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Assistente virtual de role-play em contexto de saúde

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Virtual roleplay assistant in healthcare

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Resumo

A presente dissertação de mestrado com o título "Assistente virtual de role-play em contexto de saúde" procurou dar resposta a um desafio colocado pela ESEP (Escola Superior de Enfermagem do Porto) visando a criação de uma aplicação tecnológica que ajudasse os professores a criar cenários clínicos para as aulas laboratoriais. Foi solicitado que os cenários deveriam incluir, para além de texto, aspetos gráficos capazes de ajudar o estudante a visualizar a situação problema de uma forma rápida e consistente. Do ponto de vista do professor, o processo de criação dos cenários deveria não consumir muito tempo, permitir a sua alteração para futuras utilizações. O novo formato digital dos cenários deveria ser acessível através do maior número de dispositivos tecnológicos.

Através de uma pesquisa, foram apuradas potenciais soluções a problemas similares, assim como quais as tecnologias usadas. Estabelecida a necessidade e os requisitos da nova solução, procedeu-se a uma avaliação dos valores e mais-valias da nova solução. A conceção da solução tecnológica passou por uma análise detalhada de um conjunto de etapas de desenvolvimento: desde um processo de design iterativo, escolha de frameworks e desenvolvimento do código. A solução desenvolvida foi apresentada aos professores que a testaram e deram feedback positivo. Os professores realçaram o novo modelo como pedagogicamente útil, uma vez que os campos identificados nos cenários servirão de modelo de avaliação diagnóstica aos futuros profissionais em futuros contextos reais.

Infelizmente, devido ao contexto da pandemia atual, não foi possível avaliar do ponto de vista do estudante. Apesar de se tratar de uma solução online, as práticas laboratoriais continuam dependentes do meio físico, pelo que a sua prática comprometeria o distanciamento social recomendado pelas organizações de saúde. Esta nova solução, no entanto, demonstrou dar resposta bem-sucedida a todos os requisitos funcionais inicialmente estabelecidos pelos professores, com base na auscultação dos estudantes.

Palavras-chave: Criador de cenários, aplicação web, Firebase

Abstract

The following master's thesis, titled "Roleplay assistant in healthcare", has the core objective of answering a challenge, initially proposed by ESEP (Porto Nursing School), to implement a technological solution that would help the professors creating clinical scenarios to use in laboratory classes. The scenarios should go beyond written text, including graphical elements capable of helping the student retain and visualize a clinical situation quickly and efficiently. From the professor's standpoint, this tool should not be too time-consuming, and its content should be malleable for reusability. The tool should also provide a digital format, that should be accessible from almost any device.

After initial research, similar potential solutions were evaluated as well as the adequate technologies to use. Having established the new solution's requirements, the benefits and value it would bring were analysed. The development was made in an iterative process, from design, framework selection and code development. The solution presented to the professors was tested and wielded positive feedback. They have emphasized the pedagogic value of the new design, as the identified fields in the scenarios will provide a model for nursing diagnostics in future and real professional contexts.

Unfortunately, due to the current pandemic situation, it was not possible to evaluate the solution from the viewpoint of the students. Despite it being an online solution, the physical interaction of the laboratory classes is still paramount in order to access the students' performance, which would not be recommended due to the pandemic's recommended social distancing. This new solution, however, seems to provide a positive response to all the established functional requirements from the professors based on the student's feedback.

Keywords: Scenario creator, Web application, Firebase

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Francisco Santos

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Acronyms

Lista de acronyms

AAL	Ambient Assisted Living
AWS	Amazon Web Services
BaaS	Back End as a Service
CLI	Command-Line Interface
CMS	Content Management Service
CPU	Central Processing Unit
CRUD	Create Read Update and Delete
CSS	Cascading StyleSheet
CURE	Center for Usability Research and Engineering
DNA	Deoxyribonucleic acid
ESEP	Escola Superior de Enfermagem
FAST	Function Analysis System Technique
FEI	Front End of Innovation
FFE	Fuzzy Front-End
GPS	Global Positioning System
HCI	Human-Computer Interaction
HTML	HyperText Markup Language
ICNP	International Classification for Nursing Practice
IT	Information Technology
JS	JavaScript
JSON	JavaScript Object Notation
MARS	Mobile App Rating Scale
Mn	Minimum

Mx	Maximum
NCD	New Concept Development
NPD	New Product Development
NPM	Node Package Manager
NPPD	New Product and Process Development
NUC	Nursing Undergraduate Course
NuCRE 3DS	Nursing Clinical Reasoning Education 3D Simulation
OS	Operating System
OSCE	Objective Structured Clinical Examination
PIPC	Clinical Practice Integration Platform
PoPE	Plataforma de Procedimentos de Enfermagem (Nursing Procedures Platform)
PWA	Progressive Web Applications
QFD	Quality Function Deployment
SD	Standard Deviation
SDK	Software Development Kit
SHARE	Survey of Health, Ageing and Retirement in Europe
SQL	Structured Query Language
SWOT	Strengths, Weaknesses, Opportunities, and Threats
UC	Use Case
UCD	User-Centred Sesign
UI	User Interface
UID	Unique identifier
URL	Uniform Resource Locator
UX	User Experience
WYSIWYG	What You See Is What You Get

1 Introduction

Virtual roleplay assistant in healthcare is a dissertation thesis developed in the context of the master's thesis degree in ISEP that aims to solve a challenge proposed by ESEP. This document is structured chronologically, describing every step of this project's conceptualization. The first chapter lays out the context as well as what problems it aims to solve. The second, state of the art chapter will highlight the solutions that are a merger of both technology and healthcare fields. The third chapter analyses the value of this solution and details the process of idea generation. The fourth chapter details the project's design. The fifth describes the implementation process. The final chapters elaborate on the solution's tests that validate whether it solves the problem initially laid out.

More specifically, this first chapter introduces the main concepts, context, problem and overall plan to approach and tackle the presented issues. It also highlights the main topics which are further discussed in this document.

1.1 Context

During the undergraduate nursing course, students are training to perform a set of procedures and techniques, learned primarily in a laboratory context, then in clinical environments, carried out in healthcare institutions. It is expected that a student undergoing clinical training would have mastered a set of knowledge, abilities and techniques that can guarantee safe, effective performance, enabling and easing the decision process based on good clinical practices. In this process, students learn communicational skills that enable them to establish meaningful professional relationships with others, be it patients, their families or other professionals. The laboratory classes attempt to simulate these real-life situations, typical to those found in health institutions. The main goal is to raise the student's awareness and to understand the requirements of their future profession. These experiences allow them to face challenges, stimulate their interest and motivation for the course, to learn and train

new techniques and processes, to improve their critical thinking, deal with fears and anxiety, as well as other harmful aspects.

This process is considered by many authors an area of excellence regarding the development of competences, attitudes and building a professional identity, providing a learning process that integrates and mobilises knowledge (Salvador et al., 2015). Although the environment is simulated, the context in which the student learns allows the appropriation of knowledge, skills, abilities and personal and professional skills that enable them to make decisions, solve problems and act according to the fundamental principles and values of the profession of nursing (Simões, Alarcão, & Costa, 2008). The development of cognitive, instrumental, interpersonal and critical-reflexive skills is expected in this process (Simões et al., 2008).

In ESEP (Nursing School of Porto), the syllabus includes theoretical, theoretical-practical, practical and laboratory lessons in the first two years. In the final two years, the students undergo clinical training in healthcare institutions. The laboratory lessons, with a total of 211 hours of practice, are dedicated to healthcare basic techniques and exercises in a controlled environment. The goal is for the students to incorporate the required processes and gain critical thinking and problem-solving skills on how to both perform and evaluate the various situations they will face on the future job.

The laboratory classes are structured differently from the remaining courses. A reduced number of students composes each class, an average of 10, as a comparison, the other classes have about 30 or 40 students each. The laboratory environment is designed to simulate a health ward as closely as possible, using models and simulators. These are accompanied by a lecturer and can last between 2 and 3 hours. It is demanded that the students wear proper uniform and follow the strict rules and norms required in a clinical context.

The current teaching methodology being used in a specific thematic content (how to labour and prepare caregivers of dependent people) is thus: each student is assigned a scenario, a paper which describes, succinctly, a situation, that demands a well-structured plan to collect data from the patient that will prove or disprove nursing diagnostics, establish goals and delineate an assistant plan. In order to make the scenario as realistic as possible, the roleplay methodology is used, where another student will perform the role of patient or caregiver. The student's interaction conditions a lot of the dynamic in the process of roleplaying.

The scenario itself is a simple text document detailing the fictitious clinical and socio-economic status of a patient. With this information established, the students may study and analyse all the scenarios beforehand. Since they do not know what case they will be assigned, students will need to analyse all clinical situations, as they will have to interact in at least one, during the laboratory session. Before the roleplaying begins, the teacher may appoint another student to roleplay either the patient or the caregiver, providing additional details or requesting for the emphasis of some aspects, in order to create some unpredictability and test the student's capacity to adapt under changing circumstances. In the end, the teacher grades

their performance based on the procedures, information conveyed, how they spoke and many more subtle patterns of the interactions.

1.2 Problem

The teaching-learning process in the context of healthcare demands training specific techniques and procedures where the interaction with other people is very relevant. This process is initially done in a laboratory context, through clinical simulation, resorting to mannequins or volunteers that will perform the role of patient or caregiver. Scenarios are used as a means for the simulation. These scenarios contain a brief synthesis of the required information; however, students often evaluate these as unclear, providing irrelevant secondary information, or even, that the important topics are omitted. When facing an expressionless mannequin or a volunteer merely pretending to be ill, some aspects and information are rarely perceived by the student.

Plenty of times, the context of the written data is not always understood in its entirety by the student. If the scenario's description allowed for an illustrative infographic visualisation of the main relevant variables (such as age, schooling, economic resources, social network, among others), or even visualisation of the anthropometric clinical data, it would assist the students in the process of evaluation and care conception.

The roleplaying is a dynamic process, conditioned by the student's interaction. The dialogue may converge to a well-defined ideal outcome or, sometimes, the collected data is poorly refined or outright unclear. Some students have experienced difficulties in understanding the patient's role, as they are young and without any physical or cognitive deficits. Should the roleplaying performance be done without resorting to any theatrical guidelines, it becomes hard for a young student, with a healthy and functional body, to emulate an older person with impaired functions. Furthermore, the experience is often perceived by the students as stressful, as they are under an evaluation process, and being graded for their work.

The simulation exercises are discussed and analysed by the class as a group, allowing for other students who were not directly involved also to participate. The students who participated in the roleplaying often feel difficulty in self-evaluating their performance, as they were more focused on "doing" and not observing the fine details of the performance or interaction. In this context, some assistant recording software would allow for a better, more detailed analysis of particular moments of interaction.

With these issues in mind, there is a clear need for a solution that can assist the student's learning process and facilitate their current simulation laboratory practices. The use of Information and Technology (IT), integrated with education and health, has been implemented in various contexts, contributing to the sustainability of health systems (Thimbleby, 2013). Among other options, it is possible to find a solution among the areas of

virtual learning environments, realistic simulation and Objective Structured Clinical Examination (OSCE)

1.3 Objectives

The main goal is to analyse and develop an IT-based solution with a captivating design and user-experience, that allows the creation of the before mentioned scenarios in the nursing course's curricular unit. By the end of this journey, it is also expected to research and propose different means to record the roleplay exercises, allowing for easier debriefing and analysis of the student interaction during the exercise.

1.3.1 Requirements

The plan to implement this solution will comprise the following steps:

- Perform an in-depth analysis of the requirements and specific needs of the teachers/students
- Design an interactive and satisfactory interface — to be approved by specific teachers
- Implement this interface in an adequate interface
- Test and collect feedback from both students and teachers
- Iterate the design, make changes and adapt to meet the requirements

1.4 Approach

The following steps compose the general approach plan to implement this project:

1. Gather information on the needs and problems of the NUC (Nursing Undergraduate Course) teachers and students.
2. Design a captivating interactive user interface (UI) with feedback gathered from the first step.
3. Implement the previous design in a flexible, easy to deploy infrastructure.
4. Deploy the application
5. Test the application "in the field" by having students using it during classes.
6. Associate the application with the other existing ESEP platforms.

1.5 Document structure

The structure of this document is as follows:

- Introduction: A contextualisation on the problem, context and overall concepts that will be approached in the following sections.

- State of the Art: Provides an overview of the current practices related to both technology and learning. From a more technological standpoint, an overview of the web-development scenario is also made.
- Value Analysis: Elaborates on the value of this project in the context. Some frameworks are used to illustrate the produced value.
- Design: An overview of the solution to be developed. Given the context of this project, this section will approach both the UI design and application (infrastructure) design.
- Implementation: Details the various steps of the development phase, from the tools that were used to create the application to the final version, detailing and justifying decisions made in the process.
- Experimentation and evaluation: This section details how the efficiency of the project will be measured and what results were gathered. A comparison will be provided and what information could be drawn from the data gathered.

2 State of the Art

This section describes the current state of the art regarding IT-based solutions in the nursing teaching universe. Each sub-chapter describes a particular tool that contributed to a more effective and efficient learning process. Either by facilitating teacher's workflow, or by more easily making information available to students, or even allowing them experimental grounds in which to practice and hone their skills. The final sections describe the current state of the art regarding web-applications and the current trend of technologies currently used in this scope. It is briefly discussed which of these features could be used to and how they would work in the context of the current problem.

2.1 Digital technologies in use in nursing education

Nursing, like other areas of knowledge, has resorted to new teaching tools using information and communication technologies (Tobase, Guareschi, Frias, Prado, & Peres, 2013). These new technologies have made available a set of new materials to support learning. Its use has been applied in education, mainly, in Distance Education, which seeks interaction and interactivity in different educational contexts (Tobase et al., 2013). This adherence in nursing education is based on the premise that these technologies will favour clinical reasoning, value articulation between theory and practices, capture the attention and promote student's involvement in the learning process, allowing for greater curricular flexibility (Salvador et al., 2015). It is a demanding task to sort all different types of technologies, which are mostly accessible through the Internet: virtual learning objects; virtual learning environments; and - portfolio; web- podcasting; wiki; telenursing; realistic simulation; and Tele immersion.

2.2 Virtual learning objects

A virtual learning object is a digital resource, which can be used, reused and combined with other objects to form a rich and flexible learning environment. These materials allow students to access relevant information flexibly, promoting their study according to their learning needs (Silva, Ângelo, Santos, Lumini, & Martins, 2019). These objects, which can be CD-ROMs, websites, games, hypertexts or even applications can be used in class, but above all, they work as a complement to the study, they provide students with other forms of interaction, communication and learning. Their transversal characteristic is their interactivity, adaptation to intersubjectivity and creativity in capturing interest; they are a motivating way of learning.

The digital learning environments are computer systems available on the Internet for support activities mediated by information and communication technologies. These environments support multiple formats, languages and allow users to develop and interact with each other, aiming to achieve their goals (Almeida, 2003). Distance learning dictated the development of digital environments. One of the most prominent examples, in Portugal, the learning management system Moodle, is one of the most used applications in higher education (Costa, Alvelos, & Teixeira, 2012).

2.3 e-portfolios

The e-portfolios are collections of different types of work (text, audio, images, among others) carried out over time by students. This tool is seen as a web-based information system that uses electronic means and services. The repository of objects is built by the student, used to assist the learning process (Salvador et al., 2015). The created work can then be shared with other students or teachers, allowing the same file to be created and edited by several users.

2.4 Web-podcasting

Web-podcasting is a means of conveying information, relying on audio and video formats. Anyone with a digital device such as a mobile phone, laptop, mp3 player or tablet can easily access the content, as it may be readily available and distributed via the Internet. The versatility of this format allows its content to be consumed at the most opportune moments, for example when the viewer is “on the go” or at the end of the day, at home (Salvador et al., 2015).

2.5 Wiki

The Wiki is a web-based software, a website that presupposes the collaborative work of a group in the face of a challenge. It consists of pages, which do not typically have an author, as

they are community-driven, meaning anyone who wants to contribute, edit and reformulate the content explained can do so. Given the freedom of access and editing, there is a risk that information may be biased or manipulated. However, it also has the advantage that its evolution will materialise in a more refined construction with different contributions and experiences (Archambault et al., 2013).

2.6 Telenursing

Telenursing refers to the use of information technology in the provision of nursing services, allowing the virtual connection between patients, nurses and other professionals. It includes a set of applications, which facilitate online communication, electronic mail (email), conversations (chats), groups or discussion forums being examples of Computer-Mediated Communication (Salvador et al., 2015). This topic often comes intertwined with Computer Managed Instruction; an instructional strategy meant to provide challenges and assess the student's performance. Examples of this are virtual libraries, electronic journals and scientific databases. Another group of resources that integrates education administration software via the Internet and video conferencing technologies, teleconferencing and audio-conferencing allowing access to different media constitute a designated type of Computer-Based Multimedia (Salvador et al., 2015). Those who benefit the most from this technology are groups of professionals from a specific field, who are geographically distant, constitute a network that articulates and develops work through videoconference. These groups can more easily debate, discuss and provide collaborative work at a distance.

Figure 1 – Example of telenursing situation[1]

The simulation of reality allows the student to learn techniques and skills in a controlled environment, without putting patients at risk. Realistic simulations can take place in a real

[1] source: https://blog.hipaavideo.net/2019/06/challenges-of-telenursing-redefining-the-patient-experience/

environment, using artificial materials, or in a virtual environment, combining different technologies for their development. The simulation can be used with or without internet access, using simulators or equipment programmed to perform certain functions (Kaneko e Lopes, 2019).

2.7 Tele-immersion

Tele-immersion is a process for both experimentation and interaction. It resembles in many ways a videoconference, as it encompasses a real-time audio-visual recording of two or more participants. This process further expands the experience by adding computer-generated elements and other media to extend the experience of what would be possible with regular interaction. It allows geographically distant people to perceive and interact with a shared virtual environment. Each participant is filmed, inside a laboratory, by a set of cameras that allow a three-dimensional projection, where their movements and voice are reproduced. Through 3D capture, the geometry of the real scene is preserved and mapped in the virtual environment. Tele-immersion research combines 3D computer vision, collaborative virtual reality and networking, being an extension of previous forms of video conferencing and virtual reality applications (Ranasinghe, Al MacHot, & Mayr, 2016).

Figure 2 – A tele-immersive session in progress[2]

[2] Source: www.advanced.org/tele-immersion/news.html

2.8 Practical use cases

In an integrative review carried out in Brazil, between 2000 and 2013, the authors found eight publications (which included the development and study of their application) related to technological developments in use in nursing education (Góes, Camargo, Hara, & Fonseca, 2014). One of these technologies was intended to measure the reading of blood pressure values, presenting videos, photos, animations and simulations demonstrating and teaching the performance of the procedure (Góes et al., 2014). Three publications referred to technologies designed for the teaching of medical management and control of drugs. These included learning environments, distributed modules as well as tests of knowledge, videos and photos (Aguiar & Cassiani, 2007; Cassiani, Cassiani, Benfati, & Seixas, 2012; Zem-Mascarenhas & Cassiani, 2000). One publication reported the development of a program to support the continuous training of people with Diabetes Mellitus, available in the form of a CD (Duran & Cocco, 2003). The remaining ones valued psychological aspects, namely a course with text and video materials and a reflective online interaction on abuse of the elderly (Góes et al., 2014) and another one aimed at nursing assistants in palliative care (Ersek & Wood, 2008).

Another integrative review carried out, between 2006 and 2015, to analyse the contributions of digital educational technologies in the teaching of nursing skills, the authors found 30 publications (do Prado et al., 2009; Silveira & Cogo, 2017). The authors grouped the results found in three categories: mannequin-based simulators, learning stimuli and teaching skills. Mannequin based simulators are sub-categorised as low fidelity, high fidelity, simulators with multimedia software. Some writers classify healthcare technologies as fitting three different classes, lightweight, medium and hard (do Prado et al., 2009). Hard technologies are classified as specific material, such as simulators and other mobile equipment. Medium technologies include knowledge from a specific healthcare area. Lightweight technologies are focused on communication and the bonding of the person in need of care. So, the lightweight technologies are focused on relationship building, medium on structured theoretical knowledge, and hard on technical resources.

2.9 Advantages and limitations of technologies in nursing

The creation of digital tools, aiming to reinforce the learning process are valuable resources in the nursing field. Most of the technologies mentioned thus far allow the students to have access to fundamentals, theories, questionnaires, procedures, and detailed descriptions of nursing interventions. These have been designed in ways to allow each student to manage their learning rhythm, allowing them to dive as deep as they desire on a given topic. Due to its nature, the repetition process allows students to review the same content repeatedly until they are satisfied.

Some limitations of these resources may be their high acquisition or development cost. Besides, some teachers may not have a suitable profile or may not be willing to adopt or adapt the Technologies to their learning style (Gomez, Vieira, & Scalabrini Neto, 2011).

2.10 Technologically related projects developed with ESEP

The nursing school (ESEP) has developed several projects to facilitate the learning process: the Nursing Clinical Reasoning Education 3D Simulation (NuCRE 3DS), the nursing procedures platform (PoPE), the Clinical Practice Integration Platform (e4Nursing) and Nursing Ontos.

NUCRE 3DS is a Project that aims to build a set of clinical scenarios to be used in a digital simulator, the Body Interact ™. The simulator is shaped like an interactive table, supported by a dynamic physiological algorithm and portraits acute clinical situations, where interventions (such as raising the head of the bed, aspirating the patient, administering oxygen) are necessary to maintain and ensure basic vital functions. The goal is to train clinical thinking in nursing and improve security and decision-making during clinical scenarios. Students may access the simulator during laboratory classes in the curricular units Body Responses to Illness I and II. They may also access a digital version online.

The results of this project have reinforced immersive simulation and have proved an essential strategy in the development of nursing abilities and critical thinking (Padilha, Machado, Ribeiro, & Ramos, 2018; Padilha, Machado, Ribeiro, Ramos, & Costa, 2019).

Figure 3 – eESEP, Laboratory classes with Body Interact[3]

[3] Source: https://bodyinteract.com/portfolio/esep-nursing-school-of-portoporto-portugal

PoPE is a project developed to support the undergraduate nursing course, particularly in teaching nursing techniques and procedures (Silva et al., 2019). It is an online platform, designed to integrate illustrated procedures with images/videos narrated with a human voice, hyperlinks to similar procedures that allow the users to consult more information, and quizzes that enable students to test their knowledge (Silva et al., 2019). The quizzes may be randomly generated from a set of questions. Once finished with the quiz, the student obtains a score. This platform is available on Android, iPhone/iPod Touch, iPad, Windows Phone 7 e BlackBerry.

Considering that, throughout their degree, the students learn over two hundred procedures, the PoPE platform is a long-term project and should be kept up to the date. At the time of writing, it includes information and procedures about the curricular unit of "Dependent person and family caregivers". In time, documentation and information about more course units will be added.

Figure 4 – Screenshot representing the PoPe website[4]

e4Nursing aims to allow the development of critical thinking and connecting healthcare knowledge through IT. This tool is used throughout all the nursing course; it allows students to analyse and reflect on relevant data that identifies nursing diagnostics, specify their objectives and interventions that seek to resolve the identified problems.

[4] Source: http://pope.esenf.pt

Figure 5 – e4Nursing platform[5]

The Nursing Ontos gathers ontology data for relevant diagnostics and interventions in nursing. It is based on the International Classification for Nursing Practice (ICNP). When faced with a diagnostic, Nursing Ontos suggests what data should be present, assisting the student with clinical judgement. When a diagnostic is confirmed, it also provides a set of assisting actions and secondary evaluation. Given the interest in this platform, the Nursing Order, through their website, has given access to all its associates.

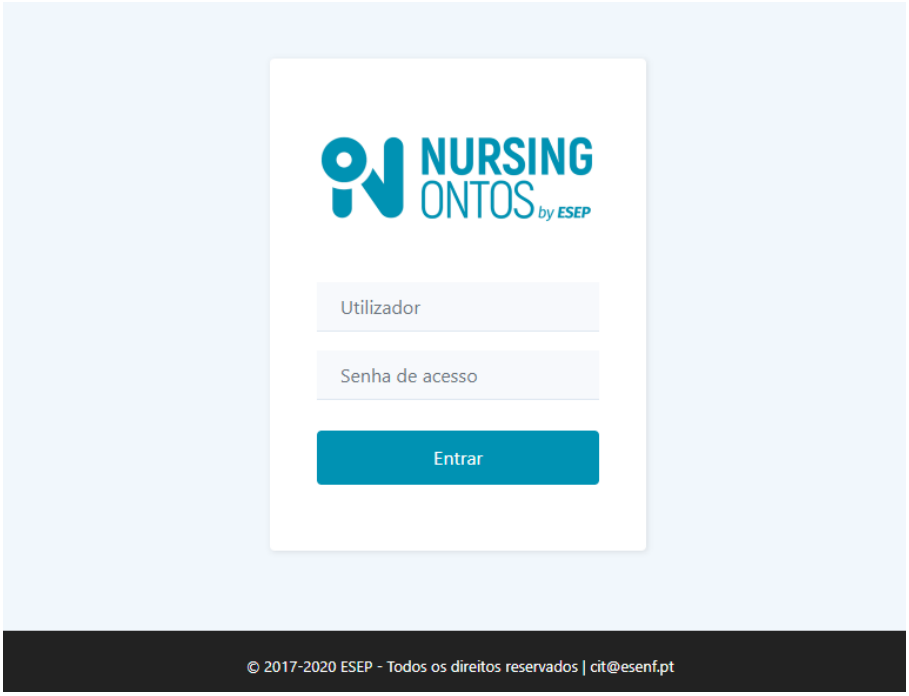


Figure 6 – Screenshot representing Nursing Ontos[6]

[5] Source: e4nursinglab.esenf.pt
[6] Source: https://nursingontos.esenf.pt

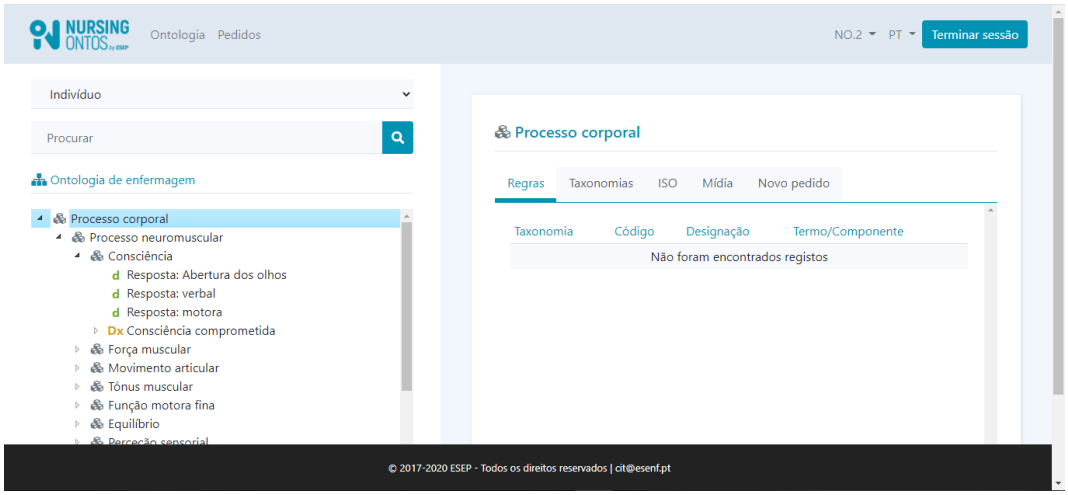


Figure 7 – Screenshot of an example page within Nursing Ontos[7]

2.11 Similar solutions

Outside of ESEP, there have been other relevant projects, some that may even partially solve the initially proposed problem. Take the wind's "full code" and CURE are such examples.

Take the Wind is a company with the mission to reduce the impact of clinical errors by healthcare professionals and students. Their software, "full code", is a full simulation that allows several procedures to be made in different scenarios. This solution, however, does not fit the more social side of the exercises conducted at the course, where the focus is more on how to communicate and extrapolate information from a patient or caregiver.

Elderly Personas is a project developed by Centre for Usability Research and Engineering (CURE), a European organisation focused on studying the fields of User Experience (UX) involving the fields of usability engineering, human-computer interaction (HCI), user interface design (UID), user-centred design (UCD) and Ambient Assistant Living (AAL) research. The personas are fictitious users based on real user data in the form of (narrative) user descriptions. This project is based on a survey on health, well-being, economic circumstances, and social networks known as SHARE. This multidisciplinary longitudinal cross-national survey on persons aged 50 years and older include data at the micro-level (Börsch-Supan & Jürges, 2005). The database of personas could potentially be used as scenarios for the NUC, solving our initial problem, with the only caveat that it lacks the dynamism and versatility of a technology-based solution. The CURE personas are static, and the teachers would face difficulties changing or creating new ones. The purpose of this project is also marginally different than that of the course. These have been used to validate technological applications

[7] Source: https://nursingontos.esenf.pt

more so than as learning tools. Therefore, we can say this solution would partially resolve our initial problem, but not completely.

2.12 State of the art of web technologies

From a technological standpoint, it seems that a fitting solution would rely on using the Internet. The modern browser provides more than enough tools to satisfy the requirements and hosting the content in a remote server allows it to be accessible pretty much anywhere. This fact creates two significant areas where technological advancement should be analysed, the front-end and the backend.

2.12.1 Front-end

The front-end is related to code running in browsers, such as Chrome or Firefox, typically written in JavaScript, CSS and HTML. Browsers are available in any computer, tablet or mobile smartphone. Front-end applications have since adapted and became more advanced to accommodate all possible devices, mostly since the use of mobile phones and tablets quickly rose in the last years (Silver et al., 2019). One of the most noteworthy advances has been the Progressive Web Applications (PWA), a term coined by Russel and Berriman (Biørn-Hansen, Majchrzak, & Grønli, 2017) have grown considerably, and its usage and adoption have expanded ever since. It builds upon existing web technology and expands the existing features, allowing for notifications, offline functionalities, among other features until then considered unfeasible in standard web technologies (Biørn-Hansen et al., 2017).

The programming community has grown considerably, and the usage of frameworks and tooling to facilitate development has grown considerably. Front-end frameworks such as Angular, React, Ember or Vue.JS, build upon the existing web foundations to help developers deliver fast and efficient software. Similarly, to other languages, JavaScript grew with its community. Node JS and NPM (Node Package Manager) allowed for any developers to create and distribute their code as individual libraries other could easily download and use by running a single command on the terminal. The main drive to these advancements is the substantial contributions and developments browsers have, both on mobile and computer devices.

2.12.2 Backend

Regarding the backend technologies, the dawn of virtualisation of hardware has facilitated and abstracted infrastructure building and maintenance costs. With the rise of Back End as a Service (BaaS), it is no longer a requirement to own a web server to deploy code to the World Wide Web. With services as Azure of Amazon Web Servers (AWS), developers can directly connect online and define what type of hardware requirements their software needs. It can even be scaled and customised at any time, drastically reducing the slow-down or

responsiveness of the server. Some services, like Firebase, even promise to abstract the need to develop a backend system entirely. This service provides a framework that can connect and produce or consume information from one of their instances (Kavis, 2014).

We can abstract the different components that make up the standard web stack in the following:

- Networking: the infrastructure that physically connects the machine to the Internet
- Storage: the physical structure to store data, such as hard drives
- Servers: the physical machine with hardware (CPU, memory, hard drives)
- Virtualisation: Software running on the machine to virtualise the OS
- OS: The operating system, capable of managing hardware
- Middleware: Software that provides services outside the OS
- Runtime: Environment in which the application will run, such as interpreter or compiler
- Data: The data layer under which the application will operate
- Application: The actual application code

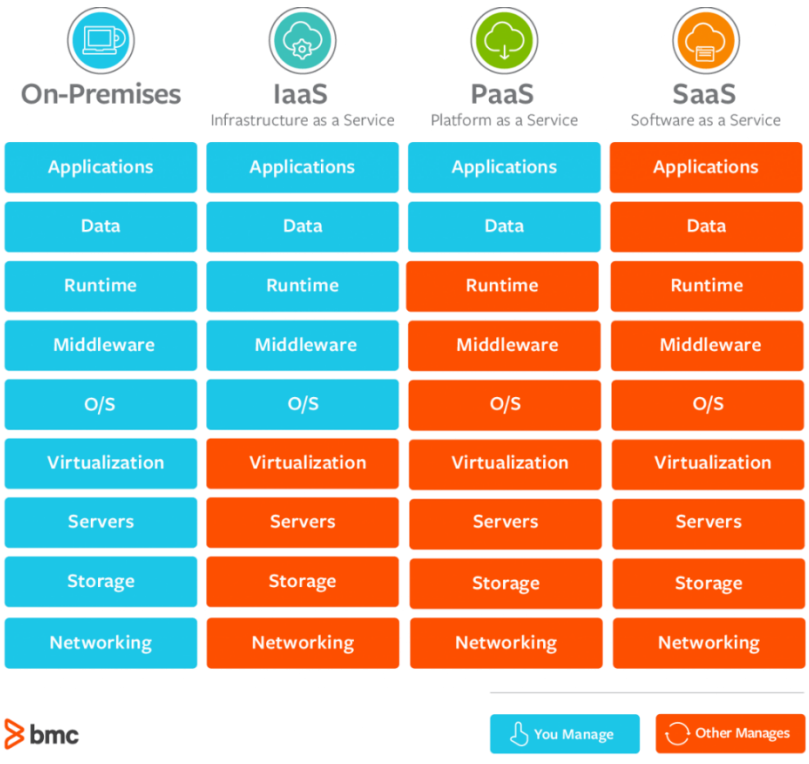


Figure 8 – Diagram representing the different responsibilities[8]

[8] Source: https://www.bmc.com/blogs/saas-vs-paas-vs-iaas-whats-the-difference-and-how-to-choose

Figure 8 demonstrates the various elements that compose the average application. Each colour represents the entity that maintains responsibility. Each of the components may be under the control of a single company or delegated to a third party.

The “private cloud” (referred in the figure as “On-Premises”) refers to personally creating and maintaining the entire stack. In this setting, the company retains its physical servers and controls everything. While this provides more control than the other options, it also implies additional work keeping the entire stack running. As the business grows, the company may find itself spending more and more resources just to maintain and scale their IT infrastructure.

On the polar opposite, the SaaS (Software as a Service) implies that a third party owns the stack. Examples of this are services such as Google Apps, Salesforce, or Cisco WebEx. Companies offer these products under their business model, requiring no need for users to be concerned with any of the application’s layers. The middle ground solutions, IaaS (Infrastructure as a Service) and PaaS (Platform as a Service) are intermediary options. These abstract only a portion of the stack, trading additional control and responsibility with its users. An example of IaaS would be AWS or Microsoft Azure, which provides the clients direct access to an OS (such as Windows or Linux). It is up to them to install any server-side applications, deploy the code and maintain the running applications. An example of PaaS would be Heroku, Firebase or Google App Engine. These services often receive the application source code and serve them under their infrastructure according to their own specific rules.

The term “public cloud” defines the structure under which the later models operate. Meaning clients share the hardware or server resources according to the business rules, pricing range and other criteria established by the provider. Choosing the best option will often depend on the specific needs, financial status and necessity of control by the clients (Watts & Raza, 2019).

2.12.2.1 Firebase

Firebase, originally an individual company founded in 2011, was acquired by Google later in October 2014, is a platform to enable the development of mobile and web applications. What was originally a tool to allow chat-based communication in applications quickly evolved to offer a complex set of products. At the time of writing, the Firebase platform provides a total of 18 products, segregated in three groups: Develop, Quality and Grow. Out of their many products and services, firebase hosting, Firestore and authentication seem to be the most interesting, within the context of the current project. Firebase also offers a CLI (Command Line Interface) through which developers can easily access their features via code, facilitating the development process. Firebase hosting allows, via their CLI, to upload a set of HTML, CSS and JS, making the client-side application easily accessible in a public CDN (Content Delivery Network). Firestore is Firebase’s flexible storage service, offering a NoSQL database that can host any data. Firestore operates using specific concepts, such as that it stores data in the form of Documents, which are key-value pairs of objects that follow the JSON notation. Documents are stored in Collections, which can be queried to retrieve specific data or sorted

under some criteria. Collections may also have sub-collections, creating a nested hierarchy structure, however querying a top-level collection will only get a shallow result, not including the inner layers of data. Firebase's authentication service streamlines the process of registering and logging in users. This service is easy to integrate with any front-end application and offers an array of integrations of third-party services that provide authentication, such as Google, Facebook, Twitter, Github, among many others. The service can be made to set up a complete authentication flow, including email validation, password reset and even some forms of two-factor authentication.

3 Value analysis

This section aims to analyse what potential value can a software solution bring in the context of nursing teaching, and what aspects should be the focus of the solution to be developed. The end goal of this analysis is to explore the solution's benefits, which would aggregate more value for the students and teachers, which translates to an easy-to-learn and easy-to-use supportive platform.

3.1 What is value analysis

Value Analysis is, as the name implies, a means to evaluate a given solution or plan according to the value it brings, who is it meant for and what problem it solves.

To have a complete value proposition, four questions must be answered:

1. What is your product?
2. Who is your target customer?
3. What value do you provide?
4. Why is your product unique?

3.2 What is the product

Our product is a web application that enables the creation of clinical scenarios, also known as personas, dynamically and intuitively. Students will then be able to access this tool online, on any device and find the information they need, summarised with visually captivating iconography, images and text.

3.3 Who is the target customer?

Primarily this solution is focused on teachers and students of the nursing course of ESEP, particularly those who are involved with laboratory classes. Their usage may expand beyond this scope, but that is not the intended primary goal.

3.4 What value is provided?

This project promotes and facilitates new tools that can provide additional value and efficiency to the laboratory lessons, improving the interaction between roleplaying students undertaking the exercises, as well as those collaborating from outside. This tool will enable the teachers to focus on detailing the specific information, organised in a visually appealing way, that would require less context since each field is related to a specific dimension of the persona. The students would also benefit from a more accessible and consistent way to access the data.

3.5 What makes this project unique?

As shown in the State of the Art, there is no single solution that covers all the use cases so far and seamlessly as our project. The proposed application's design would be tailor-made to respond to this specific problem, hence its uniqueness.

3.6 Value as a network

Value to a particular stakeholder or customer and its interchanges can be contextualised in a network. Each node represents a stakeholder and the lines connecting them the relationship and value of the interaction. Such a grid can include connections that may be internal, between members of the same company, or external, between outside members of the company. Value can be traded as physical, tangible assets, or something more ethereal such as knowledge, relationships or accomplishment (Allee, 2008). It also can only be perceived when converted into an actual deliverable. This network, in the context of this project, is illustrated in Figure 9.

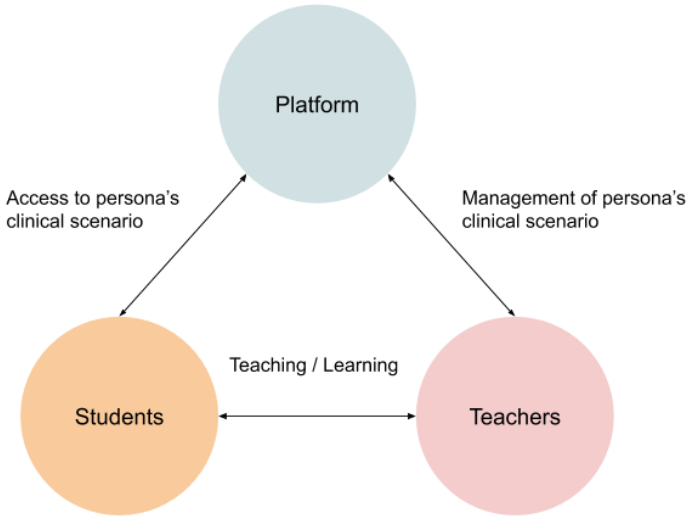


Figure 9 – Diagram illustrating value as a network

From our perspective, the main stakeholders are the teachers and the students. These establish a teaching-learning relationship, that is now facilitated by the project developed.

The current project facilitates the teachers in the creation and storage of clinical scenarios, and the student's access to these scenarios, in a format that is accessible and visually captivating.

3.7 Framework value analysis – FAST

A framework value analysis FAST (Function Analysis System Technique), is a modelling process that allows us to identify a project's main objective and its primary functions. The diagram illustrates blocks representing primary functions, connected in a logical sequence. Reading the document from left to right answers the question of "how (is this implemented)?". This connection justifies the relationship between the two functions. On the other hand, the reverse process, reading from right to left, sees the primary function explained by the one preceding it (Tan, 2007). This process seems to fit this initiative as it contextualises the main primary features in the scope of the current requirements established. The diagram in Figure 10 illustrates this.

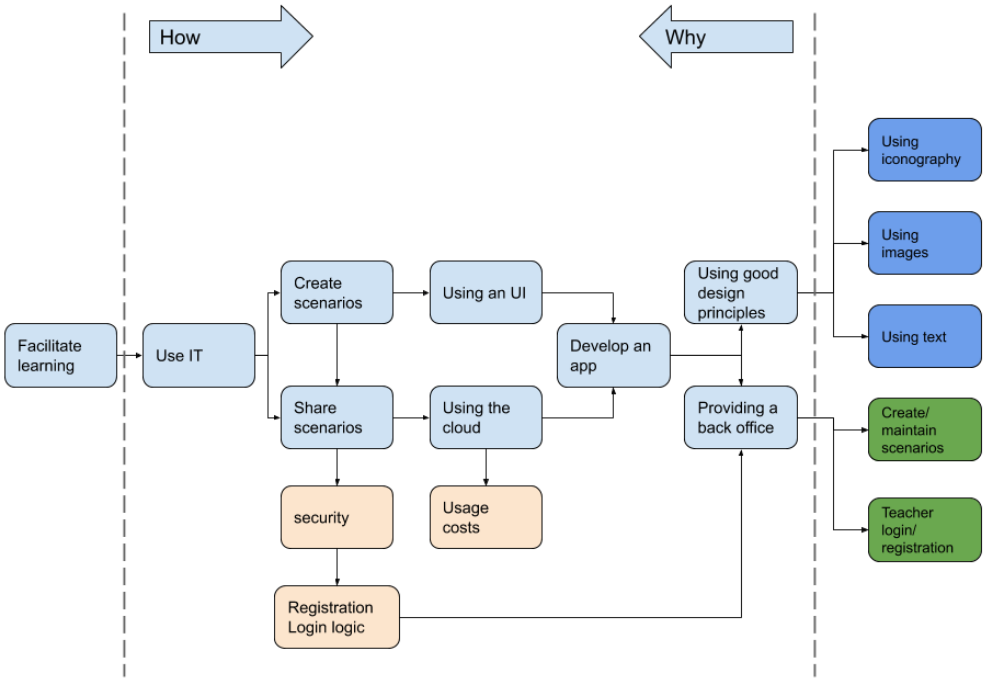


Figure 10 – FAST diagram

Facilitating the learning experience is the single primary goal of this project; it stems from the belief that the student's learning process can be further improved. Our first assumption, stated in the context section, is that IT solutions can offer assistance in some way to solve this problem. By contextualising this process further, the scenarios are introduced - it has been explained, in the context chapter, the struggles' students often encounter and the pain points that can be addressed by focusing on this topic.

Creating digital scenarios is the concrete implementation we believe may deliver the most value. This can be split down into two different components, the scenario creation, and its distribution. The scenario creation should be done in a visually enticing and intuitive means, which can only be achieved through a good interface and sound design principles, which boils down to using good typography, iconography.

Once created, there should be some means by which the scenarios are shared with both teachers and students. While only teachers should be allowed to edit scenarios, students should be able to view all existing scenarios. This additional logic will require authentication and authorisation; the application will need to know who is using it and behave accordingly. A backend is necessary to accommodate for this, which comes with the requirements for secure private connections, as well as additional server hosting requirements.

With this, we reach what may be a "bird's eye view" of the final product's requirements. A front-end that can enable the teachers to create enticing scenarios, while at the same time

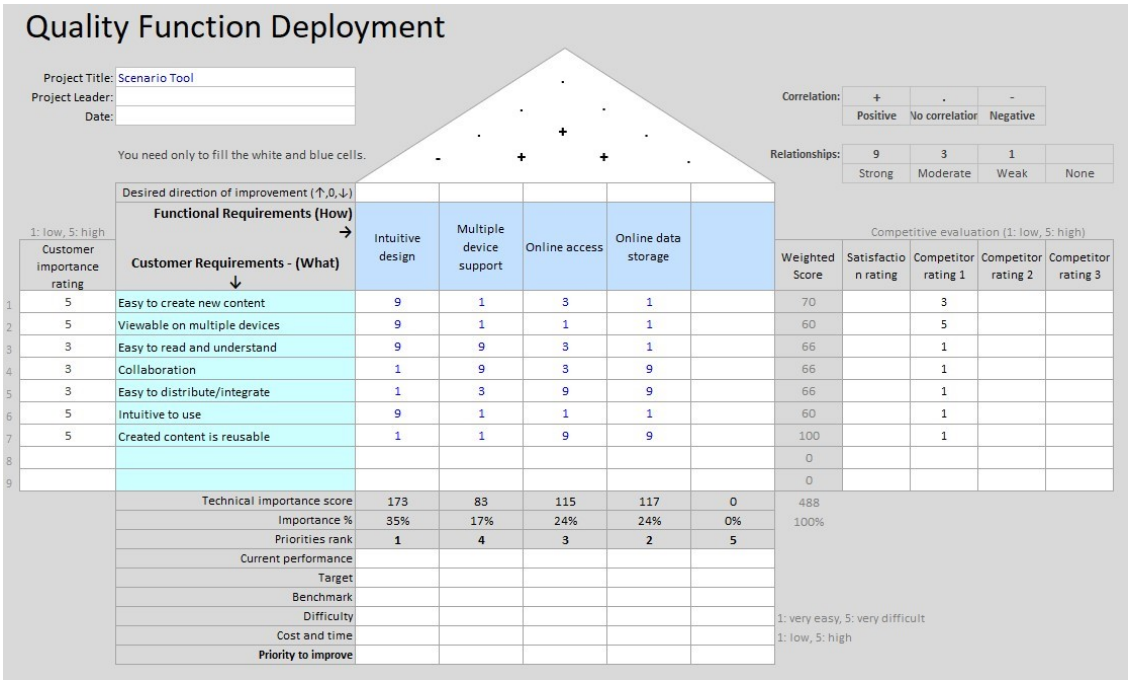
allowing the students' easy access to this information, coupled with a backend that can enable these functions.

3.8 QFD

It is paramount to establish a priority in features and determine what to do first. The QFD model accomplishes this goal. This model is, in a nutshell, a matrix that correlates the customer's needs with the main features of the product/service. It considers different weights to each of the customer's requirements, and even weights in the competitors' presence. In the end, this analysis should provide an overview of what to prioritise to satisfy the most critical client needs. The QFD can be applied in various scopes, analysing the performance of an entire company, a specific physical product or even a service.

The QFD House of Quality diagram has its name because the graph itself looks like a house. On the left side, it displays a list of the customer's needs. Each has a value detailing its relevance, 1 for low, 3 for medium and 5 for critical. On the right side of the diagram, each column represents a different competitor's product, using the same weight system, as mentioned earlier. The top of the graph represents the main features of the product. In general terms, it is the answer to "How" the product is made or composed. On top of the features, there is a triangle, the "roof" of the House of Quality. This symbol is a matrix that correlates the features. There may be positive, negative, or neutral relationships. For example, a car that has too many extra accessories will end up weighing more, which will affect its speed. The bottom of the diagram shows the final score for each of the features, allowing us to establish an order of priority.

Applying the QFD to the context of the current project will provide an overview of the priorities. The "customers" would be the teachers from the NUC and their students. The initial interviews and discussions with the teachers provided the information to establish their needs. Since this is an incredibly specific solution, there are no competitors, no other company or product satisfies the current requirements, as seen in the state-of-the-art chapter. For this reason, the "competitors" section serves to compare the previously used method with this project. Based on the initially established concept, to build a web application, it is possible to underline the core features of the application. With this analysis, Figure 11 represents the final diagram of the QFD.



Quality Function Deployment

Project Title: Scenario Tool
Project Leader:
Date:

You need only to fill the white and blue cells.

Correlation: + Positive | . No correlation | - Negative

Relationships: 9 Strong | 3 Moderate | 1 Weak | None

	1: low, 5: high								Competitive evaluation (1: low, 5: high)				
		Desired direction of improvement (↑,0,↓)											
		Functional Requirements (How) →	Intuitive design	Multiple device support	Online access	Online data storage							
	Customer importance rating	Customer Requirements - (What) ↓						Weighted Score	Satisfaction rating	Competitor rating 1	Competitor rating 2	Competitor rating 3	
1	5	Easy to create new content	9	1	3	1		70		3			
2	5	Viewable on multiple devices	9	1	1	1		60		5			
3	3	Easy to read and understand	9	9	3	1		66		1			
4	3	Collaboration	1	9	3	9		66		1			
5	3	Easy to distribute/integrate	1	3	9	9		66		1			
6	5	Intuitive to use	9	1	1	1		60		1			
7	5	Created content is reusable	1	1	9	9		100		1			
8								0					
9								0					
		Technical importance score	173	83	115	117	0	488					
		Importance %	35%	17%	24%	24%	0%	100%					
		Priorities rank	1	4	3	2	5						
		Current performance											
		Target											
		Benchmark											
		Difficulty						1: very easy, 5: very difficult					
		Cost and time						1: low, 5: high					
		Priority to improve											

Figure 11 – QFD House of Quality diagram

Regarding the “customer requirements” section:

- The creation of new content must be as intuitive and straightforward as possible.
- The scenarios should be easily accessed on any device.
- The new scenarios should be in a format that is easy and intuitive to read and acquire the most relevant information.
- Collaboration should be possible; teachers should have easy access to each other’s documents and shared information.
- This tool should be easy to integrate with the schools own existing systems. In other words, the scenarios should be easy to distribute or integrate.
- Intuitive to use, meaning a teacher or student should require little to no guidance to use the tool expertly.
- The teachers may not always want to create new scenarios from the ground up but reuse old content to create new.

The teachers have considered the previous method has generally sufficient to satisfy basic requirements. It lacked, however, in the easy of distribution, readability, and integration. In order words, the scenarios were somewhat challenging to read, as they were composed of blocks of text, and hard to share and distribute to the students. Word documents would have to either be printed and manually distributed to the students or digitally uploaded to a platform that provided support, making it hard to keep track of versioning or even what the students can access or not.

From the initial phase of this project, it was more or less established that a web application would provide the best solution since these types of solutions are generally the broadest and

accessible solutions. These naturally imply universal access (via computers, cell phones or tablets), and a centralised data source always available. A solution of this type would require good visual design and user experience.

For the “roof” of the QFD house, the following relationships we determined:

- The UI/UX design would be negatively impacted by the multiple device support, since it requires additional effort in designing something that responds to the criteria in a myriad of different screen sizes, from as small as cellphones, to as big as TV screens.
- Supporting multiple devices is facilitated by having the main contents supplied by an external source, the web-server and database.
- The data and application are tightly coupled, meaning there is an implicit positive relationship between the two.

The results, in the bottom section of the figure, show that the primary focus of the development should be on the UI/UX design, followed by the “server-side” implementation. These results are in line with the initial design and concept phases, where the priority was to establish a visually pleasing design for the scenarios and keeping in mind utility functions that would allow faster content creation that is also easy to share.

3.9 Fuzzy Front End (FFE), new product and process development

Innovation is synonymous of experimentation, discovery, and invention. It often also caries unpredictability, lack of structure, and it can be a costly process. The first stage of this process, where ideas are analysed, opportunities are explored is called the Fuzzy Front End. There is no standard process and no means to guarantee it will lead to a specific result. This stage is followed by the New Product Development (NPD), where a solution to the problem was found, which involves the development and production of said solution. Lastly, the product enters the commercialisation stage, where it is sold, and revenue is generated. This is illustrated in Figure 12.

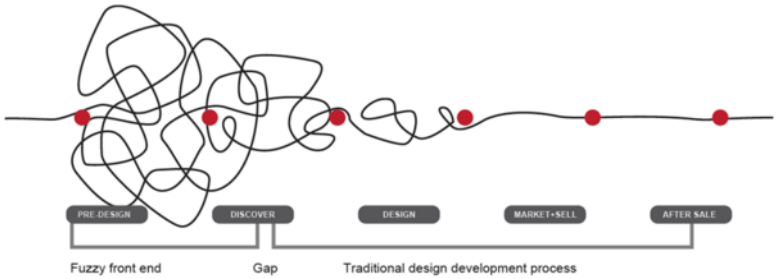


Figure 12 – Illustration of the Fuzzy front-end to production problem (Sanders, 2016)

Different groups approach the FFE differently, as a common language and definition of these terms do not globally exist (P. A. Koen et al., 2002).

With the goal to streamline the process, and remove the gap between the unstable, "fuzzy" front-end and the more reliable backend, Peter Koen and a group of researchers created a new theoretical construct, calling it the New Concept Development (NCD) model (P. Koen et al., 2001).

Avoiding the term "fuzzy" which is often associated with unreliability, Koen introduced the Front End of Innovation (FEI) (P. A. Koen, Bertels, & Kleinschmidt, 2014), detailed in the following figure.

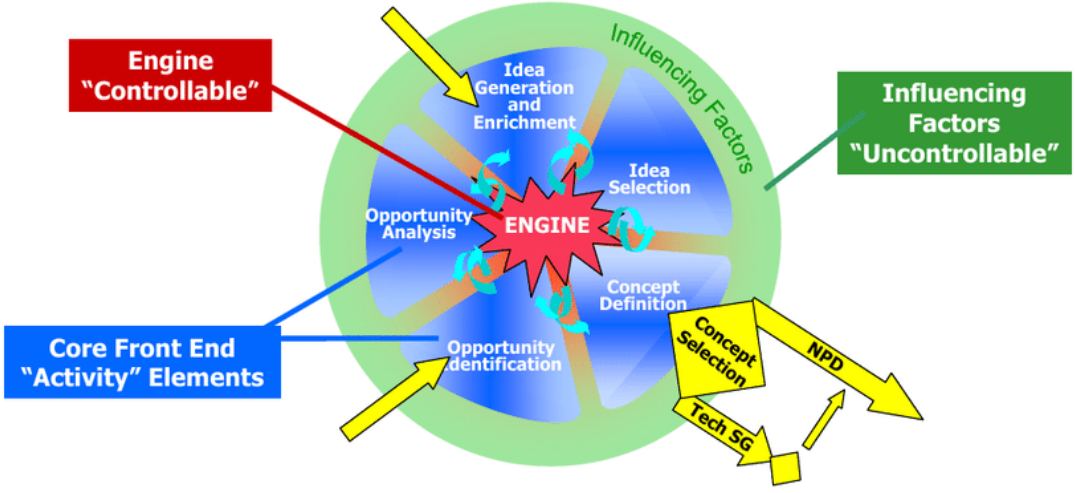


Figure 13 – New Concept Development Model (P. Koen et al., 2001).

This model is composed of three critical parts (P. Koen et al., 2001):

- The engine: this pertains to the meaning, core of the process, DNA, goals, and processes of the company, which will drive forward the innovation process. It is "fuelled by the leadership and culture of the organisation".
- The five surrounding slices: the idea genesis, selection, development, opportunity identification and analysis. These follow a circular motion, as there need not be a

specific streamlined process; instead, these ebb and flow as the concept is developed (hence the arrows connecting each of the slices).

- The rim at the border: the external environmental factors. Such as business strategy, capabilities of the organisation and competition.

Projects complete the FEI either by entering the New Product and Process Development (NPPD) or technological Stage-gate (P. Koen et al., 2001).

To contextualise this process within the scope of the current project, we must first analyse its different phases: what opportunity is the project chasing, analyse it, using frameworks such as SWOT (strength, weaknesses, opportunities and threats), and correlate it with the proposed idea and concept definition.

3.9.1 Opportunity identification

There is a call for evolution with the current model the NUC's are operating. This project is seizing the opportunity, as the current paradigm of education moves more and more to include the usage of IT-based technologies. This project aims to streamline and optimise the teacher's work and empowering the students with better tools and easier access to information. By using visual communication and design strategies, to replace the previous scenario format, it would be possible to motivate students and improve their learning experience.

This initiative would also prompt the teachers, when creating new scenarios, to focus their own clinical story and persona details, which will be essential, fitting with the design.

In the future, scenarios would provide reusability, thus optimising the teacher's preparation time, as well as better documentation of symptoms and diseases, to be more aligned and coherent with the corresponding cases. This reusability would allow for a more realistic establishment of a scenario to test.

3.9.2 Opportunity analysis

This section details the initial phase where we analyse and gather more information on the specific opportunity we are seizing, or problem we are trying to solve. We have already detailed in the Problem chapter the current issues the teachers and students are facing. The proposed solution is to create a digital tool that would replace what is, technically, a pen and paper solution. The following list will detail a SWOT (Strengths, Weaknesses, Opportunities, and Threats) of the proposed tool and its development.

3.9.2.1 Strengths

A more attractive design would stimulate students' knowledge acquisition and attention. Teachers would be allowed to create more detailed scenarios, focusing on the most crucial information to convey in each specific section of the document.

3.9.2.2 Weaknesses

New equipment may be required (devices with Internet access, server, infrastructure, among others). The development time and constraints may not fit into the course scheduling (if the application is not ready beforehand, the teachers may not feel prepared to use it, or may not have enough scenarios prepared, as they would have to create a certain amount of scenarios beforehand). Lastly, as with any tool, it will be required a learning period until the teachers can efficiently use the tool.

3.9.2.3 Opportunities

The opportunity stems from the initial connection that was established with the teachers in ESEP, their request for assistance and desire to improve their systems and workflow. The tool might prove reusable, in the future, in different schools, or even be adapted to different contexts. Coupled with that is the fact that there are not many solutions currently available that can fully solve the problem, as detailed in the State of the art chapter.

3.9.2.4 Threats

Some of the possible threats we see in the development of this project are: the potential cost of server and infrastructure requirements, the alternative is to rely on ESEP's infrastructure, which would bring another potential issue and threat, the dependency of a third party on a component that would be crucial to control from an early development phase.

Another threat is the potential poor reception of the tool; if there is not useful feedback from the teachers or students, there might not be full adoption of the tool.

Lastly, the current pandemic scenario, at the time of the development and experimentation, also poses a severe threat, as it may hinder our testing and initial use of the tool. Due to the innate need of human interaction, these classes may not occur within the desired timeframe, which would seriously affect the experimentation phase and require a revision of the development plans.

3.9.3 Idea generation and enrichment

The starting point of the process is to investigate the existing methods, the “pen and paper” format scenarios, and understand what the essential information is, and what should be left as secondary details.

From the initially stated problem and requisite gathering from the teachers, it became clear the desired solution would benefit from the reliability of the web. Having a solution that requires only a web browser would create a shallow entry bar for both teachers and students, as they would have simple, guaranteed access to the tool in normal circumstances. From a technological standpoint, it would only be required to adapt the existing technologies and design them in a way that could solve the problem at hand.

From a design perspective, the conversion of the “pen and paper” format scenario into what will become the application, is a collaboration between developers and teachers. It is paramount that both parties provide feedback, the developers by introducing UI and UX principles, tied together with the teacher’s requisites and needs.

The initial proposal is to rely on iconography and the fluid page layouts that web applications easily enable. This should provide a starting point for an early draft of a design that would get refined as the project evolves. Having the information readily available would enable both the students to study and prepare the scenario beforehand, as well as consult any information “on the fly” during the laboratory practice.

3.9.4 Idea selection

Due to the iterative nature of the design’s evolution, the selection process is very intuitive and ingrained within the development, as ideas get implemented and removed, the design would evolve into what would become a “beta” version to be tested by students and teachers, only to then be reviewed and improved further. From a technical standpoint, the selection process stems more so from the exploration of technologies that could benefit the development and deployment. On an initial stage, a preliminary architecture design was established firstly, and exploration followed, always ensuring it fits the initial conceptualised architecture plan.

3.9.5 Concept definition

Since the current objective revolves around the evolution and improvement of an already existing method, the central concept revolves around creating a new format that can gather the critical information and convey it in a visually appealing way. The process of selecting the correct information and designing a means to visualise it, via iconography, graphs or text. The final project would be generated from the iteration and evolution of this process.

3.10 The Business Model Canvas

The business model canvas is known as a means to document a lean, strategically defined business model (Barquet, Cunha, Oliveira, & Rozenfeld, 2011). This model, initially proposed in 2005 by Alexander Osterwalder (Osterwalder, Pigneur, Smith, & Movement, 2010), is used to illustrate and streamline the most critical information a company or project needs to be viable, allowing a clearer vision of its objectives, means to archive them and overall strategy and vision (Osterwalder et al., 2010). Since this initiative can be considered a technological product, with business potential, the canvas model would allow the exploration of this potential. The different sections of the model are:

- **Key Activities**: Provide software that enables the creation and maintenance of scenarios
- **Key Resources**: The primary resource is the application software, and its required infrastructure (server hosting)
- **Key Partners**: The ESEP is the leading partner, it could, in the far future, provide a way to distribute this project and business to other schools
- **Value Proposition**: A method that enables the creation of scenarios for the laboratory classes for the NUC.
- **Customer Segments**: Students of ESEP
- **Channels**: Digital (Web) or a physical medium (paper, for example)
- **Customer relationships**: Our goal is to establish a relationship of trust and transparency with the students, allowing the information to be readily available at their request.
- **Cost Structure**: Development time to create the solution, and possibly, server usage costs to deploy the application
- **Revenue streams**: Due to the scope of this project, it will not provide any expected revenue stream.

This information can be compiled into the canvas in Figure 14.

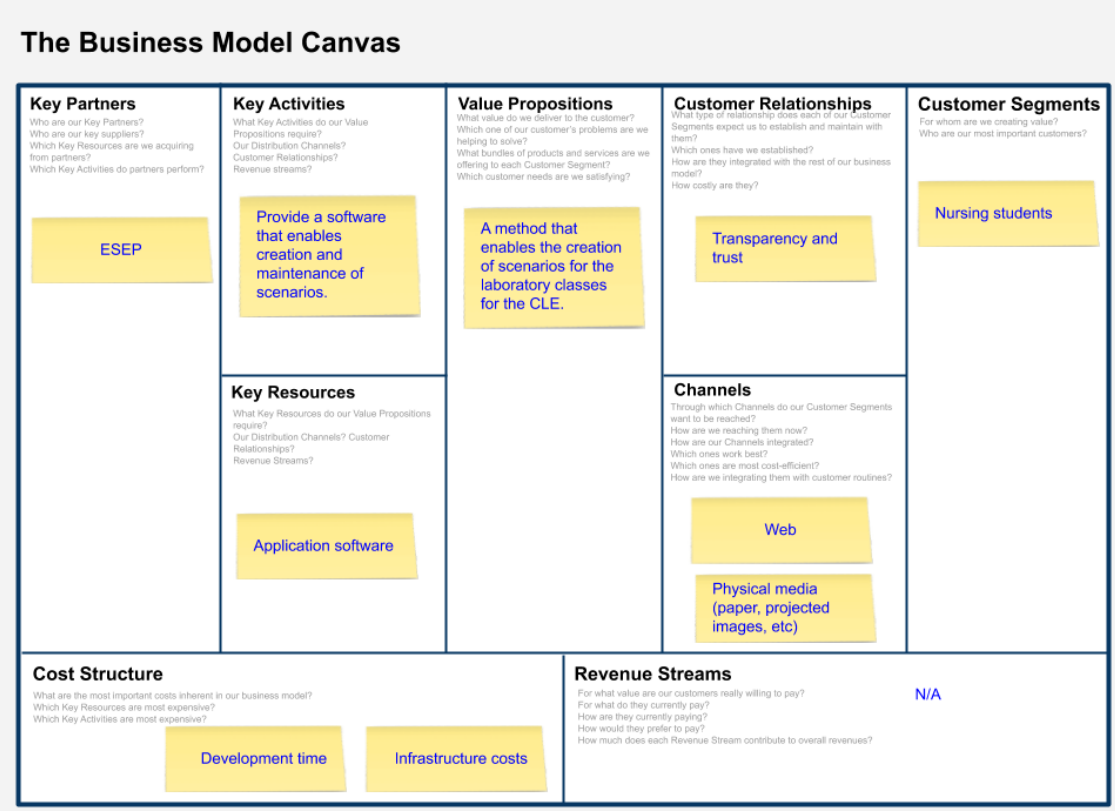


Figure 14 – Business Model Canvas for the current project

4 Design

4.1 Objectives

As established previously, this project will comprise two primary high-level functions: allow the teachers to create and publish scenarios, and students to read them. A teacher should access the platform, be presented with a dynamic document where information and details on the scenario can be introduced. Once the teachers have finished creating the scenarios, they can publish them, making them available to all the students.

4.1.1 Old scenario format

Before analysing possible design solutions, it is essential to investigate the current workflow and processes the teachers and students apply. The dynamic and process of the laboratory classes were already explored in a previous chapter. The focus of this section is to analyse what information is conveyed in a written scenario, so that we may later elaborate possible design alternatives.

The NUC teachers prepare their scenarios using a text editor, such as Microsoft Word, describing the clinical status and socio-economic details about the fictitious persona that is the patient. Firstly, they define the name, age and education level (primary school, high school, bachelor, among others). The clinical situation is briefly established afterwards, summarised in a couple of lines, they detail the medical condition of the persona. The scenario description constitutes the main body of text, describing the intricacies and context of the socio-economic and social status. This section details the clinical scenario in much more detail. It delves deeper into the persona's life, detailing whom she lives with, what complications she faces daily, for example, difficulties getting up or walking long distances.

The following Figure 15 represents an example scenario previously used by the teachers.

Cenário 1
Dados da doente: Sra Graça, 82 anos, casada, 4 anos escolaridade
Situação clinica: Pneumonia de aspiração.
Dados do cuidador: Rosa, 58 anos, 6 anos de escolaridade
Descrição do cenário:
A Sra. Graça foi admitida no CH com quadro de dispneia, febre, tosse produtiva, aumento da expetoração e presença de sons respiratórios adventícios. Foi internada no serviço de Medicina com o diagnóstico clínico de pneumonia de aspiração. Doente previamente dependente em grau elevado nas atividades que concretizam os diferentes domínios do autocuidado. As duas filhas assumiam a prestação de cuidados à mãe. Uma delas (Rosa) está em situação de desemprego, recaindo sobre ela a maior parte dos cuidados diários: dar banho, vestir, transferir e posicionar, alimentar, levar ao sanitário. Em contexto de internamento, a filha refere que alimentar a mãe se torna cada vez mais uma situação geradora de ansiedade e stress. O medo de que ocorra uma situação de engasgamento, leva a que evite alimentar a mãe (só o faz com maior confiança quando a irmã está presente). A Sra. Graça não utiliza prótese dentária e tem uma dentição muito incompleta. A filha tinha já vivenciado uma situação traumática com o pai num mesmo contexto (obstrução parcial da via aérea com necessidade de recorrer ao serviço de urgência e internamento hospitalar devido a complicações consequentes).

Figure 15 – Old scenario format

As a possible solution, the teachers delineate a plan of action, outlining what exams and or analysis the student must perform, under which scales should he evaluate specific parameters and, most importantly, how should he convey information to the patient and caregivers. These are often kept as teacher's notes.

4.1.2 Use case diagram

After an initial phase of interviews and information gathering from the NUC teachers, the most relevant use cases were compiled in a use case diagram. The teacher's overall notion was that scenarios should be comprised of patient and caregiver personas, the latter being specific only to some cases. Similar to the format used so far, each persona would have its document. Unlike the old format, however, the documents should have an appealing design, that organises information hierarchically in a visually appealing way. They should also have their expected manoeuvrability, to be edited at any time or even deleted. Some potential use cases described could be expanded upon other features, such as the ability to email the documents directly from within the app or means to duplicate the existing content for further editing. These additional use cases were left out of the diagram, as they would require further refinement and analysis. Figure 16 shows the use cases elaborated for this project.

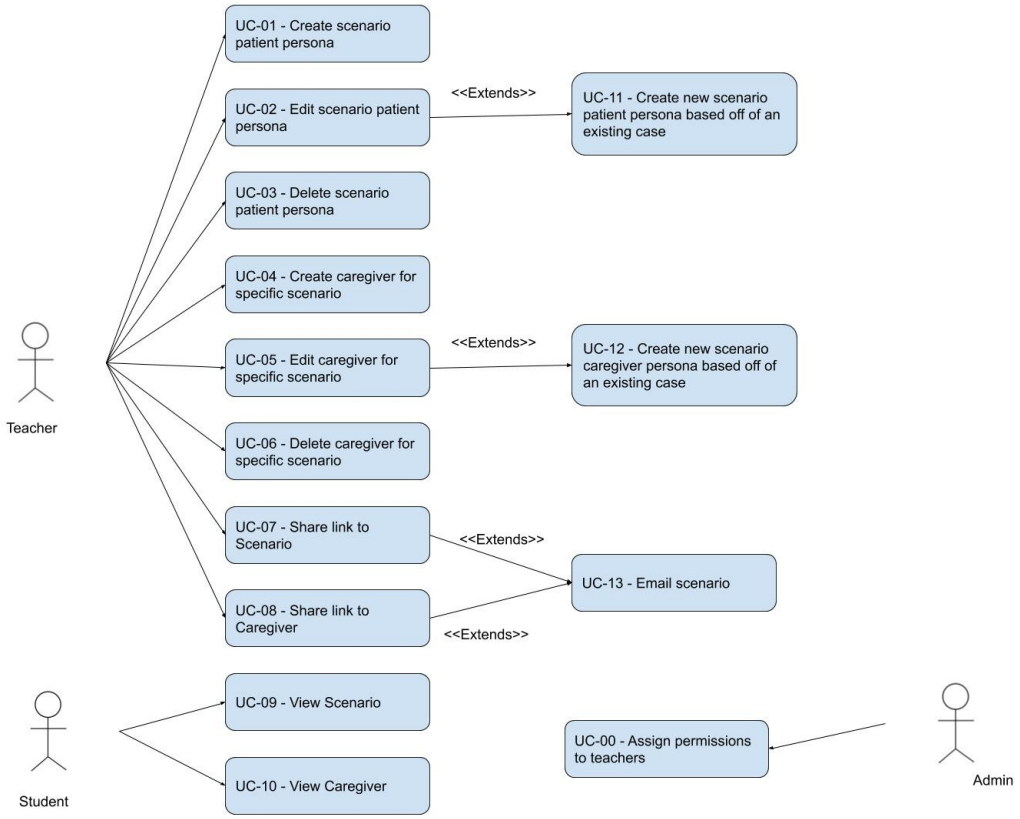


Figure 16 – Use case diagram

4.1.2.1 UC-00: Assign permissions to teachers

During the use and deployment of the tool, an entity is required to manage new users and assign the teachers the proper permissions, so that they can adequately make the best use of the application.

4.1.2.2 UC-01: Create patient persona scenario

The most important part of a scenario is the patient information, detailing the clinical state and all the nuances the students should know before the interaction exercise. When constructing these scenarios, the tool should ensure that the design and page structure follows the design.

4.1.2.3 UC-02: Edit patient persona scenario

Once created, the teachers should also have the means to edit the information.

4.1.2.4 UC-03: Delete patient persona scenario

Should the teachers see fit, the documents should also be easy to remove permanently.

4.1.2.5 UC-04: Create a caregiver persona scenario

Caregivers are additional personas that may compliment a scenario. These are optional, but when created, they must always be associated with a specific patient persona. The creation of these personas must also follow specific design guidelines.

4.1.2.6 UC-05: Edit caregiver persona scenario

Once created, the persona information should open to future edits.

4.1.2.7 UC-06: Delete caregiver persona scenario

The caregiver persona documents should also have the option to be deleted.

4.1.2.8 UC-07: Share a link to scenario page

The teacher should be able to publish and share their work with the students and the community. Once created, the scenarios should provide a URL that allows others to view the document. The same URL should allow for the simple integration with other systems, where the teachers may add the link to the created page.

4.1.2.9 UC-08: Share a link to caregiver page

Similar to UC-07, the caregiver pages may also be shared similarly.

4.1.2.10 UC-09: View patient persona

Students or members of the community should be able to read the published patient scenarios.

4.1.2.11 UC-10: View caregiver persona

Students or members of the community should be able to read the published caregiver pages.

4.1.2.12 UC-11: Create new scenario patient persona based on an existing case

This use case is an extension of the use case UC-02, beyond editing an existing scenario, the teachers should be able to create a new document using the information of another as a template. The goal is to allow for existing data to be reusable and adaptable for new cases.

4.1.2.13 UC-12: Create new scenario caregiver persona based on an existing case

Similar to UC-11, the same concept should apply to the caregiver documents.

4.1.2.14 UC-13: Email scenario

An extension the both UC-08 and UC-09, to facilitate the sharing process, teachers should be able to quickly share information with a predefined set of teachers or students, via email.

4.2 Interface design

Given the use cases so far, a web application seems to fit the requirements the most, since it allows for an easily distributable application that can be accessed via any device. A few mock-ups of the application can be drawn with this assumption. The designs illustrate the conceptual idea.

4.2.1 The application flow

It is essential to establish a hierarchy for the user's navigation. We have previously stated the use cases, and there is a notion of what pages would be required. Still, it is also necessary to establish a page structure under which the application will operate. Since only the teachers can edit existing scenarios, there is a demand for an authentication flow. There is no need to authenticate the students, as they should be able to easily access the content once it is distributed (via the URL). Although it is not a requirement by neither the teachers nor the students, it is interesting to have an "about" and "help" page. The first explains what the purpose of the web application is and who built it, with an additional form for contacts for any inquiries. The "help" page is meant to have information on how to use the application and clarifies any frequently asked questions.

In Figure 17, we can see a diagram that proposes the site map of the application. While it should be possible to navigate between any of the existing pages, there should still be a hierarchy. In this case, the decision was to separate the concepts of "patient" and "caregiver" scenarios as different pages. Since each contains information relevant to distinct students, in theory, one would study the patient scenario while another would be more focused on the caregiver to roleplay. There is also a distinction to be made between the creation and viewer

pages. While both may share the design, their functionalities are critically different. Additionally, one should be more secure, and only accessible by authorised users, i.e. teachers.

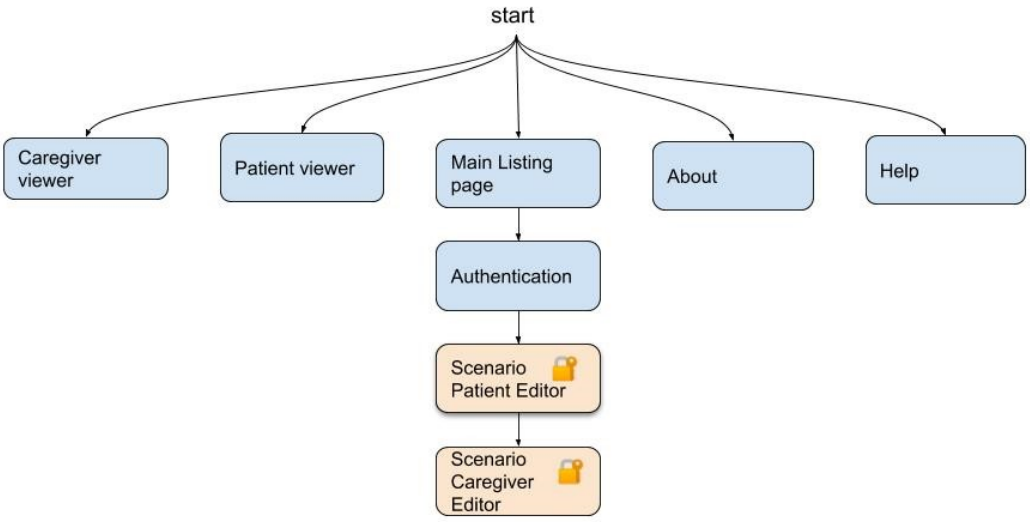


Figure 17 – Diagram demonstrating the application flow

4.2.2 The authentication interface

For the authentication interface, we can assume the standard processes of a web-based application. Providing user input for credentials and validating information on the server-side. The design is illustrated in Figure 18.

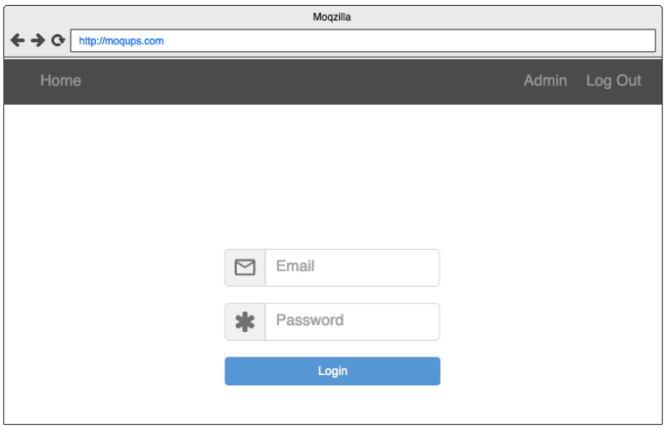


Figure 18 – Mock-up design of the authentication interface

4.2.3 Scenario creation interface

The core concept and the primary focus for designing a scenario page are to focus on as many visual elements as possible. These can be anything from images, iconography or, when necessary, rely on blocks text that is appealing and interesting to read. One of the ideas, borrowed from the CURE designs is to use avatars for each scenario. An avatar is a picture of a persona. Teachers may choose to use a stock photo sourced locally or online, or even a drawing. The main goal of this element is to create empathy with the reader by adding visual cues. The fictitious persona with the specific clinical condition would then have some face the readers would be able to associate meaning and empathise. The iconography, using different shapes, can be used to convey rapidly perceptible information about essential variables. For example, a symbol with a dollar sign would easily portrait wealth. The icon of a pill can quickly symbolise medication. A stethoscope is inherently medicine or doctor related. While it seems fair to assume the target audience will intuitively understand the visual cues, additional labels should be added for a more explicit representation. These designs are laid out in Figure 19.

Another design alternative is to allow the creators to pick and choose how they display the information. In this design option, the teacher will be presented with a blank slate, where they would add a series of assets: either text boxes, pictures or various icon scales or range selectors. These would be displayed in a grid-like layout and could be dragged and displayed in any sequence. This option would allow for the scenarios to take on a more personalised look, no two designs looking the same, depending on the teachers' preference, which could lend itself to be adapted to each class or scenario.

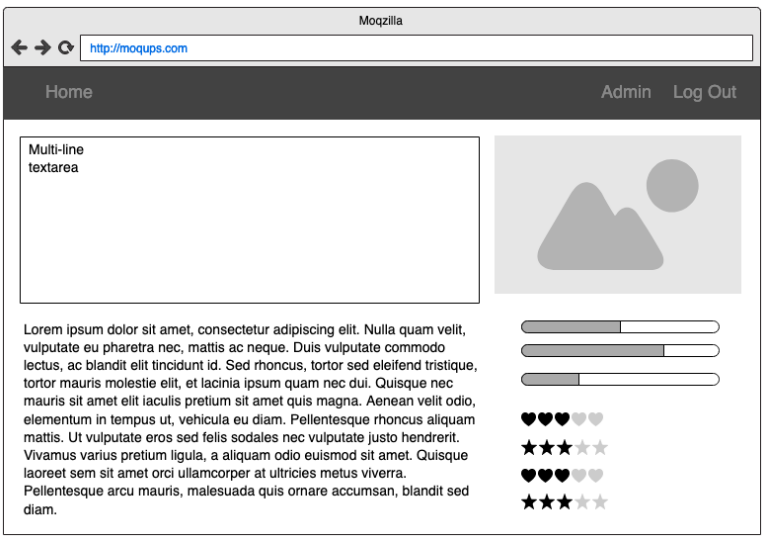


Figure 19 – Scenario creation interface mock-up

This primary mockup aims to illustrate the different components to explore when implementing the page. The image placeholder is where the picture of the patient or caregiver

would be (depending on the type of scenario). The bars half full or empty would be labelled to some aspect of their social or health status; for instance, the cognitive capability would be rated by the volume on the bar. The stars and heart icons represent a scale, typically seen in applications where the user is asked to grade an application or movie. In this context, these icons would be shaped to represent specific characteristics, the patient's motor skills or its overall mental state are fitting examples. These mockups would later be refined with further understanding of the teacher's needs.

4.2.4 Scenario management menu

There needs to be a menu screen to manage existing scenarios, with Create, Read, Update and Delete (CRUD) mechanics. This functionality can be achieved by listing the existing scenarios as can be seen in Figure 20.

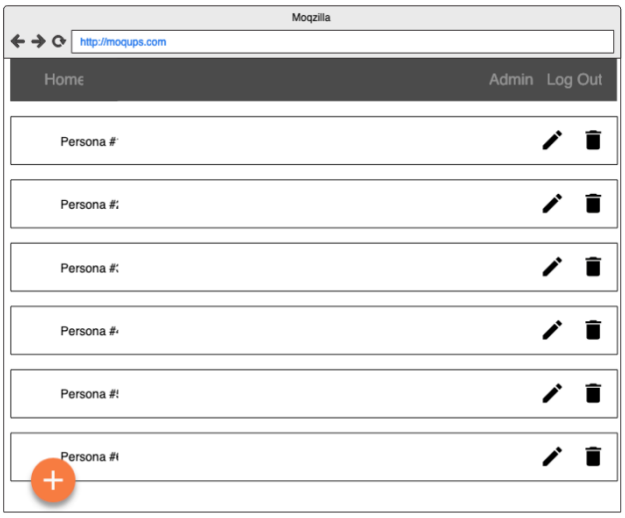


Figure 20 – Scenario management menu mock-up

In Figure 20, we can see an early mockup of the listing page. This design aimed to be as minimalistic as possible. Again iconography would be used to symbolise the primary operations. However, unlike in the scenario page designs, this iconography is already more or less established for mosts users, due to their experience on other different web platforms. General experience using web application has ingrained the simple iconographic concepts. Examples of this would be the trash can, symbolising the delete action; or the pencil icon that symbolises altering something.

4.3 Server-side application design

From the perspective of the backend logic, the concepts remain very similar. The central authentication logic will determine who can edit scenarios. The assumption is made, when these are created, that they can be viewed by anyone, though not necessarily listed publicly.

4.3.1 Scenario management

A scenario is composed of two major parts, the patient-related information, and usually up to two caregivers, often personas who are related to the patient and will take part in the interaction. Based on this, we can determine there are two types of entities who need to be coupled with a “one to many” relationship – one patient may be related with up to two or more caregivers.

Considering both patients and caregivers as different page, these would be at its core, web pages with specific content. These can be new pages added to the server, much like a Content Management Service (CMS). Meaning scenarios would behave as static pages. A public listing page may also exist, assisting users in finding specific scenarios. Alternatively, this task may be left to ESEP’s already existing applications, by linking to specific scenarios, the teachers may more easily manipulate the content, either by projecting on a screen or printing and distributing in physical format.

4.3.2 Data modelling

A data model establishes the main elements under which the application handles and the relations between them. From the previous sections, we have been able to gather some essential concepts:

- Scenarios are the documents that detail a general roleplay setting.
- Patient represents the prime persona within a scenario, the subject of analysis and interactions. During the practical exercise, the students will interact with them to retrieve and pass on information. This model should contain both clinical data and psychological and socio-economical status.
- The Caregiver model is a complementary persona, in many ways similar to the Patient, only with the psychological and socio-economical data.
- The Teachers model represents the users who create the scenarios.
- The students model represents users who will access the created scenarios.

Figure 21 represents the beforementioned entities, establishing the relationship between them results in the following data model for the current project.

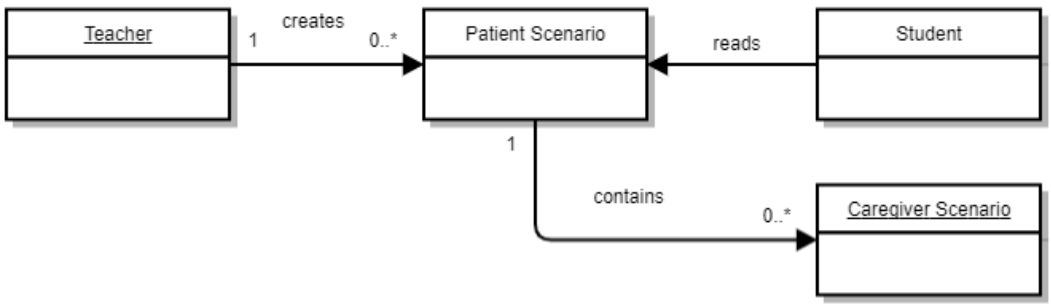


Figure 21 – data model diagram

The teacher will initially create the scenarios, preparing material for future classes. The patient scenario is a persona with a specific clinical status and socio-economic or psychological conditions that will influence the interaction. Caregivers may also act as complimentary personas within a specific scenario. The feedback from teachers established that a scenario would have no more than two caregivers. However, this was not an ironclad business rule, hence the decision for the model to support an infinite number of caregivers. The client-side of the application would manage this to ensure the data is easy to handle. The student represents the final user, who will have access to the finalized scenarios, both patients and caregivers, who will study the cases and prepare the interactions he will perform during the laboratory classes.

4.3.3 Deployment and server architecture

It is crucial to establish how the project will be developed and deployed. In the current scope, we require both a service to host the application and the data. As we have analysed in the chapter “State of the art of web technologies”, it is essential to see which solutions fit the current scope. To build the entire infrastructure would require plenty of work, which would be time-consuming and hinder the final result’s quality since the focus would shift to other more mundane yet fundamental tasks (managing databases, setting up hosting services as examples). The SaaS solution would also be too restrictive, as we have also seen in chapter “Similar solutions”, there are not any solutions capable of satisfying the requirements. An IaaS solution would also require the setup of infrastructure, databases and even the runtime environment. The PaaS solution, however, is an adequate alternative. Firebase, the PaaS of choice offers a selection of services that include database, file hosting and even offers an elaborate security system (quickly enabling authentication with third parties like Google).

5 Implementation

The implementation chapter reports the various developments and decisions made throughout the development of the application. The very first section establishes the “how” the project was developed, describing the tools and frameworks used. The different application’s components are then described in separate sections. First, the different design elements’ implementation is detailed, where each page is described, with particular emphasis on the various elements that compose the scenario’s viewer and editor pages. Following this, Firebase is explained in further detail, and the various implementations and data models used are explained. Regarding the data model, the project went through many redesigns, until reaching the final data structure, each alternative that was explored is also detailed, along with details to why it worked or did not work. Lastly, some potential future works are explored, leaving ideas for future implementations.

5.1 Concept development

As was seen in the value analysis of this project, the main focal point was the design and presence of useful UI and UX elements that facilitate access to information. The first and foremost objective was to have a beautiful interface that can quickly and easily convey the desired information. The second goal was to ensure universal access from virtually any device, which we could achieve by having the application accessible online. To accomplish this, Firebase seemed to be the best option to host both the data and the web application.

To create the designs, the CSS framework Bootstrap provided some of the much-needed basics such as responsive pages, grid system to build the layouts, consistent colour schemes and an extensive library of icons that benefited the UI/UX development. A software tool called Bootstrap Studio enabled the design process. One of the advantages of this tool is that it is capable of exporting the designs as HTML, CSS, and even JS, some of the more straightforward code logic was done inside this tool. The output was then customized and modified to integrate more complex logic. It was paramount that there was a fluid feedback loop with the

NUC teachers to establish the designs. This way, they were able to provide the best input and express their needs, creating a good design that will please its future users. Regarding the development of the application's logic, all the logic will reside in the client-side application. The implementation was done in layers so that that code could be more easily organized and debugging future issues may be simplified. While the entirety of the logic will reside on the client-side application, there will need to be considerations regarding how the data model will be implemented, how security will be handled, and other general considerations that should be taken while using the Firebases' products.

5.2 Scenario presentation and editor pages

In the previous chapters, we have broadly discussed both the page layout and the design elements that would be incorporated. This section will delve further deep into the page design itself, detailing the logic behind the various design elements. The designs that were established, after several feedback iterations, are shown in the following Figure 22 and Figure 23.

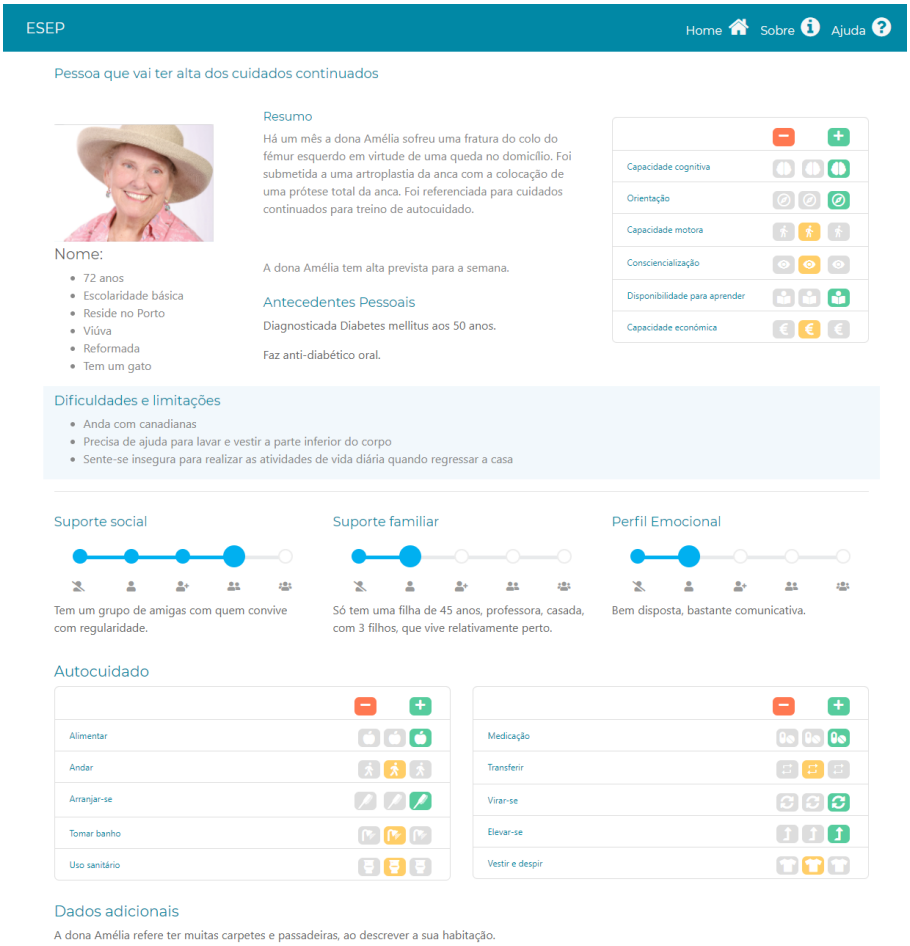


Figure 22 – example of the preview of a patient within a scenario

The patient design contains the following elements:

- An avatar, a picture of the persona
- An introductory block, in the example of Figure 22 containing a list of the patient's necessary information
- A summary section, where the short description of the scenario is provided
- The iconography section representing the patient's status
- A section labelled "difficulties and limitations", detailing the hardships, issues or complains of the patient
- An area of range selections that mark the patient's social and familiar support, as well as the emotional profile.
- An area labelled "self-care" details the different capabilities via icons (for example, how well the patient can eat)
- A final section dedicated for additional, optional details

Figure 23 – example of the preview of a caregiver within a scenario

The caregiver page has the following elements:

- The top area representing the avatar and main details (similar to the patient page)
- A section labelled “data”, meant to provide a summary of this persona
- An iconography element to detail the caregivers' different capabilities and general status (from mental state to wealth status)
- A section labelled “Roleplay evolution.” Contains specifics on how the interaction should play out (during the laboratory session)

5.2.1 Common elements and design language

As with any web-based design, there are commonly established rules and standards. Some may not even be perceived by most users until they are lacking, since these are seen a universally commonplace language of web-design. We refer to elements such as header bars, navigation icons, consistent font and colour choice. This project uses as its primary colour a blue tone, very similar to the ESEP’s primary colour, seen in Figure 24. Since this application will ideally be integrated as part of ESEP’s web applications, it makes sense that it should follow the same colour scheme and design philosophy.

Figure 24 – ESEP logo with its primary colour as the background

The header bar is a staple of any webpage and offers quick and easy access to the main functionalities or pages of the web application. The organization should follow what has been established in "The application flow" chapter. The header bar, seen in Figure 25, should include: the "main listing page", aka the "Home" page, since it is the starting point of the application and provides access to all scenarios; a dedicated page for help regarding the app; and an "About" page containing additional details about the application and a contact form for feedback.

Figure 25 – Design of the applications header bar

5.2.2 Scenario page structure

There is a hierarchical visual structure for both patient and caregiver scenarios. Its commonplace for Western cultures and most European languages to perceive information and read from left to right. On the first inspection of the page, the avatar is the most eye-catching element, particularly so as it will often have a human face, creating more symbolism and meaning to the rest of the scenario. The top sections of the page aim to convey the most crucial information: the medical condition, the summary and the badge status icons. The mid and lower divisions contain complementary information. Students that lean more on visual memory will likely find it easier to assign the different sections of the page with the various pieces of information. The assumption is that they will benefit from this organization, as it helps information access and memorization.

5.2.3 The persona (avatar)

The avatar is simply a picture that is assigned to that specific scenario. This element is very subtle but vital, as it helps to create empathy for the fictitious patient, which ultimately assists

the memorization process. Students will be able to associate a specific face with a clinical profile, as opposed to simple raw data.

We rely on Firestore, Firebase's file management system, as a means to upload the images and act as a CDN for distribution. It is expected that the teachers will use photos of their choice. The faces that are shown in this document are mere placeholders randomly picked from the Internet, and used throughout the development process.

5.2.4 Iconography

Iconography was essential to establish a quick visual means of communication. The icons themselves accompany the labels and serve as a visual shortcut to quickly remind the user what each file corresponds to, mainly after they have grown used to the interface and the general layout of the scenario's personas.

Icons are mostly taken from "Font Awesome 5", a free to use library which offers an extensive collection of icons that can be easily imported and used in any web application. They were hand-picked and selected to best suit each label. While some illustrate a clear visual example, like an apple representing the ability of the persona to feed themselves, others resort to more relative symbology, like the arrows turning up symbolising the specific mobility of the patient persona to rise (from a bed or chair). The following list details all the icons used.

- Cognitive capacity, detailing if there is any damage in the brain that could affect cognitive functions, is represented by a brain icon.
- A compass represents orientation, the ability to remember common or new spaces and to recognise paths.
- A walking figure represents motor skills.
- The icon of an eye represents the persona's awareness of its clinical situation.
- An icon of a person reading a book represents the availability to learn.
- The icon of the Euro currency represents the economic status (since this application is only meant to be used locally, there is no need to concern over other countries' currencies).

Figure 26 represents an example of the icons mentioned above.

Figure 26 – Example of iconography

On the self-care section of the page

- An apple represents the capacity of feeding.
- A walking figure represents the capacity of the persona to walk.
- A hairbrush represents the general ability to get ready for an average day, more specifically, it includes the ability to comb hair, handle oral hygiene, care for nails and use deodorant.
- The bath icon represents the capacity to: bathe oneself, open the water, use utensils
- A toilet icon is relatively self-explanatory, representing the capacity to use the facilities.
- An icon representing two pills will be associated with the ability to handle, prepare and take medication.
- The arrow icons represent the capacity to transfer between positions, that is, to transition between different positions such as sitting, lying down or standing up.
- A rotating set of arrows indicating rotation, represent the capacity to turn in bed.
- An arrow pointing upwards with slight turn attempts to imply a rising motion, to detail the mobility skills of the persona as to how well they can get up from a sitting or lying down position.
- Lastly, an icon of a shirt represents how well the persona can dress or undress.

Figure 27 represents an example of this iconography as displayed in an example scenario page.

Figure 27 – Example of iconography in the self-care section

In order to represent the state of each field, the position and colour of each icon are considered. It is universally interpreted that red is associated with something malicious or dangerous, the green being positive or safe, and yellow a sign of non-immediate dangerous warning. This attempts to mimic the same functionality of traffic lights, a very mundane everyday design element. However, it is essential to take into account that some users may have some form of colour-blindness which may hinder the perception of a status icon. An additional illustration can solve this issue. Two icons are represented at the top of each group, showing a plus and minus signs. These icons would lead to an unequivocal perception as to what each status means, being either positive, neutral or negative.

It is important to note that this iconography element aims to convey quick status information more so than to detail specifics. Establishing that a patient's parameter is good or bad may not provide in-depth clinical details. For that, the teachers designing the persona should look for other text fields where they may better describe specific details about a persona's medical condition.

5.2.5 Custom range selection with CSS elements

Another design element utilised to establish an order of greatness is the range selector. This element is a custom design, created using custom CSS styling. There is a total of three of these selectors on a patient's page, there correspond to the social support, family and the emotional profile, respectively. Each selector has a total of five levels, from left or right, "filling" the bar as they improve. These levels are related to the context of the field and accompanied by text blocks that offer additional information.

1. Non-existent
2. Insufficient
3. Reasonable, enough to sustain basic needs
4. Good

5. Very Good/Excellent

The leftmost range selected represents social support the patient currently has. This type of support is provided by daycare institutions or other similar associations, which act as agents in the integration of the elderly in society, assisting in their social inclusion and improving their healthcare.

The middle selector represents family support, how helpful and supportive the patient's family is. This item includes assistance in housekeeping, medical needs (such as accompanying to medical appointments), shopping and other similar commodities, emotional support, or even helping to socialise and to fill free time.

The emotional profile represents the personas mindset and its resilience, meaning the ability to deal with aspects of day to day life. In this section, the ranges still hold a similar meaning, but related with the emotional profile of the persona, from lowest to highest these are volatile emotional profile, unstable, reasonable (enough to tackle daily life), good and very good or excellent.

An example of these range selector can be seen in the following Figure 28. In this scenario, each value is justified by the short descriptions that follow it. In this case, the persona has adequate social support as it relies on a group of friends, with whom it socialises regularly; the low family support is justified by the persona only having one daughter, and the emotional profile describes a somewhat unstable profile.

Figure 28 – Example of range selector within the context of an example scenario

5.2.6 Skeleton body during page load

At times, mostly due to poor internet connection, the page load and data retrieval can be somewhat slow and lead to an unresponsive page. To visually communicate to the user that the content is loading a visual trick is used. A shape of the page is loaded first, with bars resembling text show a moving gradient, signalling the user that some work is occurring in the background. With this, the user perceives the page as loading and can immediately recognise where the text will be. An example of a loading screen is shown in Figure 29.

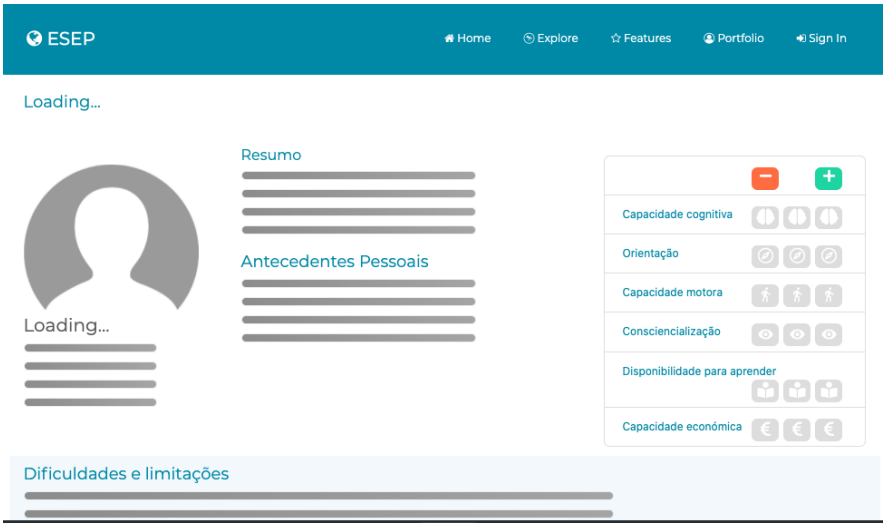


Figure 29 – Example of a loading page

5.2.7 Scenario editor

After establishing a design to present the scenarios, there is still the need to demonstrate how the teachers will introduce this information to the system. Filling out a scenario, patient or caregiver, should require a set of data: blocks of text to describe the different areas of the page. In order to provide the best possible experience for the teachers when filling out this information, the scenario editor pages are designed in similarity to their respective presentation pages. The design for the editor page can be seen in Figure 30.

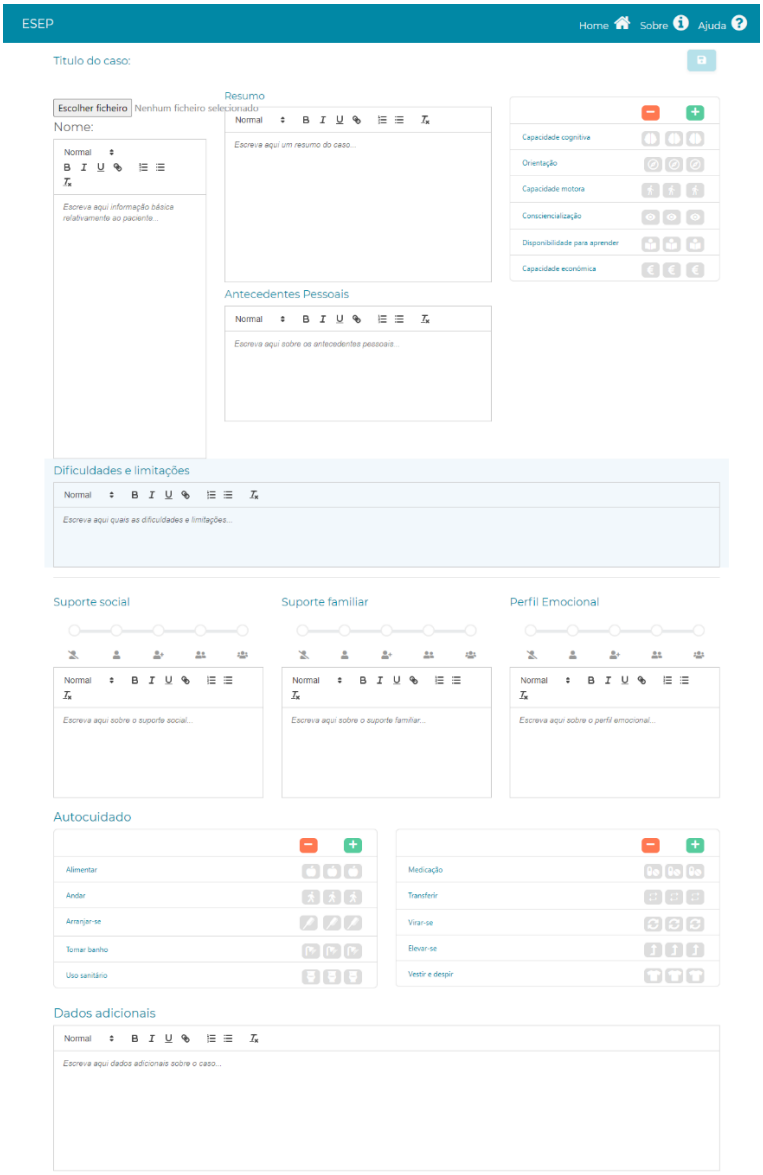


Figure 30 – example of the scenario creation page with all empty fields

While the design is very similar to the presentation page, there are some differences. The image is replaced with a file input, that uploads a picture of choice, that will then be displayed above the label. The text areas of the previous design, are now text inputs, using the Quill library, these may behave as rich text editors (which enable the use of styles like italic, bold, different fonts or sizes, bullets or other text embellishments). All the icons are greyed out; however, clicking on them will change their colour appropriately. The same applies to the range selectors in the middle of the page. Both selectors and icons can be deselected by selecting again an already existing input. Any fields may be left blank by choice. Finally, at any point during the creation, the user may press the floppy disk icon, at the top right-most corner of the page, to save the data. If the teachers are editing an already created scenario, then these fields would be populated with the already existing information. The save functionality

is aware of the document's state. If the new scenario is saved once, a new record is created, further presses of the save button will update the previously stored document.

5.2.8 Text editor functionalities with Quill

In order to fill out the text sections of the page layout, several options were initially considered. Using the default HTML text input element would be somewhat limiting, as the writer would not be able to use some elements such as bold, italic or even bullet points. The Quill library offers a WYSIWYG (What You See Is What You Get) component that can be fully customisable and would best suit the style of the page, allowing the writer to manipulate the text within the given area completely.

The application constructs a Quill object for each of the text elements in the page, this is important to maintain the data integrity, as each object is responsible for its text. When a document is being saved, these objects provide their contents in the form of a string containing the corresponding HTML code, which is persistent within the Firestore document. When a patient or caregiver document is loaded, either in view-only or edit mode, the string containing the HTML is injected in the corresponding place, displaying the information as intended. Figure 31 shows an example of this design element.

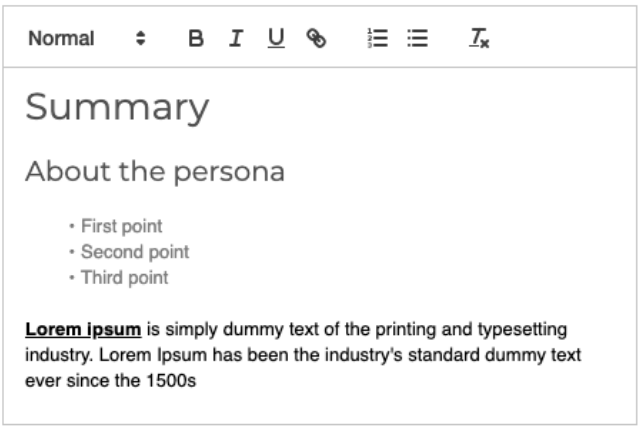


Figure 31 – Example of the text editor field in one of the areas of the page

5.3 Scenario listing page

The landing page of the application is designed to be the first point of interaction with the users, both teachers and students. Teachers will log in to and proceed to create scenarios and modify existing ones. Students, on the other hand, would typically directly access an individual scenario the teachers previously shared. However, as secondary access, the students may also visit this page and consult the complete list.

This page relies on Firebase Authentication to control the user state, modifying the experience accordingly. Authenticated users will have access to buttons that allow them to create both patient and caregiver scenarios, as well as editing and deletion buttons; an example of this can be seen in Figure 32.

Figure 32 – screenshot of the landing page (with an authenticated user)

It might be confusing whether a user is authenticated or not. In order to clarify this, the username is displayed on the top right corner of the page. The example in Figure 32 contains a single patient scenario with one associated caregiver. An example of the page with multiple scenarios can be seen in Figure 33.

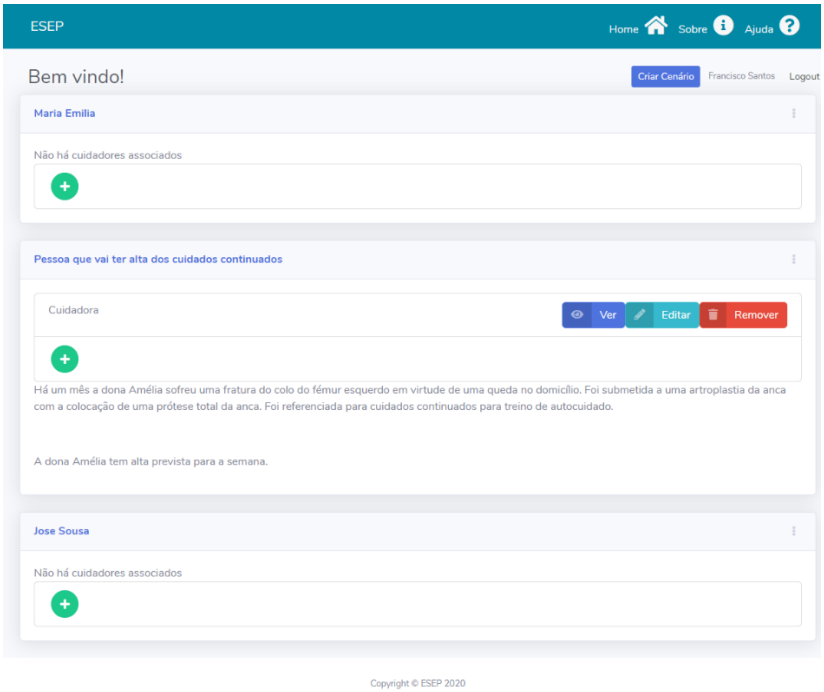


Figure 33 – Screenshot of the listing page with three different cards

Each scenario information is displayed using a design element typically know as a “card”. Cards are skeuomorphic elements, meaning design elements that mimic objects in real life with similar properties, as they are very similar to their physical counterpart, a piece of paper. The card typically has a header, a body and a footer, the latter being optional. Users may conceptualize different scenarios as different pieces of paper, each containing a preview of the information, and given controls to access the complete document. The body includes a preview of the patient data, displaying the scenario’s summary section. This brief data is essential, in case the scenario’s name is not informative enough to distinguish it from the rest. The three vertical dots in the card’s header provide access to a small dropdown that gives access to the CRUD operations, such can be seen in Figure 34. The caregiver list, above the description, displays the corresponding caregiver names. A plus icon at the bottom takes the user to the caregiver creation page. The caregivers are always created in the context of a patient, so each card in the list will have its own plus icon button.

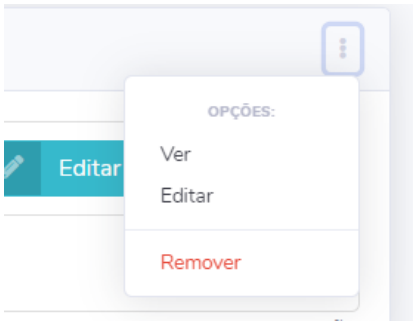


Figure 34 – close detail of the expanded card dropdown element

To summarize the available functionalities, the user can: view a scenario by clicking a card, edit or delete a patient via the dropdown options, manipulate caregivers by the respective buttons aligned in the list, and the plus button icon creates new caregivers associated with the corresponding patient. It is important to note that the delete functions will cause an interrupting prompt. This moment is crucial, as it is a sensitive operation (once delete, the scenario can no longer be retrieved), so a popup dialogue requests the confirmation before deletion, as can be seen in Figure 35.

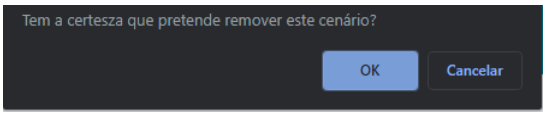


Figure 35 – Example of a confirmation dialogue on a scenario's deletion

Unauthenticated users will only be able to access the scenario pages in "view mode" or the authentication page; an example of this can be seen in Figure 36.

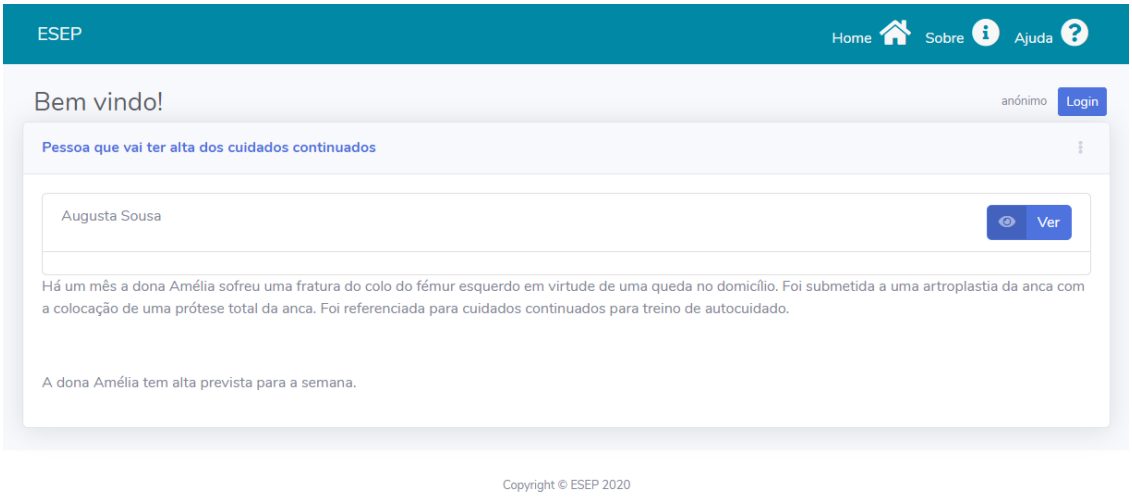


Figure 36 – screenshot of the landing page (without an authenticated user)

The label that previously displayed the username, now reveals the user is anonymous and unauthorized. The button controls for creating, editing or deleting content have also disappeared in this version of the page.

5.4 Authentication page

Firebase authentication is extensively used to manage this process. This page follows the very same patterns and conventions as most web-applications. The page layout is visible in Figure 37.

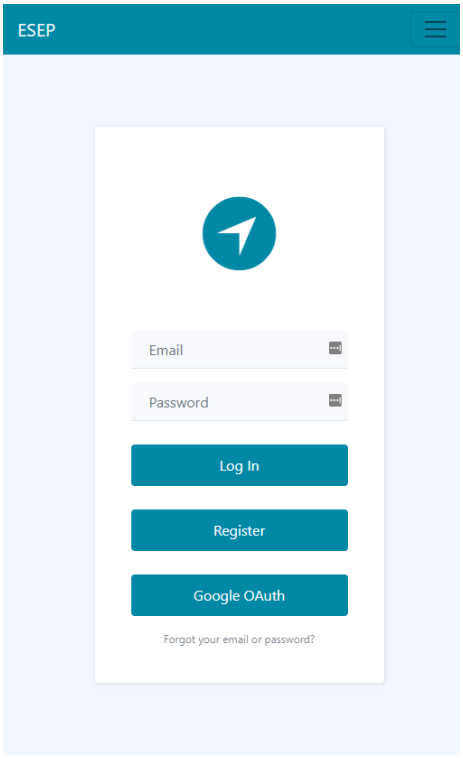


Figure 37 – Screenshot of the authentication page

The email and password fields serve as the input for both login and registration. Any error messages are displayed in red text, informing the user of what went wrong in the process; an example of this can be seen in Figure 38.

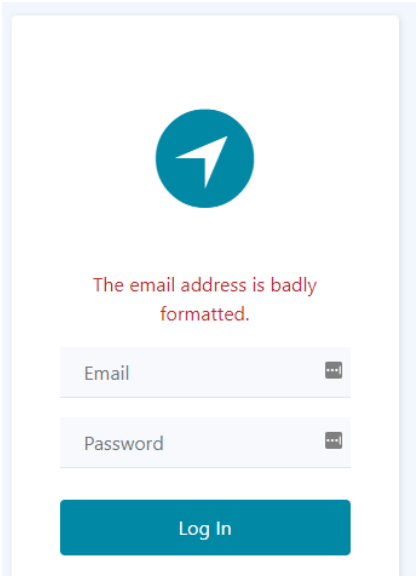


Figure 38 – Example of an error message in the login form

The “Google OAuth” button is an alternative experimental feature. It facilitates the login process by using the user’s Google account, without requiring email or password. In future implementations, this could be replaced with some form of integration with ESEP’s authentication system.

It is important to note that user authentication is not enough to be granted content management privileges since any user can create an account. Firebase rules were manually adapted to allow only specific users to have access. This topic will be covered in-depth in a later chapter.

5.5 Help and about

The “help” and “about” are secondary static pages, only meant to hold display information related to the app. The “help” page contains a guide on how to use the application, including images that adequately illustrate the prominent use cases, described in the Use case diagram section. The “about” page contains information about licensing, the authors, a brief context and problem of the main goal of the application (described in the sections Problem and Objectives).

5.6 Client-side application logic

The client-side application, particularly the scenario editor pages, demand some logic to integrate with Firestore seamlessly. From the user input to the adequately formatted document inserted into the database, there are several processing steps. The approach was to

consider the front-end application divided into four different layers, each with its responsibility. The diagram in Figure 39 illustrates this architecture.

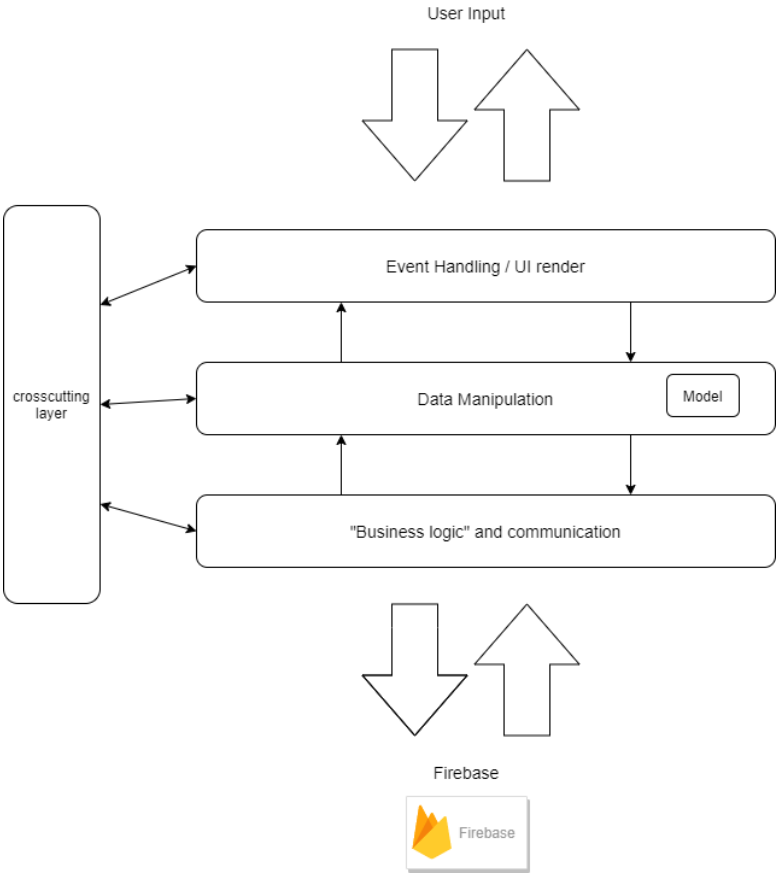


Figure 39 – Diagram representing the different layers in the client-side application

The first layer, the top-most on the diagram, has the sole responsibility of handling events (buttons clicks and text input as examples), and report the changes to the following layer. It is essential to note that this layer should have as little logic as possible, and be transparent to receive input from the layer bellow when it comes to displaying new information. In short, this layer encapsulates all the event handlers of the page and contains a render method to insert data in the appropriate places.

The second layer has the objective of manipulating the data received. A model, as demonstrated in Figure 39, is a simple JSON object, that functions as a contract of sorts, containing all the key-value pairs that the future Firebase document expects. In JavaScript, JSON objects can be processed in run time, and their fields manipulated freely. Additionally, Firesbase's database does not expect a strongly typed object. This contract merely serves as a tool to assist the creation of properly formatted data. This layer is also capable of inferring some additional scenario information, such as author or creation date.

The third layer acts as a database connector, carrying the primary responsibility of connecting to Firebase, reading and writing information. This layer contains some additional specific logic, as it needs to manage the state of the documents. While creating a new document, the teacher may desire to save their process halfway through. Suppose this happens, and they later finish the process, saving the scenario a second time. The code needs to be aware of an already existing version. All this logic and more resides in this layer. Additionally, the teacher may be in the context of a caregiver, within a patient scenario, in which case this layer holds the responsibility to ensure the proper associations are made.

The fourth and final layer contemplated in the diagram is represented in vertical since it should act a shared codebase, that communicates with all the previously mentioned layers. It holds utility functions and shared code, constants and other information that should be globally accessible anywhere.

5.7 Firebase

Firebase, originally an individual company which was acquired by Google, is a platform to enable the development of mobile and web applications. What was originally a tool to allow chat-based communication in applications quickly evolved to offer a complex set of products. Currently, Firebase offers services such as database, hosting, cloud storage, machine learning, messaging, analytics, performance monitoring, among others. This section will focus the two functionalities this project relies on, the database services (Firestore) and its hosting service. The latter is used to serve our applications front end code from a Content Distribution Network (CDN), making it the easiest way to publish our application to the World Wide Web.

5.7.1 Firebase rules

Rules are used by Firebase to control who can read or write documents to which collections. They are set in Firebase's settings page and use a specific syntax. An example of this can be visualized in Figure 40.

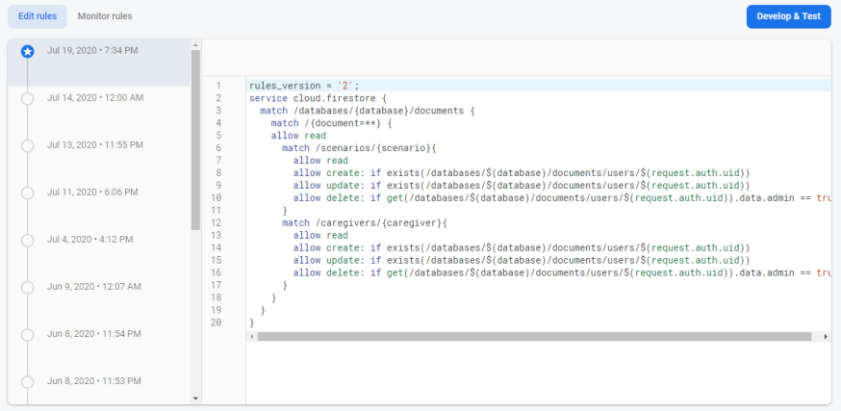


Figure 40 – Example of Firebases' rules system

In the context of the current project, we want to ensure only a specific set of users; more specifically, the teacher may have permissions to update or delete new or existing documents. The strategy to implement this was to create a "teacher" collection comprised of documents detailing the username, email and current status of each teacher. Given that, when these users sign in, a UID (Unique Identifier) is generated. So long as that identifier is in the teachers' collection, we can validate that a user is or is not a teacher. The process of registering a teacher, however, is a manual one. To add a new teacher to the system, they will have to sign-in first, and the teacher document will need to be created manually. This process is not expected to be an issue, as currently there are only a small number of teachers assigned to this NUC course. In the future, with integrations with ESEP's infrastructure, this process may be automated, given there is a method to validate the authority of a teacher online.

5.7.2 Firebase Limitations

Firebase is a service supplied by a public entity, the Google Cloud Platform, as such, some costs are expected. The service offers a free tier, suitable for development purposes, which should suffice for the development of this project. However, suppose the application is designed without taking these limits into account. In that case, it incurs the risk of not only exceeding the free tier's limitations but also incur additional costs in the future. The following Table 1 contains the limitations of the free tier:

Table 1 – Firebase free tier quotas

Free tier	Quota
Stored data	1 GiB
Document reads	50.000 per day
Document writes	20.000 per day
Document deletes	20.000 per day
Network egress	10 GiB per month

Given these restrictions and considering the current design ideas presented so far, it is possible to estimate that no more than 1 GiB will be stored. This quota should account for the source code that will be stored using Firebase's hosting, and the images used. As such, to minimize the space occupied by the source code, some steps may be considered, such as minimizing and compressing the code and importing third-party dependencies (jQuery, Bootstrap, Firebase's SDK) from external CDN's. Furthermore, the application's source may effortlessly be migrated to another platform or similar service. However, the images will account for most of the storage occupied, not only because these weigh more than source code, but also because the teachers will be able to upload one image per scenario they create. Given this, the best alternative is to include algorithm or systems that can either recycle images or reduce their quality. Thus saving user's bandwidth and making the application operate faster.

In terms of information transaction, Firebase takes into account the number of operations (reads, writes and deletions) more so than the amount of data transacted (network egress). The 10 GiB limitation is considerably generous; however, the number of operations allowed is more limiting. This limitation means that the data transferring large amounts of data at once should be preferred over transferring small batches in multiple operations. A consideration that should be taken both for receiving and sending data. This strategy could lead to the implementation of some caching strategies. For example, storing the document on a first read and reusing the stored value if requested within a short period. An approach, however, that brings additional unexpected complexity, as we will need to consider how long should cached data be considered valid or "fresh". If data is cached for long periods, it may happen that the actual server-side version had since been deleted or updated, and the user would be stuck viewing a deprecated version. The opposite is also problematic since it could also lead to eagerly fetching data when it did not change, and incur into extra unrequired document operations.

5.7.3 Firestore

Firestore is the name of Firebase's database service. It is a NoSQL, schemaless database, meaning it operates slightly different than the conventional SQL databases (such as MySQL or PostgreSQL). It has a rather loose set of rules for database-side document validation, due to its schemaless nature, and its queries are also relatively distinct than those of SQL databases. While the lack of schema provides much flexibility, it also means the application code must be defensive to ensure consistency. It operates under a few special rules and introduces two main concepts under which it sorts its data: documents and collections.

A document can be considered a JSON object, as it shares much of its functionality and syntax, which constitutes the primary form of data. They are made up of key-value pairs that can be of many basic types: integers, floating-point numbers, strings, date-time, Boolean, bytes, GPS coordinates, arrays and even other nested map objects containing other key-value pairs. Documents cannot be partially retrieved, functioning as a single block of mobile data.

Collections are aggregations of documents. Due to Firestore's schema-less nature, a collection can have different kinds of documents. For example, it would be possible to aggregate both patient and caregiver scenarios documents in the same collection (however, this would not be advisable, since additional logic would have to be used in order to distinguish each document).

Firestore also allows collections to be nested under documents, creating the concept of sub-collections. Subcollections may have documents which may also add layers of subcollections. Firestore limits this nesting to up to 100 layers of data. This nesting may also be treated in a form very similar to that of a system folder path. An example of this would be: "scenario_collection/patient_id/caregiver_list/caregiver_id". Subcollections create the dynamic relationship of "one to many", where the parent entity may have multiple children. This type of organization is very fitting to establish the relationship between patient and caregiver, which will be further explored in another section. One last important feature to note is that Firestore queries are shallow, meaning the sub-collections are not returned if only the top-level object is requested. Meaning, if we consider the previous analogy, fetching data on a specific patient would not return data related to its caregivers. In the section below, we analyse the different strategies for structuring data in the scope of this project, given Firestore's functionalities and limitations.

Figure 41 represents a visual example of Firestore's data management page. On the top layer, the path like convention reveals the context of the different layers. It is currently displaying a caregiver document, inside a subcollection that is part of a patient document, inside a parent collection called "scenarios".

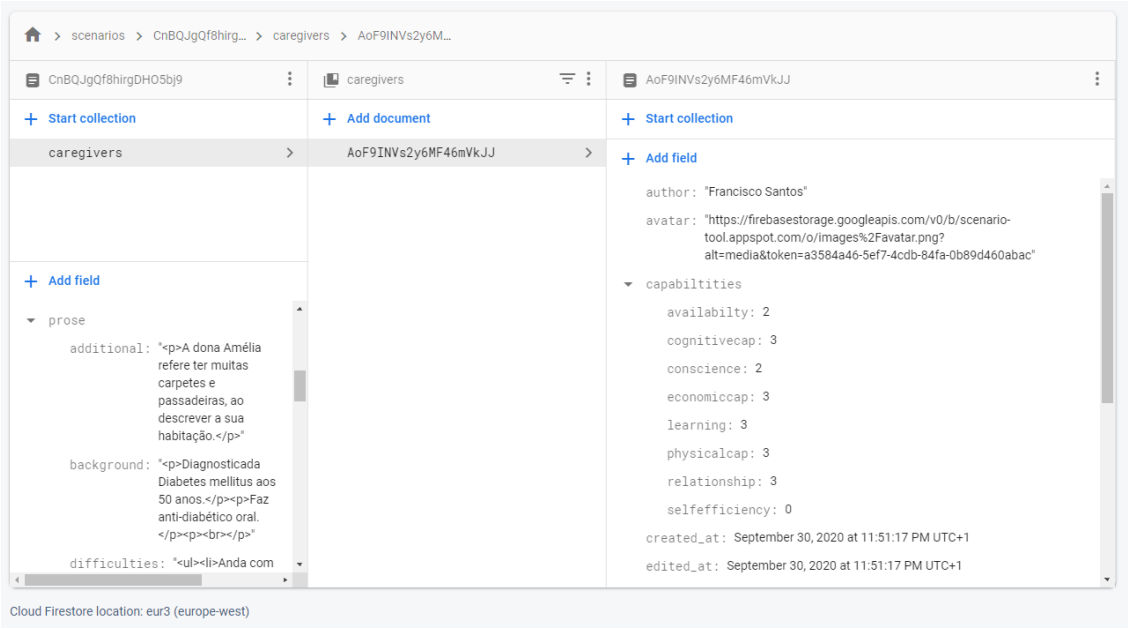


Figure 41 – Cloud Firestore data management page

5.7.4 Data structure and modelling

In the section Data modelling, we have established the main entities under which the application will operate. Having established Firebase as the infrastructure under which to store data and analysing its rules and restrictions, we must establish a data model. To quickly recap the rules:

- Firestore documents cannot be over 1MB;
- they cannot be partially fetched when queried. The larger the document, the slower the application will load, consume more battery and be generally less efficient;
- Firestore billing accounts for the number of documents read and written. Unlike relational databases querying multiple collections to aggregate data from multiple documents will cost unnecessary document reads and weight on the network costs as well since the unnecessary parts of each document are also transferred (as was established in the previous bullet point)

With these rules in mind, it appears that the best logical way to structure the data is to analyse the designs and map the data in each one into different collections. This way, when the user opens a page, only the necessary data is transferred, minimizing the document read count, as additional data does not need to be fetched. By going through the designs and the data they include, we establish the following:

- There are different pages dedicated to visualize and manipulate both patient and caregiver personas, as they also are different entities in the data model, it also makes sense to create a collection for each one;
- Both patient and caregiver pages' data can be mapped to simple data: the text fields may be mapped to strings, the selected icons to a map-like structure, and additional metadata like creation time or author are also atomic pieces of data;
- The patient has a "one to many" relationship with the caregiver. It was established in the requirements phase that a patient might have up to two caregivers;
- The main listing page will display some (or all) the existing patients, and all its associated caregivers.

At this point, it seems fair to establish that patient, and caregiver scenarios will each be sorted in documents, belonging to different collections. A teacher collection should have the responsibility to hold their data as well as serving authorization purposes, i.e. Firebase rules will check this collection to ensure that a user is a teacher and open specific pages or create and modify data. With this data structure, seen in Figure 42, we would, in theory, fetch as few documents as possible. There is still a need to determine how the patient-caregiver relationship will be laid out.

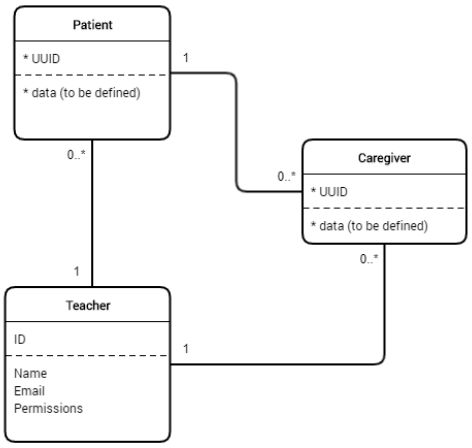


Figure 42 – Draft for the application's data model

The listing page, however, would have to query all the existing documents. There are multiple alternatives to establish the relationship between patient and caregiver. It is crucial to analyse each alternative and choose the one that involves the least documents queried in the listing page so that we can avoid needlessly increasing the document count and slowing down the app. With the current designs, from the "Scenario page structure" section, it is established that the page will only display a patient's title, summary, and the caregivers' names.

The first option is to encapsulate both patient and caregiver data into the same document. A document can have multiple nested maps, so long as the size of the entire structure stays under 1MB size. While there are quite a few fields, the atomic data itself is pretty lightweight and should not go anywhere near the limit. This approach would result in a structure like the one in Figure 43.

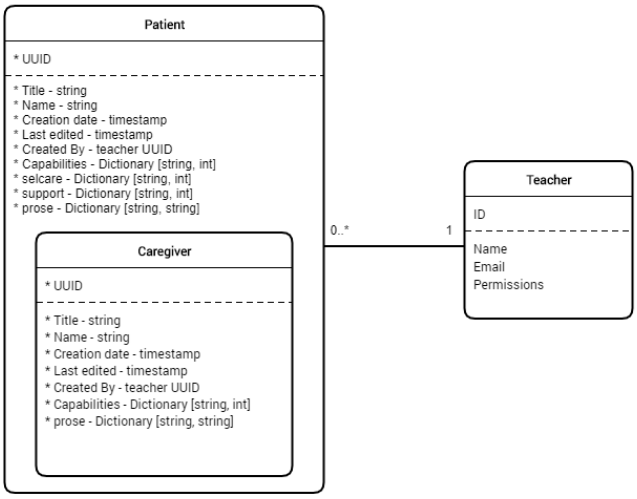


Figure 43 – One alternative to structure data using nested object maps

The nested structure would lead to a consistent and straightforward way to maintain data, particularly useful should the two pages be merged into one. However, this would make the

patient document unnecessarily large. When loading the patient page, the caregiver page is useless and vice-versa. When loading the listing page, the entire data block would be retrieved when only three fields are required to display. Should Firebase support partial document retrieval, however, this could have been a good alternative.

The second option is to operate in a similar way that relational databases would. Patients and caregivers are each stored in their respective collections, and caregivers would store a reference to the caregiver document to which they are related. This approach can be seen in Figure 44.

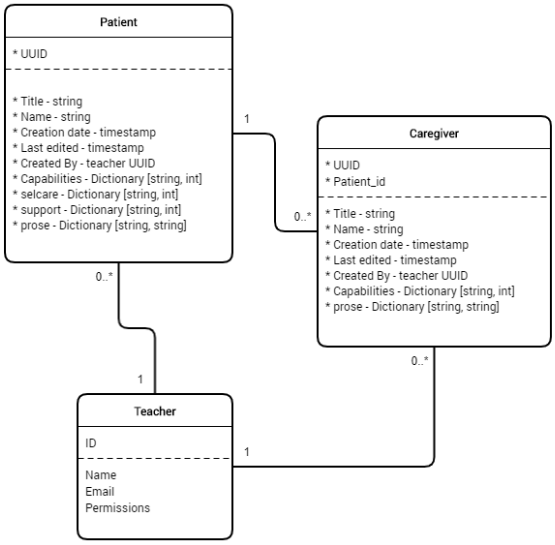


Figure 44 – Data model alternative, following relational database principles

The approach is sound, as most pages would retrieve only the data they need. The caregiver holds a reference to the corresponding patient document, and both hold metadata that refers to the teacher that authored it. Nonetheless, the main listing page will still need to query a large number of documents from two different collections. Unlike relational databases, Firestore cannot join two tables into a single view for easy information retrieval. First, it will need to retrieve all the patient scenarios (or a set if we consider pagination), then for each document, the corresponding patients will have to be retrieved. In terms of the total number of documents read, and data transferred, this approach is worse than the first. A considerable number of visits to the landing page would quickly spike the number of reads, and waste bandwidth needlessly. To summarize this approach could work well on a small scale, but be problematic as the application grows and its usage increases.

An alternative approach is to use subcollections to establish the one to many relationships. Patients are stored in a collection, and each document will contain a caregiver sub-collection. The only downside to this approach is that queries to multiple caregivers from different patients are costly, but this is not a foreseeable requirement. This approach is very similar to the first one discussed; the primary difference lies in the use of sub-collections. As queries are shallow, retrieving a patient document will not carry all its underlying subcollections. The

desired relationships are established, regardless we are still left with the fact that the listing page will require too many documents. There is one potential approach, one that is considered an anti-pattern in relational database structures but may the best fit for this context. The listing page will always query the patient documents, and only the ID and name of the caregivers are required. If we replicate this caregiver data into the patient document, then we eliminate the need for additional queries or data retrieval. This structure can be seen in Figure 45.

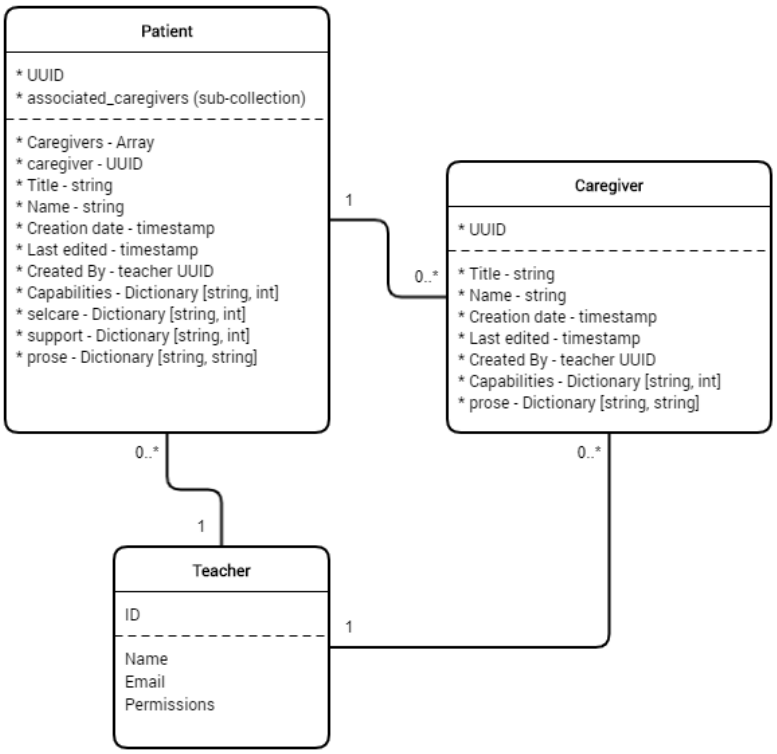


Figure 45 – Diagram representing the application's data structure

For reading purposes, the caregiver collection is aligned with the patients; however, the patient collection contains a field, on the second line, that indicates these caregivers are, in fact, a sub-collection. The patient document will have the following fields:

- A UID automatically handled by Firebase
- A sub-collection of caregivers
- The scenario title and patient name
- The status icons, detailed in "Iconography" are mapped into different key-value pairs (for the page's sections titled "capabilities" and "self-care"), holding the label corresponding to the icon and a number between 0 and 3 describing its state (0 for empty, 1 for bad/red, 2 for medium/yellow and 3 for good/green);
- The "support" item corresponds to the range selectors, detailed in "Custom range selection with CSS elements", are also key-value pairs as the previous ones; However, their values can range between 0 and 5 (one for each state of the selector);
- The "prose" represents a more complex map object that contains as keys each of the section's pages that will have the custom text (summary, clinical data…);

- The time a document was created and last edited are stored as date-time;
- The author can be stored both as a string (the name) and the UID reference to the teacher ID

To store the stylized rich text supplied by Quill, as we have seen in "Text editor functionalities with Quill", the HTML will be stored as a string, thus preserving both content and styles. This fact raises concerns over possible exploits via code injection, by tampering with the HTML code. Additional logic is used when loading this data, to sanitize these fields and ensure some degree of safety.

The downside to this approach is the added cost of replicating data. When a caregiver is created or edited, the parent scenario's document will also have to be edited to ensure the data stays consistent as updates are made. This consistency is achieved with additional logic in the application, that automatically keeps track of and updates the documents. Even if this approach costs a few extra documents writes, it saves on a more significant number of reads. This approach could even be further expanded through other Firebase features, which will be left to future developments.

5.7.5 Sharing patient and caregiver scenarios

The main goal of this project is that the students can have quick and effortless access to scenarios. The best way to achieve this, particularly in a web-application, is via a URL. Given a link, the students may simply open and browse the contents of a scenario in any device. The way our project facilitates this is by appending the scenario's ID as parameters in the URL. In the case of a scenario, the URL would appear similar to Figure 46. In the case of a patient scenario, the application would need to know the patient's document, in order to query its subcollection. In this situation, both patient and caregiver ID are appended to the document, as seen in Figure 47.

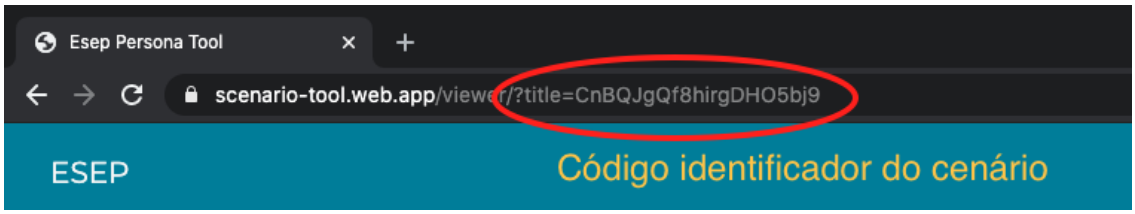


Figure 46 – Screenshot of a patient scenario's URL, highlighting the ID as a parameter

Figure 47 – Screenshot of the caregiver page, with highlights on both IDs

If someone were to open these pages without any parameters, then the page would display and error since it would not know what content to load and redirect to the home page. An example of this, as displayed in Google Chrome, can be seen in Figure 48.

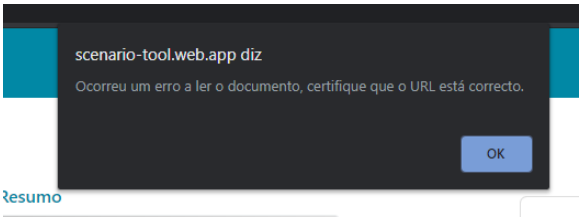


Figure 48 – example of the error message when opening the viewing page with no ID

With this, the teachers should copy the link to a scenario and distribute it on their chosen platform that the students can access.

5.7.6 Document saving implementation

Having established a means to access the content, it is also important to detail how it is created and maintained, particularly having in mind the data-replication issues discussed in “Data structure and modelling.” The core logic is the expected of any standard application: saving a scenario creates a new document is none exists or updates the contents of the existing one. In order to improve the experience for teachers creating a set of scenarios (that is a patient and a caregiver), when storing a new patient document, the application will prompt the user to create a caregiver directly. A logic diagram of this can be seen in Figure 49.

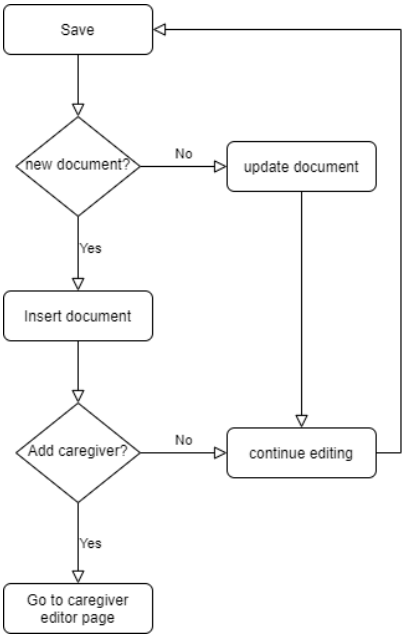


Figure 49 – Flowchart representing the steps and validations when saving a patient scenario

In the case of a patient scenario, there are two IDs the system needs to know: the parent patient scenario and the caregiver within its sub-collection. Because of the data replication necessity discussed earlier, to avoid excessive document reads in the main page, the data needs to be replicated when the caregiver is either created or updated. In the case of creating a new caregiver, the additional information needs to be appended to the patient's document. If the caregiver is updated, the system needs to verify whether or not the parent's information is still valid, and react accordingly. This algorithm's logic can be visually explained in the flowchart in Figure 50.

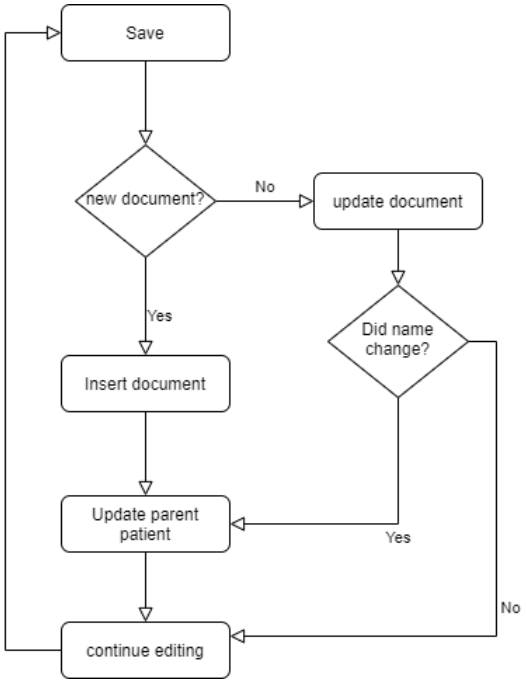


Figure 50 – Flowchart representing the logic for saving caregiver scenarios

The algorithms and additional logic are of utmost importance. Should the patient scenarios collection fail to match the caregiver data, the scenarios would be inaccessible.

5.8 Future implementations

While the project can be considered ready for the testing phase, there are still many areas of improvement. It would be interesting to study possible ways to integrate with the ESEP's infrastructure. The current approach to handle authorization, i.e. identifying which users may create or edit documents, currently relies on an administrator and direct manipulation in Fribases' web console. While not necessarily a bad practice, the current implementation has the side effect of requiring additional document reads, of validating that the UID is in the teacher's collection. In future implementations, perhaps a second application could use Firebases' SDK and be used by the teachers to manage user permissions, adding and extra security layer to the system.

Regarding Firestore's limitations, as teachers begin to create scenarios, and students consulting them, the system should stay within the limits of the free tier. However, after the document read/write threshold is surpassed, additional costs will have to be considered. By this point, it would be essential to analyse if a different logic should be used to save unnecessary reads. One possible way to decrease the number of documents queried is to handle the data replication using Firebase Cloud Functions instead of client code. These are, as the name implies, code stored directly in Firebase, that can be triggered by the creation, update or deletion of documents specific collections. In short, when a caregiver document is

created or edited, the cloud function would automatically be triggered, and update the corresponding parent patient document, ensuring the replicated data always remains consistent.

6 Experimentation and evaluation

The significant effort in this project will rely on the design choices and their implementation, without an enticing interface and a captivating experience, the users will likely give up on using this tool in favour of the already existing systems.

The design should be experimental, improved and iterated with feedback from the teachers, who have a more intuitive understanding of the specific requirements and details. Initially, the requirements exposed were:

- Software to allow the creation of clinical scenarios,
- Scenarios should contain iconography to express the personas "status",
- Scenarios should contain images, in order to be more expressive,
- Scenarios should be flexible and allow for specific information.

As new designs and alternatives are produced, it is paramount to maintain a constant feedback loop to iterate on the process.

The test plan, albeit susceptible to change, can be broken down into three equally important parts. The first being data collection and feedback enrichment from the teachers of the NUC, followed by a pre and post-test performed on the target audience - the students partaking in the laboratory classes. Finally, the last step would be to directly gather feedback from interviewing the students participating in the previous test that used the tool, in order to fine-tune and improve upon the design.

6.1 Gathering information from the teachers

The professors can assist in gathering the main requirements and even provide useful information on how to structure the design, therefore interviewing them is of utmost relevance.

"Thinking aloud" aggregation methodology, by Nielsen (Nielsen, Clemmensen, & Yssing, 2002), may provide a valuable usability engineering method. In this context, it would involve the

teachers using the system and describing their actions, feelings, ideas and suggestions (Jørgensen, 1990).

To perform thinking aloud usability study 3 things are needed:

1. Recruit participants from the target audience,
2. Write a script of actions for them to perform,
3. Give them the script and let them perform the actions, without any help or tips.

Once the main functions of the software are developed, even though the design need not be final, we may perform a test with actual students, once the laboratory classes start.

6.2 Gathering information from students

Our primary goal is for the students to find the new medium more effective at conveying the same information as the old method. A useful metric by which to measure this is the student's opinion, satisfaction, and feedback.

A single group, pre and post-test design will be adopted, taking into consideration the ethics references. Because students take part in a class, the unit of observation needs to be the class. Four classes are working at the same time in the laboratory, divided into different rooms but all finishing the classes at the same time and gathering during breaks. It would be difficult to say that one student is a control or an experience participant since information can be quickly exchanged uncontrollably, which introduces a bias factor.

The pre-test will be performed using two simulation experiences into each class. It will be applied a survey question form to each student, adapted from the Mobile App Rating Scale(MARS) by Stoyanov that inquiries about: 1) engagement, 2) functionality, 3) aesthetics, 4) information and 5) subjective quality (Stoyanov et al., 2015).

A Likert scale will be used for each assessed item, ranging from 1 (the worst classification) to 5 (the best classification). After the second simulation, students will answer the question form.

The third and fourth simulation will be performed with the new scenarios provided by the application. A new question form with the same questions will be applied, assessing the new scenarios. The statistical analysis will be performed using a paired t-test for scale variables. Content analysis will be used for qualitative variables using Bardin methodology (Bardin, 2009).

6.3 Preparation of the testing phase

There were many interviews with the teachers of ESEP, which led to some informal testing and feedback retrieval. While at first there were plans, as mentioned above, to perform test and interviews with the students, these plans were suddenly put on hold during the ongoing

2020 pandemic. The COVID-19 pandemic has managed to hinder the testing phase of this project. Testing with students became impossible since the laboratory classes mentioned so far were cancelled. The alternative, using video-conferencing technologies, would not be adequate, as the evaluation of the student's performance is significantly related to the nuances and detailed aspects of their behaviour. Through a web-cam, the teachers would not be able to access the posture or positioning of the student, much less how well they could perform specific tasks. Additional, there was a need to shorten the course material to strictly necessary topics; all classes that involved student's interaction were abolished, as they would have compromised the safety of social distancing rules. The alternate solution that was decided was to rely solely on the teachers' appraisal of the application. While the information gathering phase with the teachers did continue via online meetings and was very crucial for the development of the project, their feedback does not constitute a measurable success metric. The MARS proved to be the best to gauge the success of this project.

This scale was loosely adapted to fit our current project. The original scale was primarily meant to gauge mobile applications, typically distributed online via either Google or Apple's stores. Furthermore, the current project is a web-application with responsive design, suitable to both desktop and mobile devices. While technically not a mobile app, we believe it can be evaluated by the same core principles of the MARS. In our adapted survey, four of MARS original questions were removed, since these regarded specific aspects of the app store. It also featured a question to gauge whether the user would pay for the app, which does not apply in this context, as we are not gauging the commercial validity of this product.

6.4 The results

The survey was distributed to 9 NUC teachers, along with access to a beta version of the application. They were tasked with evaluating the usefulness of the application in a real context. The results are presented in Table 2 and Figure 51.

Table 2 – survey results

	M(SD)	Median	Observed Mn-Mx
1. Entertainment	4.56(0.73)	5	3-5
2. Interest	4.67(0.50)	5	4-5
3. Customization	3.22(1.20)	5	1-5
4. Interactivity	4.33(0.71)	5	3-5
5. Target group	4.78(0.44)	5	4-5
6. Performance	4.33(0.50)	5	4-5
7. Ease to use	4.67(0.71)	5	3-5
8. Navigation	4.78(0.44)	5	4-5
9. Gestural design	4.67(0.50)	5	4-5
10. Layout	4.44(0.73)	5	3-5
11. Graphic	4.67(0.50)	5	4-5
12. Visual appeal	4.33(0.50)	4	4-5
13. Accuracy	4.67(0.50)	5	4-5
14. Quality of information	4.78(0.44)	5	4-5
15. Quantity of information	4.56(0.73)	5	3-5
16. Visual information	4.67(0.50)	5	4-5
17. Recommend this app	4.67(0.50)	5	4-5
18. Would use this app	4.22(0.44)	5	4-5
19. Overall rating	4.67(0.50)	5	4-5

The results are set on a scale from 1 to 5. Where 1 implies poor performance, and 5 an excellent impact. The application demonstrates an excellent rating, with a variation between 4-5 in almost all items. Five of the survey items have a varied range of 3-5, and one item, regarding customization, has a range of 1-5. The mean value is almost always more than 4.5, which is a very positive assessment. The standard deviation is very low, implying there was a significant concordance between teachers.

The lowest scores are related to customization. While the teachers may indeed create their own content, the application does not lend itself to many configurations, such as choosing a different colour-scheme or automatic saving. These features were considered a “nice to have” and therefore were scraped in detriment of other more important features.

The highest score, with a mean of 4.78, was given to the target group, quality of information and navigation. Regarding the target group and quality of information items, since the application was designed with the teacher’s feedback in mind, it stands to reason why they should have such a high score. As for the navigation item, this score reinforces that the page organization was ideal. Much thought was put into streamlining the process of creating a scenario, making it as intuitive as possible. This result reinforces some UX decisions, such as the one to jump to a caregiver creation after finishing the patient scenario.

Regarding the “would you use this app” item, the teacher’s answers pertain to their estimate of the average scenarios they will create. Each teacher creates one scenario per student, and each class has about ten students, resulting in a total of ten scenarios they would create each school year. While each teacher may have several classes, they often re-use the same scenario for each.

The following Figure 51 represents the same results in the form of an error bar graph.

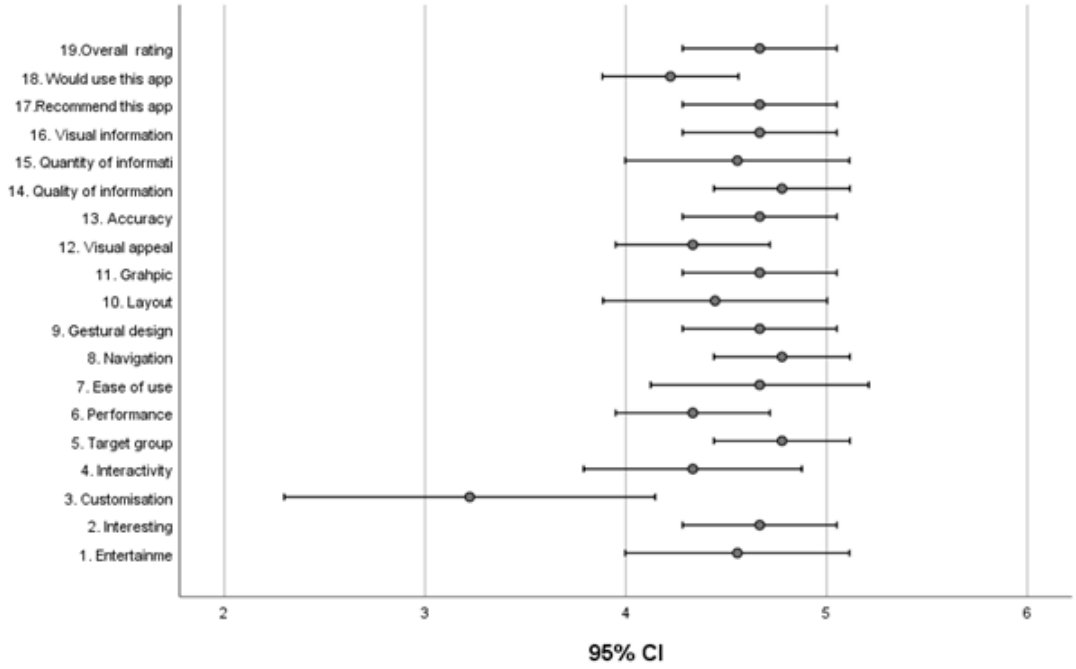


Figure 51 – Graph displaying the survey results

In this graph, the vertical line includes each of the topics the survey inquires. The horizontal line represents three significant aspects: the dot is the average, and both edges represent the minimum and maximum value in the 95% range of responses.

The survey also left some open-ended questions for suggested improvements were: to use additional ways to label the different icons; changing the way scenarios are stored and managed; adding some examples and details for the various fields, and giving more relevance to the save button in the editor.

7 Conclusion

The overall development of this process has revealed to be a success. It is capable of meeting the needs and heeding the requests of the teachers. With the analysis of the results, we can safely access that the application delivers the desired value, and it appears to fulfil the initial expectation of being a good substitute for the previous scenario tool.

Unfortunately, it was not possible to assess the efficacy of this solution directly with the students, due to the COVID-19 pandemic heavily impacting all teaching institutions. Despite the online nature of the application, the laboratory interaction still requires physical presence, which would go against the pandemic social distancing recommendations. We hope the system can return to its former self as soon as possible, and this solution can be put to its full potential use.

The design and implementation process, while not necessarily innovative, demonstrate that the current approach is still useful and efficient in delivering the intended results. The PaaS solution that was Firebase proved to be quite flexible and helpful. There are still many of Firebase's features that could inspire additional future developments.

In this design process, the teachers were led to analyse and deconstruct their scenarios, narrowing down and establishing what they deem to be the fundamental variables that compose each clinical case. It is expected that students will maintain this template in mind when analysing future patients in a real clinical scenario, as they incorporate different health institutions and progress on their professional careers. Ideally, students will consider the various fields of the scenarios, bearing in mind the patient's social support, their background and many other aspects as they interact in the future.

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