind of result we are after.

$$Skills\ Gap = \sum_{i-1}^{n} \left[\frac{(stuperception - iduperception)}{n} \right]$$

I	refers to the ith respondents
N	refers to the total number of respondents
$stuperception$	refers to the student perception on the importance of skills
$iduperception$	refers to the industry perception on the importance of skills

Figure 3: Skill gap formula (Adapted from Patacsil et al. 2017).

1.4 Project risks and limitations

As with everything in life, there are always risks involved in every new challenging endeavor you take upon. This project was not different. Just to mention a few, there were time constraints, lack of experience from the developer and therefore a small lack of self-confidence. Choosing the right tools was also essential to develop the project so that no time would be wasted using the wrong technology so as to avoid dead ends and/or bottle necks. More on this in the second chapter.

Another limitation was the training of the clients on the use of the final product once this was launched as there was certainly going to be a learning curve for the client with regards to its use so the availability of the developer was important in order to solve any questions or doubts the clients might have when using the toolkit. I would say, with a cautious degree of confidence, that I have been there to support and help my clients whenever my assistance was needed. A poor user experience would also diminish its user-friendliness and usefulness.

2 Research methodology

For the project to succeed, it was paramount to choose the proper research methodology in order to identify how best to gather essential data for developing the intended solution. This would also help identify what kind of technology would be needed to effectively accomplish such objective. Previous gathered knowledge during my studies quickly helped me identify that a *qualitative* approach to the research work would be the best approach for this kind of project. Thus, this methodology was chosen for the aforementioned reason.

Generally speaking, the phrase *qualitative methodology* describes a type of research that generates descriptive data. This could be defined as a person's own written or spoken words and perceptible behavior (Taylor et al. 2015, 17).

From the different types of Qualitative Research Methods, the research type chosen for this project was *case study*. According to Yin (2009a, 18), "A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real life context, especially when the boundaries between phenomenon and context are not clearly evident".

2.1 Research methods

The research methods that were applied to the case study were crucial for understanding the whole picture and for envisioning a solution based on the gathered data. These techniques would shed light, identify, and provide a clear idea of what the clients are after, their wishes, the specifics of what they want and how they want it. These data collecting techniques consisted of interviews, prototypes and pictures, benchmarking, and service design.

2.1.1 Interviews

Interviews formed the main source of information gathering when doing research and it was the backbone of the research work as a whole. The clients, as members of Laurea's teaching staff, were well seasoned and had ample experience with regards to research. This, together with their pedagogical skills, made interviews very professional as well as very casual, which helped in creating an optimal atmosphere for the exchange of ideas. As a student, this was of great value. Qu & Dumay (2011, 239) refers to a framework by Alvesson (2003, p. 14) where he summarizes interview methods as belonging to three main types: structured, semi-structured and unstructured interviews. The casual and conversational nature of the interviews conducted with the clients can also be categorized as unstructured interviews as these were completely open and the exchange of ideas was fluent. This flexibility enabled us to fully cooperate with each other in order to exchange information regardless of hierarchical differences.

2.1.2 Pictures and graphic images

Making use of visual methods permits us to extent research to include information that cannot be accessed verbally (MacDougall 1997,84, cited in Seale et al. 2004, 361). An initial sketch on how the project could hypothetically look like was provided in the first interview by the clients themselves in the form of a graphic image, which provided the kind of information that is hard to explain using words. The clients reassured me that in any way the layout had to necessarily look like the image provided. The intention of that image was to convey the main points they were after like a list of skills, the input of values to those skills, and the resulting radar graph. Figure 4 below visually presents an example of a potential design.

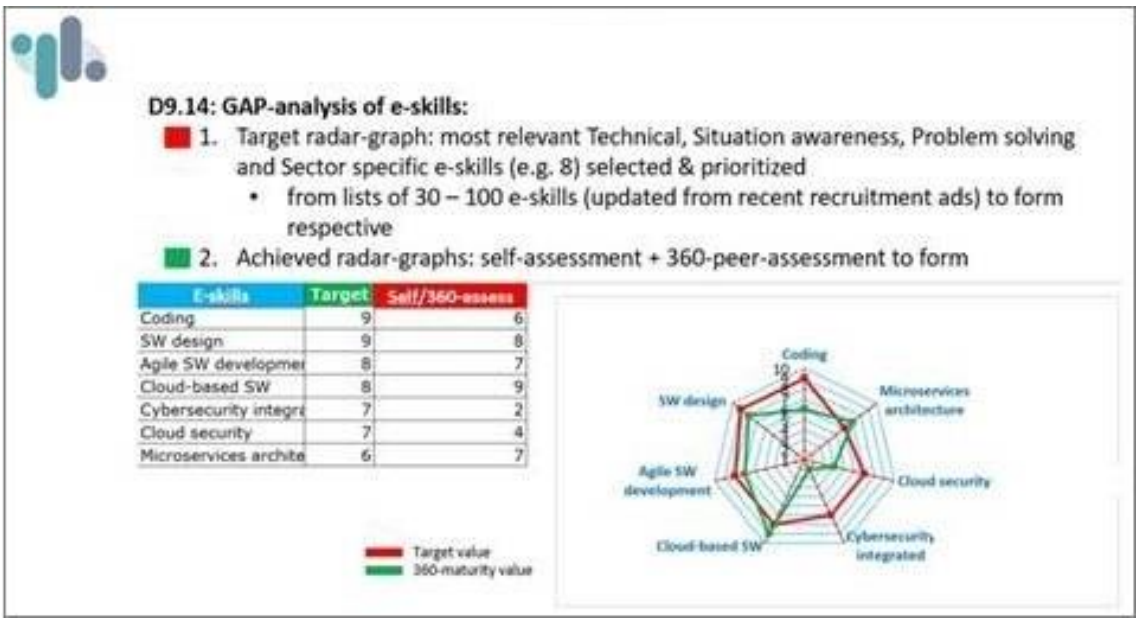

Figure 4: Picture provided by the clients

2.1.3 Benchmarking

Benchmarking is closely tied to the previous chapter as no *wireframes* were needed because of an already existing web site belonging to the ECHO project that showcased the layout template; and because of the image, mentioned in the previous section, provided by the clients.

Benchmarking is an improvement process where a company or organization contrasts and measures its performance compared to companies or organizations considered to be at the top or ahead of others (Bemowski, 1992, 20, cited in Jaideep et al. 2006, 229).

In other words, no wireframes were needed due to the fact that the clients wished the project to utilize the same layout style of that of the ECHO project web site. Therefore, there was no need to create a new theme, banner, navigation bar, footer, colors, icons, etc.

as this template already existed. *Wireframes* are blueprints that convey developers a general idea of what the most significant elements are in a web site or app. They are like a bare structure that a developer uses to fill up or give shape by inserting other elements like visual ones, brand elements, etc. (Miller, 2011,162).

The clients particularly expressed they wanted to emulate the style and quality of said web site. Overlaying the image provided by the clients on top of the ECHO project web site template without content would more or less illustrate how it could potentially look like, which graphically could convey a far superior impression than a wireframe could ever give as it would closely resemble a mockup or static prototype of a solution. In other words, the quality of this visual representation was graphically superior to a handmade drawing and/or wireframe. In that sense, my job was not to improve the quality of an existing page (as usually is the case with benchmarking) but to "*mimic it*". Figure 5 represents the initial mental visualization of a potential layout from the developer's point of view disregarding functionality and logic.

N.B: Benchmarking was applied only to mimic the visual quality of an existing web site and a graphic image. The ECHO project is a non-profit project so the intention at this point was never to improve economic performance nor fulfill any other requirement variables that might be considered to be part of a benchmarking process.

Figure 5: Preliminary visual representation of a potential layout.

2.1.4 Service design

Service design could be defined as an approach to engage stakeholders, be those customers or staff, in the creative part of the developing process. This type of "co-creation" could be thought of as designing *with* stakeholders, not for them. Allowing customers to participate in the designing of ideas as well as having the opportunity to examine their behavior as they do so, offers a strong foundation for improvement (Reason, 2015, 17). Figure 6 represents the design thinking process involved (Butler, 2018). Figure 7 gives another visual example of a service design process from the same source.

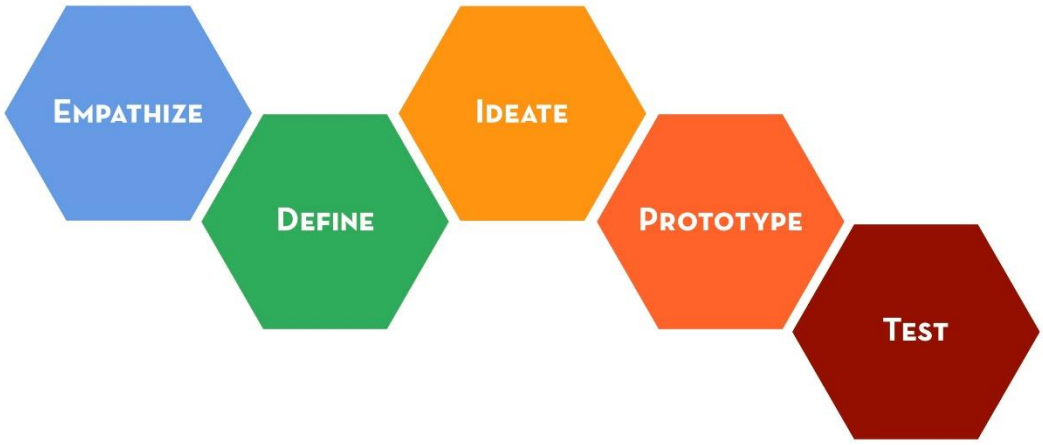

Figure 6: Design thinking process

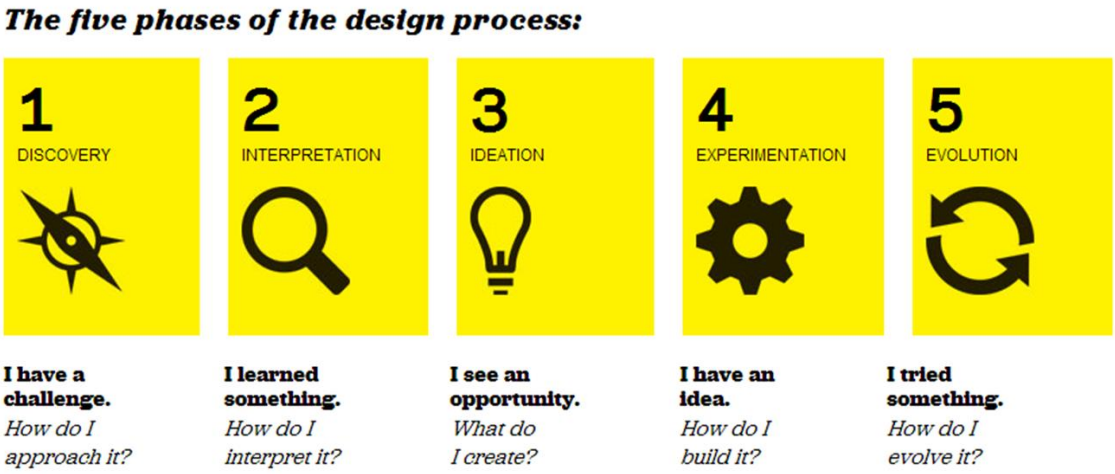

Figure 7: Alternative example of the service design process.

This process proved to be invaluable as it was used not only during research, but it was also recurrently applied during the ideation and development process of the project in a deliberate as well as instinctive way. It allowed all stakeholders to continuously exchange ideas throughout the project to achieve the most optimal solution by always considering technical issues and limitations, client wishes, overall requirements, and the like.

2.2 Development methodology

The preliminary research was key for identifying what kind of methodology would be the most suitable for the task at hand. For this reason, a *sui generis* as well as an *ad hoc* approach was chosen for this project, which can confidently be classified as an *agile* approach.

Agile is a general definition for practices and methodologies that have surfaced over the last two decades to improve quality, flexibility, and business value of software solutions by continuously producing low-risk, high value software solutions (Cooke, 2012, 29). Two of the most popular software development agile methodologies used nowadays are *Scrum* and *Kanban*. Although similar to each other, they differ in a few points (Bauer, no date). The techniques that were used during the development of this projects, and that are part of both methodologies, were: setting of priorities, regular meetings with the clients when needed or agreed upon (every 1-2 weeks, or even longer periods), and frequent feedbacks from clients. What made it different from both methodologies were: there was only one developer so there was no team nor team leader (also known as *scrum master*), and meetings were arranged at the client's and developer's discretion. Hence the term *sui generis*. Figure 8 from Bauer (no date) illustrates the agile process and steps.

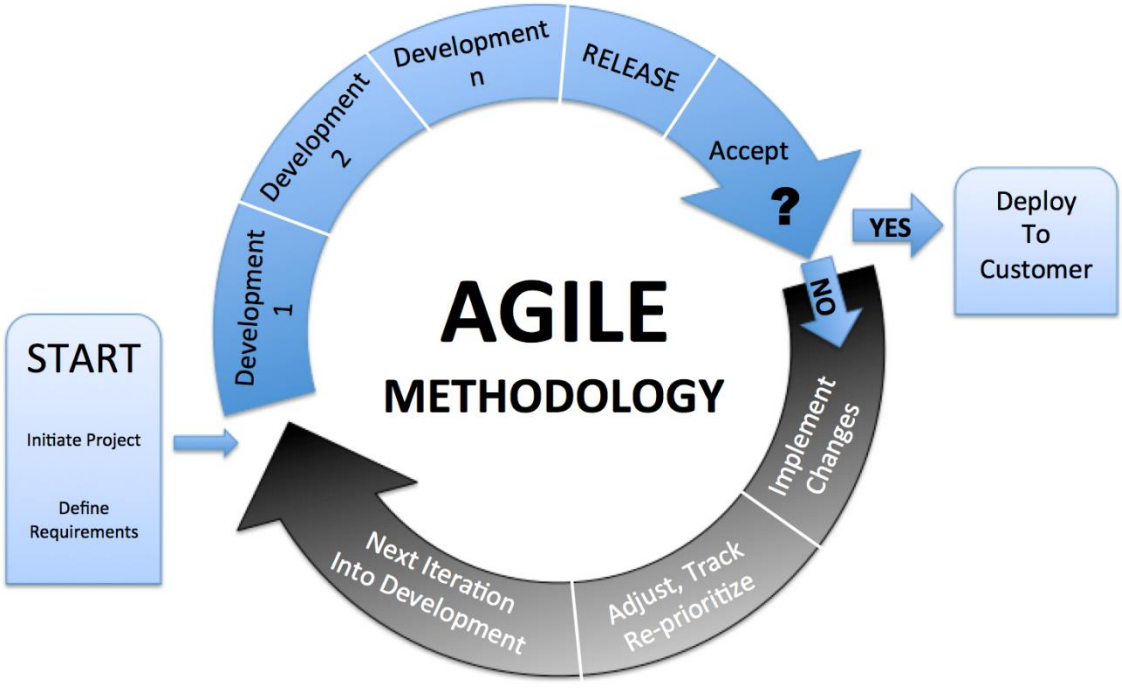

Figure 8: Agile Development Process

3 Development Tools & strategy

A variety of tools were used during the development of the ECHO project toolkit. The decision for choosing said tools was based on a preliminary assessment of the technical requirements that took place during the research work. Some of the tools that were used include use case diagrams, a local test server environment, web development programming languages, web development frameworks, and hosting environment. Every one of these tools played an important part in the development process and as an intrinsic part of the final web app. Their role will now be individually described and why they were chosen for this project.

3.1 Modelling

In order to construct functionality and logic, some sort of strategy was required to help picture the steps needed to accomplish such task. One such tool is *use case diagrams*. Use case diagrams offer a general idea of the relationships and connections amongst all parts in an individual use case. These diagrams are clearly recognizable, easy to create and comprehend. They are a good way for all stakeholders to convey and understand the workings of a system (Jorgensen, 2009, 172). Figure 9 from Jorgensen (2009, 173) illustrates an example of use case diagrams.

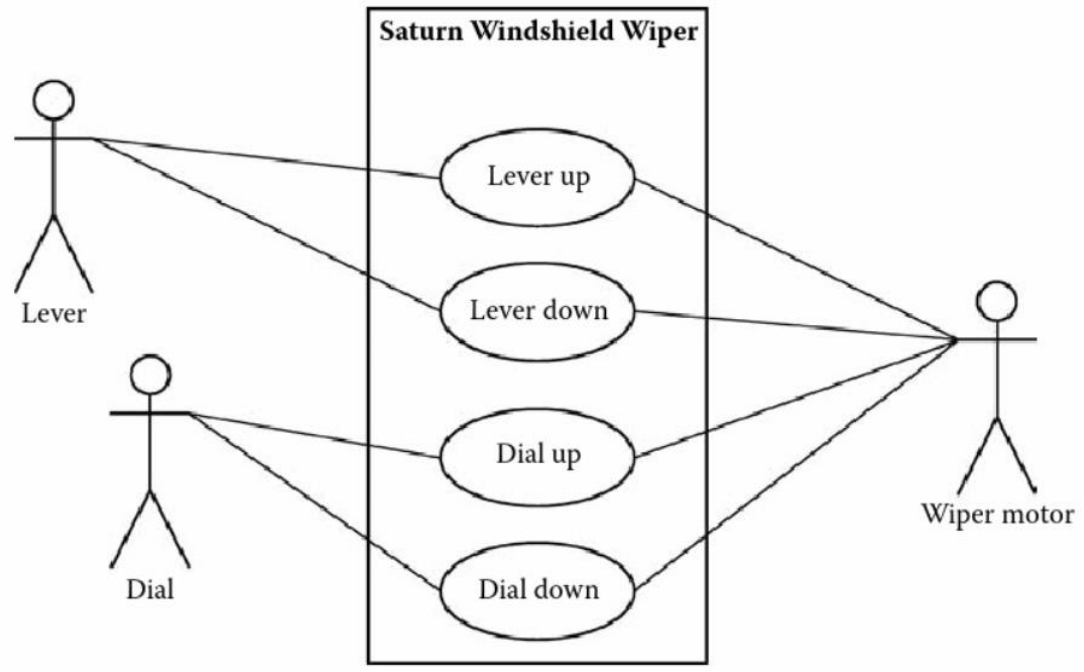

Figure 9: Example of a use case diagram

3.2 Web development tools

Research work, and use case diagrams created during the modelling process, helped identify what kind of web developing tools would be required for the creation of the toolkit. These tools would allow the developer to encompass visual as well as logic and system requirements. At this point, it was essential for the developer to choose the best ingredients in order to integrate and ensemble visual requirements with functional requirements to create a comprehensive solution. Web development tools can be categorized as front-end and back-end technologies.

3.3 Front & Back-end Web Technologies

In order for a web app to work properly, the developer needs to integrate all technologies to produce a comprehensive solution, as stated in the previous section. The way to integrate all these moving parts is by smoothly bringing together front-end and back-end technologies to work in tandem.

What we understand today as Front-end and Back-end development was once known as Web Design and a Web Development, respectively (Wellens, 2015, 7).

The difference between Front-End and Back-End is that Front-End has to do with to how a web page looks and its outside appearance, while back-end, on the other hand, refers to how it works, the structure, and what happens under the hood behind the scenes. It helps to think of Front-End as client-side and user interface (browser) and Back-End as server-side and databases (w3schools, n.d.).

Since this project leveraged from both front-end and back-end technologies, it could be described, for all intents and purposes, as a *full stack* application, which as the very name suggests, it is a combination of both front and back technologies. Figure 10 illustrates a Front-end vs Back-end graphic representation by Dabbs (2019).

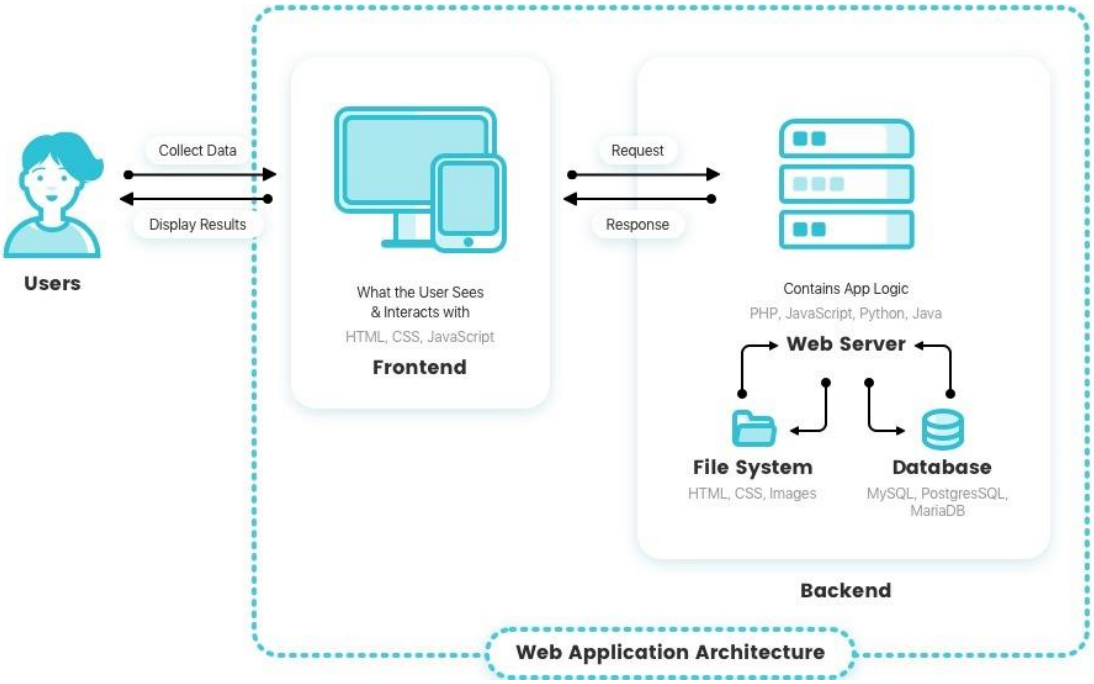

Figure 10: Front-end vs Back-end graphic representation

Table 1 briefly and superficially describes all tools used in this project.

Front End (Client/browser side)	Back End (Server side)
HTML (The language for building web pages)	PHP (A web server programming language)
CSS (The language for styling web pages)	MySQL (A language for accessing databases)
JavaScript (The language for programming web pages)	XAMPP (A local test server environment)
Bootstrap (A CSS framework for designing better web pages)	Azure (A cloud computing service operated by Microsoft)
jQuery (A JavaScript library for developing web pages)	
RGraph (A JavaScript library for the creation of charts and graphs)	

Table 1: Front-end & Back-end web technologies used for this project

3.3.1 HTML

HTML is short for Hypertext Markup Language. Hypertext is text that has hyperlinks, which are sections of a document that can be clicked on in order to go to a different HTML document connected to that link. HTML gives content to a site. An HTML document consists of tags with text in the middle of them (Wellens, 2015, 2-3).

3.3.2 CSS

Cascading Style Sheets (CSS) is a technology that functions in conjunction with HTML and enables the developer to choose the layout and style of the page, and how it will look like (Wellens, 2015, 10).

3.3.3 JavaScript

JavaScript is used for programming web pages and for adding life and behavior to these. JavaScript code is interpreted by the browser, as it is the case with HTML and CSS. JavaScript allows the developer to program the behavior of web pages and interaction with the visitors of a website. It can also change the contents and style of a web page through coding (Wellens, 2015, 11, 61). Although JavaScript can nowadays be also used as a server-side language, for this project it was used only as a client-side language, which it is how the language was originally designed for.

3.3.4 Bootstrap

Bootstrap is a popular free and open-source HTML, CSS, and JavaScript framework that allows you to create mobile-first, responsive sites, or applications. It saves you time and the trouble of, among other things, having to write extra code to make the site or app responsive (Wellens, 2015, 234).

3.3.5 jQuery

jQuery is still a popular JavaScript library that allows you to write faster, clean, and more efficient code. It becomes a lot easier and faster to write JavaScript code that controls and modifies the web site. Furthermore, jQuery will handle a number of things under the hood, such as workarounds for preventing browser incompatibilities. This saves the developer the time and trouble of having to code these himself. This JavaScript library allows you to write JavaScript code without being an advanced user of JavaScript (Wellens, 2015, 121).

3.3.6 RGraph

RGraph is an open-source modern JavaScript-based charts and graphs library that allows developers to display a variety of charts and graph on websites. RGraph was first created in 2008, is 100% unrestricted to use, and is available under the MIT license (RGraph, n.d.). This tool was of extreme importance as without a graph library it would have been next to impossible to successfully develop this toolkit.

3.3.7 PHP

PHP is a server-side scripting language that was created by Rasmus Lerdorf, who called it Personal Home Pages. Now the three letters stand for *PHP: Hypertext Preprocessor*. PHP is an interpreted programming language that is used for making dynamic and interactive web pages (Wellens, 2015, 83).

3.3.8 MySQL

MySQL is a widely used free and open-source relational database management system (RDBMS) (https://www.w3schools.com/mysql).With MySQL one can manage a database and perform basic CRUD (create, replace, update, delete) operations using a server-side language like PHP. These operations are performed within a PHP script though the use of SQL language, which handles relational databases (Wellens, 2015, viii).

3.3.9 XAMPP

XAMPP is a free tool for website developers that consist of a web server (Apache web server), a database server (MariaDB - previously MySQL), and scripting engines (for Perl, and PHP scripting languages). XAMPP is used for learning web development, and it provides the necessary tools to test a developer's work on their own computers by setting up a local server (digitaltrends).

3.4 Hosting

After the developing work was completed within the "virtual" server environment (XAMPP), it was time to search for a permanent (or temporary) hosting solution to deploy and test the web app in the real world: a real server environment in this case. There were talks with the clients about the different options regarding hosting. After some inquiries with a number of different parties, we arrived at the conclusion that temporarily using a hosting service would be suitable enough for this purpose since this project, as previously mentioned, is a work in progress that will be improved and further developed over time with the help of other developers so hosting options may change over time. The option we went for was to host the solution in Azure, which is a cloud platform operated by Microsoft.

Web hosting companies and services, as it is also the case with Azure, are usually for-profit businesses that provide clients with a domain name as well as hosting possibilities in one of their computers (or servers) that operate nonstop 7 days a week, 24 hours a day. Thereby, allowing anyone in the world to visit your website at any time, provided they have an internet connection (Wellens, 2015, 86).

3.4.1 Azure

Microsoft Azure is a service that offers cloud computing possibilities for building, managing, deploying, and testing applications and services. It supports a variety of programming languages, Microsoft-specific software as well as software from different parties. It provides three alternatives depending on your project's needs: infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS) (Pramatarov, 2018). By hosting the project in Azure, all three services were used in one way or another. Figure 11 illustrates cloud computing services offered by Azure (Azure, n.d.).

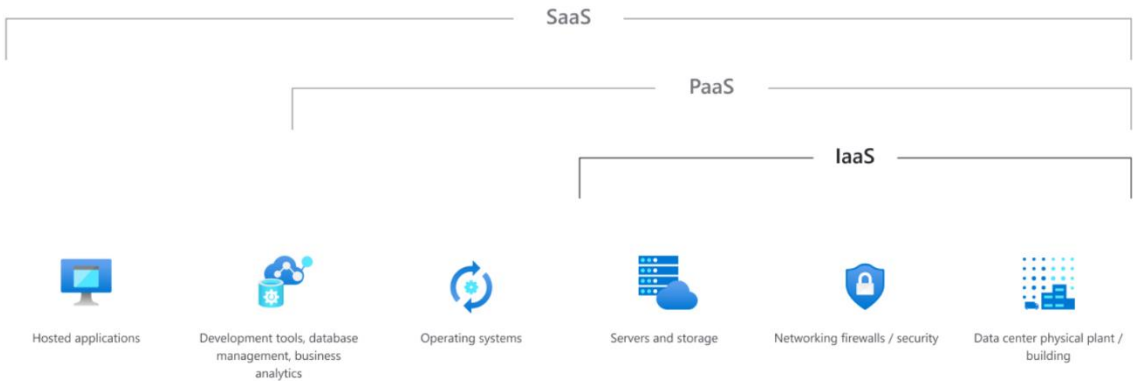

Figure 11: Cloud computing services offered by Azure

3.5 Security

Although no vital information was intended to be hosted in the project's database, it was incumbent on the developer to create and maintain certain security features, which are briefly explained next.

3.5.1 Firewalls & hosting security

Azure's own *infrastructure as a service* (IaaS) provides networking firewalls and other security features (Figure 11) so in that respect, the developer had to only host the project in Azure to

enjoy those security benefits. This is so because, as the very name suggests (Iaas), Azure takes care of the *infrastructure* (security being a part of it).

3.5.2 Login & logout

A way to avoid unwanted visitors to the web page was to create a login form from which authenticated users would enter their login information in order to access the site. Later, a logout feature was also added to further increase security. Both features were created using PHP and a MySQL database table.

3.5.3 PHP & SQL best practices

There are clear security risks when PHP and SQL best practices are not observed. Therefore, the developer had to adhere to these practices to the best of his knowledge and skills. Without going into much detail (this type of technical terminology may be overwhelming to the layman), some of these best practices include, among other things, making use of prepared SQL statements and sanitizing input data.

4 Development work

In this segment, the start of the development work, and the actions and details that gave form to the ECHO project toolkit will be described. The research work and methods together with the development tools and strategies previously chosen will converge to shape the basis for the production of this web app.

As previously stated, this project began on October 9, 2021, and it was scheduled to be completed by the end of December 2021. Although the development work was initially completed at the beginning of January 2022, which was a bit outside the original time frame, it was finally completed and up and running on January 16, 2022. The reason for this delay will be further explained in future sections. All last minute changes, new requirements, and technical challenges will be explained in appendix 1.

4.1 Work Outline

The progress of this project was divided into weekly iterations or sprints of prototyping and development as it is usually the case when applying an agile development process. Contact with the clients took place using the communication platform called Teams and as previously mentioned, was carried out on a (almost) weekly basis. The agreed schedule and plan was to have a working final product by the end of December 2021. Table 1 below gives a description of the planned work schedule for the start and completion of the project.

Milestones	Dates
Start	October 8, 2021
Finish	December 31, 2021

Table 2: Preliminary and desired project timetable

4.2 First phase – stage A

This first phase represents the first cycle of the agile development process that was latter to be called stage A. This stage, unbeknown to us at first, became the timeframe that was needed to produce the first of three steps that would form part of the whole project. This stage is named and based on a PowerPoint graphic presented by the clients, which divided into three parts the whole project in order of priority, being stage B and stage C the next two stages. Figure 12 illustrates the three phases that comprised the project. This graphic was provided by the clients to better understand the required steps and phases.

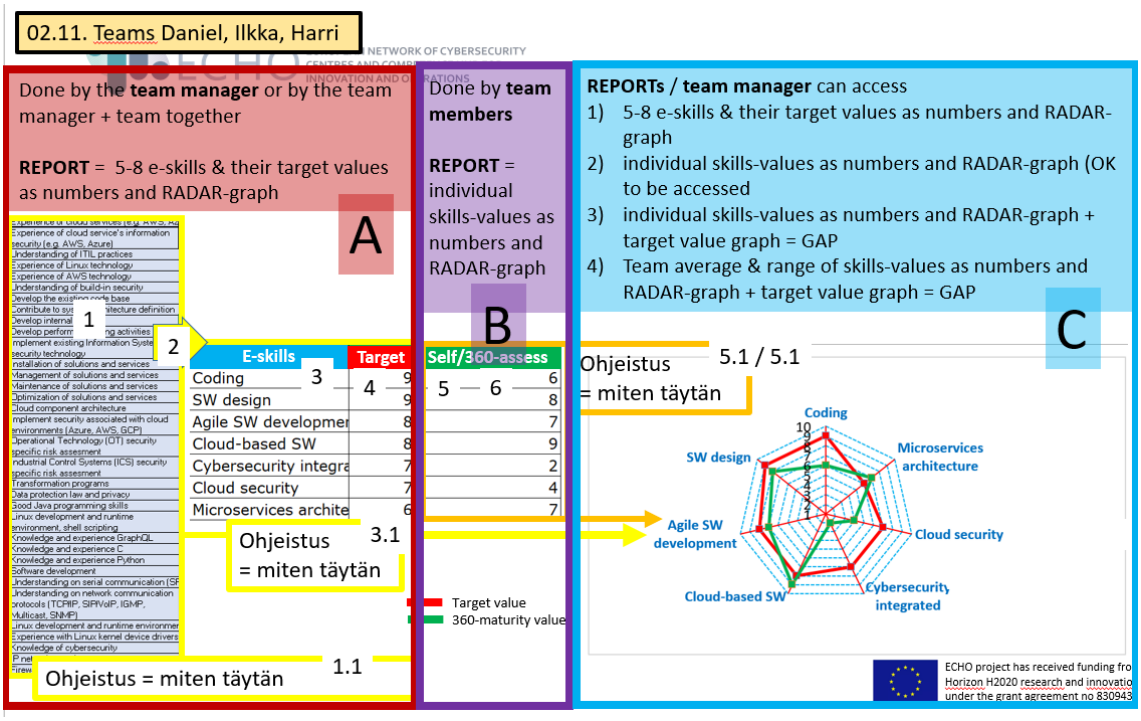

Figure 12: Illustration of stages A, B, and C

During this first phase, there was continuous information gathering from clients on a weekly basis as well as technical research from web developing sites and literature, planning,

developing, and testing, that eventually would prompt an early and final release date at the end of this stage. Table 3 below shows the schedule and plan for the first stage in more detail. The release of this first part was November 9, 2021.

Dates	Actions	Details
October 8-12	Kick-off, setting up & organizing	Interview with clients, establishing requirements and priorities
October 12-19	Planning and development	Further talks, showcasing first mockups
October 19-November 2	Further planning and developing	Further talks & showcasing simple prototypes
November 2-9	First release	Checking functionality of prototype using XAMPP, Stage A prototype presented to client, planning for next stage

Table 3: Schedule and plan for the first phase of the ECHO project

4.2.1 First information gathering

The kickoff of this project started with the gathering of requirements, wishes, ideas, caveat, and objectives, that were collected during the first interview with the clients. This meeting took place on October 9, 20021. The primary goal of this first interview was to find out more about the project and to assess whether it was achievable or technically feasible for a developer or student with limited skills. Most of the requirements and important points were gathered writing notes in physical paper. This old-fashion method allows the interviewer to quickly write down important points without losing the thread of the conversation.

After this first interview, four main conditions that this project required for its success were identified. Specifically, a way to upload a list of skills from an Excel file provided by the clients; choosing a set of skills; the possibility to give a numerical value to each of the chosen skills; and a way to illustrate the information gathered in the form of a radar graph. These three conditions would form the core of the project (a kernel if you like), so finding a way to satisfy these requirements was paramount for the developer before accepting the project.

Following that initial meeting, a few days were spent investigating and finding an open-source graph library that was easy to use and that would work in the desired manner. After finding a seemingly adequate graph library (RGraph in this case), it was necessary to try it first and tinker with it to see if it was real option. Fortunately, it met all requirements so the clients were informed that the developer would take on the project as the main challenges and concerns were put at ease. Figure 13 below shows an example of a radar graph when the RGraph API script and libraries, with original data provided by RGraph, are imported into a HTML document.

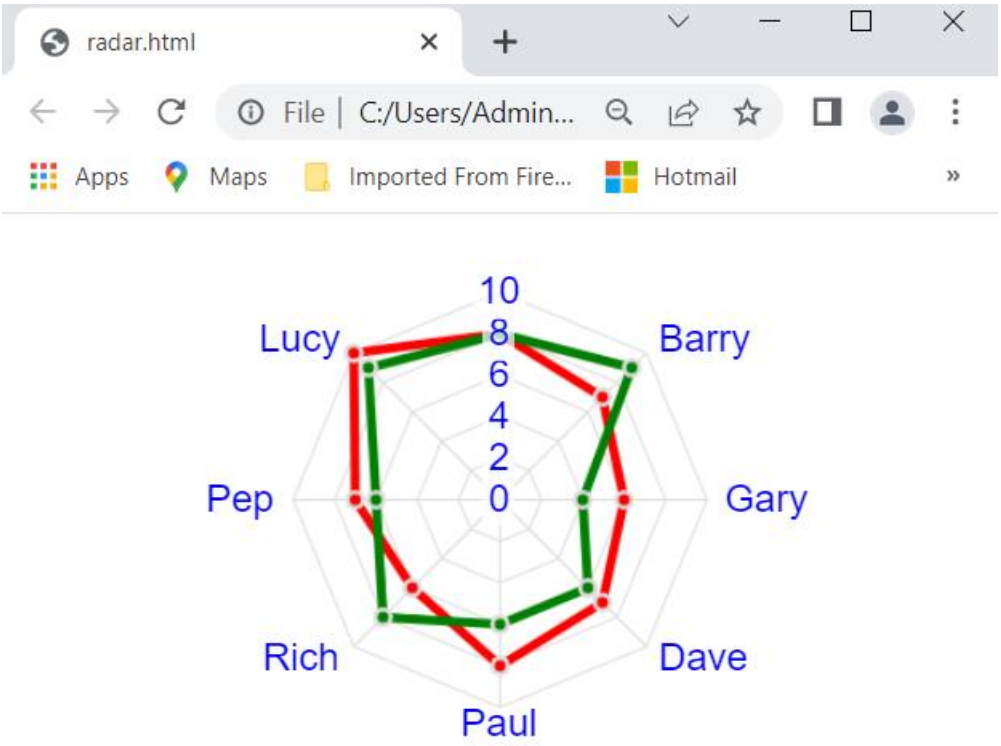

Figure 13: Radar graph with original data provided by the RGraph API

radar.html

```
1  <!DOCTYPE html>
2  <html>
3  <head>
4  <script src="RGraph/libraries/RGraph.common.core.js"></script>
5  <script src="RGraph/libraries/RGraph.common.effects.js"></script>
6  <script src="RGraph/libraries/RGraph.radar.js"></script>
7    </head>
8
9  <body>
10
11 <div style="text-align:center">
12
13 <canvas id="cvs" width="500" height="400" >
14     [No canvas support]
15 </canvas>
16 </div>
17
18 <script>
19     new RGraph.Radar({
20         id: 'cvs',
21         data: [
22             [8,7,6,7,8,6,7,10],
23             [8,9,4,6,6,8,6,9]
24         ],
25         options: {
26             backgroundCirclesPoly: true,
27             backgroundCirclesSpacing: 30,
28             colors: ['transparent'],
29             axesColor: 'transparent',
30             highlights: true,
31             colorsStroke: ['red', 'green'],
32             linewidth: 5,
33             labels: ['', 'Barry', 'Gary','Dave','Paul','Rich','Pep', 'Lucy'],
34             labelsAxes: 'n',
35             textSize: 16
36         }
37     }).trace().responsive([
38         {maxWidth: null, width: 500, height: 400,css:{'float':'center'}},
39         {maxWidth: 600,  width: 300, height: 300,css:{'float':'none'}}
40     ]);
41 </script>
42
43 </body>
44 </html>
```

Figure 14: RGraph API and libraries imported into HTML file

API stands for Application Programming Interface and is code that permits two software programs to connect and communicate with each other (Nolle, n.d.). Simply put, an API is some sort of intermediary (a piece of code) that takes requests from users and conveys these requests to (in this case) the RGraph library in order to generate some graph. You could think of it as a waiter getting orders from clients, taking these orders to the kitchen, and bringing the ordered dishes back to the clients. Figure 14 above depicts the RGraph API (lines 19-40), and its libraries (lines 4-6) imported into an HTML file to produce the graph shown in figure 13.

4.2.2 Use Casing System

At this stage, creating a use case model for stage A was fairly straightforward and simple as it only had to showcase desired skills and values from the team leader or organizer (surveyor) without much functionality under the hood. In other words, there was only one actor performing three actions: viewing and choosing skills, give values to said skills, and produce a radar graph from those values and skills. Figure 15 below illustrates this phase.

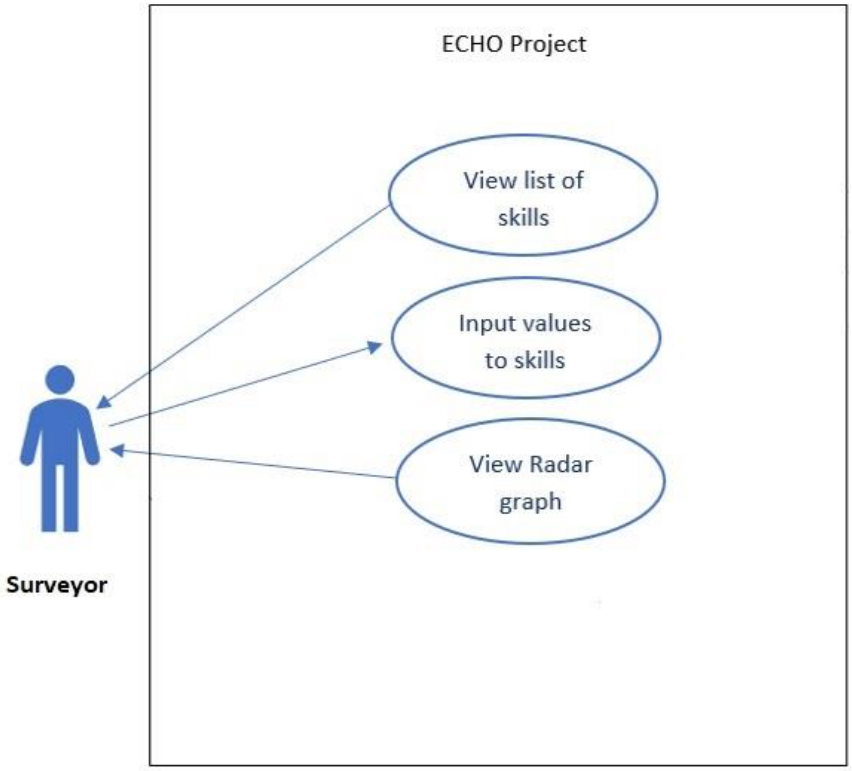

Figure 15: Use case diagram for stage A

4.2.3 Layout design

The layout design was not a priority at this stage, only functionality. As explained in section 2.1.3, the clients wanted to maintain the same, or similar, template layout design of that of the ECHO project's web site. For this reason, not much design effort was required from the developer's part but to accurately mimic the ECHO project's web site layout. However, discussions took place about the layout and design of the contents, i.e., the list of skills, table of chosen skills with values, and radar graph. Section 4.2.6 will display some prototypes which will showcase the layout previously mentioned.

4.2.4 Building

The development of this first phase was fairly straightforward and required most of the development tools presented in table 1 of section 3.3 except for database (MySQL) and hosting (Azure) capabilities. This is so due to the fact that there was no need at this stage to permanently save data, and because the hosting was still provided by the local test server environment (XAMPP) for developing purposes, as the project was still in its early stages and too incomplete to be hosted somewhere else at that point.

For coding this first phase, the main tools used were simple HTML, CSS, JavaScript, and bootstrap. A homepage, and another page to display the radar graph, were created. These two pages imported CSS, JavaScript, and RGraph (also JavaScript) files for styling and functionality. During development, these two HTML files (files ending with .html) had to be changed to PHP files (files ending with .php) as the JavaScript script for uploading data from Excel files would not work outside a server environment (i.e., outside XAMPP).

The text editor chosen for writing HTML, CSS, JavaScript, Bootstrap, and PHP was Notepad++, which is an excellent and simple to use tool yet very well-rounded and efficient. A simple example of Notepad++, HTML, CSS, and JavaScript were already shown in figure 14.

4.2.5 Testing

Testing was continuously carried out throughout the whole process, so no specific testing took place at the end. That is to say, nothing was presented to the clients before functionality and debugging of all encountered issues were taken care of and fixed. You could say there was nonstop testing from the very beginning until there was a fully operational release. Only then, it was presented to the clients.

4.2.6 Prototype of first release

The first stage was finally completed on November 9, 2021. The prototype was then presented to the clients for viewing and feedback. Figures 16 and 17 below showcase the prototype presented.

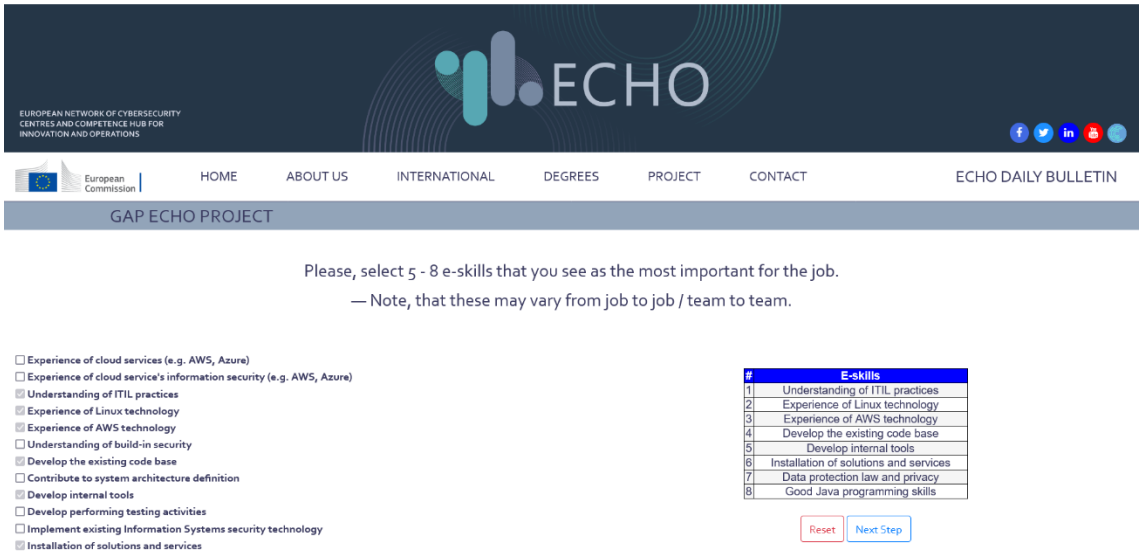

Figure 16: First prototype release – Home page

Figure 17: First prototype release – radar graph page

4.3 Second phase – stage B

The second phase of the project was not as straightforward as the first one. The developer had to first ideate how to proceed ahead and second, choose the tools and technologies that would be appropriate for the task ahead. Once these were identified, a great deal of time and effort were invested in their implementation as well as in solving some challenging technical issues. For this reason, no meetings with the clients took place during this phase, which lasted for about four weeks. Table 4 below shows the schedule and process for the second phase.

Dates	Actions	Details
9 November 2021	Kick-off and planning	Interview with clients, establishing requirements and priorities
10 November- 6 December 2021	Individual research and development work (i.e., no meetings)	Coding & checking functionality of prototype B, testing new hosting service
7 December 2021	Second release	Stage B prototype presented to client, planning for next stage

Table 4: Schedule and plan for the second phase

4.3.1 Second information gathering

There was a gathering of extra information on November 9, which was the date when the first release took place. After said release, the last part of the meeting was spent gathering a new list of requirements, wishes, and ideas.

After this second gathering, another set of conditions were identified in order to successfully accomplish this new phase. Among other things, there was a need to gather data to a database; create some sort of survey form; and a way to illustrate the information gathered in the shape of a radar graph that would simultaneously contrast target data with individual user data.

4.3.2 Use case for second phase

The first use case was fairly simple and not much system requirements were needed. For this use case, however, some features were added to the system in order to reflect certain requirements like the possibility to introduce other actors or users (surveyed) and saving their data into databases, as well as the surveyors' data. This is a new action that is visually reflected as a new ellipsoid below the original three. Figure 18 below illustrates the use case diagram for the second phase.

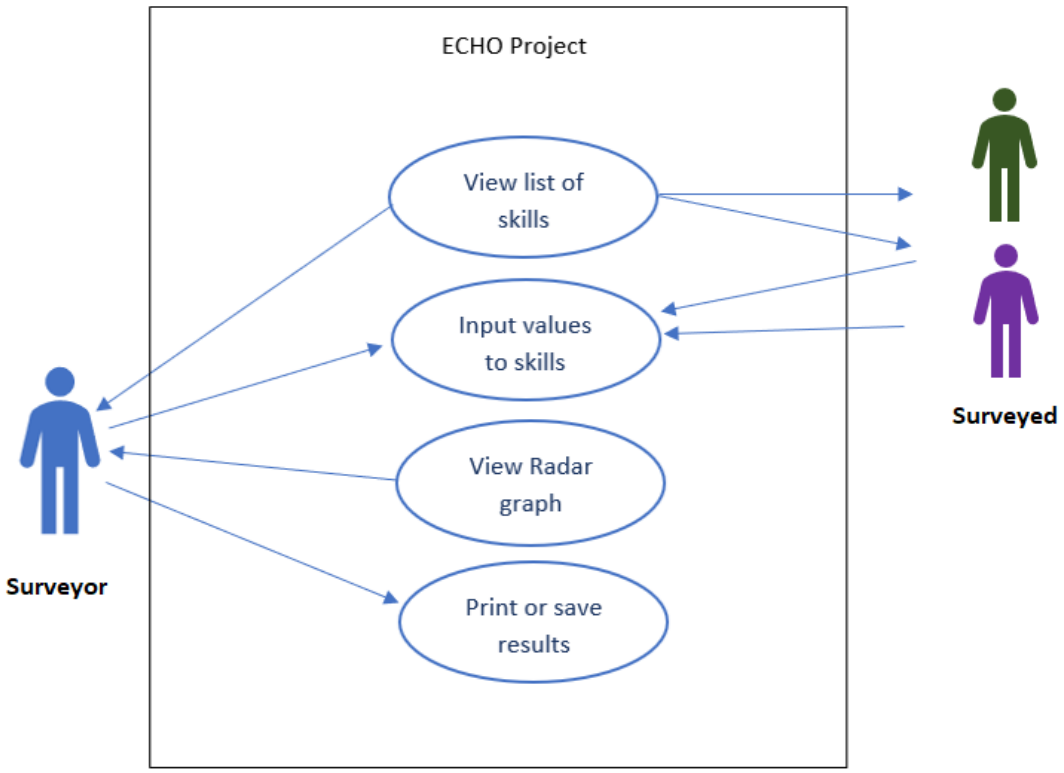

Figure 18: Use case diagram for stage B

4.3.3 Second layout

On the client's request, some changes were made to the web app layout. Among other things, the links on the navigation bar had to be changed. Until now, these were a mere copy of the original ECHO project web site, so these had to be removed and include links to the different pages (PHP files) of the web application. Also, a login page and a survey page had to be

created. These did not have to mimic the ECHO project's template layout so there was plenty of room for designing possibilities. More on this in the next section and on stage B prototypes.

4.3.4 Building of phase two

The development of the second phase turned out to be quite challenging for the developer and this time it required all of the development tools presented in table 1 of section 3.3, including database (MySQL) and hosting (Azure) capabilities. During the development of the first phase, data was saved in the browser's local memory (local storage). This was quite insufficient. From this moment on, the data from the surveyor and surveyed would need to permanently be stored somewhere in order for it to be later retrieved and contrasted. Additionally, the data should be inputted and accessed using any computer used by any user or actor. By simply using local storage, this would not be possible. For this reason, there was a need for a database. This database was created using MySQL resources inside XAMPP's environment. A database is generally comprised by different tables, and these tables (as well as the database itself) are in turn created by writing MySQL (SQL) queries using a series of different statements. Figure 20 below displays the e-skills table created with MySQL.

```
10
11  CREATE TABLE `eskills` (
12    `ID` int(5) UNSIGNED NOT NULL AUTO_INCREMENT,
13    `skills` varchar(255) DEFAULT NULL,
14    `grades` varchar(255) DEFAULT NULL,
15    PRIMARY KEY (`ID`)
16  ) ENGINE=InnoDB DEFAULT CHARSET=utf8mb4;
```

Figure 19: Table created with MySQL

In order to upload these tables to the database, a MySQL administration tool called *phpMyAdmin* was used. This tool is found inside XAMPP's as well as Azure's environment.

Besides the database and tables, there was also the need to write a number of PHP scripts that hosted inside a variety of SQL queries to perform basic CRUD (create, replace, update, delete) operations in the database. However, the two most common operations these queries perform are *insert* and *select*, which are self-explanatory. The coding work was again carried out using Notepad++. Additionally, Visual Studio Code, which is a code editor created by Microsoft, was also used. Figure 19 below illustrates a PHP script hosting an embedded SQL query (line 91).

```php
<?php

$sql = "SELECT skills FROM eskills ORDER BY ID";


$result = mysqli_query($conn, $sql);


if (mysqli_num_rows($result) > 0) {
  $x = 1;
  while($row = mysqli_fetch_assoc($result)) {
    //looping the result of the query to rows which are displayed in the form of a table
    echo "<tr><td>" . $row["skills"] . "</td><td id='num1$x'><input type='number'id='numb1$x'
    name='numb1$x' min='1' max='5' value='0'></td></tr>";
    $x++;
  }
}else {echo "0 results";}


mysqli_close($conn);
?>
```

Figure 20: PHP script hosting an embedded SQL query

Once the PHP and SQL scripts were coded, and database tables were created, it was time for the web app to be hosted somewhere else. This was necessary because the survey form could not function inside XAMPP's environment as a real URL link (i.e., a link to a web page) would need to be sent to different users connected to the internet. Therefore, a real hosting service, not a local server environment, was necessary, which in this case meant hosting the web app in the cloud using Azure.

Since there was going to be data hosted in a database, the developer thought it would be appropriate to create a login system for security reasons. Also, a survey form was created whose link would be sent to the surveyed which in turn would be filled and then their input would be saved in the database. This form, when open by a surveyed, should reflect exactly the same skills that were selected by the team leader (surveyor). Therefore, the survey form should have to work "in synch" with the database data.

At the end, and after a period of research and debugging, the developer managed to overcome all challenges and phase two of the web site was ready to be shown to the clients.

Let the reader know that at this stage the input from team leaders (surveyor) and other users (surveyed) was to create a Gap analysis for only one set of skills, namely electronic skills (e-skills). This is relevant as this will change in the third and final phase.

4.3.5 Testing

As with the first phase, nothing was presented to the clients before functionality and debugging of all encountered issues were taken care of and fixed. For this very reason, no meetings took place as all issues had to be solved before releasing this prototype to the client. A final test was successful, so a meeting was scheduled to present the final version of this second phase.

4.3.6 Prototype for second phase

A few new features were created and there were modifications to the original files. Figure 20 below illustrates a login page that was created for security reasons. Figure 21 shows a search page where a specific individual can be found from the database to produce a gap analysis. Figure 22 shows an individual gap analysis after the search page was used. Figure 23 illustrates the survey form that is sent to users to gather individual data.

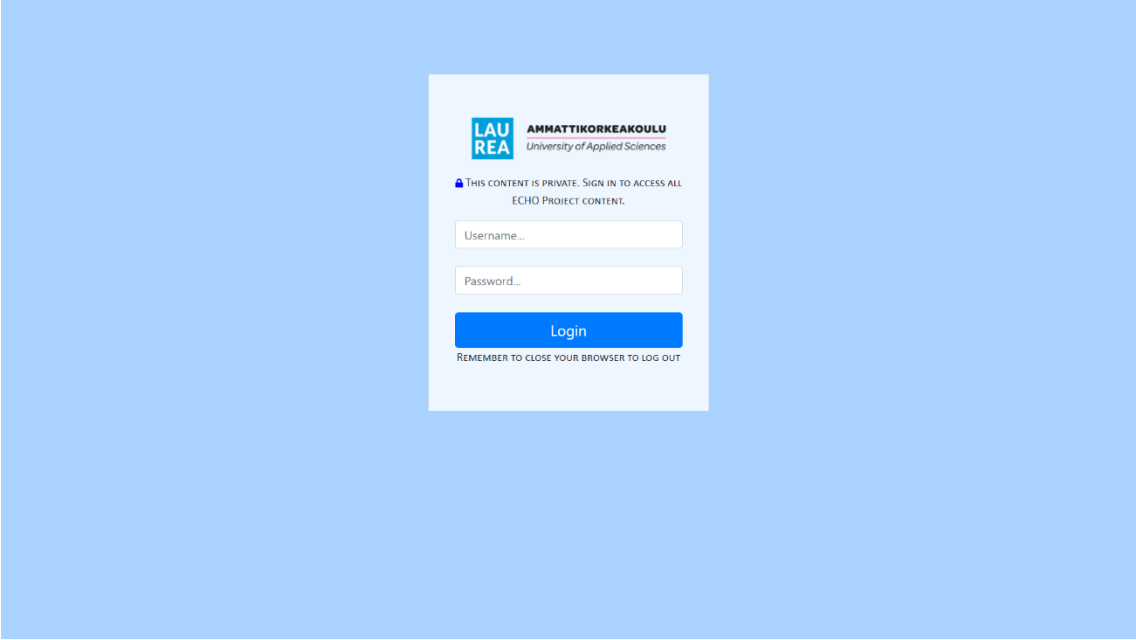

Figure 21: Login page

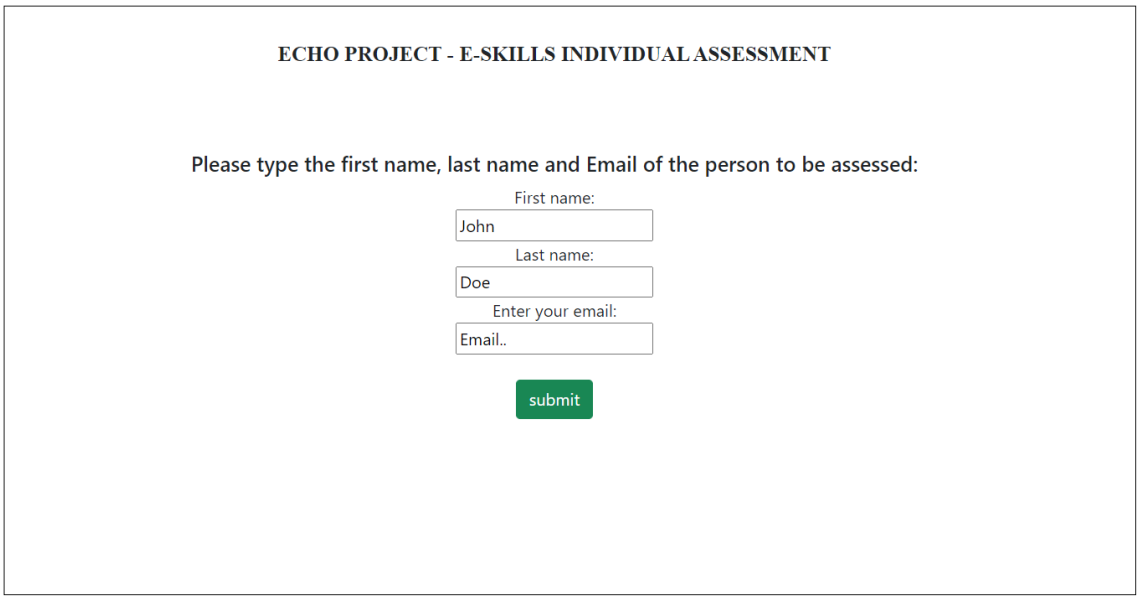

Figure 22: User search page

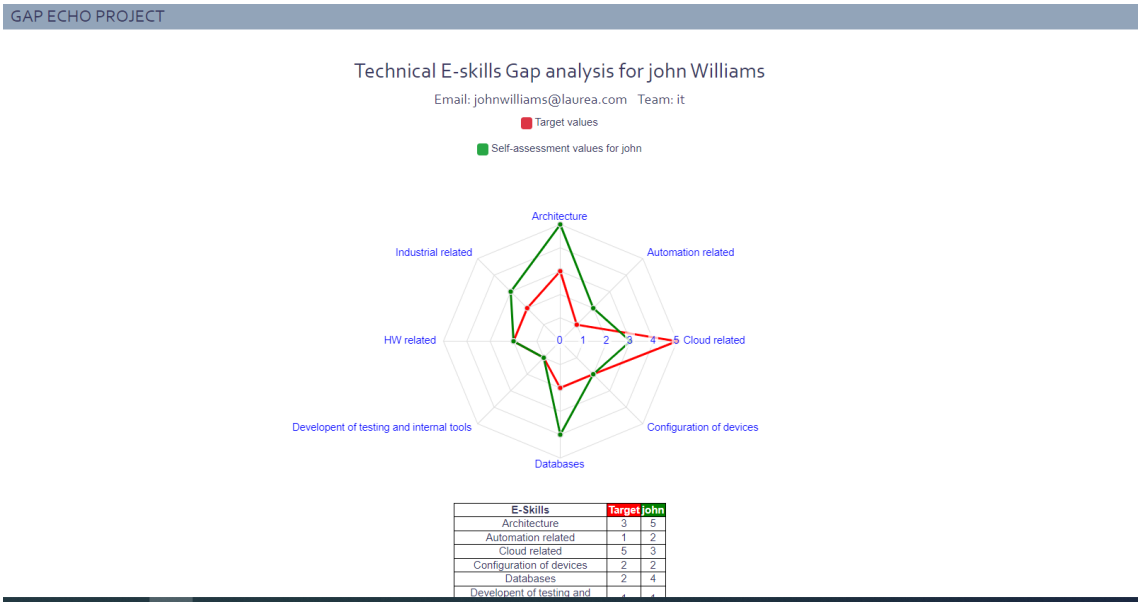

Figure 23: Individual Gap analysis

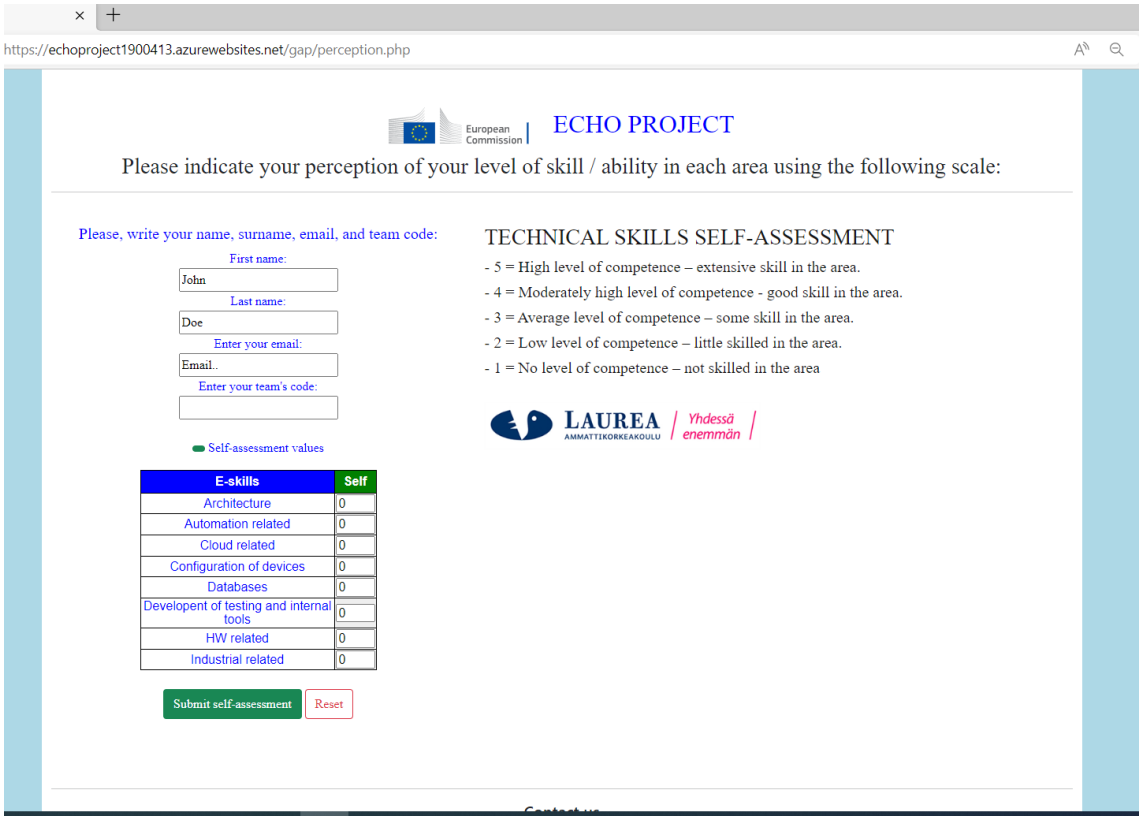

Figure 24: Self-assessment form

4.4 Third phase – stage C

During this last phase, there was further technical research from web developing sites and literature, planning, developing, and testing, that eventually would prompt the last and final release of this project. During this last phase, there were not many gatherings but not as few as during the second one. Table 5 below shows the schedule and process for the third and last phase. Even though the project was up and running at the beginning of January, some meetings took place afterwards due to some last minute requirements that were outside the scope of the project itself. All these actions and challenges will be further explained in Appendix 1.

Dates	Actions	Details
8 December 2021	Kick-off and planning	Interview with clients, establishing requirements and priorities
9 - 14 December 2021	Individual research and development work	Interview with clients, coding & checking functionality of prototype C
15 December - 4 January 2022	Research and development, demonstration, and final release	Demonstration, Stage C prototype presented to client

Table 5: Schedule and plan for last phase

4.4.1 Third information gathering

There were two main meetings before the release of the last phase. In the first one, on December 8, 2021, the developer was asked to device a way to produce the average Gap analysis of users. This would be done by selecting all users belonging to a certain group. In the following meeting, on December 14, 2021, another requirement was presented in which two more sets of skills would have to be included in the project. The reader will find a detailed account of these requirements and their development in section 4.4.4.

4.4.2 Third layout

Yet again, more changes were made to the web app layout. This time, the links on the navigation bar had to accommodate two more set of skills. Also, a new link for producing the team average was included in the report dropdown as well as a modification of the dropdown link in charge of changing username and passwords and erase users. Also, new files had to be created for the tasks aforementioned. The survey form had to be modified to accommodate two new sets of skills. More on this in section 4.4.4 and on stage C prototypes. Figure 25 below illustrates the final layout of the navigation bar for the last phase. A very small modification took place in March 2022. This will be further explained in appendix 1.

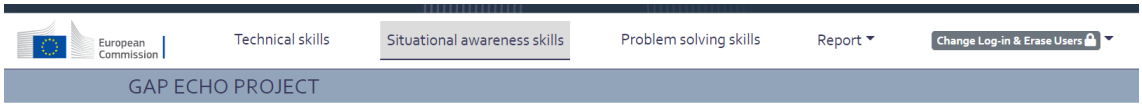

Figure 25: Final layout of the navigation bar

4.4.3 Third use casing

For this last use case, some new features were included to the system in order to reflect certain requirements like the possibility to produce an average Gap analysis of the surveyed according to their group. This is yet again a new action that is visually reflected as a new ellipsoid below the previous four. However, this use casing does not reflect the new set of skills that were included as these do not fundamentally change the system and follow the same pattern. Figure 26 below illustrates the use case diagram for the last phase.

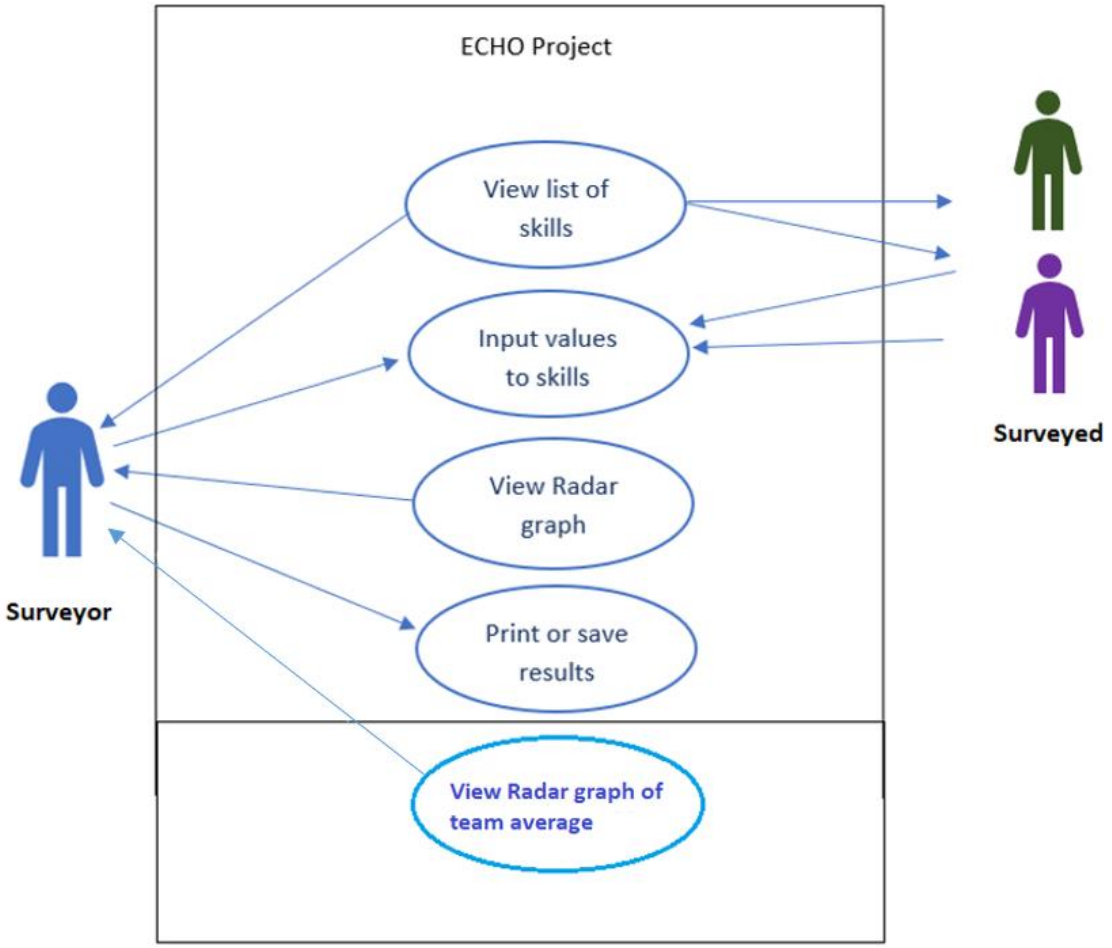

Figure 26: Use case diagram for stage C

4.4.4 Building of last phase

The third phase of the project proved to be also demanding but fortunately not as challenging as the second phase. This is so because the most complicated coding and debugging issues were solved during the second phase of the project. After the meeting that took place on December 8, it was time to start working on stage C of the project. This meant creating a way to gather all input data from all users according to the group or team they were assigned to and produce a radar graph of the mathematical average of the group in question. This average should again be contrasted against the target values in the same fashion as individual values were. This meant that it was necessary to gather data from the database and produce a gap analysis from the average number of all values according to team name or the code consigned to each user. For this very reason, the survey form had to also accommodate this new requirement by asking the user to insert or input a code or name of the group they belong to.

Furthermore, during a meeting on December 14, the clients expressed that they also wanted to include two more set of skills, besides e-skills. A new Excel file was provided by the clients for this purpose, so the web app had to substantially increase in size to accommodate two more sets of skills besides electronic skills. Namely, *situational awareness skills* and *problem solving skills*. This seemingly small detail meant that there was going to be a threefold increase in the size of project. This meant, among other things, that the developer had to triplicate the already existing files in a way that there would not be clashes between different files because of for example variables, functions, and/or files sharing the same names. Hence, great care had to be observed to prevent such issues as later on this proved to be the case. Without going into many details, some clashes did occur, and these went unnoticed by the developer even after the final release. The clients themselves found some inconsistences that had to be corrected so a new final release took place around the middle of January after these bugs were identified and fixed. That same week, on January 16, 2022, a final report with user instructions was also handed to the clients.

4.4.5 Final prototype

All new features and modifications mentioned in previous sections would give shape to the final prototype which is now presented. Figure 27 below illustrates a team (average) gap analysis. Figure 28 shows a search page where a specific team can be found from the database using a specific code to produce a team gap analysis.

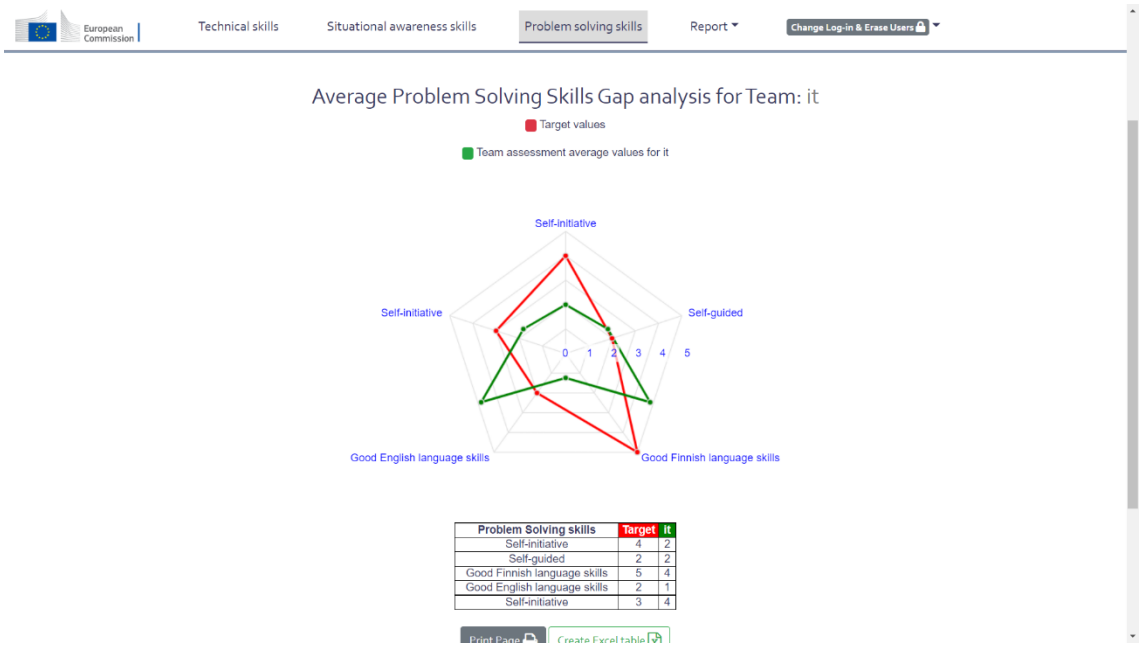

Figure 27: Team Gap analysis

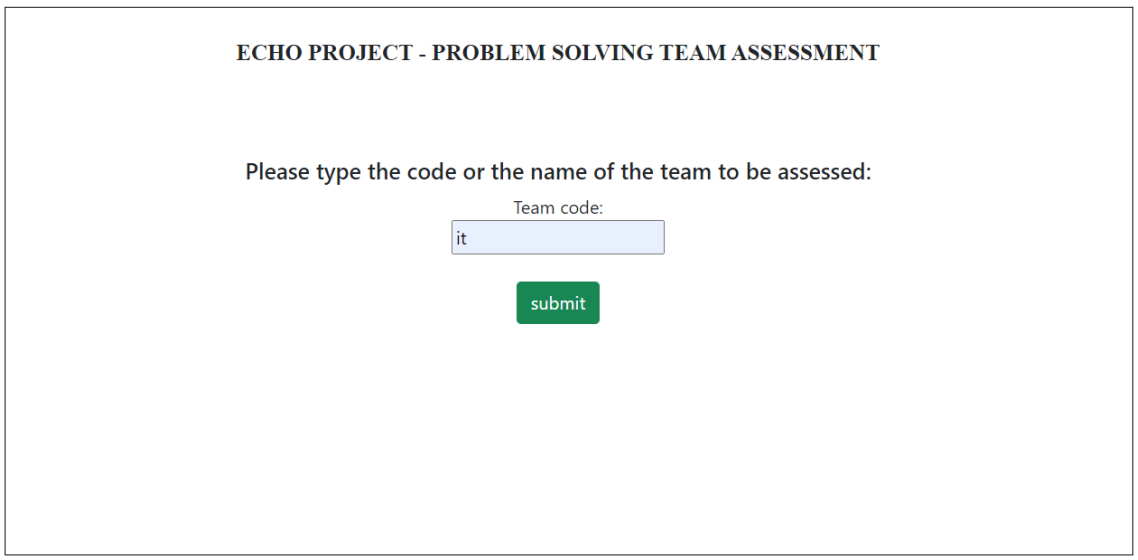

Figure 28: Team search page

Figure 29 demonstrates the new layout of the main pages and of the navigation bar where a new dropdown menu prompts two new links. Figure 30 illustrates a page where an individual, team members, or all users, can be erased from the database.

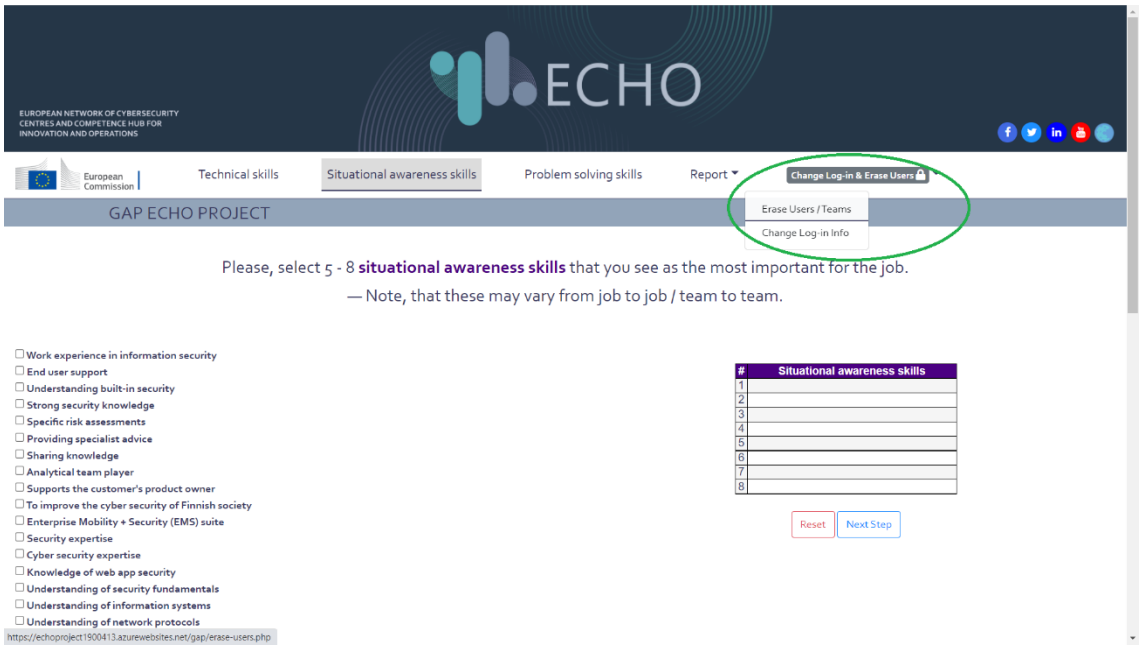

Figure 29: New layout and new dropdown menu

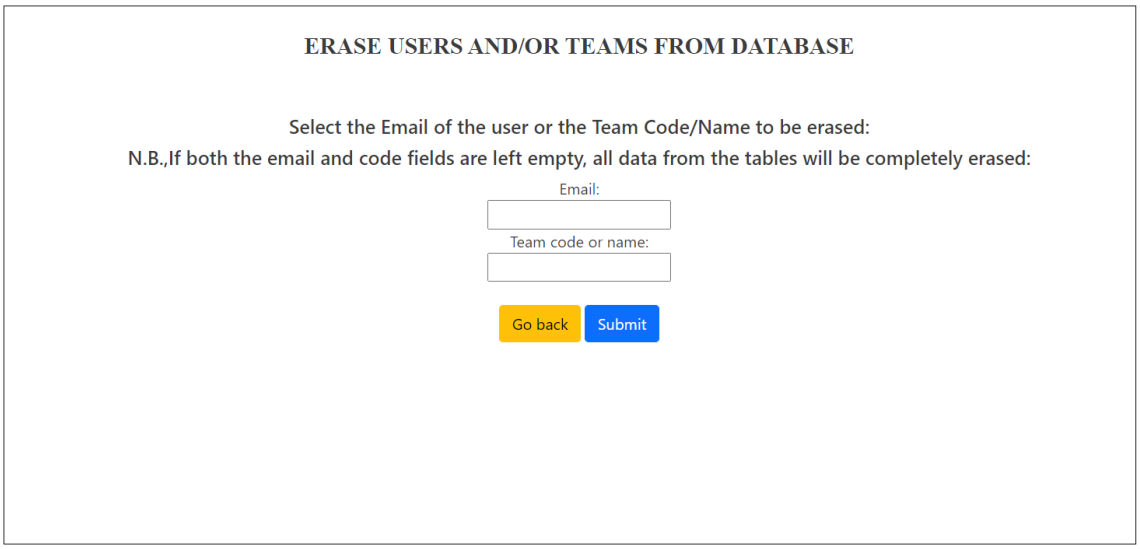

Figure 30: Search page for erasing users

And finally, figure 31 below shows a new page where the team leader or surveyor can change its username and/or password.

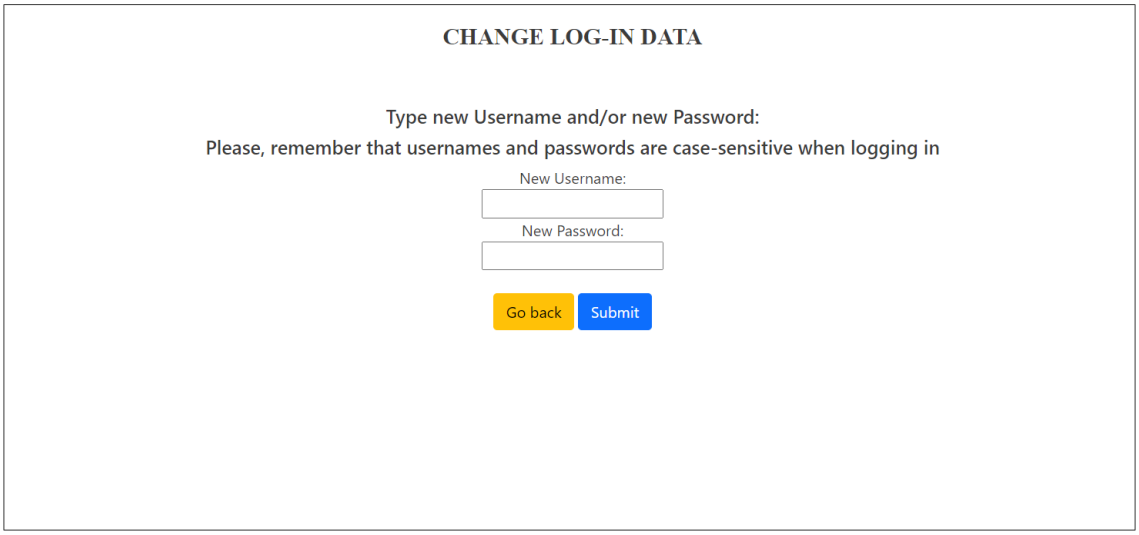

Figure 31: New page for changing username and/or password

4.4.6 Final testing

Continuous testing was carried out throughout the entire final phase until the release and demonstration day on January 4, 2022. As mentioned in section 4.4.4, some hidden bugs went unnoticed by the developer that were corrected afterwards. On January 16, 2022, a final and properly working release was hosted in the developer's own Azure resource. Next, a few bullet points that describe the most important testing results:

- Compatibility: The tool was successfully tried on different web browsers, like Google Chrome, Firefox, and Microsoft Edge, so it is safe to assume that it is fully compatible with most browsers.
- Responsiveness: Although fully responsive, it is strongly recommended that this tool is used in screens of the size of at least a tablet but preferably larger (i.e., laptops and desktops). The reason for this is that the graphic library (RGraph) is not well adapted for small screens (smartphones), despite the tool being fully responsive overall.
- Databases: All operations related to the database were properly working.
- Security: Through the improvement of all aspects related to security, it is safe to presume that the solution observes a minimum level of security standards.

See appendix 1 for more information.

5 Conclusion

The research, design, and implementation of a software solution was the main objective in this project. This was accomplished and it proved to be an invaluable learning experience for the developer. All the test and demonstrations, despite some occasional obstacles and delays, were finally overcome successfully. The web app produces reliable and valid data, and it works as intended when properly used. The clients informed the developer that there were further testing and demonstrations to third parties after the project was delivered.

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Figures

Tables

Appendices

Appendix 1: Testing and troubleshooting

This segment goes through the troubleshooting process that took place after the final release, which took place on January 16, 2022. This process occurred outside the scope of the project itself, and therefore the developer thought it pertinent and appropriate to include this information in its own appendix as it is not part *per se* of the development process of the original web app, or master copy. Yet again, the availability of the developer was important in order to solve the problems, questions, and doubts the clients encountered after the original release date.

After the final release of the master copy, the clients expressed the need for the creation of four backup copies, besides the master copy, which would also need to be hosted online. The reason for this new requirement was that each client, as well as other third parties, were interested in having their own copy for testing purposes. For this reason, the owner of the Azure resource being used by the developer had to be contacted in order to obtain his consent. The owner of this resource is a senior member of Laurea's teaching staff, who also happens to be the supervisor of this thesis. The supervisor agreed to meet all interested parts, and during an online meeting, four new copies were created inside that same resource. Unfortunately, some issues related to the connection of said copies with their respective databases occurred. Due to a tight schedule, and the unavailability of all parts involved, the resolving of this issue lasted until the following month.

On March 23, 2022, after a new online meeting, all issues were successfully fixed, and all copies were properly working thanks to the invaluable help from the thesis supervisor who spotted the problem. The solution to the conundrum was to change the data from the PHP files running the connection operations. Each backup copy has its own connection file so each of them had to be modified so that they would be linked to the correct database.

Likewise, and as mentioned in section 4.4.2, a minor modification of the navigation bar was added in March 2022 while fixing the database connection problem. During one of the meetings held with all interested parts regarding the creation of more copies of the toolkit, the supervisor suggested the inclusion of a logout feature for security reasons. This was done as suggested and now all copies of the web app share that feature in the form of a clickable icon. A new PHP file was created for this purpose. Also, a stronger default password was suggested and that also was corrected. Figure 32 below illustrates the final navigation bar with the new logout feature on the far right.

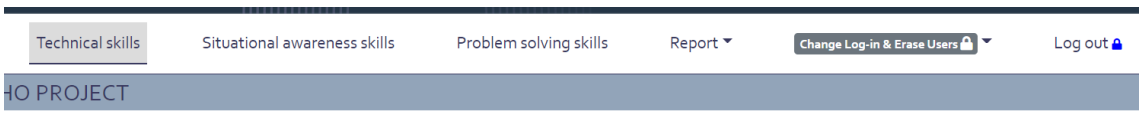

Figure 32: New logout feature

Lastly, on April 29, 2022, the clients contacted the developer with a new requirement. Namely, the original excel file, from where digital skills are uploaded, was thought to have too many skills so a way to re-classify them was needed. It was successfully changed that same day and now the project is running with a new shorter list of skills.