CS5099: Dissertation in Computer Science

Title - Pioneers in Computer Science:
An Electronic Resource

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Abstract

This dissertation explains the development and implementation of an online resource called *"Pioneers in Computer Science"*. The main aim of this platform is to systematically catalogue and showcase the contributions of computer scientists from diverse backgrounds and regions. The platform incorporates the **ACM Classification System** to achieve a structured data representation. A precise and replicable search strategy was utilised to ensure proper data collection and representation.

The platform has been diligently crafted with a focus on the convenience of its users. It boasts an interactive interface that facilitates effortless navigation and information retrieval. Its architecture is built to ensure steadfastness, expandability and low maintenance. The design principles have been meticulously chosen to prioritise the convenience of modular and reusable components.

Diverse user groups evaluated the platform's effectiveness as a computer science history repository and software engineering educational tool.

Acknowledgments

Firstly, I express my deepest gratitude to my dissertation supervisor, *Dr. Dharini Balasubramaniam*. Your unwavering support, insightful feedback, and patient guidance have been the foundation for this dissertation. Without your expertise and dedication, this work would undoubtedly have fallen short of its potential.

This thesis is dedicated to my beloved grandfather *V.M. Krishnasamy*, who passed away during my Masters's. He was the rock of our family and a constant source of inspiration and encouragement to me.

I am grateful for his unwavering support and guidance and for instilling a love for learning and a passion for knowledge. Although he is no longer with us, his memory will always live on in my heart and in the work that I have accomplished. Thank you, Grandfather, for everything.

I express my profound gratitude to my friends and loved ones at St Andrews. Your continued support, cherished memories, and shared good times have been my anchor throughout this Degree.

To my family, your sacrifices and unwavering belief in me have been instrumental in this journey. Your contributions have not only allowed me to focus but also to excel.

This Degree is a testament to your love, commitment, and belief. I am eternally indebted to you all. Thank you.

Declaration

I declare that the material submitted for assessment is my work except where credit is explicitly given to others by citation or acknowledgement. This work was performed during the current academic year except where otherwise stated. The main text of this project report is **14559** words long, including project specification and plan.

In submitting this project report to the University of St Andrews, I permit it to be made available for use per the regulations of the University Library. I also help the title and abstract to be published and for copies of the report to be made and supplied at cost to any bona fide library or research worker and made available on the World Wide Web. I retain the copyright in this work.

Ajay Pradeep Mahadeven (August 15, 2023)

Chapter 1

Introduction

1.1 Background and Motivation

Throughout history, the field of Computer Science has been significantly influenced by exceptional individuals from various parts of the globe. These visionary leaders, who spearheaded the digital revolution, have established the groundwork for our contemporary digital realm. Their concepts have constituted the fundamental principles of what we now recognise as Computer Science, encompassing its languages, theories, and systems.

The brilliant minds behind the creation of computing machines and the development of algorithms have significantly impacted society and the scientific community. Their exceptional work has acted as a guiding light, illuminating our path through the ever-changing landscape of technology. As a result, they have inspired countless generations of researchers, educators, and students to follow in their footsteps.

Recognising academic trailblazers' varied backgrounds and distinctive journeys can ignite a sense of inspiration within creators from all walks of life.

The objective of this project is to establish an electronic resource devoted to the pioneers of Computer Science, to commemorate their innovation and preserve the evolution of the discipline. I aim to preserve the legacy of Computer Science and its pioneers for future generations by shedding light on its rich history.

1.2 Scope and Limitations

This project has a broad scope, as it intends to acknowledge pioneers in computer science from every part of the world. It is important to mention that while I will try my best to include as many pioneers as possible, some notable individuals may not be mentioned due to resource and information limitations. Additionally, considering the complexity of computer science as a discipline, it may not be easy to cover every aspect of every pioneer's contribution comprehensively.

Our objective is to create a digital platform that is accessible and user-friendly. However, the platform's usability and accessibility will depend on the technological capabilities and limitations of the development tools used.

1.3 Objectives of the Dissertation

1.3.1 Primary Objectives

1. Research and select a suitable classification system (ACM Digital Library) to group the contributions of pioneers in computer science. - **Implemented**

2. Identify pioneers in computer science from all over the world using a reproducible search strategy.- **Implemented**

3. Design and develop a website that can be easily accessed by all group ages and learn about the pioneers (Global perspective more than academic focus) and submit ownership to the University of St Andrews. - **Implemented**

4. Develop a user-friendly interface that makes it easy for all user groups to interact with the website. - **Implemented**

5. Incorporate a basic, user-friendly search and filter facility that allows users to efficiently locate and sort information about the computer science pioneers on the website. This function should accommodate the needs of diverse users and enable them to navigate the content easily. - **Implemented**

1.3.2 Secondary Objectives

1. Evaluate the digital platform with various user categories to ensure usability, accessibility, and relevance. - **Implemented**

2. Visualising the contributions of pioneers and citing sources and web links. - **Implemented**

3. Create supporting documentation to help users navigate and use the electronic resource. - **Implemented**

4. Implement a feedback system to gather user feedback on the electronic resource's usefulness and areas for improvement. - **Implemented**

5. Creating road maps based on search criteria or era (century or decade).

1.3.3 Tertiary Objectives

1. Investigate the potential for expanding the resource to include pioneers in related fields, such as electrical engineering or mathematics. - **Implemented**

2. Tailoring to St Andrews by dedicating part resource by highlighting the contributions of pioneers that have studied or taught at the University of St Andrews. - **Partially Implemented**

3. Explore ways to incorporate multimedia content (such as videos or podcasts) to make the electronic resource more engaging. - **Not Implemented**

1.3.4 Evolution of the Project Objectives

Like many extensive projects, the course and objectives of this dissertation evolved. Factors such as resource availability, user feedback, and technical constraints influenced the project's direction, refining the priorities and targets I initially set out to achieve.

There was a change in prioritising the objective related to highlighting contributions of pioneers from the University of St Andrews. This objective was initially considered secondary but was eventually demoted to tertiary due to challenges in accessing relevant sources and potential complexities in representation.

During the project, two objectives became more important: the incorporation of a feedback system and the creation of road maps based on search criteria or era. These objectives improved the website's functionality and made it more user-friendly.

Projects of this scale often undergo evolution, demonstrating adaptability and dedication to delivering the best outcome, even when faced with unforeseen challenges.

1.4 Dissertation Overview

This dissertation explores computer science pioneers and their contributions, focusing on creating an electronic educational resource. The chapters are organised as follows:

Chapter 2: Literature Review
The chapter starts with an overview of computer science pioneers, their survey methodologies, and global contributions. It then explores classification systems, their methodologies, and comparative analysis. The creation and significance of online educational resources are highlighted. Finally, the chapter discusses the role of user interface and experience in digital platforms and reviews related works.

Chapter 3: Requirements & Design Specifications
The introductory chapter outlines the essential user requirements, including personas and specifications. This summarises the important elements of information architecture, content and technical needs, and security and privacy considerations.

Chapter 4: Project Methodology
This chapter thoroughly analyses the project management process, strongly focusing on implementing agile practices, CI/CD, documentation, ethical considerations, design processes, and iterative strategies directly relevant to the electronic resource.

Chapter 5: Designing the Electronic Resource
The chapter covers the crucial principles of user experience design, site mapping, navigation strategies, and accessibility. Additionally, it presents the work process flowchart and software system architecture with clear and convincing reasons for their selection.

Chapter 6: Implementing the Electronic Resource
The chapter delivers an overview of the implementation phase, covering critical areas such as evaluation feedback, database implementation strategies, codebase organisation, deployment process, and actualisation of key features.

Chapter 7: User Testing and Evaluation
This chapter focuses on efficient functionality testing, seamless user interactions, valuable beta release feedback, evaluations with Postman API, and precise performance insights derived from Google Page Insights Analysis.

Chapter 8: Conclusion & Further Works
In the last chapter, the dissertation delves into potential improvements and future research directions, concluding with reflective thoughts on the journey and implications of the work.

Chapter 2

Literature Review

2.1 Overview

The following chapter examines crucial computer science topics through an extensive literature review. Beginning with a historical overview of the pioneers who have shaped this field, it delves into the classification systems in computer science. The importance of online educational resources is emphasised, followed by an in-depth analysis of the crucial role of user interface and user experience in digital platforms. Each section builds upon existing scholarly works and confidently situates this thesis within the academic discourse.

2.2 Pioneers of Computer Science: A Global Perspective

The discipline of Computer Science (CS) has been influenced by numerous thinkers and innovators worldwide. However, many accounts of the history of CS tend to overlook contributions from specific regions and focus on a limited number of individuals. This section sheds light on how the pioneers in Computer Science were identified, analysed, and globally represented. It emphasises the significance of a global approach to appreciate the diverse nature that has characterised the field's evolution.

2.2.1 Survey Methodology

Data Sources

The primary academic resources consulted were the English Wikipedia, MacTutor Index [1], Google Scholar, ACM Digital Library, IEEE Xplore, and DBLP. Beyond the academic sphere, insights were gleaned from reputable technology news outlets, blogs, and industry-specific websites such as Medium, TechCrunch, Wired, and the CodeCombat Blog [2].

Search Terms

Relevant keywords and phrases used include:

- "Alan Turing wiki."
- "Grace Hopper contributions."

- "Ada Lovelace"
- "History of Computer Science."
- "Global Contributions to Computer Science"
- "Diversity in Computer Science."
- "Under-represented groups in Computer Science."
- "Computer Science Pioneers."

Inclusion and Exclusion Criteria

The criteria for inclusion in this study were:

- Peer-reviewed articles, books, and reputable industry reports discussing the history and development of CS on a global level.
- Credible biographies of individuals who have made noteworthy contributions.
- All resources are published in English.
- Individuals must have made a significant contribution to CS with a substantial impact on its evolution.

The exclusion criteria consisted of the following:

- Non-English resources.
- Non-reputable resources.
- Resources that do not address diversity in CS.
- Individuals whose work in CS was not primary or didn't have a broad impact.

2.2.2 Global Contributions to Computer Science

Computer Science originated from mathematical logic and electrical engineering. Contributions from pioneers in these areas were vital for its formation [3]. British mathematician, Alan Turing, is recognised for his pioneering research [4].

Figure 2.1: Alan Turing, a founding father of modern computer science [4]

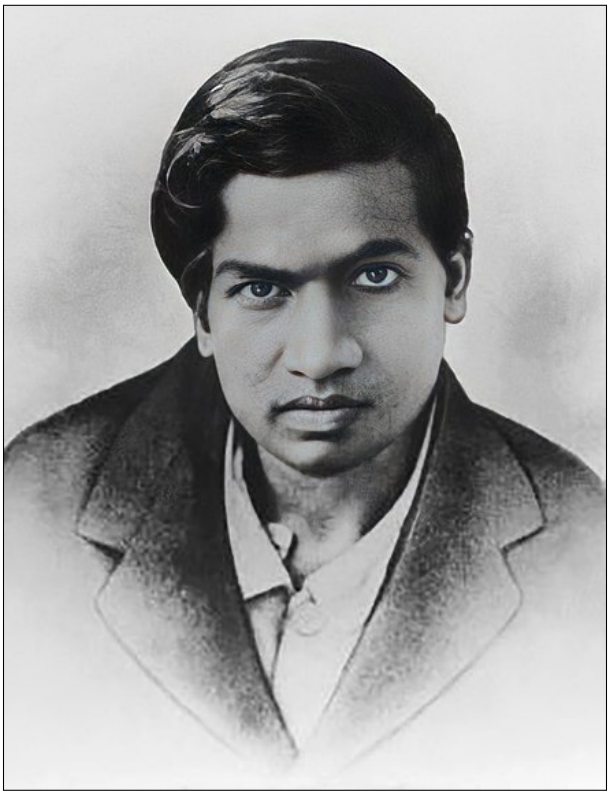


Figure 2.2: Srinivasa Ramanujan [5]

Contributions are not confined to the Western world; Srinivasa Ramanujan, an Indian mathematician, made significant contributions to number theory, crucial for computer science [5].

Figure 2.3: Grace Hopper [6]

Among other notable figures are Grace Hopper [6], Ada Lovelace [7], and Hedy Lamarr [8], emphasizing the pivotal role of women in shaping CS.

The remarkable accomplishments of women like Grace Hopper and Ada Lovelace have had a profound impact on the field of computer science; Hopper's development of the compiler [6] helped to make computing more accessible to a broader audience, breaking down barriers and opening up the field beyond just scientists and mathematicians. Similarly, Lovelace's contributions [7] laid the foundation for modern computer programming providing a more structured and systematic approach to teaching machines.

Diversity among CS pioneers extends beyond location and gender, and the path can also be non-linear. Heady Lamarr [8], an Austrian-American actress, co-invented a spread spectrum communication method, laying the groundwork for today's wireless communication technologies. Lamarr's story highlights how individuals from seemingly unrelated fields can still contribute substantially to Computer Science.

In conclusion, emphasizing global contributions ensures acknowledgement of pioneers from various cultures, nations, and backgrounds, fostering diversity and inclusion in the field [2, 9].

Figure 2.4: Ada Lovelace [10]

Figure 2.5: Hedy Lamarr [8]

2.3 Classification Systems in Computer Science

I utilised a multi-step approach to fully comprehend each mentioned classification system (2.3.2).

2.3.1 Survey Methodology

Data Sources

I gathered data from official documentation and websites from various classification systems like ACM Digital Library, LCC, DCC and UDC.

Search Terms

I utilised various search terms to obtain information on the classification systems, including the system names and related phrases such as 'classification system', 'computer-based classification systems', 'information organisation', 'data categorisation', 'library classification systems' and 'hierarchical structure.

Inclusion and Exclusion Criteria:

The criteria for inclusion in this study were as follows:

- Resources that provided detailed information on each classification system's structure, use and benefits. I also sought resources that discussed the context in which each system was developed and its evolution over time.

The criteria for exclusion in this study were as follows:

- Resources that provided only superficial information or did not provide references to verify these claims.

To determine the best system for our project, I compared each one's strengths and weaknesses and how they aligned with our needs. I evaluated factors such as the system's comprehensiveness, ability to adapt to the field and flexibility in representing relationships between different subjects.

2.3.2 Selection, Implementation, and Comparative Analysis of the Classification System

Selecting an appropriate classification system was the foremost step to creating a highly efficient and user-friendly database of computer science innovators. With the extensive range of contributions in this field, it was critical to establish a versatile and easily understandable system that perfectly aligned with the project's objectives.

Criteria for selecting the system included its adaptability to trends, clarity for diverse users, and synergy with project goals emphasizing intuitive structure and highlighting computer science pioneers' contributions.

Amongst various classification systems like the Library of Congress Classification (LCC) [11], Dewey Decimal Classification [12], and Universal Decimal Classification [13], the ACM Computing Classification System (CCS) [14] stood out. Its globally recognized

Figure 2.6: Association for Computing Machinery (ACM) Logo [15]

taxonomy tailored for computer science and hierarchical nature offers an in-depth categorization, bolstering the project's credibility.
While the CCS was adept at categorising computer science works [16], it lacked specific provisions for the pioneers of the field. Addressing this, a thorough analysis was performed on the significant contributions of each pioneer, aligning them with pertinent CCS categories. This harmonisation ensured pioneers were systematically arranged based on their seminal contributions, fostering efficient navigation.

{} classification
"applied computing", "hardware"
"theory of computation", "hardware"
"theory of computation", "hardware"
"theory of computation"
"theory of computation", "hardware"
"hardware"
"theory of computation", "mathematics"

Figure 2.7: Sample Database Entries Classified as per ACM CCS

As portrayed in Figure (2.7), pioneers are linked to specific CCS categories/subcategories reflective of their contributions. This feature helps users filter and search for luminaries by specialised areas, providing a complete view of each pioneer's legacy.

ACM's CCS offers a taxonomy highly focused on computer science, whereas LCC and DDC provide a broader, multidisciplinary approach. UDC stands out for its remarkable flexibility in highlighting the interconnectedness between subjects and the contributions made by pioneers in the field.

Implementing a prestigious classification system enhances our tool, instilling credibility and reliability among users. This systematic approach results in a detailed and user-friendly database of esteemed computer science figures.

2.4 Creation of the Online Education Resource

In this section, I will explain how I created an online educational resource that focuses on the pioneers of Computer Science. I will discuss the data sources, the search terms I employed, and the criteria I used to determine what content to include in the resource.

2.4.1 Survey Methodology

Data Sources

I collected information on online educational resources from a diverse range of sources, comprising:

- Some valuable resources for research include Google Scholar, IEEE Explore, ACM Digital Library, and the MacTutor Index.
- Google, as our primary search engine, for publicly available general information and news articles.
- Online educational platforms, including MacTutor Index, Khan Academy, Coursera, Codeacademy, Duolingo, and Wikipedia, to glean insights into the creation and organisation of educational resources.

Search Terms

To gain a proper understanding of online educational resources, I employed various search terms:

- "Evolution of online educational platforms."
- "Peer-reviewed studies on online education platforms."
- "Diversity and inclusivity in online educational resources."
- "Effectiveness of digital educational tools."
- "Comparative analysis of online education platforms."

Inclusion and Exclusion Criteria

I aimed to create a rich and well-rounded dataset related to online educational resources. I adopted the following criteria:
Inclusion Criteria:

- Articles, papers, or resources highlighting the evolution and effectiveness of online educational platforms.
- Studies or information from credible and reputable sources about best practices in online education content creation.
- Content that highlights diversity, inclusivity, and accessibility in online education.
- Recognisable milestones or innovations in online education.

Exclusion Criteria:

- Data that is not supported by trustworthy sources or conflicts with established academic consensus.
- Overly promotional content about a specific platform without objective evaluation.
- Outdated resources that no longer reflect the current state of online education.
- Content perpetuating misinformation or stereotypes about online education or its users.

I acknowledge that our approach is thorough, but I recognise that the ever-changing landscape of online education may not be wholly accounted for in our dataset. Any feedback or contributions to expand the scope and accuracy of our research are greatly appreciated.

2.4.2 Importance of Digital Educational Resources

In our daily lives, digital technology has a significant impact, and as a result, digital educational resources have become increasingly important [17]. These resources are vital tools that facilitate the learning and teaching process, and they have now become an integral part of various educational systems worldwide. This section will explore the significance of digital educational resources, specifically how they foster learning, improve accessibility, and promote diversity.

Digital education resources have a significant impact on improving learning experiences and outcomes. These platforms offer a variety of multimedia materials, such as text, images, audio, and video that cater to diverse learning styles and preferences. They also encourage interactive learning, allowing learners to engage with the content actively. Interactive simulations or quizzes can reinforce concepts and assess understanding effectively and entertainingly [18].

Moreover, these resources allow individuals to learn independently. They can review the material whenever convenient, which is advantageous for people with varying schedules and learning speeds. This flexibility is especially helpful in Computer Science, where difficult concepts may require repeated revisiting. It also encourages lifelong learning and enables people to continuously enhance their knowledge and abilities [17].

Digital educational resources also play a crucial role in enhancing accessibility to education. They offer a means to disseminate knowledge widely, transcending geographical, socio-economic, and time constraints; this remote learning access is especially critical in a globalised world where education and information are key drivers of development [19].

Further, these resources can be designed to accommodate diverse needs, improving accessibility for learners with disabilities. For instance, text-to-speech features can assist learners with visual impairments, while closed captions can aid those with learning difficulties [20] [21].

Digital educational resources can promote educational diversity by highlighting contributions from diverse individuals or groups [22]. This fosters a more inclusive understanding of fields such as Computer Science. Showcasing the work of pioneers from different parts of the world can challenge stereotypes and highlight the global nature of the discipline. Similarly, featuring contributions from underrepresented groups can inspire a diverse range of individuals to engage with the field.

In today's education, digital resources are crucial for improving learning experiences, accessibility, and promoting diversity. They are essential for creating more inclusive and effective education systems, especially in fields like Computer Science that are central to the digital age. Therefore, it is important to prioritise developing these resources in educational initiatives [23].

For this project, it is crucial to create an online educational resource focusing on the pioneers of Computer Science. This resource will aid in learning about the discipline's evolution and highlight the diversity among these pioneers, promoting a more inclusive understanding of the field.

2.5 Role of User Interface and Experience in Digital Platforms

When creating a digital resource, it's crucial to consider User Interface (UI) and User Experience (UX) as they affect various aspects, including simplicity and convenience, ensuring that people of different ages and abilities can easily use it. UX describes a user's overall experience when using a product or service. At the same time, UI refers to the various tools that enable users to engage with the product or service [24].

2.5.1 Survey Methodology

Data Sources

Blogs, articles, reports from reputable UX/UI and digital design websites and interaction among peers from Human-Computer Interaction (HCI).

Search Terms

The search terms listed below were utilised to identify relevant sources:

- "User Interface Design."
- "User Experience Design."
- "UI and UX in digital platforms."
- "Impact of UI/UX on user satisfaction."
- "UI/UX principles."
- "Evaluation of UI/UX"

Inclusion and Exclusion Criteria

The criteria for inclusion in this study were as follows:

- Papers, articles, and reports within the past ten years with the exclusion of a book published in 1993 [25] which still stands as a standard in the field.
- The focus was on studies and articles that specifically addressed UI/UX in the context of digital platforms.
- The sources had to be written in English.

The criteria for exclusion in this study were as follows:

- Non-peer-reviewed articles for academic references.
- Outdated sources (more than ten years old) unless they are seminal works in the field.
- Studies or articles not directly relevant to UI/UX.

Data Analysis

Once the data was collected, it was analysed according to the following steps:

- Reviewing the content for relevance to the topics of UI and UX.
- Extracting key points and findings related to the role of UI and UX in digital platforms.
- Categorising information based on its relevance to specific sections of this report.
- Evaluating the sources' quality, methodology, and conclusions to ensure credibility and validity.

2.5.2 Understanding User Interface (UI)

UI refers to how humans interact with computers through devices such as screens, keyboards, and mice [26]. The main objective of UI is to make this interaction as easy and effective as possible. This involves anticipating the users' needs and providing easy-to-use elements that allow them to carry out their desired actions [25].

The five quality components of usability which are still widely accepted are as follows [25]:

- Learnability
- Efficiency
- Memorability
- Errors
- Satisfaction

A good system design should be easy to learn and use, complete tasks quickly, be easy to remember, have a low error rate and be pleasing to the user. Following these principles, a well-designed UI should be intuitive and satisfying.

2.5.3 Importance of User Experience (UX)

UX is about designing from a user-based perspective, aiming to fulfil the users' needs, desires and experiences. It extends beyond the interface, taking into the account factors such as the users' emotions, preferences and perceptions before, during, the after using a product.

It's essential to prioritise UX in digital platforms. A good user experience boosts user satisfaction, leading to higher engagement, conversion rates, and user loyalty. This is supported by research [27].

2.5.4 Intersection of UI and UX in Digital Platforms

When creating digital platforms, it's essential to consider the relationship between UI and UX. The interface needs to look good while also being user-friendly. Ultimately, the user should have a satisfying experience that meets their needs. A digital platform can be successful by carefully considering and executing both aspects [28].

For the proposed project, it is crucial to have a well-designed UI with a positive UX. The interface should make navigating and interacting with the content accessible, while the overall experience should encourage users to explore and learn more.

2.6 Related Works

2.6.1 Survey Methodology

Data Sources

I relied heavily on the ACM Digital Library to gather data on computer science pioneers. In addition, I added Wikipedia, Gurer's study [29], a GitHub repo called "pioneers" [30] and other scholarly sources that delve into the history of computer science. For information on mathematics pioneers similar to the project's objectives, I found the University of St Andrews' digital resource (MacTutor Index [1])

Search Terms

Various search terms were used to maximise the range and relevance of the results. These included words such as:

- "computer science literature."
- "bibliometric mapping"
- "computer science pioneers."
- "Women in computer science."
- "mathematics pioneers."
- "historical mathematicians."
- "St Andrews maths pioneers."

The search terms were revised and refined throughout the review to ensure the identification of a broad range of relevant works.

Inclusion and Exclusion Criteria

The criteria for inclusion in this study were as follows:

The sources are written in English, published in peer-reviewed academic journals or recognised academic websites, and focused on computer science or mathematics history and pioneers. Moreover, these sources should include insights into categorising or classifying contributions within these fields.

The criteria for exclusion in this study were as follows:

Some examples of works that may not be considered relevant include non-academic sources like blogs or opinion pieces and works that focus on unrelated fields outside of computer science or mathematics. Additionally, works that do not offer significant insights into categorising or classifying contributions may also be excluded.

2.6.2 Brief Description of Sources

The ACM Digital library is a widely recognised classification system for grouping computer science contributions. Van Eck and Waltman [31] conducted a study of the bibliometric mapping of computer science literature using a program called VOSviewer. This program, which they have developed, is freely available and allows for constructing and viewing bibliometric maps. The study has implications for the classification system.

Identifying pioneers in computer science is a complex task. The best identification source is the English Wikipedia website, and there is a study by Gurer that highlighted the role of women in the early history of computer science, providing an example of how to identify pioneers in a particular demographic segment of the discipline. They used an analytical approach, assessing contributions based on their impacts on the field, to determine these pioneers [29].

The Maths Department of the University of St Andrews has created a Digital Resource called MacTutor Index [1] that showcases the pioneers of Mathematics. These mathematics can be categorised based on their geographical locations, periods, and specific contributions to the field. Another valuable resource that provided insights into computer science pioneers was a GitHub repository titled "pioneers" [30].

The resources include an interactive map allowing users to explore mathematics by region. It pinpoints the birthplaces of prominent mathematicians and the areas where their work thrived. Each location on the map contains information about the mathematicians associated with it. The resource also groups mathematicians chronologically, providing a fascinating glimpse into the evolution of mathematical thought across centuries.

This digital resource categorises influential figures in mathematics based on their specific contributions, covering various areas, including algebra, geometry, calculus, number theory, mathematical physics, and statistics. By doing so, it showcases the broad scope of mathematical study and emphasises how these are interconnected. This resource aims to increase appreciation for the pioneers who have shaped mathematical history by highlighting its richness and diversity.

Academic research and knowledge sources are ever-evolving. Although I aim to provide a review of available resources, there may always be newer sources emerging to enrich our understanding of the subject further.

Chapter 3

Requirements & Design Specifications

3.1 Overview

Creating an accurate online resource about computer science pioneers requires precise design. It is important to note that the electronic resource aims to present accurate, easily accessible, and searchable information about pioneers, classified appropriately as per their contributions. Furthermore, it is designed to cater to users from a global perspective, with a user-friendly interface.

An in-depth understanding of the user, technical, and content requirements is essential to this project. This chapter outlines the design specification and requirements necessary to realise the objectives set out for this project. Moreover, I discuss selecting appropriate technologies and tools for development, the information architecture and the strategies for ensuring user accessibility and usability.

3.2 User Requirements

The primary users of the electronic resource will include students, educators and researchers, as well as individuals interested in the history of computer science. These user categories have diverse needs and expectations that must be considered in the system's design. Finding a design strategy that provides a unified platform for information presentation for all user types is essential. This united front would ensure that the diverse user categories can access and interact with the data in a manner best suited to their individual needs.

To ensure the system meets the needs of all potential users, I will develop user personas and scenarios representing typical users and their interactions with the system. I will derive user requirements from the data guiding the system's design.

3.2.1 User Personas

User Persona 1: Ava, Computer Science Student

Age	21
Occupation	Undergraduate Computer Student @ University of St Andrews
Technology Skills	Highly Competent
Goals	To learn about pioneers in her field to better understand computer science evolution.

Table 3.1: Details of User Persona: Ava, Computer Science Student

Scenario: Ava has an assignment where she has to write about the evolution of computer science and the pioneers who contributed significantly to its advancement. She logs onto the online resource and uses the **search and filter functions** to look up pioneers in specific eras and areas of computer science. She uses the **road map feature** to understand the time of their contributions. Lastly, she uses the **references** and **web-links** provided for each pioneer to get more detailed information.

User Persona 2: Ben, History of Science Researcher

Age	35
Occupation	Researcher specialising in the history of science
Technology Skills	Intermediate
Goals	To gain comprehensive information about computer science pioneers for his research.

Table 3.2: Details of User Persona: Ben, History of Science Researcher

Scenario: Ben is working on a research paper about the impact of computer science on modern society. He accesses the online resource to find information about pioneers who have shaped the field. He acknowledges the **classification system** used in the resource and uses the **visualization** feature to understand their contributions better. He finds the **sources** and **web links** useful for cross-referencing and getting more information.

User Persona 3: Cathy, High School Computer Science Teacher

Age	42
Occupation	High School Computer Science Teacher
Technology Skills	Intermediate
Goals	To provide her students with additional learning resources about the history of computer science.

Table 3.3: Details of User Persona: Cathy, High School Computer Science Teacher

Scenario: Cathy wants to make her classes more engaging and informative for her students. She accesses the online resource to prepare her lesson plans. She appreciates the **user-friendly interface** and **easy navigation**. She uses the **multimedia content** to make her lessons more engaging and interactive. She recommends the online resource to her students as supplementary reading material.

User Persona 4: David, Lifelong Learner

Age	65
Occupation	Retired Engineer
Technology Skills	Basic
Goals	To pursue his interest in computer science's vast history and understand the evolution of technology over the decades.

Table 3.4: Details of User Persona: David, Lifelong Learner

Scenario: David, being a retiree, has always been fascinated by technological advancements. Now with plenty of spare time, he wishes to learn more about the pioneers in computer science. He appreciated the **user-friendly interface** and **intuitive navigation**. He explores the **multimedia** content and finds the visualisation of pioneers' contributions particularly fascinating.

User Persona 5: Celine, High School Student

Age	16
Occupation	High School Student
Technology Skills	Intermediate
Goals	To explore her growing interest and possibly pursue a career in computer science.

Table 3.5: Details of User Persona: Celine, High School Student

Scenario: Celine, a high school student with a budding interest in computer science, uses the online resource to explore the pioneers in the field. She's immediately drawn to its **user-friendly interface**. **The intuitive layout** makes it easy for her to navigate the platform, despite it being her first visit. She uses the **search function** to look up *Grace Hopper*, a name she hears frequently. She can access detailed information about Hopper's contributions to computer science, along with **references** and **links** for further reading. This makes her study both educational and engaging, making the subject even more appealing. This further fuels her interest and inspires her future study plans to pursue computer science in her higher studies.

User Persona 6: Micheal, University IT Professional

Age	28
Occupation	University IT Professional
Technology Skills	Highly Competent
Goals	To guarantee the seamless functioning and ongoing enhancement of the Computer Science Pioneers website.

Table 3.6: Details of User Persona: Micheal, University IT Professional

Scenario: As the University of St Andrews IT professional, Micheal maintains and develops the Computer Science Pioneers website. He daily reviews the site's health and user feedback, adeptly handles technical issues, updates the MongoDB database, and tweaks the Node.js and Express backend as necessary.

Responding to Ava's feedback about adding a pioneer, he researches, verifies, and adds a new pioneer Dr Kriti Sharma to the site. When a broken link issue arises with Ada Lovelace, he quickly resolves it.

Micheal ensures site performance and security through regular checks, database backups, and security audits. His efforts support a reliable, user-friendly platform that effectively highlights the pioneers of Computer Science.

To further visualise the scenarios, Appendix (D) represents the use case diagram based on user scenarios derived.

3.2.2 Functional Requirements

From the above personas and scenarios, I derive the following functional requirements:

- **Search Functions:** Users should be able to search for information about specific pioneers in computer science using keywords.
- **Filter/Browse Functionality:** The system should provide a filter function, allowing users to filter/Browse content based on various criteria such as century, country, field contributed to and name.
- **Classification:** The system must classify the contributions of pioneers according to the selected classification system(ACM Digital Library).
- **User-Friendly Navigation:** The navigation menu should be intuitive for users to access different site sections easily.
- **Multimedia Content:** The system should support displaying multimedia content such as videos and podcasts.
- **Visualisation:** The system should provide visualizations of the pioneers' contributions.
- **Cross-Platform Compatibility:** The system should be accessible and function correctly on various platforms(desktop,mobile,tablets) and web browsers.
- **User Feedback:** The system should provide a mechanism for users to give feedback on the electronic resource and suggest improvements.
- **Road map Creation:** Users should be able to create road maps based on search criteria or era.
- **Supporting Documentation:** The system should provide a mechanism for users to give feedback on the electronic resource and suggest improvements.
- **References and Links:** The system should display references and web links used as sources for the provided information.
- **Accessibility:** The system should comply with accessibility standards to cater to users with different abilities.

3.2.3 Non-Functional Requirements

The criteria used to evaluate a system are based on its requirements rather than specific behaviours. These include but are not limited to system performance, reliability, security, etc. Based on the project's objectives, the non-functional requirements for the resource are listed below.

- **Usability:** The system should have an intuitive and user-friendly interface that caters to all age groups, making it easy to navigate and locate information.

- **Performance:** The system should respond quickly to user inputs and queries, ensuring a seamless user experience.

- **Security:** User Data, if collected, should be securely stored and managed to maintain privacy and confidentiality.

- **Accessibility:** The system must comply with standard accessibility regulations to ensure people with different abilities can use it.

- **Scalability:** The system should be capable of handling an increasing amount of work by adding resources. This includes the ability to accommodate more users and more data over time.

- **Compatibility:** The system should function correctly on various platforms (desktop, mobile) and web browsers.

- **Maintainability:** The system should be easy to update and maintain, allowing for the addition of new pioneers and updates to existing content.

- **Reliability:** The system should function without failure and provide accurate and consistent information.

- **Availability:** The system should always be available for use, barring scheduled maintenance or unforeseen incidents.

- **Extensibility:** The system should be designed in a way that allows for the inclusion of additional features or functionalities in the future.

- **Responsiveness:** The system should render appropriately and quickly across various devices and screen sizes.

- **Legal Compliance:** It is important for the system to abide by all applicable data protection and privacy laws and regulations.

- **Sustainability:** The chosen technologies for the system should be modern and widely supported to ensure the longevity and sustainability of the project.

3.3 Information Architecture

3.3.1 Introduction

Considering the user requirements outlined in the previous section, our approach to information architecture seeks to design a platform that meets those needs. As defined by [32], information architecture encompasses:

i The structural design of shared information environments.

ii The art and science of organizing and labelling web content.

iii Ensuring usability and findability in digital landscapes.

iv A discipline that brings design and architecture principles to the digital domain.

To create an architecture that aligns with user requirements, research-driven design is paramount, ensuring the platform caters to the needs and behaviours of its users.

3.3.2 Translating User Requirements into Architectural Steps

The main steps that go into designing the information architecture are [33] :

i Conduct user research

- UX Research
- User Personas

ii Review and update content

- Content Inventory
- Content Audit

iii Apply card sorting for content classification

iv Build a user-friendly hierarchy

- Navigation and Labeling
- Site Mapping

v Create a UI prototype

- Wireframing

Conduct user research

As determined by the user requirements, I identified distinct needs among three primary user groups: students, researchers, and computer science enthusiasts. This knowledge informed our research approach, ensuring I deliver content and features tailored to these diverse user requirements.

UX Research

I grasped industry best practices and user expectations by diligently studying related works (2.5). Our platform's beta release (7.3) was instrumental in gathering invaluable user feedback and identifying potential challenges they may face during exploration. Our primary objectives were to thoroughly understand how users navigate the website and determine the types of information that hold the highest priority.

User Personas

Random user personas were developed based on the data collected in related works. These personas, serving as fictional representations of the different user types that might use the website, included demographic information, profession, needs, preferences and behavioural patterns. The creation of these personas facilitated a deeper understanding of the users' needs, experiences, behaviours and goals of the user.

3.3.3 Review and Update Content

I conducted a thorough review to ensure our platform provides accurate, up-to-date, and trustworthy user content.

Content Inventory

The initial step in this phase was to conduct a content inventory, which comprised producing a list of all the present content related to the computer science pioneers that would be featured in the online resource.

The inventory included information such as the Pioneer's name, their contributions to the field, their country of origin and the area they contributed to. This inventory served as an overview of the content organised and presented on the website.

Content Audit

After conducting a content inventory, a content audit was performed. This involved thoroughly examining each piece of content to evaluate its accuracy, relevance, and currency. Any information that was outdated or inaccurate was either removed or updated. Moreover, this audit facilitated the identification of any content gaps that required attention. For example, if pioneers who made noteworthy contributions to computer science were not included in the initial content inventory, they were included in this stage.

3.3.4 Apply Card Sorting for Content Classification

Card sorting, a method widely accepted for its efficacy in understanding user thought processes, was chosen to classify content. This approach ensures that our content organisation aligns with user expectations, a critical requirement for our platform's usability.

3.3.5 Build a User-friendly Hierarchy

Creating a user-friendly hierarchy was paramount because users emphasised easy navigation during the requirements-gathering phase. This step sought to ensure users could effortlessly find the information they sought.

Navigation and Labelling

The first step in this phase was to design an intuitive and user-friendly navigation system with menus, links, and buttons for users to move around the website. The labelling scheme involved deciding on names for each navigation element and content category, such as "By Name", "By Country", and "By Field", reflecting the classification system used to organise the content.

Site Mapping

The first step in creating an online resource is designing a site map. This visual representation shows how different pages and sections of the website are connected, reflecting the user-friendly hierarchy and navigation system. For example, the "By Name" page is a sub-page of the main "Browse" page, indicating that users can navigate to it from the "Browse" page.

3.3.6 Create a UI Prototype

Incorporating user feedback and requirements, a UI prototype was developed. This prototype serves as a tangible representation of how the finalised platform will function, allowing for adjustments based on user interactions and feedback.

Sketching

Before the wireframing phase, a sketching process was undertaken. Sketching plays a pivotal role in the design process, offering a hands-on approach to conceptualising ideas, organising layouts, and establishing the fundamental framework of a project [34].

The sketches for the online resource primarily revolved around the following:

- Conceptualising the primary navigation layout.
- Visualising the general placement of elements on individual pages.
- Imagining user interactions, such as accessing a certain feature or navigating between pages.
- Generating creative solutions to potential design challenges identified during the requirement gathering phase.

Wireframing

In this phase, Wireframes were created for the online resource. They serve the role of depicting how an individual page or temple should look from an architectural perspective. They stand at the intersection of the site's information architecture and visual and information design [32].

The wireframe for the online resource includes the following:

- A Home Page with an overview of the purpose of the resource and links to the main sections(e.g. Browse (Browse By Field, Name and Country).

- Individual pages of the main sections, showing how the content will be organised and displayed.
- Additional pages such as "About", "Chat with EVA", "Contact", "Map", and "Road Map", each with their own specific layout and content placeholders.

Prototype

A prototype is a functional model that includes the website's basic structure and user interface. Although this version was incomplete regarding content and final aesthetic details, it mirrors the intended final product's primary navigation, interaction patterns, and overall layout [34].

Sketching and wireframing help organise features and design a visual layout. But prototyping provides a functional representation of the product, allowing us to understand how it will operate during user interaction. It's a valuable tool for testing all components and getting a feel for the final product's performance.

3.4 Content Requirements

An essential part of the design specification for the electronic resource is determining what content it will host. The system will primarily contain biographical details and contributions of computer science pioneers will around the globe.

The biographical details will include:

- Name of the Pioneer
- Picture of the Pioneer
- About
- Achievement
- Classification (as per ACM Library)
- Birthplace (Latitude and Longitude to region level)
- To know more (Links to other websites containing information on the Pioneer)
- References

The pioneers' contributions will comprise:

- The area of computer science where the pioneers made significant contributions.
- Description of the specific achievements or contributions.
- Impacts and significance of contributions on the field and the world.

The source of the information will be drawn from reputable academic databases and publications, ensuring the accuracy and reliability of the content. The system will also include references and web links, enabling users to trace the sources of the information.

A dynamic system is essential for the electronic resource, allowing adding and modifying data as new pioneers emerge and additional information about existing pioneers becomes available.

3.5 Technical Requirements

The technical requirements form a core aspect of the online resource, encompassing the choice of programming language, database management, server requirements and other critical requirements.

3.5.1 Programming Language and Frameworks

Selecting the appropriate programming language is crucial for the success of the project. As the resource requires a user-friendly interface and interactive features, a combination of EJS [35], CSS, and JavaScript were employed for front-end development. These languages allow for an interactive and aesthetically pleasing user interface. These options offer robustness, flexibility, and efficient performance.

3.5.2 Database Management

The project involves managing essential data related to pioneers in computer science and contact form queries sent by various users. Hence, an efficient and secure database management system (DBMS) is needed. A relational DBMS like MySQL or PostgreSQL could be a viable choice for this project due to their strong support for structured data. However, MongoDB [36], a NoSQL database, was considered the final choice for added flexibility and to accommodate future requirements.

3.5.3 Server Requirements

The server should be robust and capable of handling multiple requests concurrently without compromising the speed or performance of the website. A suitable server-side environment would be Node.js [37] since JavaScript is chosen for the back end.

3.5.4 Choice of Technology Stack

The technology stack for this project was chosen to reflect the specific technical requirements. Table (3.7) details the components of our technology stack, selected for their ability to meet the project's demands for an interactive, user-friendly interface and efficient, secure data handling.

Component	**Technology**	**Purpose**
Front-end	EJS, CSS, JavaScript	Used to build the user interface, including the website's layout, design, and interactivity.
Back-end	Node.js, Express.js	Responsible for server-side web application logic and integration of the front-end work.
Database Management	MongoDB	Stores retrieves and manages data related to the website.

Table 3.7: Technology Stack

By aligning with the technical requirements, this technology stack allowed for robust, flexible, and efficient performance throughout the development and implementation stages.

3.6 Security and Privacy

In creating an online resource for pioneers in computer science, security and privacy are top priorities. User data must be protected, particularly in areas where it is collected, such as Chat with EVA and Contact. Our platform adheres to all applicable data protection regulations to ensure user privacy and security. The data on the forum is stored on a NoSQL server, MongoDB [36], which requires unique security and privacy considerations. The website is being developed using Node.js, which also has specific security practices that have been implemented.

Data Collection and Storage

The online resource will only collect necessary personal data, such as user feedback and interaction data, with EVA, a ChatGPT chatbot securely stored in MongoDB.

Data Protection Compliance

The platform will comply with relevant data protection regulations, including GDPR [38] if users from the European Union are expected to access the resource. This involves providing transparency about how their data will be used.

Secure Connections

The website will use HTTPS [39] to encrypt data transmitted between the user's browser and the website. MongoDB supports TLS [40] and SSL [41] for network encryption.

Environment Variables

In Node.js development, sensitive data like API keys are stored as environment variables to prevent exposure in the database for an extra layer of security.

User Privacy

User privacy is our top priority. I only collect information that users choose to share and do not share personal data with third parties. Any data obtained is solely used to improve the online resource.

Security Measures

The platform will implement standard security measures to protect against potential threats. This includes regular security audits, secure coding practices, and updating all system components to protect against known vulnerabilities.

Privacy Policy and Terms of Service

The website will display its privacy policy and terms of service, outlining data collection and usage and rules for website use.

Chapter 4

Project Methodology

4.1 Project Management

Throughout the three months from May 22, 2023, to August 15, 2023, we utilised an agile approach to software development to complete my dissertation successfully. After carefully considering various methodologies, we chose the Agile methodology due to its unparalleled adaptability, swift iterations, and unwavering focus on the user. My approach allowed me to maintain a steady pace, progress significantly towards my milestones, and quickly respond to feedback.

4.1.1 Agile Development Process

In alignment with the Agile methodology, this dissertation project was guided by the following key principles [42, Pg.397]:

- **Customer Involvement:** The system requirements were refined iteratively by incorporating user feedback and prioritising their needs. This methodology ensures a design that aligns with users' expectations while evolving with their preferences and requirements. This research-backed approach underscores my dissertation's commitment to delivering a user-friendly and interactive resource.
- **Incremental Delivery:** The website was developed in increments, allowing for regular evaluation and revision. This allowed me to ensure that each increment added value and met user expectations. This aligns with my dissertation's goal to produce a functional and efficient online resource.
- **People not Process:** As a solo developer, I relied on my skills and preferences in the development process, promoting creativity and efficiency. This aligns with my dissertation's objective of utilising my knowledge and skills to their full potential.
- **Embrace Change:** Acknowledging that requirements may change, I designed the system and my work process to be flexible. This enabled me to accommodate changes, thus ensuring the final product remained relevant and valuable. This flexibility was crucial in meeting my dissertation's objective to deliver an up-to-date and accurate online resource.
- **Maintain Simplicity:** Throughout the development process, simplicity was my guiding principle. I actively sought to eliminate complexity from the system and

my methods, making the resource easy to use and the development process efficient. This principle directly corresponds with my objective to create a user-friendly online resource.

These principles shaped my development process and ensured that my dissertation objectives were met effectively and efficiently. By employing the Agile methodology, I produced a high-quality online resource within the project timeline.

When working on my dissertation project, I incorporated Agile methodology and utilised a tool called Notion [43] to create a Gantt chart. This chart was incredibly helpful in visualizing the project timeline and managing my tasks more efficiently. I have included the Gantt chart in Appendix (C), which covers the entire duration of the project from May 22 to August 18, including the final demo.

The project was planned thoroughly, with specifications and direction established. Two-week sprints were used for focused work, with planning sessions at the start and daily meetings to review progress. After each sprint, reviews and retrospective sessions were held to assess progress and identify areas for improvement.

4.1.2 Continuous Integration and Continuous Deployment (CI/CD)

As part of modern software development practices, I have implemented a Continuous Integration and Continuous Deployment (CI/CD) pipeline in my project workflow. The core concept of CI/CD is to automate the integration of code changes from various contributors into a project and ensure reliable software releases at any time. This approach emphasises the principles of Agile methodology by enabling frequent and dependable releases.

- **Code Storage in GitHub:** The project's codebase was stored on GitHub, a version control platform [44]. GitHub provided a centralised source for the project, enabling simple change tracking, collaboration, and versioning.
- **Server Integration with GitHub:** Server platforms can now integrate with GitHub repositories, allowing for seamless deployment upon commits with appropriate permissions.
- **Automated Deployment:** After each GitHub repository commit, the CI/CD pipeline automatically deploys the latest website version, ensuring the live site reflects the latest updates and improvements. This drastically reduces manual deployment efforts.
- **Rollbacks and Stable Commits:** In case of a significant bug or instability, the CI/CD pipeline automatically reverts the deployment to the last stable commit, ensuring a functioning website for users.

By utilising GitHub's integrative capabilities and implementing CI/CD practices on server platforms, I maintained the project in a continuously deployable state. This streamlined development and ensured prompt delivery of features, enhancements, and bug fixes to end-users.

4.1.3 Documentation and Tracking

To maintain an organised approach to development and keep track of daily progress, I used a tactile and visual documentation system with a whiteboard. I chose a whiteboard over digital tools for multiple reasons:

- **Visual Overview:** The whiteboard allowed me to quickly understand the project's progress by visually representing the tasks and facilitating decision-making and prioritisation.
- **Flexibility:** The whiteboard's ease of adding, erasing, and modifying entries allowed me to quickly adapt to changes, reflecting the flexibility of the Agile methodology.
- **Immediate Tracking of Bugs:** Any bugs or issues found during development were quickly logged on the whiteboard, ensuring prompt resolution and avoiding oversight.
- **Daily Logs:** Every day, I wrote down the key activities I completed, milestones achieved, and the primary tool or technology used. This habit helped me stay focused on my goals and gave me a retrospective view of my progress, including any patterns or challenges I encountered.
- **Motivation:** By physically crossing out completed tasks and visualising the decreasing pending tasks, I felt motivated to maintain momentum and achieve my goals.

In addition to using digital documentation tools and Gantt charts on Notion, I incorporated a whiteboard into my daily workflow. This ensures meticulous tracking and reinforces my commitment to systematic and transparent project management.

4.2 Ethics

This chapter explores the ethical considerations involved in creating and implementing electronic resources, as well as the documentation supplied to MMS.

During the initial stages, the 'Preliminary Self-Assessment Form' identified the necessity for human interaction, specifically through the user study. Subsequently, the 'Artefact Ethical Approval Form' was carefully examined. After consultations with the supervisor, it was concluded that this form would sufficiently address the ethical considerations related to the creation of the tool and the questionnaires utilised in the user study.

Participants could complete the user study questionnaires in less than 10 minutes, ensuring a hassle-free participation experience. Additionally, the confidentiality of participants was strictly maintained, and the development of the website did not involve the use of any real student data.

Data privacy is of utmost importance regarding electronic resources. Any user data, such as search queries, contact information, chat data and website interactions, will not be stored or utilised beyond this project's scope. In addition, no personally identifiable information is collected, ensuring user privacy and alignment with General Data Protection Regulation (GDPR) [38] standards.

It's important to accurately and respectfully represent the diversity of pioneers in computer science. The website provides unbiased and well-researched content while avoiding discrimination or misrepresentation.

By prioritising user needs and ensuring transparency in processes and intentions, the project adheres to a high ethical standard.

The 'Preliminary Self-Assessment Form' and the 'Artefact Evaluation Form' have been submitted to MMS and are included in Appendix (B).

4.3 Design Process of the Electronic Resource

I followed a careful and thorough process in designing the electronic resource to create an easy-to-use, readily available, and informative platform. Here is a breakdown of each step involved:

4.3.1 Principles and Guidelines

I prioritised certain principles and standards throughout the design process to ensure our platform is user-centric. I gained valuable insights from our literature review, specifically sections ((2.5.1),(2.5.2)), where I explored user interface (UI), the importance of user experience (UX), and their intersection in digital platforms.

Our main objective was to design a website that is user-friendly and easy to navigate. This was a crucial aspect during our research on the importance of UI and UX in digital platforms in section (2.5.1). I aimed to deliver a resource that would be easily understandable to all users, including those who need to be technologically savvy.

In addition to a user-centric approach, I followed the Web Content Accessibility Guidelines (WCAG) [45] to ensure the website is accessible to people with disabilities. Inclusivity was a crucial aspect of our design ethos. I wanted our resource to be informative and accessible to all, reflecting the diverse range of individuals who have contributed to the field of computer science.

Our website's accessibility is of utmost importance to us, so I have taken steps to ensure it can be accessible to all. To achieve this goal, I have adopted Siteimprove [46], a tool that is popularly used for evaluating the accessibility of websites. I chose Siteimprove because of its credibility and use by official bodies such as the UK government in their official service manual [47]. Our use of this tool is a testament to our unwavering commitment to making our website accessible to everyone.

4.3.2 Preliminary Sketches and Wireframes

I created a set of hand-drawn sketches on whiteboards at the beginning of designing, as recommended in the section (3.3.6). These sketches allowed us to brainstorm and refine design ideas flexibly and spontaneously, transforming the theoretical understanding gained from the literature review into practical applications for our project. I created more formal wireframes once these preliminary sketches were refined and agreed upon. For this, I used Balsamiq Wireframes [48], a dedicated wireframing tool that allowed us to create more detailed, structured, and interactive mock-ups of our website.

During the design process, the preliminary sketches and wireframes were extremely helpful. They gave us a clear and tangible idea of how the website would look and function, serving as a blueprint for the development stage. Additionally, they were crucial in communicating our design vision to users, providing them with a clear understanding of the final product.

4.3.3 Prototyping

Prototyping, a crucial step in designing a user experience (UX) as suggested in section (3.3.6), was meticulously undertaken in our project. This allowed us to delve deeply into numerous technical possibilities, fine-tune our development plan, and set a precise schedule for the concluding phase of our project, all in line with the theoretical insights.

This systematic approach enabled us to carefully scrutinise and validate our design choices while allowing us to refine and perfect the website before moving on to the final development stage. Our efforts have yielded a polished and thoroughly vetted product.

4.3.4 User Testing and Feedback

In line with the testing and evaluation framework discussed in the section (4.4.2), our website underwent proper testing process, encompassing various stages from functional and usability testing to accessibility and performance testing.

This feedback phase extended beyond the prototype testing, with a beta release from July 24, 2023, to August 3, 2023. During this period, the website was accessible to a broader audience through the computer science administrative email system, among other channels. This aligned with our outlined user feedback strategy described in section (4.4.2).

Feedback was crucial to the website's iterative development process, allowing us to implement changes based on direct user experience. The continuous testing and evaluation process, detailed in section (4.4.2), played a vital role in this phase.

4.3.5 Iterative Design and Finalization

I followed an iterative design process, gathering user feedback and making necessary adjustments at each stage. Our objective was to create a website that was accessible and user-friendly to a diverse audience. Once I achieved positive user testing results, I finalised the design and moved on to development. The result was a visually appealing, inclusive, and accessible website.

4.4 Development and Implementation of the Electronic Resource

4.4.1 Search and Filter Functionality

One of the critical features of our website is the ability to search and filter information. I employed a specific algorithm to provide efficient search results. The algorithm works in a

way that it displays the most relevant results first, improving the overall user experience. The underlying code snippet for the search functionality is presented below:

Listing 4.1: Search algorithm

```
Pioneer.find({ name: { $regex: new RegExp(".*" + searchRegex + ".*", "i") }
    })
    .skip(skip)
    .limit(pioneersPerPage)
    .exec()
    .then((pioneers) => {
        Pioneer.countDocuments({ name: { $regex: new RegExp(".*" +
            searchRegex + ".*", "i") } })
            .then((totalPioneers) => {
                console.log("Found " + pioneers.length + " pioneers");
                res.render("searchResults", { pioneers: pioneers,
                    searchTerm: searchTerm, totalPioneers: totalPioneers,
                    pioneersPerPage: pioneersPerPage });
            });
    })
    .catch((err) => {
        console.log("Error retrieving pioneers");
        res.render("error");
    });
```

This code finds all the pioneers whose names match the search term. It is configured to skip a certain number of results and limit the results per page, providing a paginated response. If the search is successful, it renders the search results page with the pioneers, the search term, and the pagination information. In case of any errors, an error page is rendered.

The filter functionality was implemented to help users narrow their search based on specific criteria. The integration of these features played a crucial role in making our website a user-friendly and efficient resource.

4.4.2 Testing and Evaluation

The final stage of the project's development involves rigorous testing and evaluation. This is critical to ensure the developed resource aligns with the requirements and provides a seamless, high-quality user experience.

Functional Testing

This stage focuses on ensuring the optimal functionality of all features, including the search and filter functionalities, navigation aspects, and other website elements. Any detected bugs or discrepancies are addressed and rectified before progressing to the subsequent stages.

Usability Testing

Following the functional testing, usability testing is conducted. A target audience will be asked to interact with the website to perform specific tasks while observing their actions and interactions. The outcome of this testing will shed light on the website's usability parameters and pinpoint areas that may need refinement.

Accessibility Testing

It is important to test website accessibility for all users, including those with disabilities. This testing stage incorporates assistive technologies and ensures all content is clear and easily navigable.

Performance Testing

Performance testing ensures that the website delivers optimal performance across various conditions. This includes testing parameters such as loading times, responsiveness, and the site's reliability under high-traffic conditions.

Security Testing

The security of the website and the user data it holds is of paramount importance. Hence, meticulous testing will be conducted to identify potential vulnerabilities and ensure the effective functioning of all security measures implemented.

User Feedback

After the initial rounds of testing, a beta version of the website will be launched for a selected group of users. Feedback will be actively solicited from these users regarding their experience with the website. The insights gained from this feedback will be instrumental in guiding further improvements and refinements to the website.

Evaluation

The final step is an exhaustive evaluation of the online resource's success metrics. This involves a detailed analysis of user feedback, website usage statistics, and other relevant data. The primary objective of this evaluation is to ascertain if the website successfully highlights the diversity of pioneers in the computer science field and whether it provides an easy-to-navigate and efficiently searchable resource.

Chapter 5

Designing the Electronic Resource

5.1 UX Design Principles

The electronic resource was crafted with the utmost consideration for the User Experience (UX). Chapter (3) laid out the requirements & design specifications, which helped establish the principles meticulously incorporated throughout the design process. The objective was to produce a website that was intuitive but also engaging and user-friendly, with a robust information architecture to govern its structure and organisation. The principles that were applied proved to be highly effective.

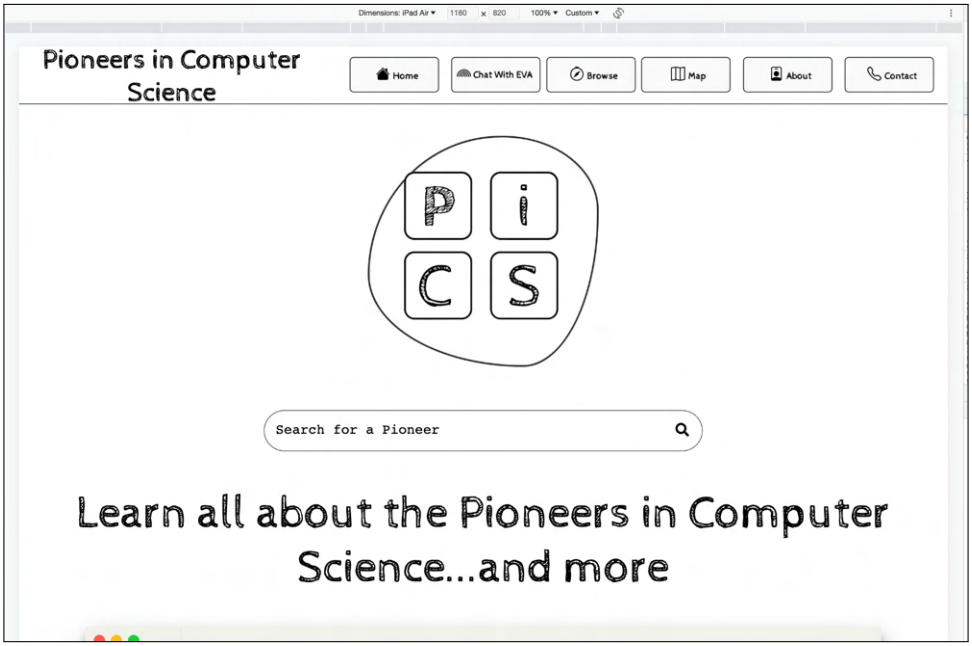
5.1.1 Understanding the Users

Our website was created through user research, as detailed in the section (3.3) and referring related works (2.5). By gaining a deep understanding of our user's needs and behaviours, I designed the site to cater to their preferences. I even developed user personas (3.2.1) to represent the main user groups: students, researchers, and computer science enthusiasts. This allowed me to understand better their needs, experiences, behaviours, and goals and ultimately informed my design decisions.

5.1.2 Mobile-first Design

The site was designed to accommodate the increasing use of mobile devices for accessing information. The approach was mobile-first, ensuring that the site was developed to fit smaller screens before scaling it up to ensure compatibility with all device sizes, including larger screens.

(a) Website home page on a mobile device (iPhone 12 Pro).



(b) Website home page on a tablet (iPad - Air).

Figure 5.1: Comparison of the website home page displayed on mobile and tablet devices.

5.1.3 Iterative Design Process

One of the critical methodologies employed during the website's design was the iterative design process. This approach, often used in UX design, operates on a cycle of prototyping, testing, analysing, and refining a product or process. This project involved the repeated application of three significant stages: sketches, wireframes, and prototypes.

5.1.4 Sketching

During the initial stage of the design process, I began sketching. This step involved creating basic, free-hand drawings that quickly captured the website's layout and composition. The sketches were a visual guide and discussion regarding the site's layout and features. They were also easy to modify, making them an excellent tool for early conceptualisation. Please see the Appendix (E) for examples.

5.1.5 Wireframing

After finalising the sketches, I moved on to creating wireframes. These simplified outlines of the product provide a clear overview of each page and how the elements will work together. You can see examples of wireframes in the Appendix (F).

5.1.6 Prototyping

The last step in this cycle was creating prototypes, which can be anything from basic paper models to interactive digital versions that simulate the final product. Prototypes were used for this project to gather user feedback and conduct testing. This stage was critical in assessing the site's workflow, navigation, and overall user experience. Examples of prototypes are in Appendix (G).

5.2 Site Map and Navigation Design

The site map can be visualised as a hierarchical structure that organises the website's pages and their relationships:

5.2.1 Site Map

1. **Home Page**
    - Chat
    - About
    - Browse By
        - Name
        - Field
        - Country
    - Contact
    - Map

- Road Map
- Search Results
- Pioneer Profiles
- Legal and Policies
  - Privacy Policy
  - Copyright
  - Accessibility
  - Disclaimer
  - Takedown Policy

5.2.2 Navigation Design

Main Navigation Menu

Navigation Element	Description
Home Page	The central hub for users, linking to all main sections.
Chat	Direct access to live chat support or community interaction.
About	An informative page about the website's purpose and creators.
Browse By	A sub-menu allows users to browse by Name, Field, or Country.
Contact	A straightforward way to reach out for inquiries or support.
Search Bar	A universal search function.

Table 5.1: Main Navigation Menu

Footer Navigation

- **Legal and Policies:** Privacy Policy, Copyright, Accessibility, Disclaimer, Take down Policy.

Breadcrumb Navigation

- Implemented on individual pages (e.g., Pioneer Profiles).

Search Results Page

- Customised navigation for search results.

Responsive Design

- User-friendly across various devices.

User-Centered Features

- Clear labels, intuitive design, and user-centric features.

5.3 Designing for Diversity and Accessibility

5.3.1 Partial Compliance with Web Content Accessibility Guidelines

- **Alt Text for Images**: Alternative text is present for every image element on our website, including visuals on pages like Home, About, and Browse By. This essential accessibility practice ensures that assistive technology users receive a text-based description of images.
- **Color Scheme**: To ensure maximum readability and avoid any contrast issues, the website maintains a consistent black-and-white colour scheme across all pages, including Chat, Search Results, Pioneer Information, and more.
- **Language and Content**: Please note that the content on the site is exclusively available in English. Though I have endeavoured to use plain, easily understandable language, non-English speakers may encounter challenges.

5.3.2 Limitations and Areas for Improvement

- **Keyboard Navigation**: Currently, the website does not offer keyboard navigation features, which can present accessibility obstacles for individuals who rely on a keyboard or alternative navigation methods that do not entail using a mouse.
- **Screen Reader Compatibility**: Visually impaired users may face accessibility limitations as the website is not fully compatible with screen readers.
- **WCAG Compliance**: The website has taken steps to adhere to WCAG standards, but there is room for improvement to enhance accessibility for a wider range of users.

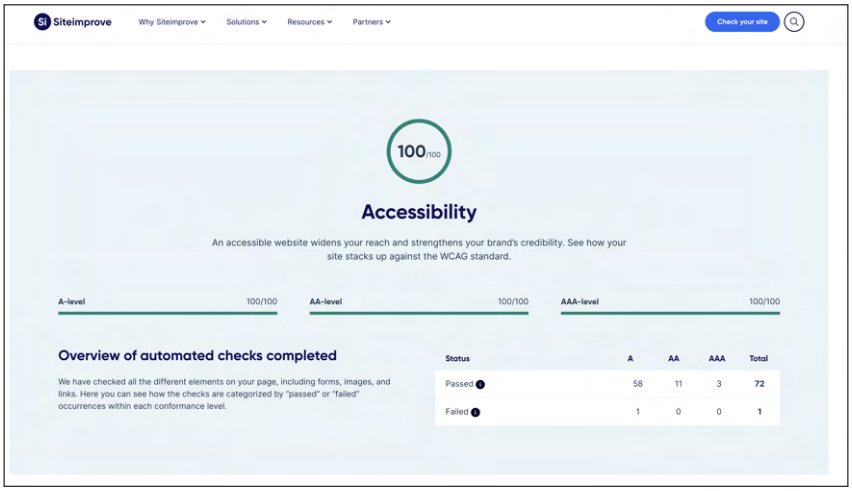


Figure 5.2: Accessibility Compliance Assessment of the Home Page by Siteimprove [46]

5.3.3 Responsive Design

- **Mobile and Tablet Accessibility**: The website's design and layout seamlessly adjust to different devices and screen sizes, ensuring a consistent and effortless user experience across all platforms.

5.3.4 Privacy and Safety Considerations

- **Clear Policies**: The pages for Privacy Policy, Copyright, Accessibility, Disclaimer, and Take Down Policy state the website's position on user privacy, ethical conduct, and legal issues.

Despite the website's efforts to promote accessibility and inclusivity, such as incorporating alt text for images and a simple black-and-white design, improvements still need to be made. To fully comply with WCAG standards, it is necessary to implement keyboard navigation and multilingual support. Although the current design reflects a commitment to accessibility, ongoing enhancements are essential to meet all users' diverse needs and abilities.

5.4 Work Process Flowchart

In software engineering, comprehending the logic and relationships of a process is paramount, and visualising its flow is an absolute necessity before implementation. Flowcharts are a handy tool that offers a graphical representation, simplifying understanding of the sequence of actions and decision-making processes involved in a specific function.

The "Pioneers in Computer Science" website was developed using flowcharts to conceptualise different functions. This visualization made it easier to break down complicated processes into manageable steps, thus enabling clear and systematic development.

5.4.1 Role in Software Development

Flowcharts play a crucial role in software development, particularly in the following areas:

- **Design Understanding:** Assisting in grasping the design intricacies and interdependencies between different components.
- **Problem Solving:** Aiding in identifying and resolving potential issues before they occur during implementation.
- **Communication:** As a communication tool among team members and stakeholders to understand the system's functional flow.
- **Documentation:** Providing valuable documentation for future reference and understanding of the implemented functions.

Examples of flowcharts are included in Appendix (H). Flowcharts helped the "Pioneers in Computer Science" website with clear and logical development, following best practices for software engineering. This ensured proactive problem-solving and clarity throughout the project.

5.5 Software Architecture of the System

Initially, managing the project was a breeze as there was a clear vision of the architecture and components. However, as the project expanded in size and complexity, it became increasingly challenging to mentally map out the entire structure. This complexity emphasised the importance of having a more tangible representation of the system's architecture.

Utilizing a whiteboard, I expertly crafted a visual representation of our plan, resulting in a streamlined implementation process. This blueprint proved to be a vital tool in navigating the intricacies of the project, ultimately ensuring a well-organized and highly efficient outcome.

Appendix (I) includes a photo of the whiteboard with the drawn architecture.

The "Pioneers in Computer Science" website uses a robust three-tier client-server architecture with a thin-client model. Implementing the Model-View-Controller (MVC) design pattern contributes to a highly organised and effective system.

5.5.1 Client-Server Architecture Model

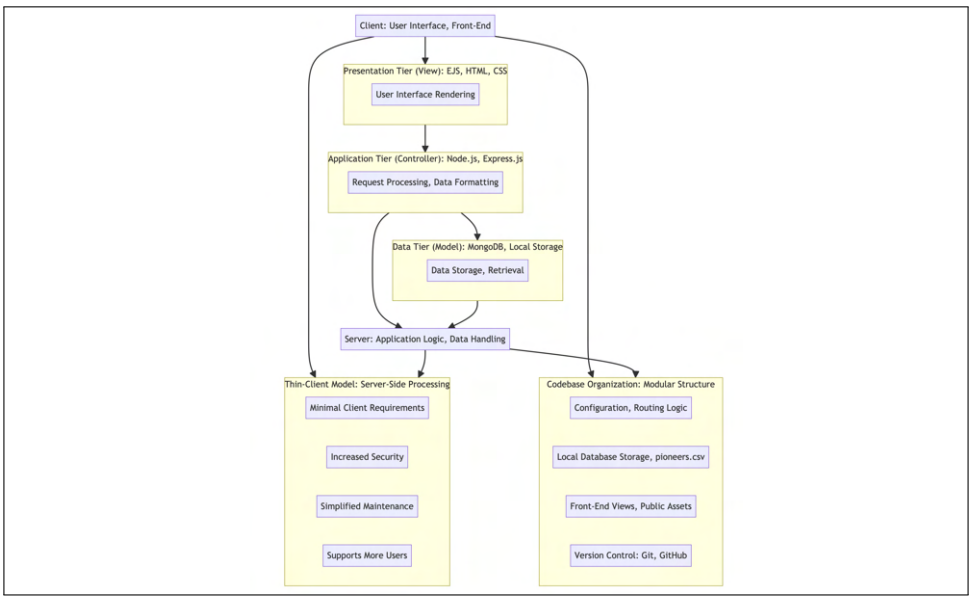


Figure 5.3: This illustration showcases the client-server architecture utilised by the system.

The client-server architecture model is organised as a set of services, associated servers, and clients that access and use the services [42, p. 249]. The major components of this model are:

- A set of servers that offers services to other sub-systems
- A set of clients that call on the service's servers offer.
- A network allowing clients to access these services.

In the client-server architecture of the system:

- **Client:** Represents the user interface and the user's interactions with the system. The client is considered a "thin-client" [42, p. 271] as most processing work is performed on the server. It mainly includes the HTML, CSS and EJS files responsible for rendering the front-end view to the users.

- **Server:** This is where the application's logic is processed. It includes handling client requests, interacting with the database, and sending responses to the client. Their server-side components are developed using Node.js and Express.js, which handle routing, data processing and more.

Component Diagram

Below is a figure representing the architecture of the "Pioneers in Computer Science" website:

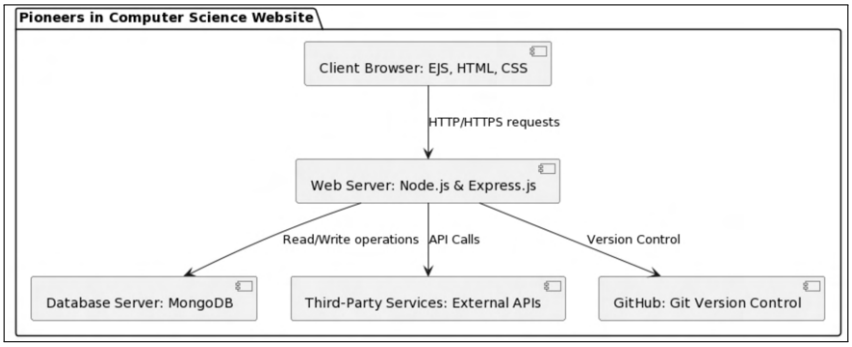


Figure 5.4: UML Component Diagram of the Electronic Resource

- **Components**
  - **Web Server:** Handles the application logic, processes user requests, and communicates with the database.
  - **Database Server:** Responsible for storing and retrieving data related to the website.
  - **Client Browser:** Represents the user's interface to interact with the website.
  - **Third-Party Services:** External services or APIs that the web server might communicate with.
  - **GitHub:** Used for version control and code storage.
- **Relationships**
  - **The Client Browser:** sends HTTP/HTTPS requests to the Web Server.
  - **The Web Server:** performs read/write operations with the Database Server.
  - **The Web Server:** can make API calls to Third-Party Services.
  - **The Web Server:** interacts with GitHub for version control purposes.

Thin-client Model

The system follows a thin-client model, where the server handles most processing tasks. The client's primary role is to display data, with very little local processing involved. Using a thin-client model offers advantages such as:

- **Reduced Client Requirements:** Clients require less processing power or storage, as most tasks are handled on the server.
- **Enhanced Security:** Most logic and data reside on the server, increasing security.
- **Ease of Maintenance and Updates:** Server-side updates simplify maintenance.
- **Scalability:** Efficiently supports more users since the server does the heavy lifting.

5.5.2 Model-View-Controller(MVC) Pattern

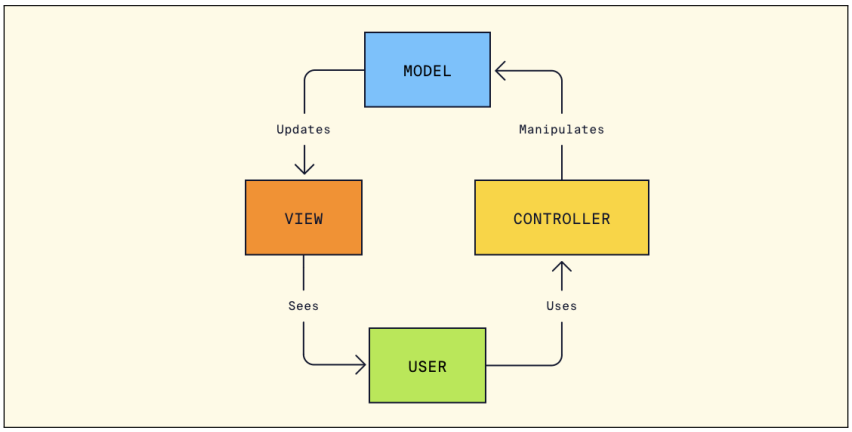


Figure 5.5: Model-View-Controller (MVC) Design Pattern [49]

MVC stands for Model, View, and Controller. It organises your code into distinct sections, each with its purpose. This approach simplifies app development, making it easier to revisit and share in an organised way [49].

The MVC pattern has been implemented to separate the application into three interconnected components:

- **Model:** Represents the system's internal state and encapsulates the data structure. In this case, MongoDB and local storage files like pioneers.csv.
- **View:** Responsible for everything the user experiences on the screen. It includes the layout and design handled through EJS, HTML, and CSS.
- **Controller:** The Node.js and Express.js manage the data flow, handle user input and mediate between the Model and View.

5.5.3 Three-Tier Architect

In this case, a three-tier architecture optimises the information transfer between the web and database servers. The communication between these systems can use fast, low-level communications protocols [42, p. 278].

Presentation Tier(View):

This level encompasses the front-end elements created with EJS, HTML, and CSS. Its role is to display information to the user, create the user interface, and manage user inputs. This aligns with the "View" aspect of the MVC pattern.

Application Tier (Controller):

Node.js and Express.js power the back-end processing layer, handling tasks like overseeing application logic, processing requests, and communicating with the database. The layer also ensures correct data formatting before sending it to the client, aligning with the "Controller" component in the MVC pattern.

Data Tier (Model):

The MongoDB database and local file paths store and retrieve website data. They serve as the "Model" component in the MVC framework.

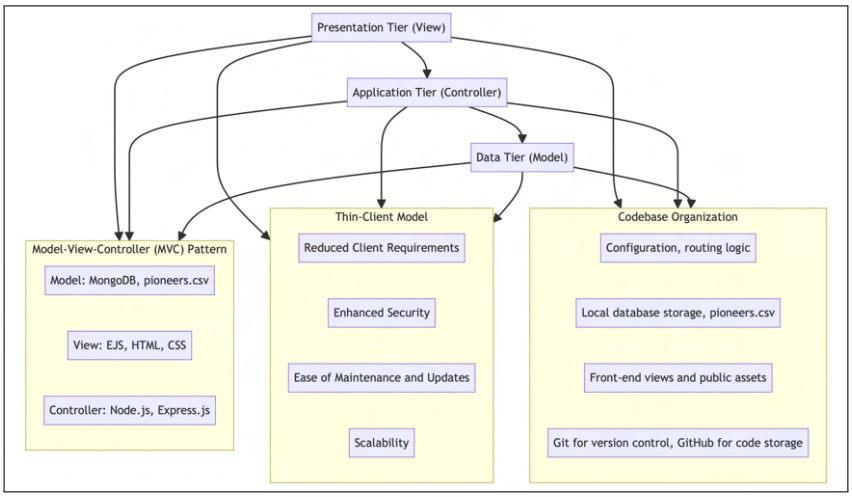


Figure 5.6: "Pioneers in Computer Science" Three-Tier Architecture Usage

5.5.4 Codebase Organisation

The codebase is organised into distinct directories and files, reflecting the separation of concerns. The paths provided indicate the location of various components:

- Configuration settings, environment variables, database connections, and routing logic.
- Local database storage, including *pioneers.csv*.
- Front-end views and public assets.
- The use of Git for version control and GitHub for code storage promotes collaboration and tracks changes.

5.5.5 Why This Architecture?

This architecture was chosen to support the website's functionality and performance, providing several advantages [50]:

- **Scalability:** Allows for easy scaling to accommodate more users.
- **Maintainability:** Separation of concerns makes the code more maintainable.
- **Security:** Server-side processing enhances security measures.
- **Compliance with Non-functional Requirements:** It aligns well with needs such as responsiveness and reliability.

The system's architecture pattern guarantees a seamless, secure, and efficient user experience. Utilising a thin-client model, the three-tier client-server architecture perfectly aligns with the design objectives and is pivotal to the website's triumphant performance.

Chapter 6

Implementing the Electronic Resource

6.1 Overview

The Implementation chapter details the step-by-step process of transforming the design and requirements into a functional electronic resource. We confidently guide this process by incorporating the previously established methodologies, design specifications, conditions, and feedback from testing and evaluation.

6.2 Reflecting Changes from Evaluation

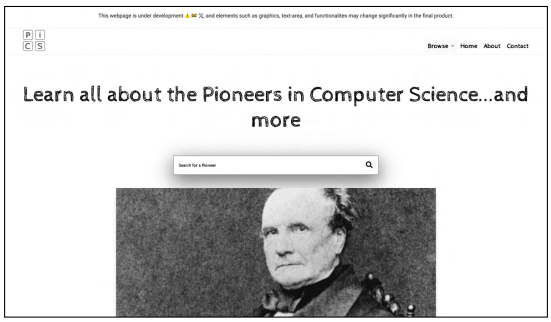


Figure 6.1: Home Page Before Redesign

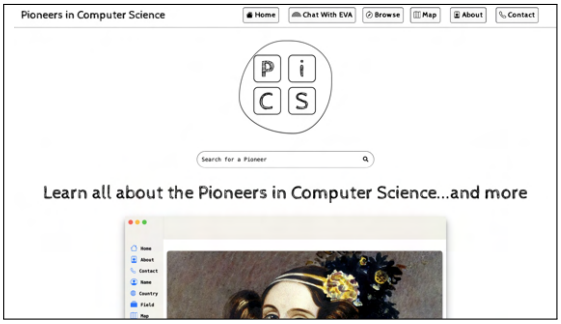


Figure 6.2: Home Page After Redesign

Figure 6.3: Comparison of the home page before and after the major UI redesign, reflecting the changes made in the evaluation.

Several crucial adjustments were made to the system following the testing and evaluation phase. The implementation process has been aligned with these changes to ensure the final product is robust, user-friendly, and achieves the project's objectives. One such example is given above.

6.3 Codebase Organization

The organization of the codebase for the "Pioneers in Computer Science" website is illustrated in Figure 6.4. This Component Diagram shows the various directories, files,

Figure 6.4: Component Diagram showing the codebase organisation for the "Pioneers in Computer Science" website.

Directory/File	Description
vscode	Contains settings for the Visual Studio Code environment.
config	Includes database connections and environment variables.
local_db_storage	Contains the pioneers.csv file for local data storage.
models	Contains the schemas for Chat, Contact, and Pioneer.
node_modules	Includes dependencies required for the project.
public	Contains assets such as images, stylesheets, and scripts.
routes	Contains the routing logic for handling different URL paths.
views	Contains the front-end views developed using EJS, HTML, and CSS.
Other Files	Includes app.js, .env, .gitignore, LICENSE, package-lock.json, package.json, Procfile, and README.md, which are essential for the application's configuration, licensing, and documentation.

Table 6.1: organization of the codebase for the "Pioneers in Computer Science" website.

and their relationships, providing a clear overview of the project's structure.

6.4 Implementation of Key Features

6.4.1 Map Feature: Birthplace of Pioneers

The visual display of the map feature showcases the birthplaces of computer science pioneers in a highly engaging manner. By exploring the map, users can quickly pinpoint the exact locations of these pioneers, providing a unique and fascinating perspective on this crucial aspect of history.

API Selection and Map Visualization

While developing our map feature, I encountered a significant challenge in choosing the most suitable mapping API to fulfil our website's requirements. However, after thorough evaluation, I narrowed our choices to two well-known options: OpenStreetMap [51] and MapTiler [52].

- **OpenStreetMap:** OpenStreetMap has the benefit of allowing unlimited requests,

but it poses a challenge. Location names are localised to their respective languages, which could make it challenging for users to identify them. Other resources have acknowledged this problem, including MacTutor's [1] website.

- **MapTiler:** On the other hand, MapTiler provided an interactive map with street features built over the OpenStreetMap API. It was visually appealing and offered more user-friendly features. However, the free tier of MapTiler was limited to 5,000 requests per month, which might become a constraint if the website traffic were to increase. Future considerations might include exploring a more suitable API to accommodate potential growth in user interactions.

The decision to use MapTiler was influenced by its enhanced user experience and the current expected level of user interaction. If traffic were to increase substantially, it might become necessary to reevaluate this choice.

For the actual visualization of the map, Leaflet [53] was employed. Leaflet is an open-source JavaScript library used for building mobile-friendly interactive maps. It provides convenient methods to place markers, popups, and other elements on the map. In the context of this project, it played a crucial role in delivering the interactivity and visual appeal of the map feature, allowing users to explore the birthplaces of computer science pioneers with ease and engagement.

The code for the map feature, implemented using JavaScript and Leaflet, is given in Appendix (P).

The map can be accessed at https://pics-usa-d37de900c431.herokuapp.com/map.

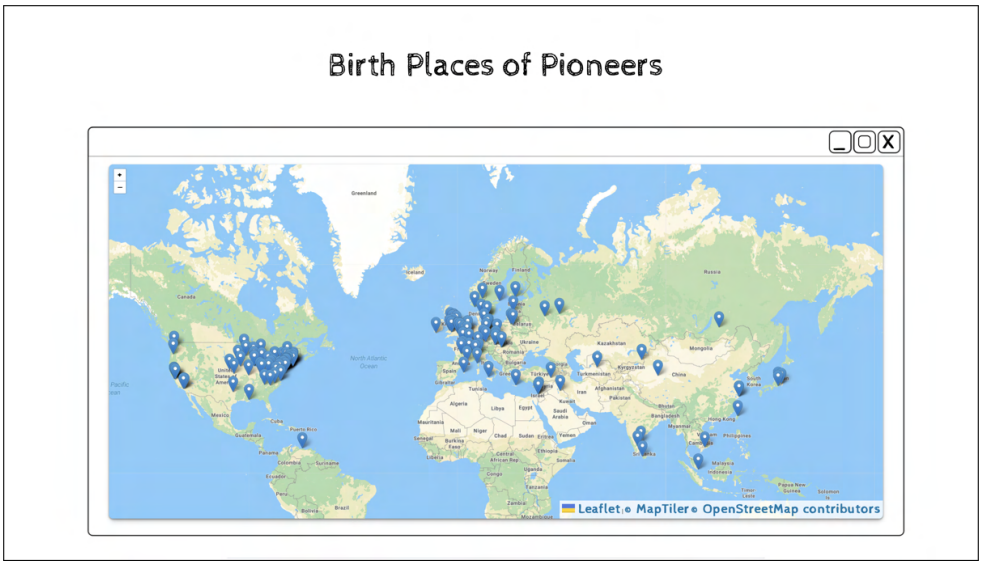


Figure 6.5: Screenshot of the map feature showcasing the birthplaces of computer science pioneers.

6.4.2 Chat Feature: Engaging with Computer Science Pioneers

During the project's enhancement period, I devised the idea of using a chatbot to answer questions about computer science pioneers. As I achieved the main goals of the website, I realised that providing users with an interactive way to engage with the material could

significantly enhance their experience. Thus, I created a chatbot that could offer prompt and informative answers about computer science pioneers. I utilised ChatGPT's [54] capabilities to process and reply to user inquiries in real-time, ensuring that users could get the answers they needed quickly and efficiently.

The chat feature's implementation was complex, requiring careful integration with the OpenAI API and the development of the front and backend components. The following code snippets detail the core functionality of the chatbot:

```
//Initialising the chatbot model with the backend.
const { Configuration, OpenAIApi } = require("openai");

//...more code...
router.post('/', async (req, res) => {
  //...interaction handling code...
});

//...error handling code...
```

The chat feature can be accessed at https://pics-usa-d37de900c431.herokuapp.com/chat.

This addition to the website aims to provide an engaging and informative experience, allowing users to explore the world of computer science pioneers interactively.

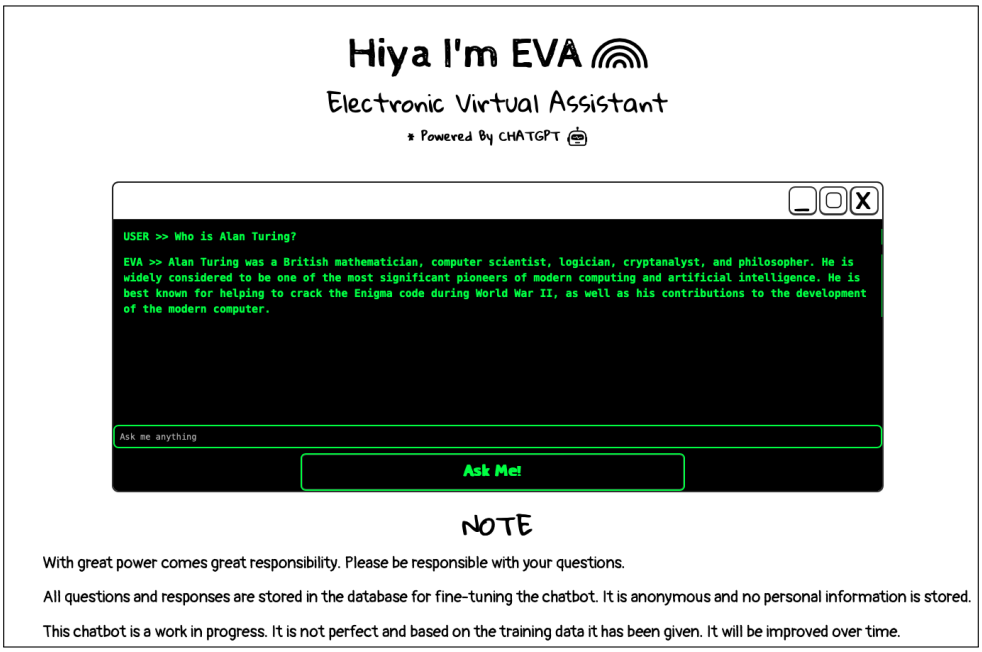


Figure 6.6: Screenshot of the ChatGPT integration for engaging with users.

Limitations and Challenges

While the chatbot provides a highly interactive and informative feature, it has certain limitations that need to be considered:

- **Hallucinations:** The chatbot may sometimes generate information that is not accurate or grounded in truth. These so-called "hallucinations" can mislead users and must be accounted for in future iterations.
- **Strict Domain:** The chatbot is currently restricted to answering questions only about computer science and pioneers in the field. Expanding its knowledge base could make it more versatile and valuable.
- **Language Understanding:** The model's understanding of natural language is still a work in progress, and it may occasionally misunderstand or misinterpret user queries.
- **Rate Limitations:** The current implementation is subject to API rate limits, which might limit the usability for many simultaneous users.

Future work on this feature would involve addressing these challenges, enhancing the model's accuracy, and expanding its scope to cover more areas of interest. The chatbot remains a promising addition to the system but requires careful consideration and ongoing development to reach its full potential.

6.5 Database Implementation

This section focuses on the implementation of the MongoDB database [36], including details on the schema design, data storage and retrieval, security measures implemented, and other relevant information specific to the database aspect of the project.

I confidently opted for MongoDB as the database solution for this project due to its exceptional versatility in managing unstructured and semi-structured data as a NoSQL database. Unlike traditional relational databases, MongoDB stores data in JSON-like documents, providing a more adaptable and scalable schema design. This adaptability makes it perfect for the project's dynamic requirements and iterative development approach.

The selection of MongoDB for the "Pioneers in Computer Science" initiative was a strategic move based on its compatibility with modern, agile development practices. Its ability to scale horizontally and optimize performance ensures efficient management of large data volumes [55]. At the same time, its user-friendly query language and well-documented APIs promote ease of use and accelerated development. Compared to other database options, MongoDB's unique features and community-driven support made it the clear choice for fulfilling the project's distinctive requirements and objectives.

6.5.1 Schema Definition

The database uses three schemas: pioneer, contact, and chat. These are defined using MongoDB's schema definition language, as shown below:

```
% Pioneer Schema
const pioneerSchema = new mongoose.Schema({
  % ... (other fields here)
});
```

```
const Pioneer = mongoose.model("Pioneer", pioneerSchema);

% Contact Schema
const contactSchema = new mongoose.Schema({
  % ... (other fields here)
});
const Contact = mongoose.model("Contact", contactSchema);

% Chat Schema
const chatSchema = new mongoose.Schema({
  % ... (other fields here)
});
const Chat = mongoose.model("Chat", chatSchema);
```

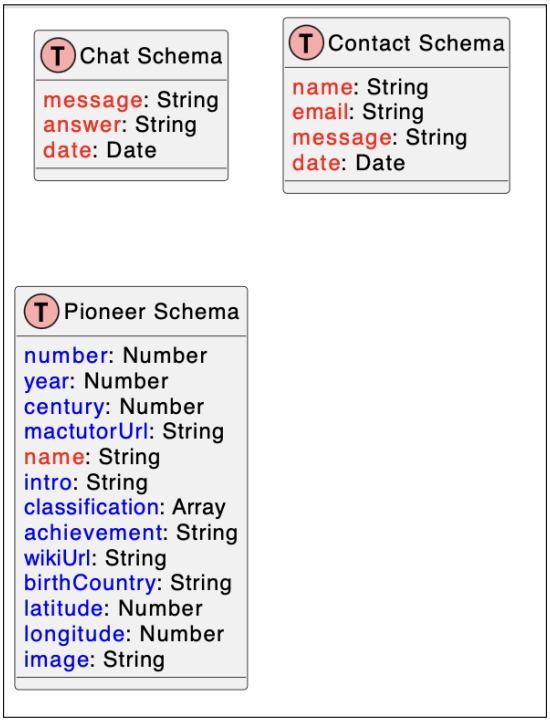


Figure 6.7: UML class diagram representing the database schemas for the "Chat," "Contact," and "Pioneer" collections

6.5.2 MongoDB Connection

The connection to the MongoDB database is established as follows:

```
const mongoose = require('mongoose');

const connectDB = async () => {
  try {
    await mongoose.connect(process.env.MONGO_URL, {
      useNewUrlParser: true,
      useUnifiedTopology: true,
    });
    console.log("Database connection has been established");
  } catch (err) {
    console.log(err);
    process.exit(1);
  }
};
```

6.5.3 Database Usage

Queries are made to the database using Mongoose's query methods. Examples of usage include searching for pioneers by country and classification and rendering the search results.

```
% Example code for searching by country
Pioneer.find({ birthCountry: { $regex: new RegExp("^" + searchTerm, "i") } })
% ... (other usage examples here)
```

The code snippet above demonstrates the search functionality for pioneers by country. Similar techniques are employed for other search functionalities.

6.5.4 Database Interaction

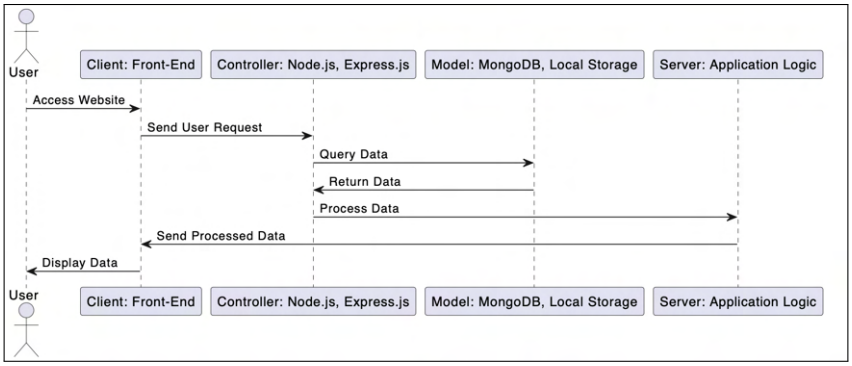


Figure 6.8: UML sequence diagram illustrating the flow of a user request

- **User:** The individual accessing the website.

- **Client:** Represents the front-end components where the user interacts with the system.
- **Model:** Includes the MongoDB database and local storage files for storing and retrieving data.
- **Server:** Includes the application logic and data handling components responsible for processing requests and managing data.

6.6 Deployment Strategy

6.6.1 Development Phase: Localhost

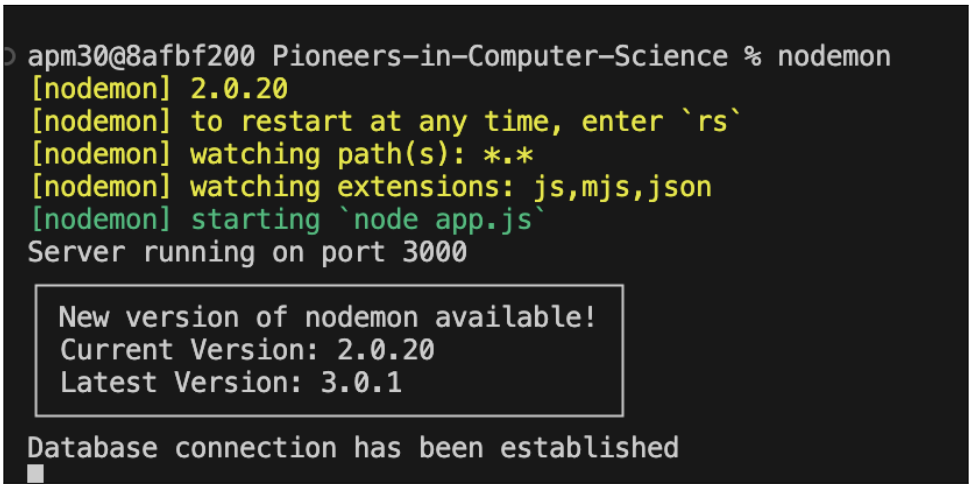


Figure 6.9: Screenshot of the application running on localhost during the development phase. This environment allowed for real-time testing and iterative improvements without affecting the live version.

The application was hosted locally on the developer's machine during the development phase, utilising port 3000. This local host environment provided an isolated, controlled setting for testing and iterative enhancements.

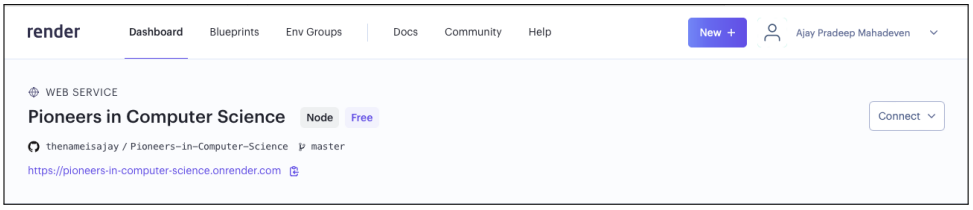
- **Advantages**: Quick updates, full control, no costs, immediate feedback.
- **Procedure**: Running the application on `http://localhost:3000` allowed real-time testing and debugging without affecting the live version.

6.6.2 Staging Environment

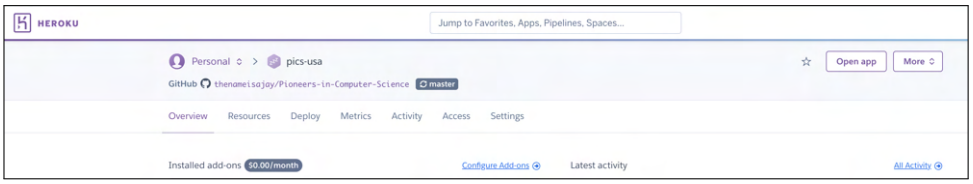
Before the live deployment, the system was deployed in a staging environment to mimic the production setting, allowing for final validation and tweaks.

Initial Deployment on Render

In the initial deployment phase, the Render [56] platform was utilised to host the beta version of the "Pioneers in Computer Science" website. While Render offered a range of features, it was eventually abandoned for a few key reasons:



(a) Render Platform: Initial deployment faced challenges such as slow server start and unsatisfactory results.



(b) Heroku Platform: Subsequent deployment showcasing improved performance and responsiveness.

Figure 6.10: Comparison of the "Pioneers in Computer Science" website deployment on the Render and Heroku platforms.

- **Slow Server Start**: The server's start-up time on Render was significantly slower than desired. This affected the responsiveness and speed of the website, impacting the overall user experience.
- **Unsatisfactory Results**: Certain performance and functionality aspects did not meet the project's requirements during the testing and evaluation stages. This led to reassessing the hosting platform to find an alternative to better fulfil the system's needs.

Transition to Heroku

Based on the challenges faced with Render, the decision was made to transition to Heroku [57] for hosting the beta release and subsequent usage until submission. Heroku provided a more stable and responsive environment, allowing for the following:

- **Faster Deployment**: Heroku's deployment process was more efficient, with faster server start times, contributing to a seamless user experience.
- **Enhanced Performance**: Heroku's infrastructure provided better compatibility with the application, resulting in improved performance and alignment with project goals.

Continuous Integration and Continuous Deployment

CI/CD practices were followed to automate the deployment process on Heroku, ensuring quick and error-free transitions from development to production.

Monitoring and Maintenance

Post-deployment, continuous monitoring and regular maintenance were planned to ensure optimal performance and security on Heroku. The ongoing maintenance strategy includes

frequent updates, "backups, and performance tuning.

6.7 Conclusion

The "Pioneers in Computer Science" project was made practical and user-friendly by carefully selecting development tools and adopting Agile principles. The codebase was organised, and a thoughtful deployment strategy was implemented despite challenges. Monitoring and maintenance ensured the project remained functional and optimised through real-world testing and feedback. In this chapter, you will find a detailed guide to help you successfully navigate the development process.

Chapter 7

User Testing and Evaluation

7.1 Functional Testing

The website testing process began with a detailed homepage examination, as it is the primary entry point for most users. Ensuring the correct functionality of every element on the homepage, including buttons, links, and interactive features, was crucial.

7.1.1 Identification and Resolution of Bugs

Any detected bugs or inconsistencies were immediately documented during the functional testing phase for further investigation. A recurring theme in the issues identified was related to User Interface (UI) bugs. These often stemmed from CSS issues and problems related to site responsiveness on different devices or browsers.

7.2 User Testing

The website underwent several iterations based on user feedback, including a drastic home page redesign (6.2) to improve UI/UX functionality.

7.3 Beta Release and User Feedback

The website was launched in beta to gather direct feedback from users. A tailored questionnaire was created using Microsoft Forms [58] to understand user behaviour, preferences, and potential issues.

7.3.1 Questionnaire Structure

The questionnaire evaluates user interaction with the website, covering navigation, content, visuals, responsiveness, and satisfaction. It includes both qualitative and quantitative questions. Refer to the questions and structure in the Appendix (L).

7.3.2 Feedback Analysis and Resolution

The received feedback was analysed, categorised, and evaluated. A table of identified issues and their descriptions is shown below. The insights led to necessary adjustments

and refinements on the website. The outcomes are in the Appendix (M).

Issue	Description
Font Issues	Users reported confusion in understanding the site's content on some pages.
Map Coordinates	One user pointed out some of the pioneer birthplaces were of the wrong lat & long coordinates.
Favicons	Favicons were not displayed on the pioneer and search results pages.
Mac Icons	Users were confused by using Mac icons for UI beautification, mistaking them for actual button functionality.
Source Links	Know More & References containers on the Pioneer page had the same purpose, and users requested clearer source definitions and buttons accordingly.
Copyright Page	Additional language has been included to emphasise respecting intellectual property rights.

Table 7.1: Example Issues and Descriptions from User Feedback

These issues were fixed in the final version of the website, and the comparison images before and after are placed in the Appendix (N).

7.4 Evaluation with Postman API

Postman [59], a reputable API testing tool, was employed to analyse the website's API interactions. Various endpoints, methods, headers, and parameters were tested to ensure all interactions function properly. The key areas of focus during the assessment were as follows:

7.4.1 Method Testing

I meticulously assessed HTTP methods throughout this stage, including GET, POST, PUT, and DELETE [60]. A thorough examination was conducted to confirm that each way effectively executed its intended action while upholding the fundamental principles of RESTful design.

7.4.2 Request and Response Validation

The request and response data underwent meticulous scrutiny to ensure they were meticulously structured and contained all the required information. Thorough checks were carried out to verify the request headers, body, and query parameters and to confirm that the response data adhered to the expected format and included all the necessary details. Rest assured that the utmost care was taken to ensure the entire process was flawlessly executed.

Refer to Appendix (J) for visuals related to the Postman API testing.

7.5 Google Page Insights Analysis

I thoroughly analysed the website's performance, utilising Google Page Insights [61] to gather insightful metrics on its accessibility, SEO, best practices, and overall performance. The scores I received accurately reflect the website's loading speed, user accessibility, and search engine visibility, providing invaluable data for future improvements. The table below shows the metrics for thoroughly analysing the website's performance.

Metric	**Score**	**Interpretation**
Performance Score	(Your score)	(Interpretation of the score, e.g., excellent performance)
Accessibility	(Your score)	(Details about accessibility, e.g., well-designed for various users)
SEO and Best Practices	(Your score)	(Details about SEO and best practices, e.g., good visibility on search engines)

Table 7.2: Google Page Insights Analysis Example Evaluation Table

Metric	**Score**	**Interpretation**
Performance Score	(92)	(Excellent performance)
Accessibility	(91)	(Well-designed for various users)
SEO and Best Practices	(100 & 91)	(Good visibility on search engines)

Table 7.3: Google Page Insights Analysis for Home Page

For visuals related to the analysis of the website's performance, refer to Appendix (K).

7.6 Conclusion

The website was developed with utmost care and attention to detail. I created a highly effective and user-centric website through rigorous user testing, adherence to Agile principles, and careful evaluation of beta feedback, Postman API, and Google Page Insights. The final product is robust and sets the standard for future development best practices.

Chapter 8

Conclusion & Future Works

8.1 Conclusion

The following document outlines the development process of a digital tool to enhance the study of computer science history through user-centred design and rigorous testing. The creation of this tool signifies a valuable step in pursuing educational resources that can be further improved upon in the future. Version 1.0 is a proud milestone and the beginning of an incredible journey driven by passion, innovation, and a community that believes in the power of knowledge.

8.2 Project Summary and Outcomes

This project aimed to create a digital platform showcasing computer science pioneers' works and achievements.

The goal of this project was to develop an easily navigable digital platform that exhibits the accomplishments and contributions of distinguished figures in computer science. To proficiently arrange and categorise the material, the ACM Classification system was utilised. The platform incorporates a mechanism for collecting user feedback and furnishes visual presentations of the pioneers' works and references for further study.

Efforts were made to include information about pioneers in computer science and related fields such as electrical engineering and mathematics. Although highlighting those connected to the University of St Andrews was partially achieved due to limited access to sources, the platform offers a range of features. One limitation of the current version is the inability to include multimedia content like videos and podcasts, despite their value in engaging users. Future refinements will rely on feedback and evaluations to better serve users.

8.3 Limitations & Future Works

8.3.1 Limitations

1. **Scope Limitation**: The platform focuses on cataloguing contributions without considering their interconnectedness in the evolution of computer science.

2. **Language and Cultural Limitation**: The platform's limited accessibility and relevance to a global audience may be due to its exclusive use of English.

3. **Historical Accuracy**: Due to the vastness of computer science history, some important contributions may be unintentionally omitted or overlooked.

4. **Dependency on External Data Sources**: The platform may introduce biases or inaccuracies due to some external data sources.

8.3.2 Further Works

The methodology presented in this dissertation represents a starting point, denoted as version 1.0, for a potentially more extensive and refined system. While the current approach demonstrates notable strengths and adaptability, it is important to acknowledge that it is not the only possible path nor the final solution.

There are opportunities to expand the scope of this methodology by incorporating multimedia content, including video tutorials, interactive games for children, and other educational tools. This content could significantly enhance the user experience by catering to various learning styles and age groups. Moreover, ongoing refinement and evolution of this methodology may lead to the development of more advanced and comprehensive versions better suited to meet the diverse needs of users.

This project does not serve as a conclusion but rather as a motivating start.

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Appendices

Appendix A

Description, Objectives, Ethics & Resources

A.1 Description

Project Title: *Pioneers in Computer Science: An Electronic Resource*

The project aims to create a global online educational resource focusing on the pioneers of Computer Science (CS), highlighting their contributions, promoting understanding of the discipline's evolution and emphasising diversity among pioneers.

This digital resource aims to provide easily searchable and navigable information. The methodology involves researching pioneers, developing an appropriate classification system, and designing and evaluating diverse user groups.

A.1.1 Objectives

Primary Objectives

1. Research and select a suitable classification system (ACM Digital Library) to group the contributions of pioneers in computer science. - **Implemented**

2. Identify pioneers in computer science from all over the world using a reproducible search strategy.- **Implemented**

3. Design and develop a website that can be easily accessed by all group ages and learn about the pioneers (Global perspective more than academic focus) and submit ownership to the University of St Andrews. - **Implemented**

4. Develop a user-friendly interface that makes it easy for all user groups to interact with the website. - **Implemented**

5. Incorporate a basic, user-friendly search and filter facility that allows users to efficiently locate and sort information about the computer science pioneers on the website. This function should accommodate the needs of diverse users and enable them to navigate the content easily. - **Implemented**

Secondary Objectives

1. Evaluate the digital platform with various user categories to ensure usability, accessibility, and relevance. - **Implemented**
2. Visualising the contributions of pioneers and citing sources and web links. - **Implemented**
3. Tailoring to St Andrews by dedicating part resource by highlighting the contributions of pioneers that have studied or taught at the University of St Andrews. - **Partially Implemented**
4. Create supporting documentation to help users navigate and use the electronic resource. - **Implemented**

Tertiary Objectives

1. Investigate the potential for expanding the resource to include pioneers in related fields, such as electrical engineering or mathematics. - **Implemented**
2. Implement a feedback system to gather user feedback on the electronic resource's usefulness and areas for improvement. - **Implemented**
3. Creating road maps based on search criteria or era (century or decade). - **Implemented**
4. Explore ways to incorporate multimedia content (such as videos or podcasts) to make the electronic resource more engaging. - **Not Implemented**

A.2 Ethics

Given the nature of the project, it primarily involves historical and publicly available data and doesn't directly engage with people, sensitive private data, animals, etc. Users can provide feedback on the Electronic resource without sharing any personal information. Therefore, the project is expected to pose minimal ethical concerns.

However, appropriate care will be taken to ensure that the information presented about each pioneer is accurate, respectful, and unbiased. Moreover, copyrights and intellectual property rights related to any used material will be fully respected. The self-assessment form will be duly filled out and submitted as required.

A.3 Resources

Resources needed for the project will mainly involve software tools for web development, databases for data storage, and potential web hosting services. These resources will likely be standard software applications, open-source tools, and cloud-based services. As of now, there are no unusual or special resource requirements. Nonetheless, any additional resource needs during the project will be identified and requested appropriately.

Appendix B

Ethics Documents

UNIVERSITY OF ST ANDREWS
TEACHING AND RESEARCH ETHICS COMMITTEE (UTREC)
SCHOOL OF COMPUTER SCIENCE
PRELIMINARY ETHICS SELF-ASSESSMENT FORM

This Preliminary Ethics Self-Assessment Form is to be conducted by the researcher and completed in conjunction with the Guidelines for Ethical Research Practice. All staff and students at the School of Computer Science must complete it before commencing research.

This Form will act as a formal record of your ethical considerations.
Tick one box

☐ **Staff Project**
☒ **Postgraduate Project**
☐ **Undergraduate Project**

Title of project

PIONEERS IN COMPUTER SCIENCE

Name of researcher(s)

AJAY PRADEEP MAHADEVEN

Name of supervisor (for student research)

DHARINI BALASUBRAMANIAM

OVERALL ASSESSMENT (to be signed after questions, overleaf, have been completed)

Self-audit has been conducted **YES** ☒ **NO** ☐

There are no ethical issues raised by this project.

Signature Student or Researcher

AJAY PRADEEP MAHADEVEN

Print Name

AJAY PRADEEP MAHADEVEN

Date

24TH MAY 2023

Signature Lead Researcher or Supervisor

D Balasubramaniam

Print Name

Dharini Balasubramaniam

Date

24 May 2023

This form must be date stamped and held in the files of the Lead Researcher or Supervisor. A copy must also be lodged with appropriate Risk Assessment forms if fieldwork is required.

The School Ethics Committee will be responsible for monitoring assessments.

Computer Science Preliminary Ethics Self-Assessment Form

Research with secondary datasets

Please check UTREC guidance on secondary datasets (https://www.st-andrews.ac.uk/research/integrity-ethics/humans/ethical-guidance/secondary-data/ and https://www.st-andrews.ac.uk/research/integrity-ethics/humans/ethical-guidance/confidentiality-data-protection/). Based on the guidance, does your project need ethics approval?

YES ☐ **NO** ☒

** If your research involves secondary datasets, please list them with links in DOER.*

Research with human subjects

Does your research involve collecting personal data on human subjects?

YES ☒ **NO** ☐

If YES, a full ethics review is required.

Does your research involve human subjects or potentially harm human welfare and well-being?

YES ☐ **NO** ☒

If YES, a full ethics review is required.
For example:
Will you be surveying, observing, or interviewing human subjects?
Does your research have the potential to have a significant negative effect on people in the study area?

Potential physical or psychological harm, discomfort, or stress

Are there any foreseeable risks to the researcher or any participants in this research?

YES ☐ **NO** ☒

If YES, a full ethics review is required.
For example:
Is there any potential that there could be physical harm to anyone involved in the research?
Is there any potential for psychological harm, discomfort, or stress for anyone involved in the research?

Conflicts of interest

Do any conflicts of interest arise?

YES ☐ **NO** ☒

If YES, a full ethics review is required.
For example:
Might research objectivity be compromised by sponsorship?
Might any issues of intellectual property or roles in research be raised?

Funding

Is your research funded externally?

YES ☐ **NO** ☒

If YES, does the funder appear on the 'currently automatically approved' list on the UTREC website?

YES ☐ **NO** ☐

If NO, you will need to submit a Funding Approval Application as per instructions on the UTREC website.

Research with animals

Does your research involve the use of living animals?

YES ☐ **NO** ☒

If YES, your proposal must be referred to the University's Animal Welfare and Ethics Committee (AWEC)

University Teaching and Research Ethics Committee (UTREC) pages
http://www.st-andrews.ac.uk/utrec/

UNIVERSITY OF ST ANDREWS
TEACHING AND RESEARCH ETHICS COMMITTEE (UTREC)
SCHOOL OF COMPUTER SCIENCE
ARTIFACT EVALUATION FORM

Title of project

PIONEERS IN COMPUTER SCIENCE

Name of researcher(s)

AJAY PRADEEP MAHADEVEN

Name of supervisor

DHARINI BALASUBRAMANIAM

Self-audit has been conducted **YES** ☒ **NO** ☐

This project is covered by the ethical application CS15727.

Signature Student or Researcher

AJAY PRADEEP MAHADEVEN

Print Name

AJAY PRADEEP MAHADEVEN

Date

24TH MAY 2023

Signature Lead Researcher or Supervisor

D Balasubramanian

Print Name

Dharini Balasubramaniam

Date

24 May 2023

Appendix C

Gantt Chart

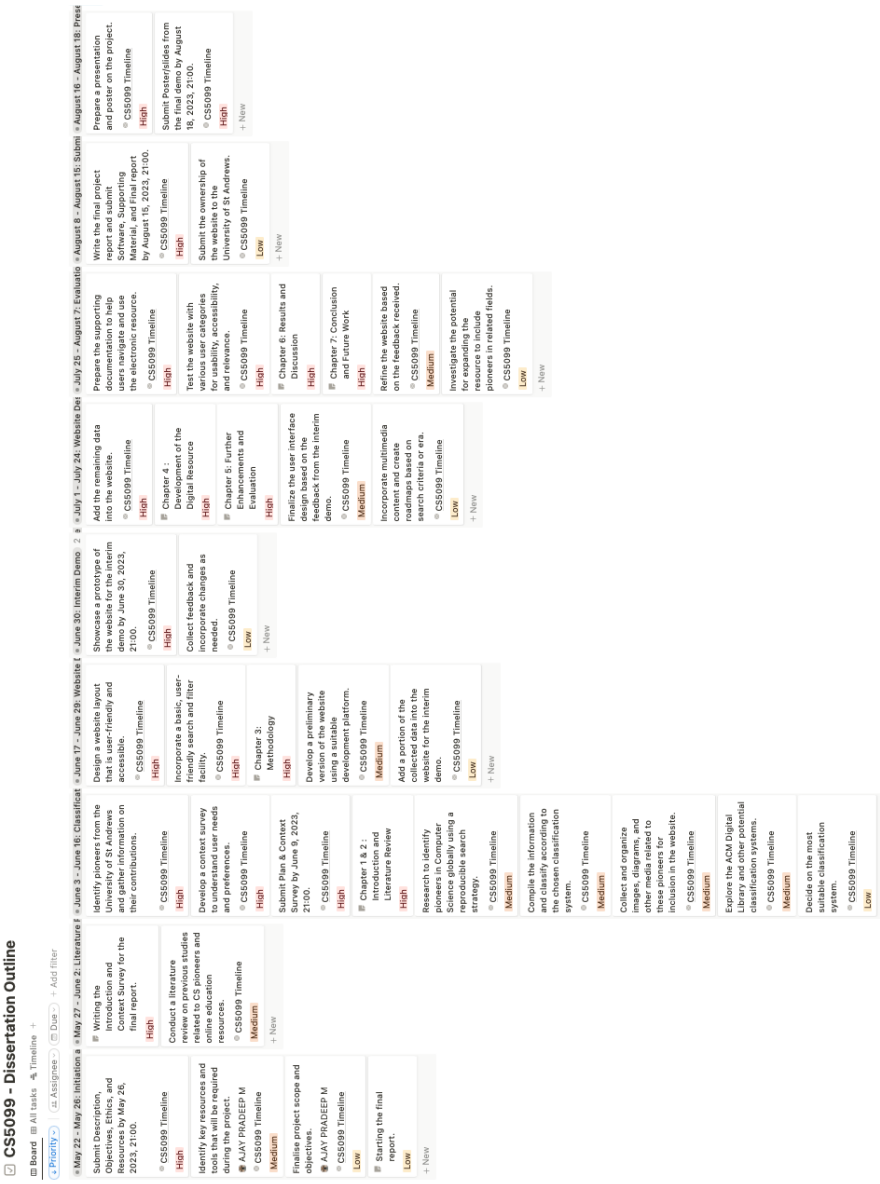


Figure C.1: Gantt chart showing the project timeline.

Appendix D

Use Case Diagram

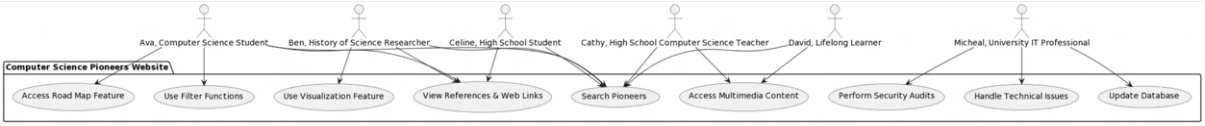


Figure D.1: Use Case Diagram based on the provided user scenarios (3.2.1)

Actors

- **Ava, Computer Science Student:**
  - searches for pioneers
  - filter results
  - accesses the road map
  - views references and web links on the website
- **Ben, History of Science Researcher:**
  - searches for pioneers
  - visualises data
  - accesses references and web links
- **Cathy, High School Computer Science Teacher:**
  - searches for pioneers
  - accesses multimedia content
- **David, Lifelong Learner:**
  - searches for pioneers
  - access multimedia content
- **Celine, High School Student:**
  - searches for pioneers

  - view references & web links

- **Micheal, University IT Professional:**
  - maintains the website
  - updates the database
  - handles technical issues
  - performs security audits

Use Cases:

- **Search Pioneers:** users are able to search for particular pioneers.
- **Use Filter Functions:** It is possible for the users to narrow down their search results by browsing by based on their criteria.
- **Access Road Map Feature:**Users are able to access a timeline showcasing the various contributions of pioneers throughout history.
- **View References & Web Links:** For further information, users can access external references and web links.
- **Use Visualization Feature:** Users have the ability to visualise the pioneers.
- **Update Database:** Micheal can update the database with new information.
- **Handle Technical Issues:** Micheal can address and resolve technical issues on the website.
- **Perform Security Audits:** Micheal ensures the security of the website.

Appendix E

Design Sketches

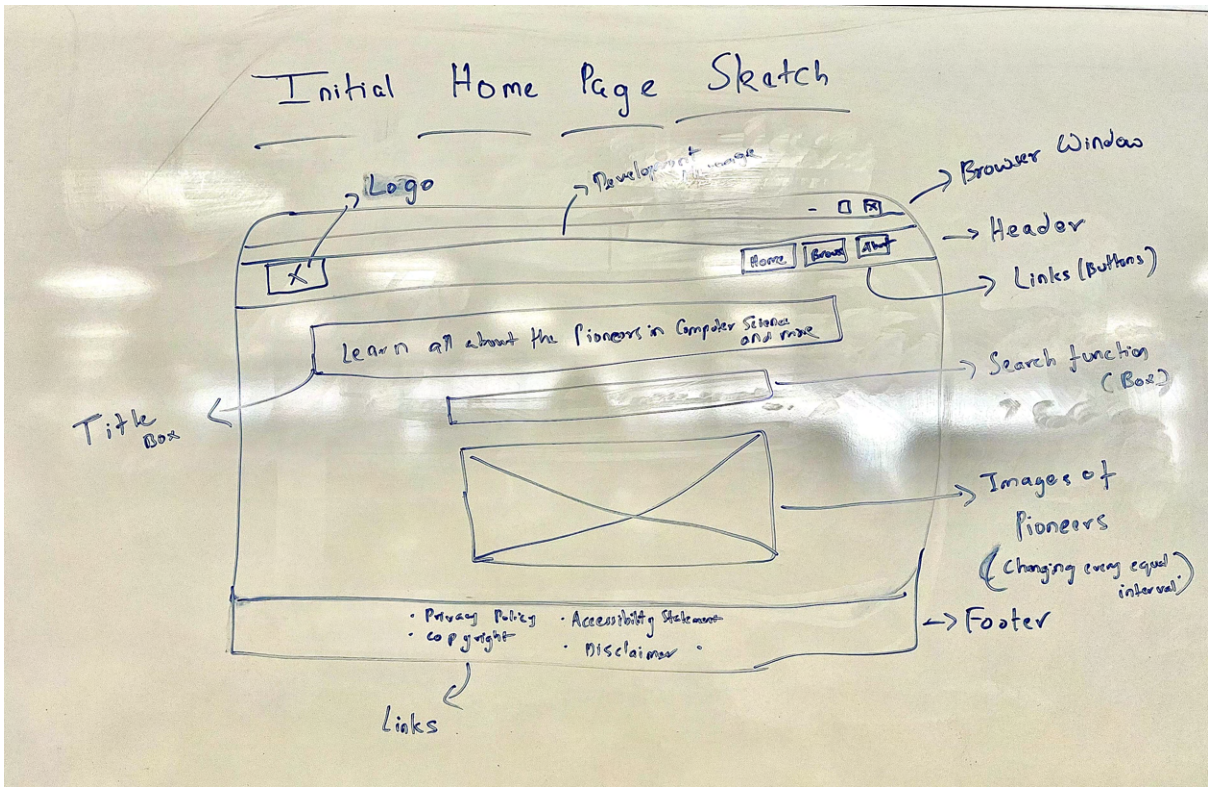


Figure E.1: Home page sketch

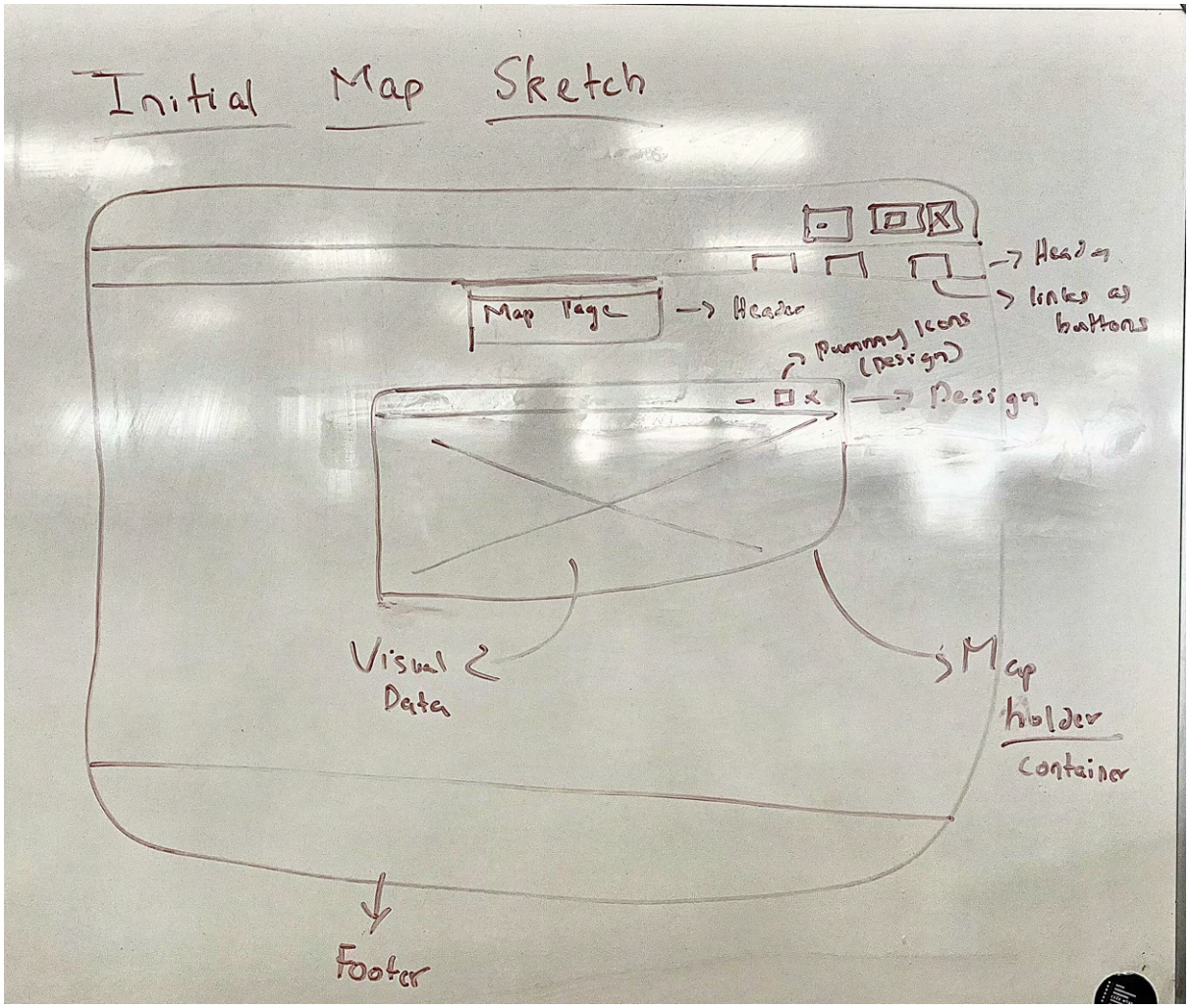


Figure E.2: Map feature sketch

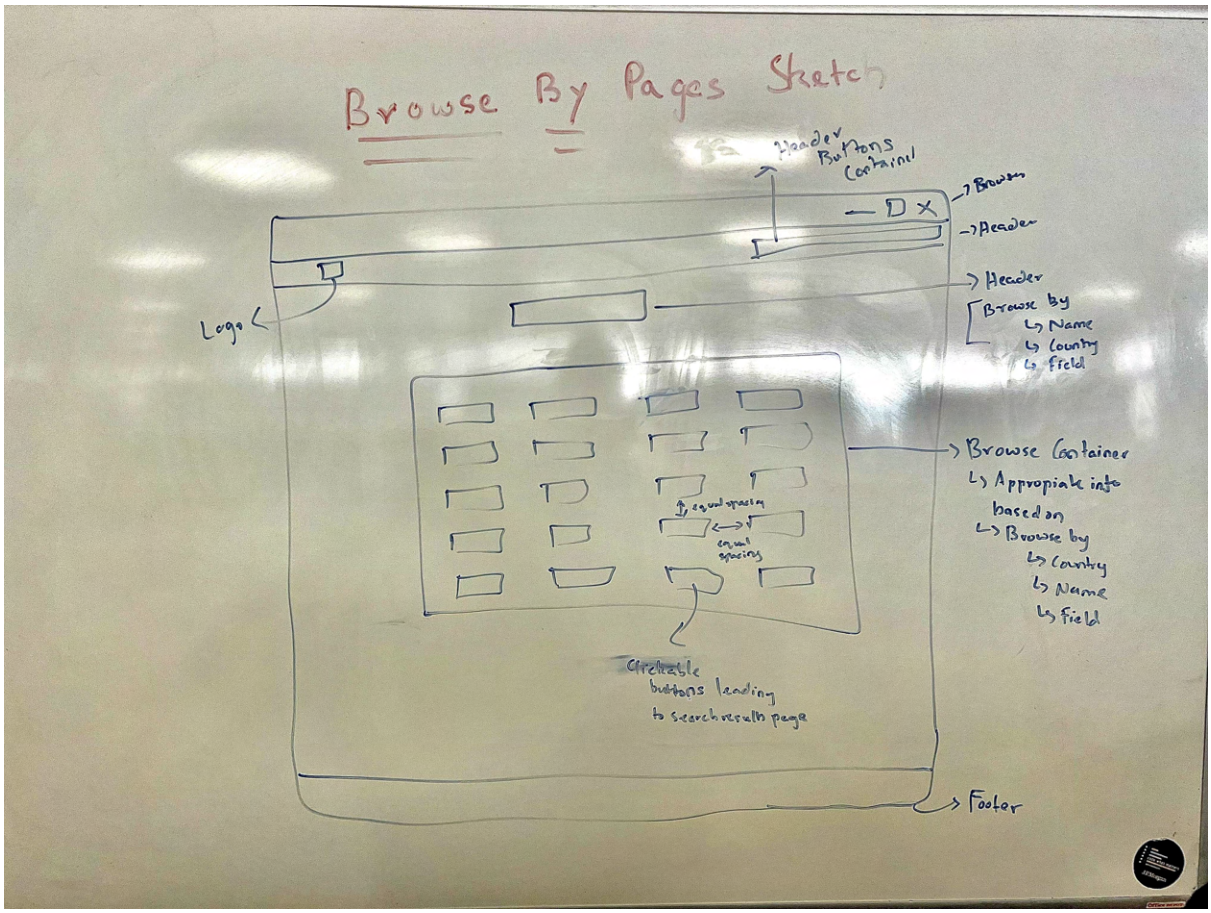


Figure E.3: Browse by sketch

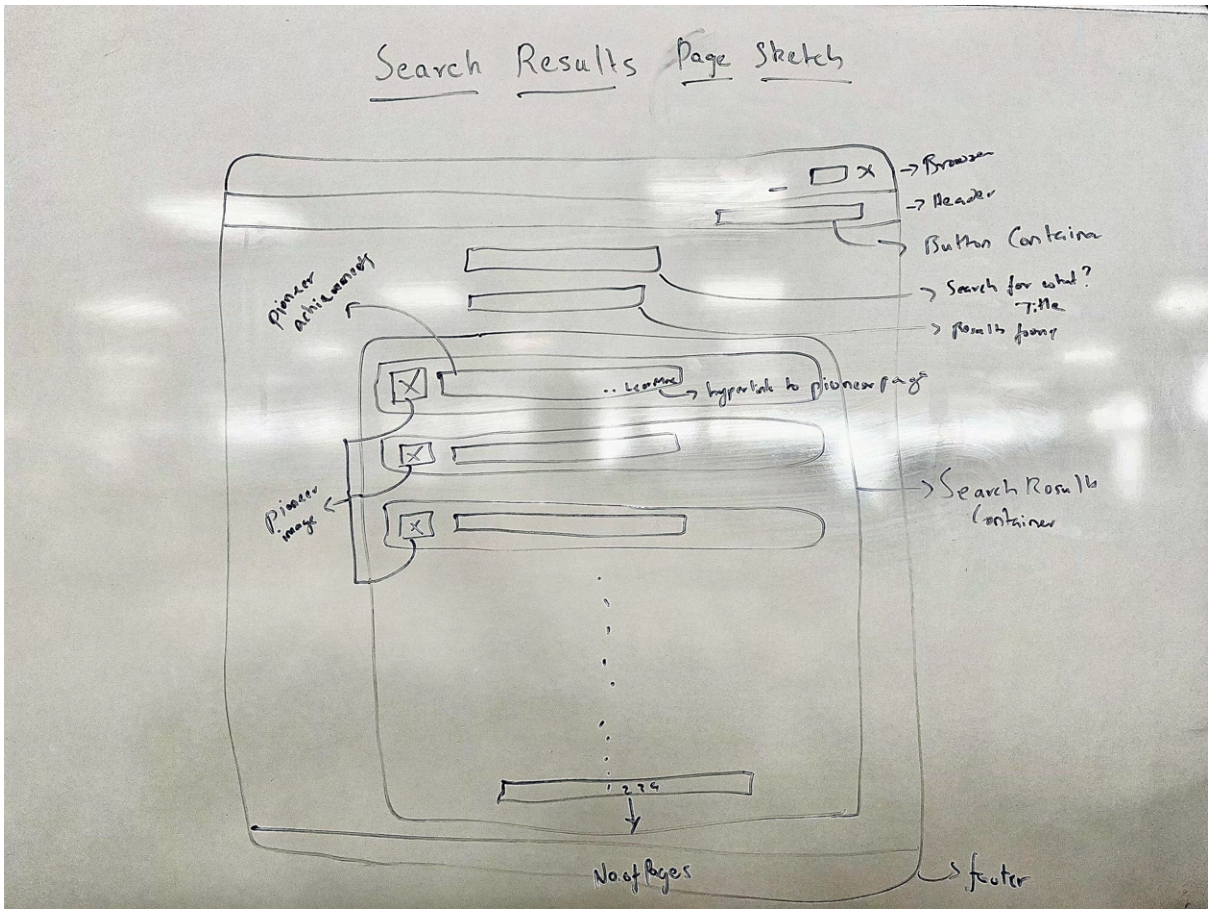


Figure E.4: Search results page sketch

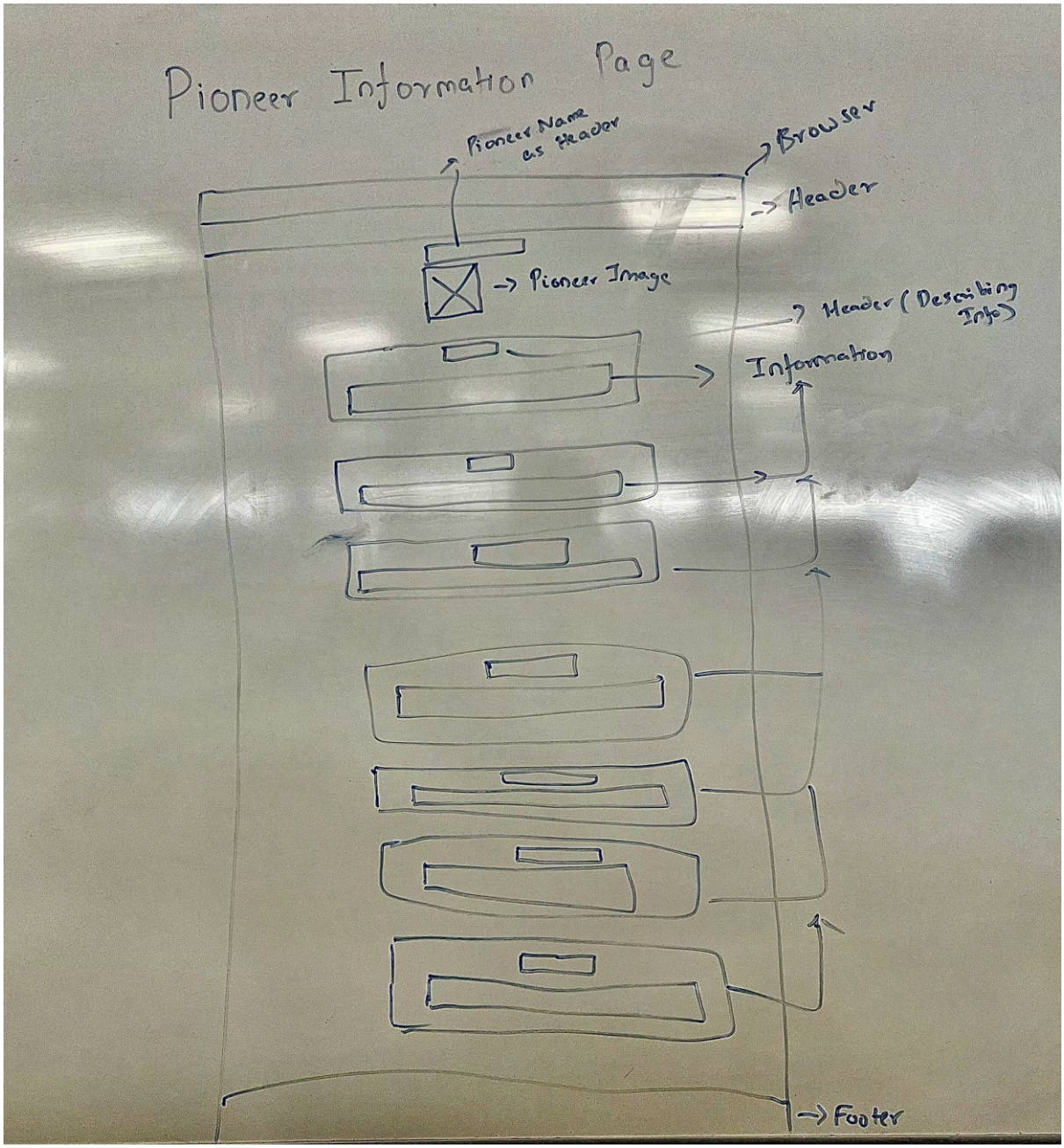


Figure E.5: Pioneer information display page sketch

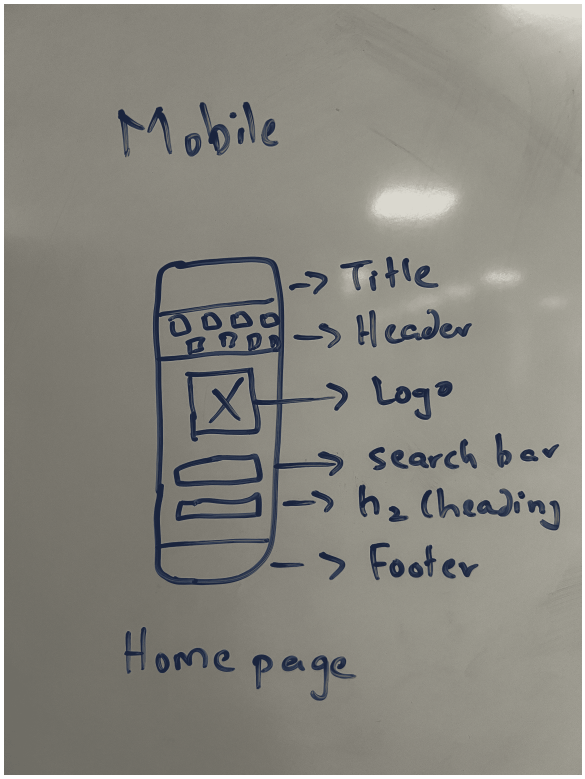


Figure E.6: Home Page Sketch for Mobile Devices

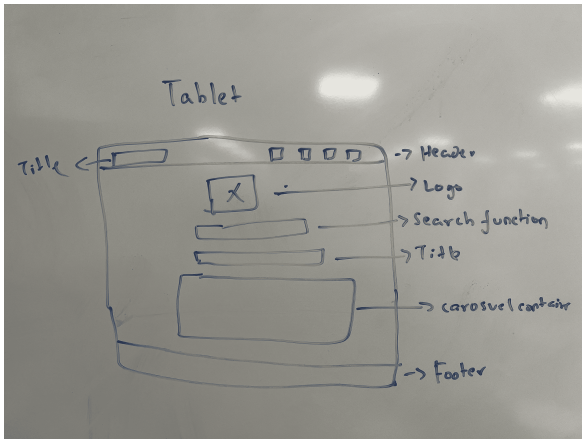


Figure E.7: Home Page Sketch for Tablets

Appendix F

Design Wireframes

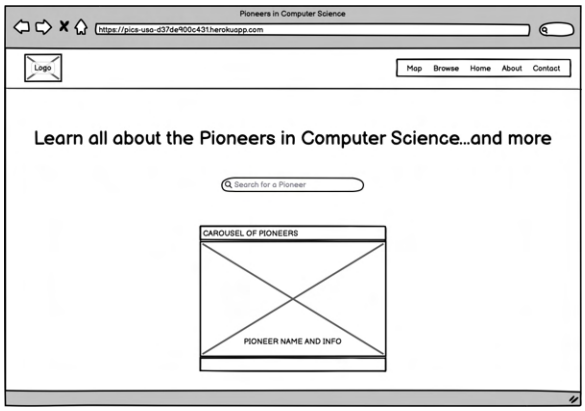


Figure F.1: Home page wireframe

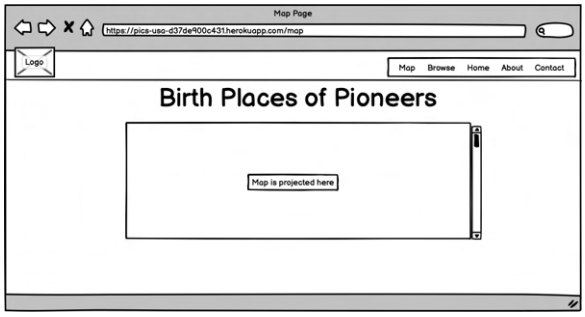


Figure F.2: Map feature wireframe

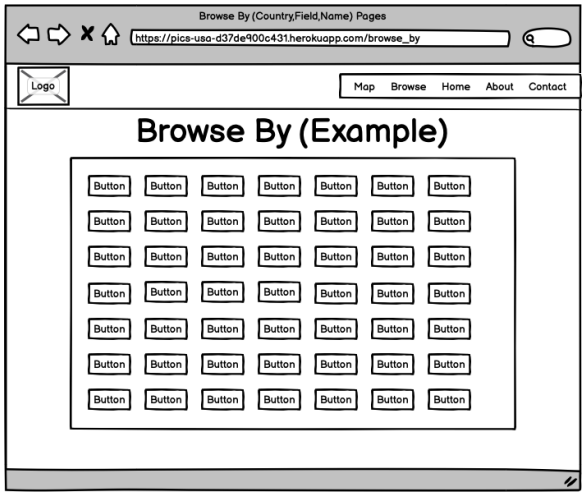


Figure F.3: Browse by wireframe

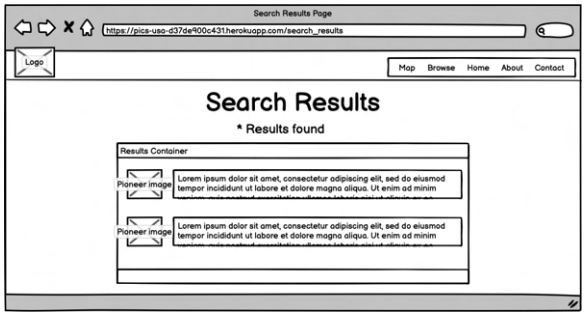


Figure F.4: Search results page wireframe

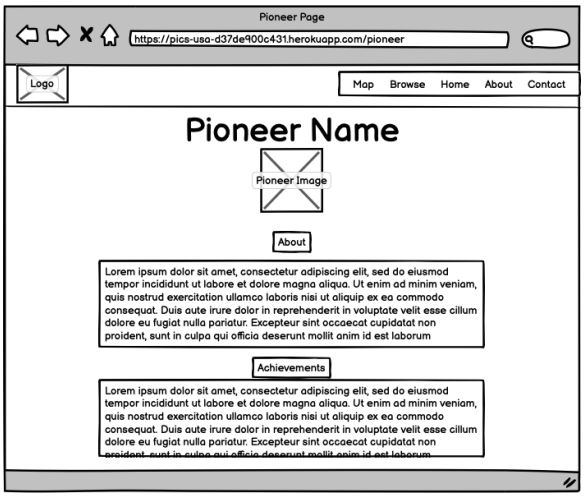


Figure F.5: Pioneer information display page wireframe

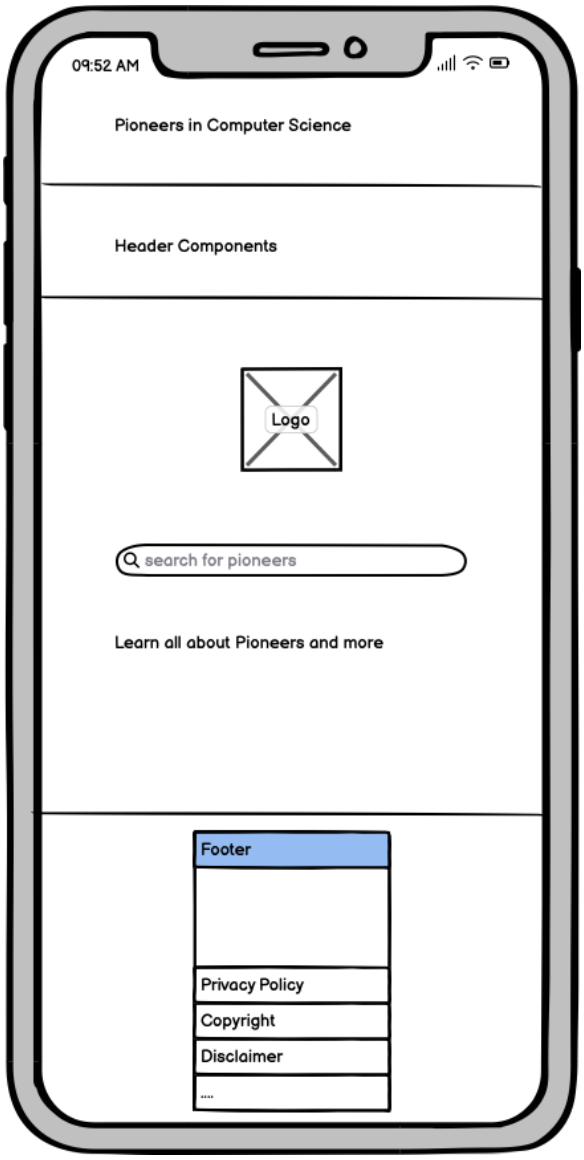


Figure F.6: Home Page Wireframe for Mobile Devices

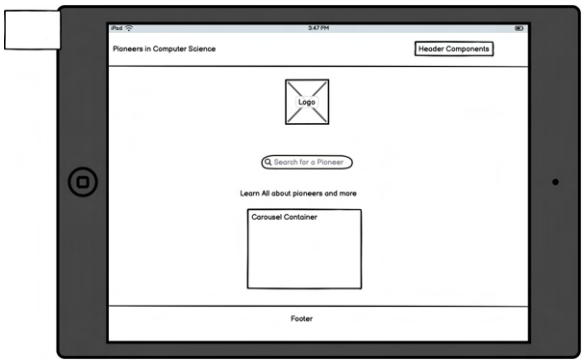


Figure F.7: Home Page Wireframe for Tablets

Appendix G

Design Prototypes

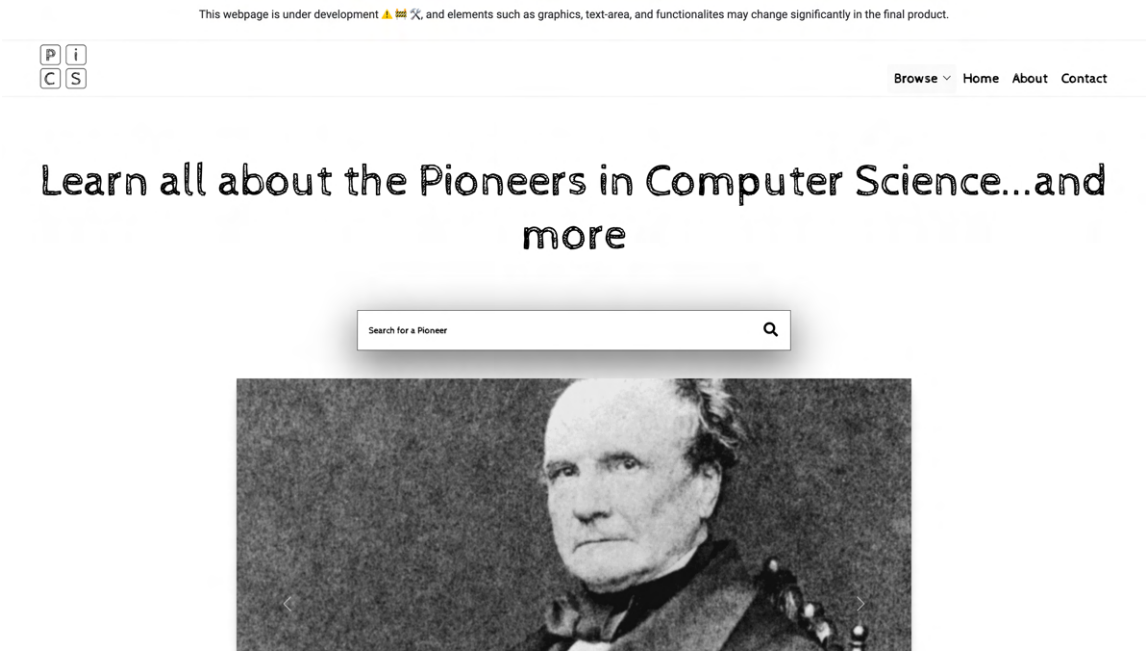


Figure G.1: High-fidelity prototype of the home page (later changed in enhancements)

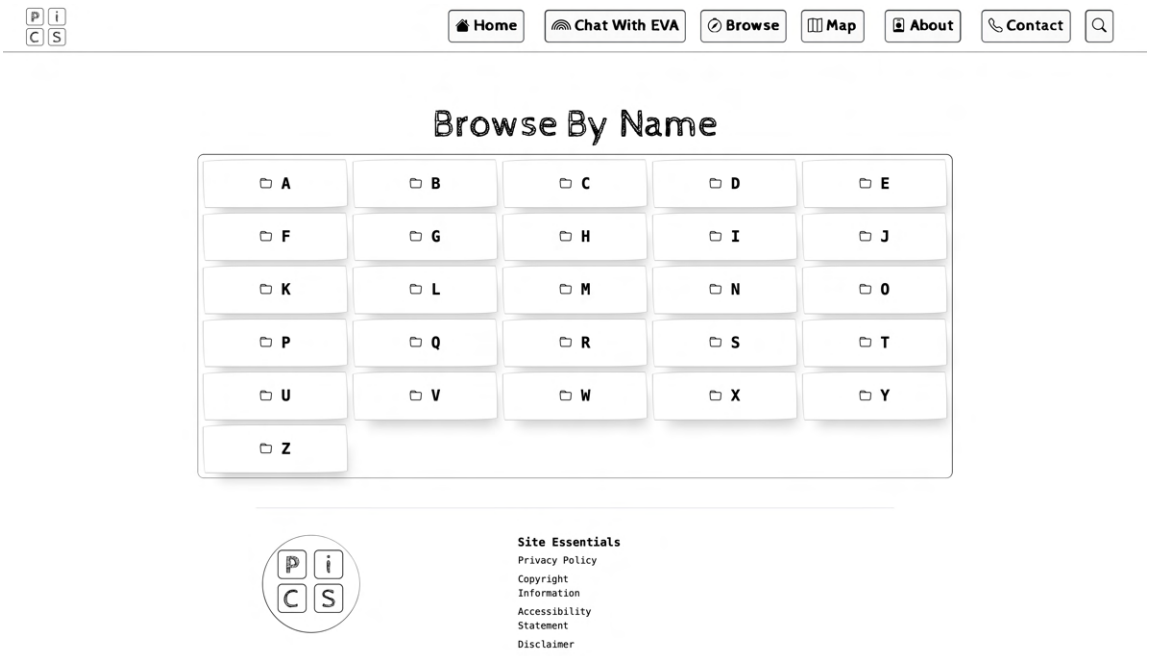


Figure G.2: High-fidelity prototype of the Browse By Name page

Figure G.3: High-fidelity prototype of the Map page

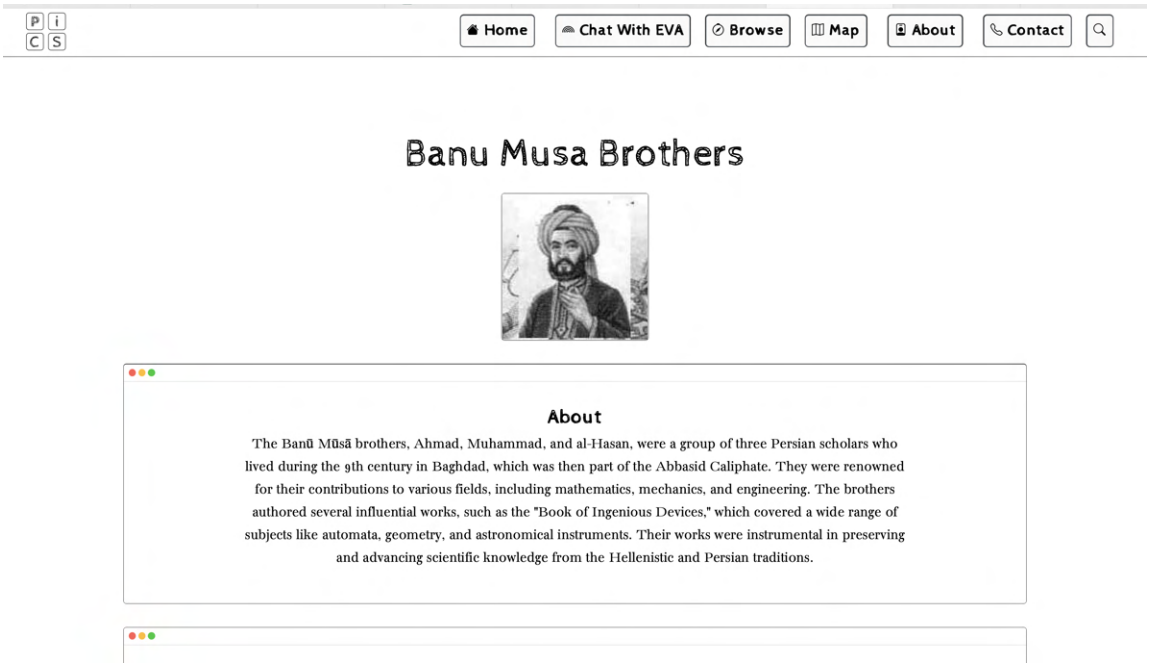


Figure G.4: High-fidelity prototype of the Pioneer Information page

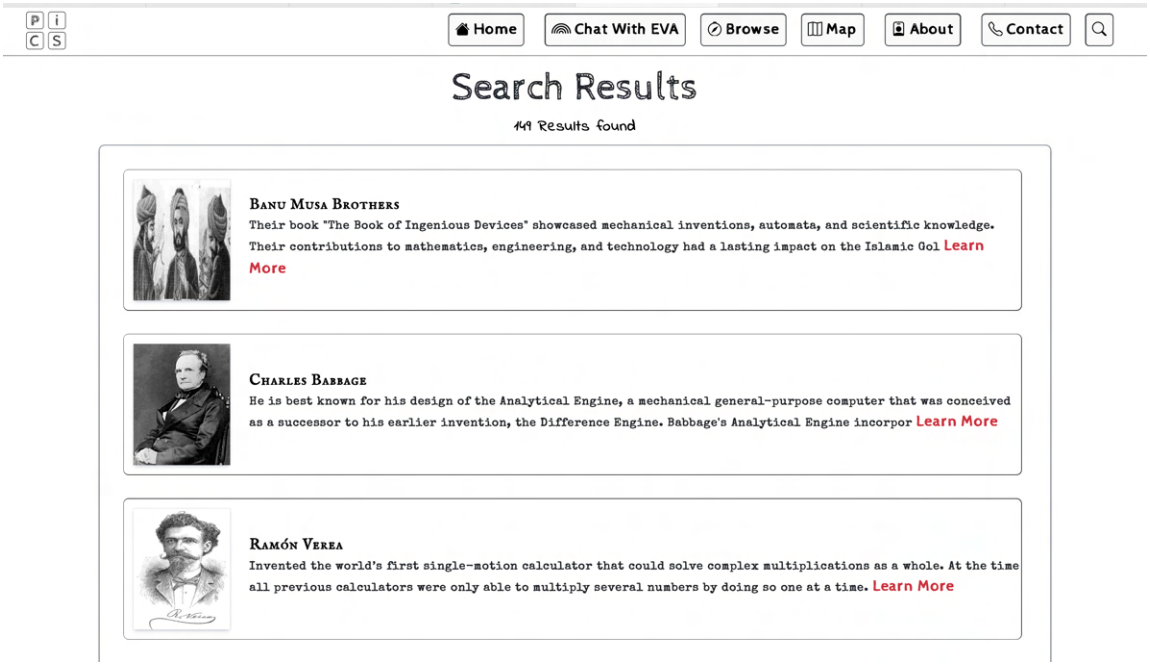


Figure G.5: High-fidelity prototype of the search results page

Appendix H

Work Process Flowchart

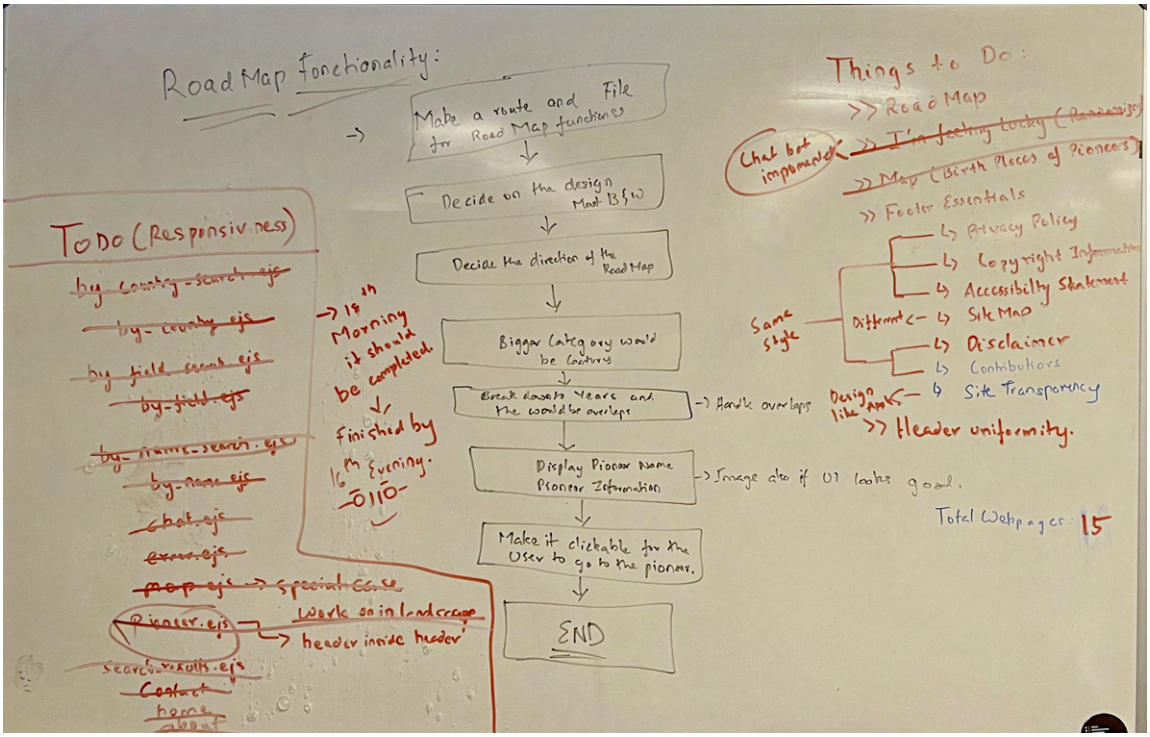


Figure H.1: The utilisation of flowchart to visualise Road Map Functionality

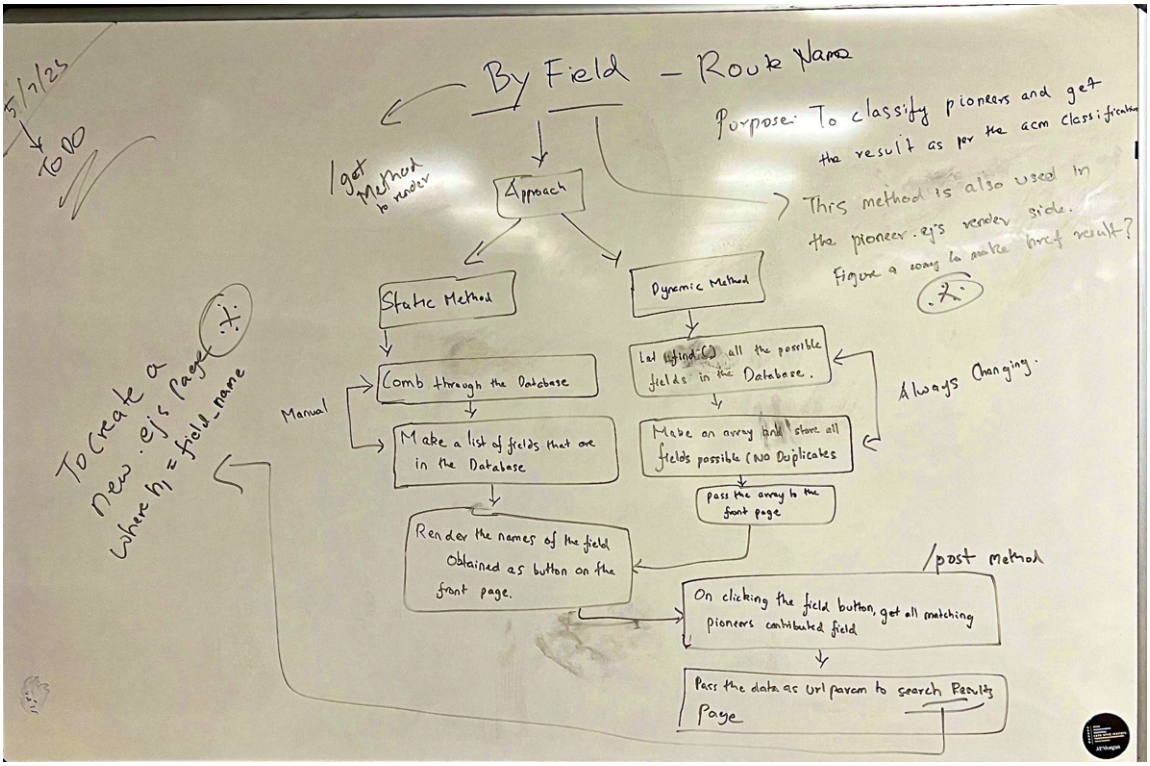


Figure H.2: The utilisation of flowchart to visualise By Field Functionality

Appendix I

Whiteboard Illustrated Architecture

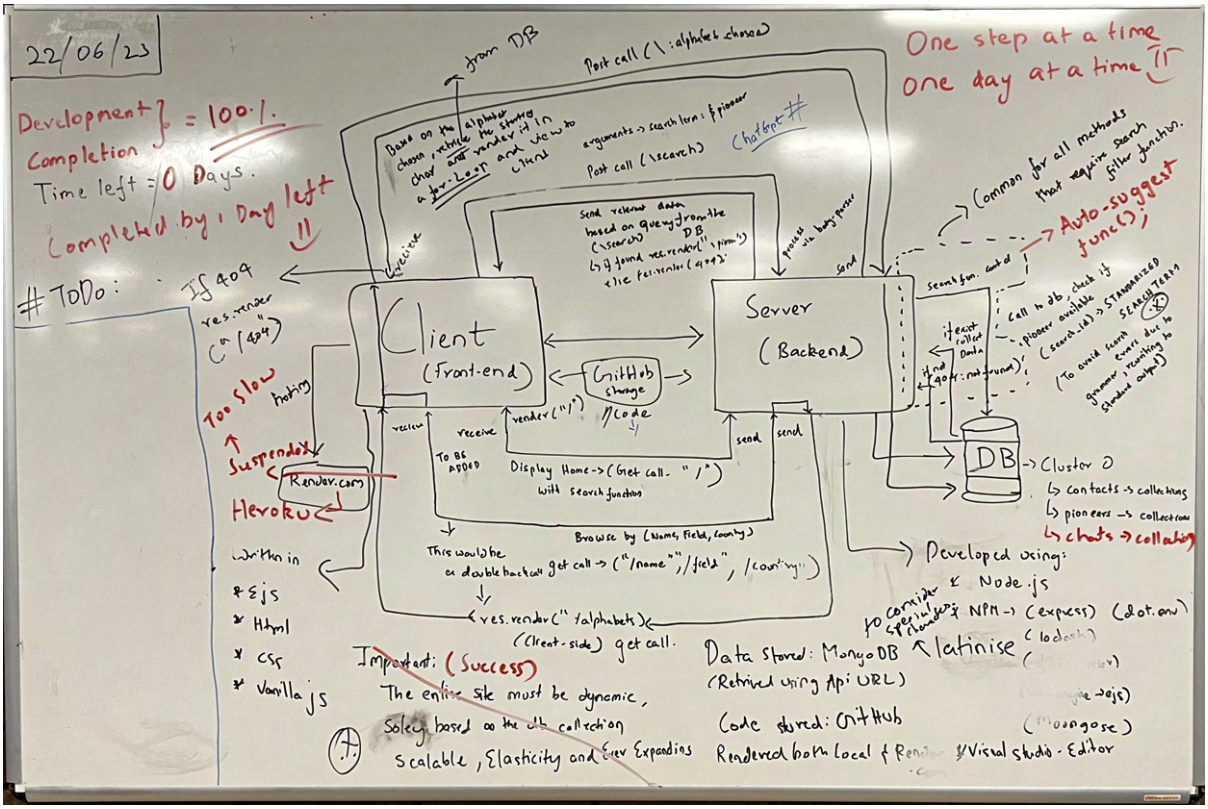


Figure I.1: Whiteboard illustration of the system's architecture used to guide the implementation.

Appendix J

Evaluation with Postman API

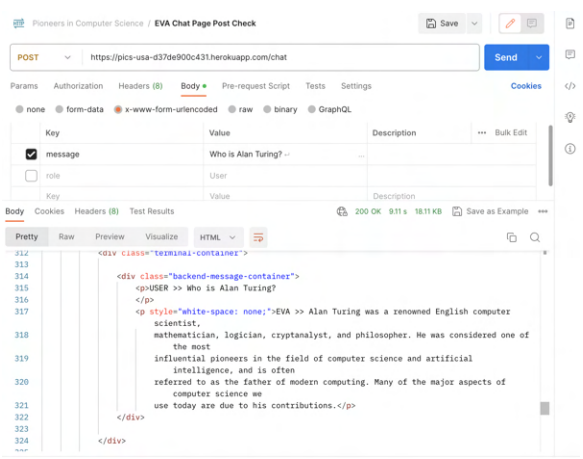


Figure J.1: (POST) Method and Response Test for EVA

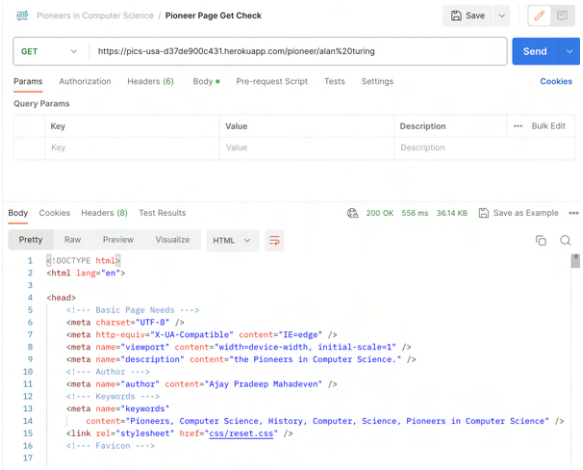


Figure J.2: (GET) Method Test for specific Pioneer (Alan Turing)

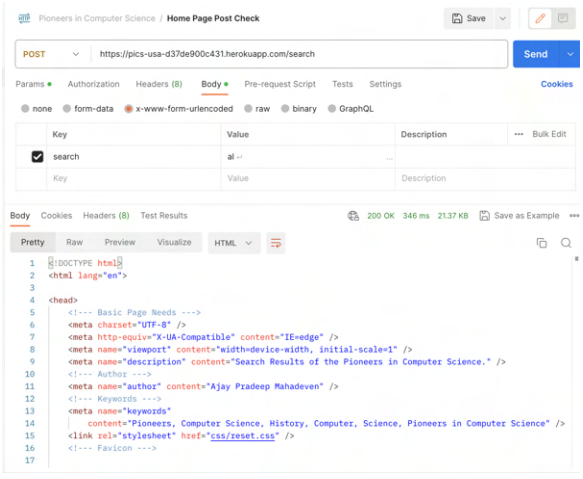


Figure J.3: (POST) Method and Response Test for Search Function

Appendix K

Google Page Insights Results

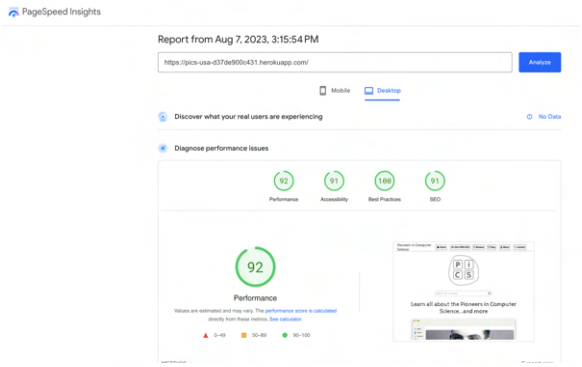


Figure K.1: Results for Home Page

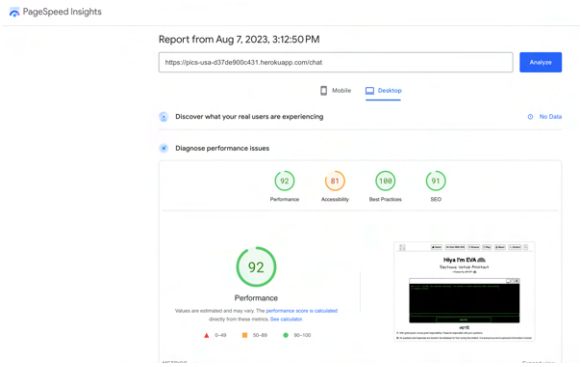


Figure K.2: Results for Chat Page

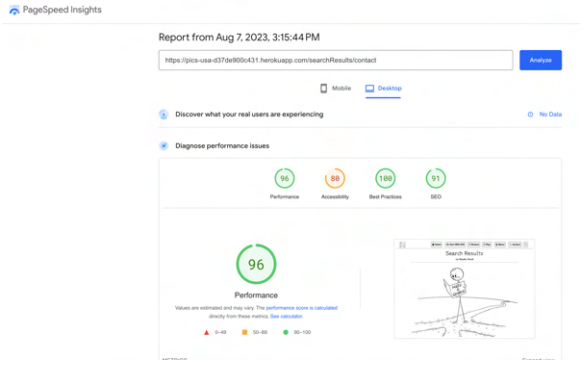


Figure K.3: Results for Contact Page

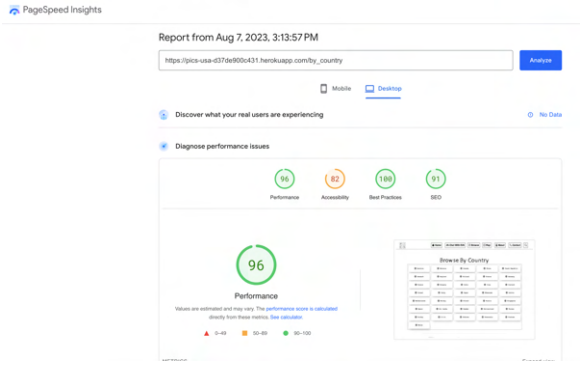


Figure K.4: Results for Browse By Country Page

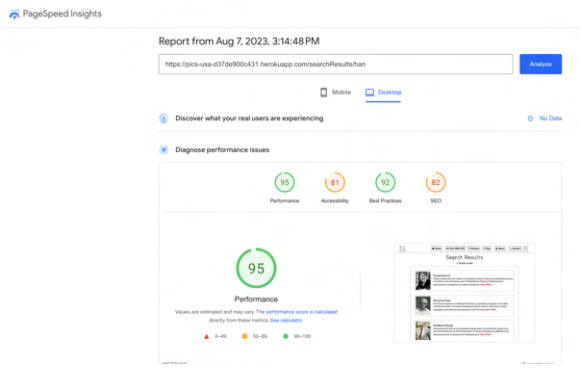


Figure K.5: Results for pioneer search results page

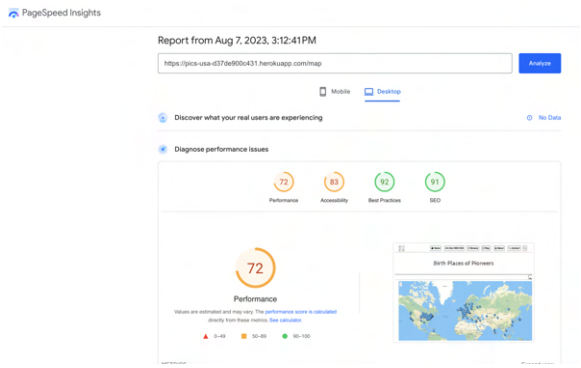


Figure K.6: Results for Map Page

Appendix L

Microsoft Questionnaire

Pioneers in Computer Science - An Electronic Resource

You are being invited to participate in a research study titled "PIONEERS IN COMPUTER SCIENCE".
Project Title: Pioneers in Computer Science - An Electronic Resource
Researcher: Ajay Pradeep Mahadeven
Affiliation: School of Computer Science, University of St Andrews
Link: { **https://pics-usa-d37de900c431.herokuapp.com** }

The primary aim of this research project is to evaluate the effectiveness, design, and utility of a newly developed educational website dedicated to pioneers in the field of computer science. The feedback from the participants will provide critical insights into user interaction, potential improvements, and overall site performance, further informing the development and design of similar educational resources in the future.

If you are interested, please download a copy of the participant information sheet here :

Link = **[https://universityofstandrews907.sharepoint.com/:b:/s/Ajay-CS5099/EfiZI58BjB5Ot0dGsNHZdG0BKy46SWPq1OXBMTUe3rG1yA?e=Zb60tR]**

and retain this for your records before starting the questionnaire. **If you have any questions, please email me at apm30@st-andrews.ac.uk.**

Your participation is entirely voluntary, and you can withdraw from the website at any time. You are free to omit any question.

The time to fill this form is 15-20 mins.

Please note :
This project is covered by the ethics application for "Evaluation of artefacts produced for CS projects". The data is anonymous and will be accessible to the name researcher on the project.

EFFECTIVENESS OF THE WEBSITE

1. How easy was it for you to navigate through the website?

☆ ☆ ☆ ☆ ☆

2. Were you able to find the information you were looking for?

☆ ☆ ☆ ☆ ☆

3. Did the website load quickly and without any errors?

☆ ☆ ☆ ☆ ☆

4. How would you rate the overall performance of the website?

☆ ☆ ☆ ☆ ☆

5. Did you encounter any broken links or pages?

☆ ☆ ☆ ☆ ☆

6. Your personal feedback on the effectiveness of the website.

7. What are your thoughts on EVA - ELECTRONIC VIRTUAL ASSISTANT ?

DESIGN OF THE WEBSITE

8. How would you rate the visual appeal of the website?

☆ ☆ ☆ ☆ ☆

9. Did the design of the website enhance your user experience?

☆ ☆ ☆ ☆ ☆

10. Was the text on the website easy to read?

☆ ☆ ☆ ☆ ☆

11. How would you rate the quality of the images and graphics on the website?

☆ ☆ ☆ ☆ ☆

12. Did the layout of the website make sense to you?

☆ ☆ ☆ ☆ ☆

13. Your personal feedback on the design of the website.

14. The website was specifically designed to cater to a wide range of age groups spanning from 10 to 60 years old. Considering its intended audience, do you believe the website effectively fulfills this purpose?

UTILITY OF THE WEBSITE

15. Did the website provide useful information or services?

☆ ☆ ☆ ☆ ☆

16. Did the website meet your needs or expectations?

☆ ☆ ☆ ☆ ☆

17. How likely are you to return to the website for future needs?

☆ ☆ ☆ ☆ ☆

18. Would you recommend this website to others?

☆ ☆ ☆ ☆ ☆

19. How would you rate the overall utility of the website?

☆ ☆ ☆ ☆ ☆

20. Your personal feedback on the utility of the website.

21. What is your age group?

- ◯ Under 18
- ◯ 18-25
- ◯ 26-35
- ◯ 36-45
- ◯ 46-55
- ◯ 56-65
- ◯ 65+

22. Please share any areas and aspects that we can improve on.

Appendix M

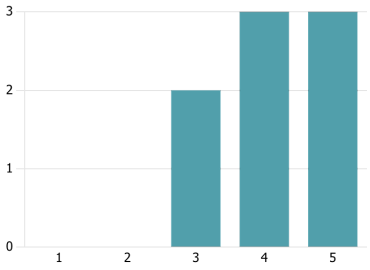
Results from Beta Release

Pioneers in Computer Science - An Electronic Resource

8	15:00	Active
Responses	Average time to complete	Status

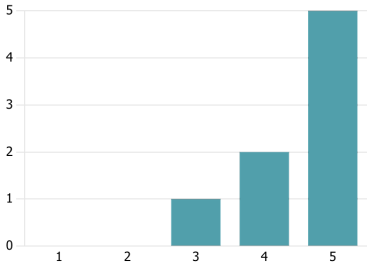
1. How easy was it for you to navigate through the website?

4.13
Average Rating



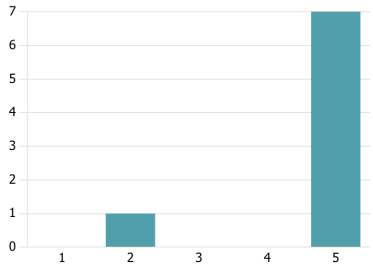
2. Were you able to find the information you were looking for?

4.50
Average Rating



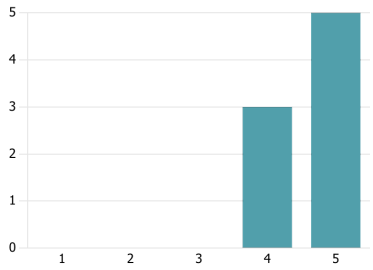
3. Did the website load quickly and without any errors?

4.63
Average Rating



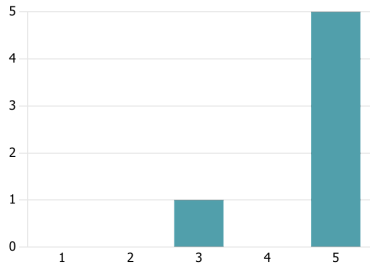
4. How would you rate the overall performance of the website?

4.63
Average Rating



5. Did you encounter any broken links or pages?

4.67
Average Rating



6. Your personal feedback on the effectiveness of the website.

7
Responses

Latest Responses

"The website performed quickly. It was easy to navigate however I disliked ...

"I like the format - not sure if it is necessary to have "Learn more" open in ...

3 respondents (**43**%) answered **website** for this question.

7. What are your thoughts on EVA - ELECTRONIC VIRTUAL ASSISTANT ?

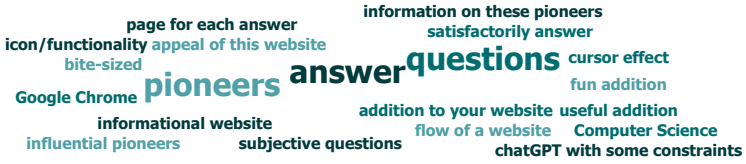
7
Responses

Latest Responses

"It was a fun addition and was able to satisfactorily answer the questions I ...

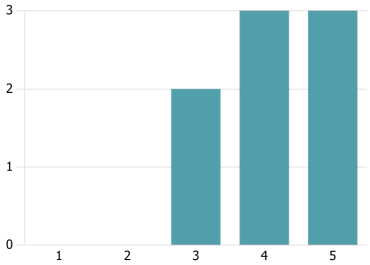
"Very cool! Played around with it for a little and think it's handy to have a s...

2 respondents (**29**%) answered **answer** for this question.



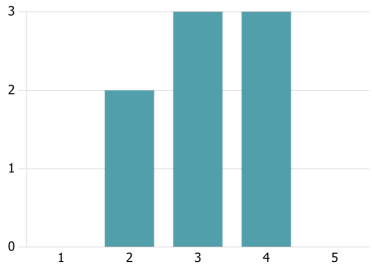
8. How would you rate the visual appeal of the website?

4.13
Average Rating



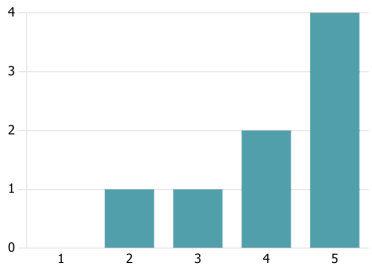
9. Did the design of the website enhance your user experience?

3.13
Average Rating



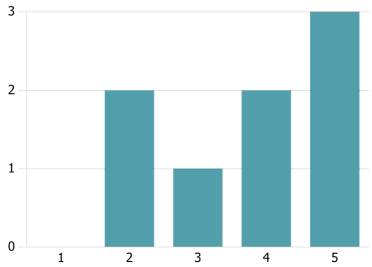
10. Was the text on the website easy to read?

4.13
Average Rating



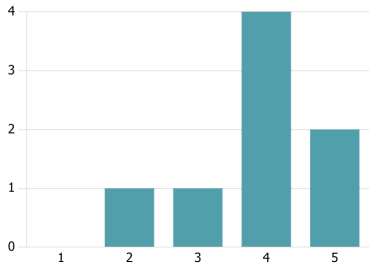
11. How would you rate the quality of the images and graphics on the website?

3.75
Average Rating



12. Did the layout of the website make sense to you?

3.88
Average Rating

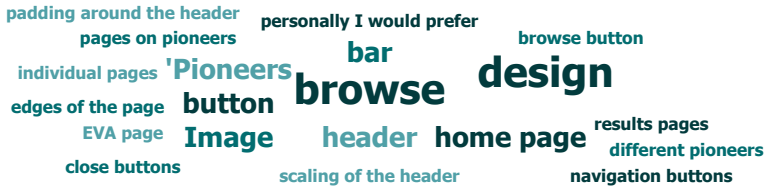


13. Your personal feedback on the design of the website.

6
Responses

Latest Responses
"The design was crisp, albeit a little sparse. I would have like a more neutra...

3 respondents (**50**%) answered **browse** for this question.



14. The website was specifically designed to cater to a wide range of age groups spanning from 10 to 60 years old. Considering its intended audience, do you believe the website effectively fulfills this purpose?

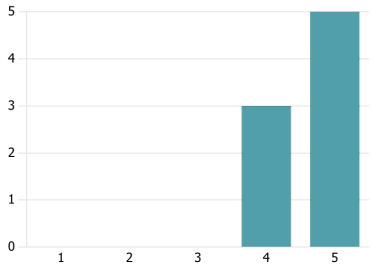
6
Responses

Latest Responses
"Yes. Like I mentioned before I think a dark mode would have been useful ...

2 respondents (**33**%) answered **yes** for this question.

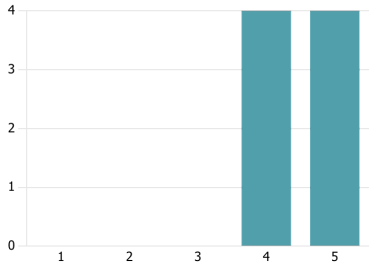
15. Did the website provide useful information or services?

4.63
Average Rating



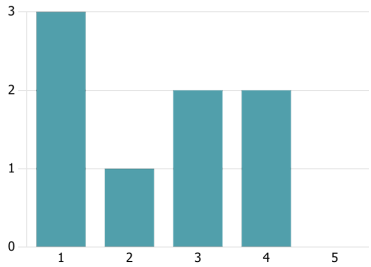
16. Did the website meet your needs or expectations?

4.50
Average Rating



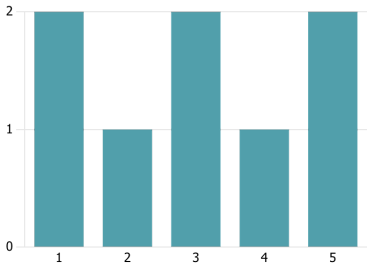
17. How likely are you to return to the website for future needs?

2.38
Average Rating



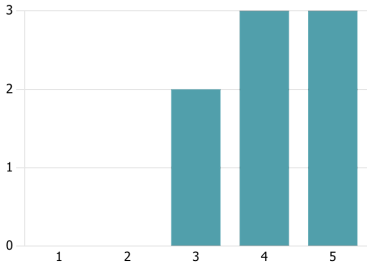
18. Would you recommend this website to others?

3.00
Average Rating



19. How would you rate the overall utility of the website?

4.13
Average Rating



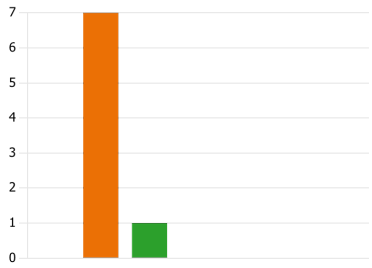
20. Your personal feedback on the utility of the website.

4
Responses

Latest Responses
"It is an easy to use website however its utility is weakened by the fact that...

21. What is your age group?

Under 18	0
18-25	7
26-35	1
36-45	0
46-55	0
56-65	0
65+	0



22. Please share any areas and aspects that we can improve on.

3
Responses

Latest Responses
"Maybe add a dark mode in the future and links to more academic sources...

Appendix N

Comparison of Issues Before and After Fixes

N.1 Font Issues

Users reported confusion in understanding the site's content on some pages.

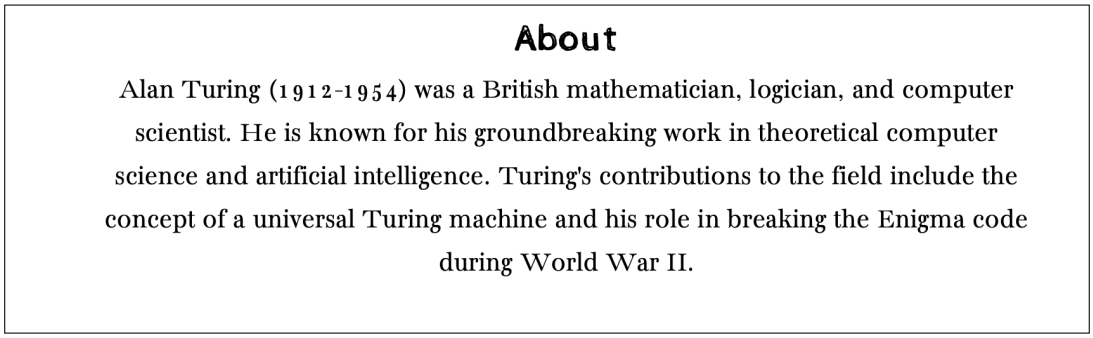


Figure N.1: Font Issues Before Fix

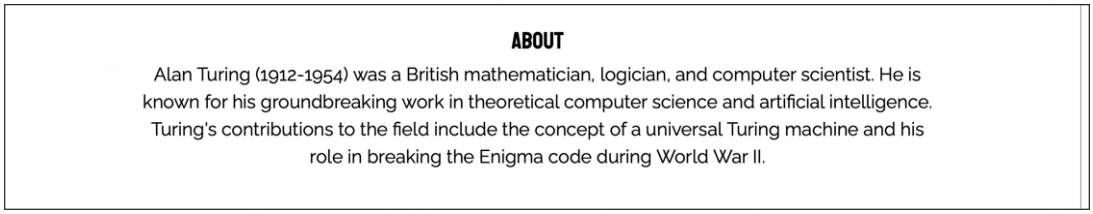


Figure N.2: Font Issues After Fix

N.2 Map Coordinates

One user pointed out some of the pioneer birthplaces were of the wrong lat & long coordinates.

Figure N.3: Map Coordinates Before Fix

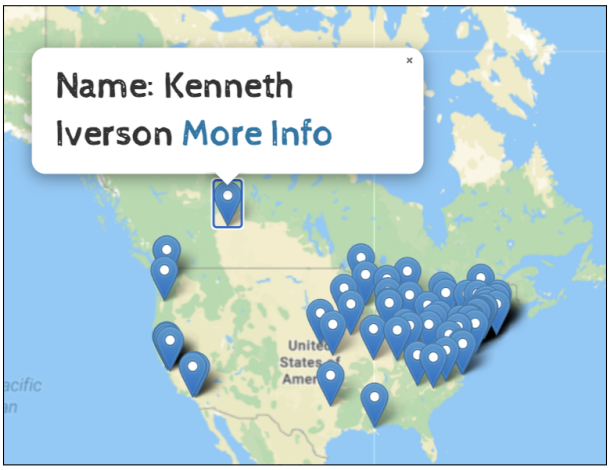


Figure N.4: Map Coordinates After Fix

N.3 Favicons

Favicons were not displayed on the pioneer and search results pages.

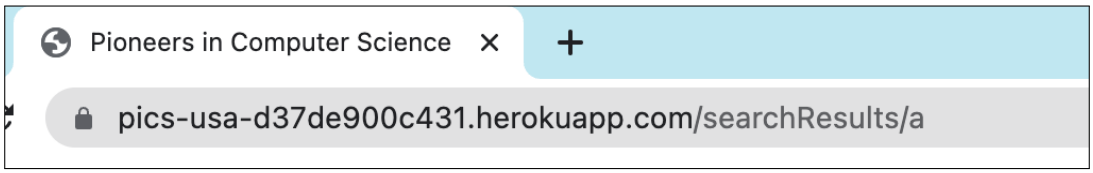


Figure N.5: Favicons Before Fix

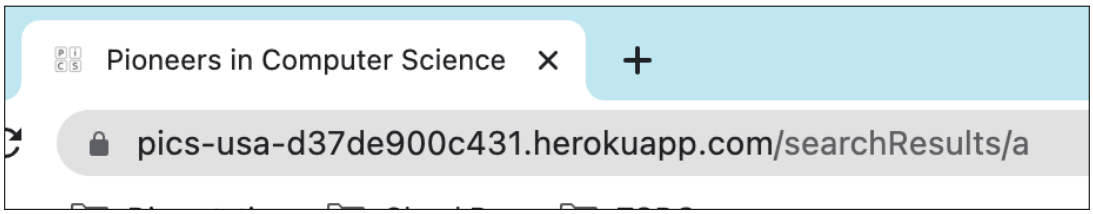


Figure N.6: Favicons After Fix

N.4 Mac Icons

Users were confused by using Mac icons for UI beautification, mistaking them for actual button functionality.

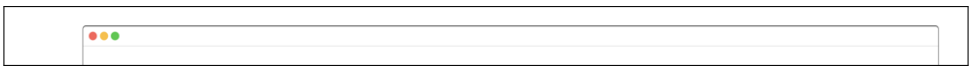


Figure N.7: Mac Icons Before Fix

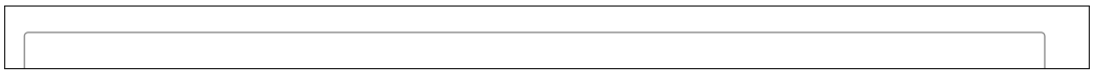


Figure N.8: Mac Icons After Fix

N.5 Source Links

Know More & References containers on the Pioneer page had the same purpose, and users requested clearer source definitions and buttons accordingly.

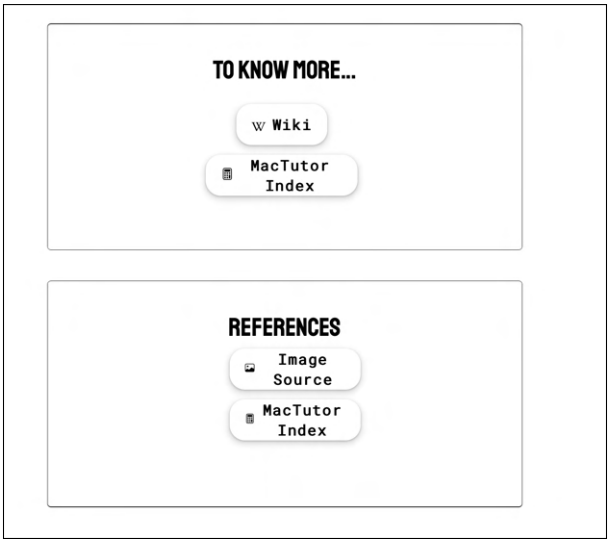


Figure N.9: Source Links Before Fix

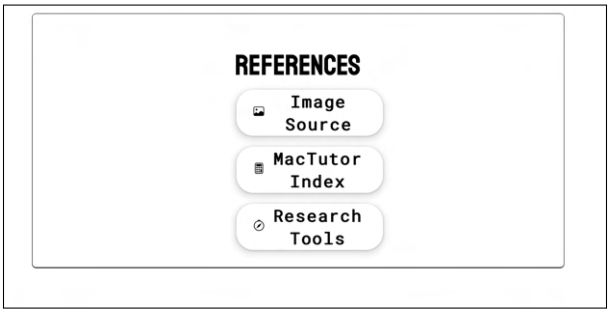


Figure N.10: Source Links After Fix

N.6 Copyright Page

Additional language has been included to emphasize respecting intellectual property rights.

Figure N.11: Copyright Page Before Fix

Figure N.12: Copyright Page After Fix

Appendix O

User Manual

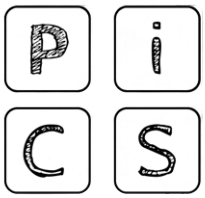
User Documentation

Title - Pioneers in Computer Science:
An Electronic Resource

Ajay Pradeep Mahadeven
220031985

Supervised by Dr.Dharini Balasubramaniam

In Partial Fulfillment of the Requirements for the Degree of
Master of Science in Software Engineering



August 14, 2023

Contents

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Chapter 1

Home Page

Link: Home Page

1.1 Introduction

Welcome to the user manual for the Pioneers in Computer Science **(PICS)** website. This guide is designed to help users navigate and understand the features and functionalities of the website. The PICS website is a comprehensive resource providing information about computer science pioneers. It offers various ways to explore and learn about these pioneers, including browsing by name, field or country, viewing the birthplace of pioneers by the map and knowing our mission on the About page, contacting the maintainer on the contact page and also interacting with a chatbot named EVA (Electronic Virtual Assistant).

1.2 Home Page

The Home Page serves as the starting point for the user exploration of the website. It briefly introduces the pioneers in Computer Science, highlighting a selection of pioneers with their names and a short description of their contributions to the field.

The Home page was designed to be welcoming, user-friendly and intuitive. At the top of the page, Users will find a navigation bar that allows users to access other sections of the website quickly, such as "Chat with EVA", "Browse By Name", "Browse By Field, "Browse By Country", and more.

In the central area of the page, users can see the website's logo, and below is a search bar that can be used to search for a pioneer using their name; it could even be a partial match to their actual name. Below it is a heading which says, "Learn all about the Pioneers in Computer Science...and more".

Below the heading, users will find a selection of featured pioneers. Each pioneer is presented with a name, a photo and a summary of their contributions to computer science. This carousel container/section provides a quick overview of the diverse range of pioneers featured on the website.

Users can find the website's footer at the bottom of the page. This section links the website's ethical guidelines, copyright regulations, and privacy policies. " Footer " chapter

understanding, please refer to the ” Footer ” chapter in the document. Users can access this chapter directly by clicking the hyperlink: Footer.

The Home Page is designed to be a launching pad for user exploration of the pioneers in computer science. Whether a user wants to chat with EVA, browse pioneers by name, field, or country, or learn more about the project, the Home Page provides easy access to all these features.

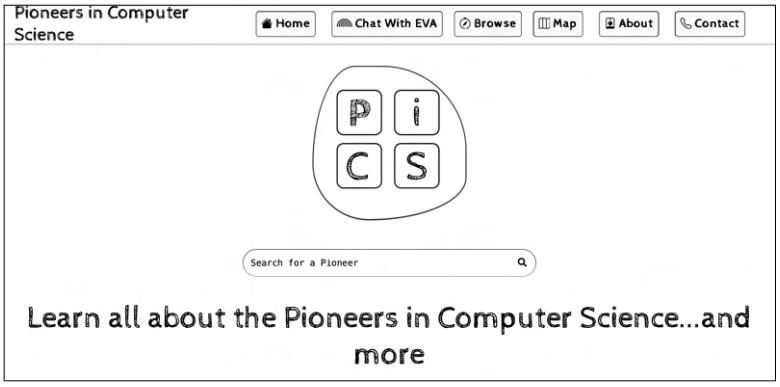

Figure 1.1: Top of the Home Page

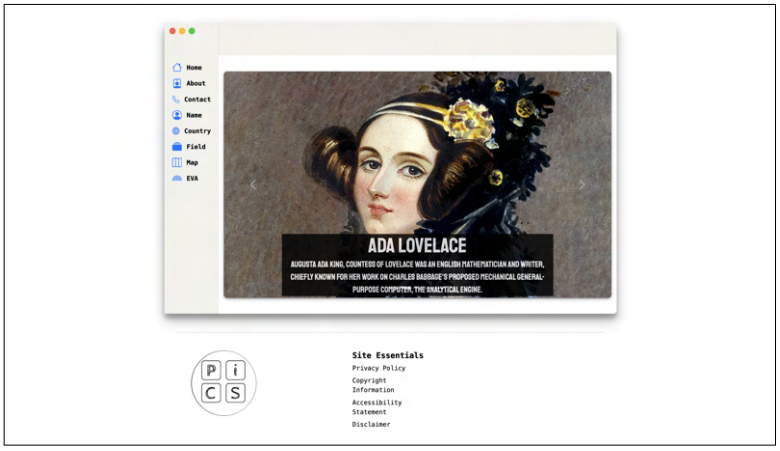

Figure 1.2: Bottom of the Home Page

Chapter 2

Header

2.1 Introduction

One of the critical components of the website design is the header. This chapter will introduce using a title in website design, specifically focusing on the website.

2.1.1 Use of a Header

The header is a section located at the top of each page. It typically contains the website's logo, navigation menu, and sometimes additional features like search bars or login buttons. The header is a crucial part of a website's navigation system, providing users with quick access to the main sections of the website. It benefits first-time visitors who are getting to know a website and returning visitors who need to find specific information quickly.

2.2 Header on the PICS Website

On the website, the header contains links to several important pages:

Home : This is the website's main page, providing an introduction to the pioneers in Computer Science.

Chat with EVA : This page allows users to interact with EVA, a personal assistant trained to answer questions about the pioneers of computer science.

Browse By Name : This page allows users to browse the pioneers by their names.

Browse By Field : This page allows users to browse the pioneers by their field of expertise.

Browse By Country : This page allows users to browse the pioneers by their country of origin.

Birth Places of Pioneers (Map) : This page provides a map showing the birthplaces of the pioneers. However, this feature is only available on tablets or devices with larger screens. Alternatively, users can switch their device to landscape orientation to check if the feature is enabled.

Road Map : This page provides a timeline of pioneers in computer science, showcasing their achievements based on the year. It starts from the year 830 with Al-Khwarizmi, whose work led to the term "algorithm", and continues through the centuries to include

pioneers like Charles Babbage, Ada Lovelace, and many others. Each pioneer is presented with their name, the year of their achievement, a brief description of their contribution, and a "Learn More" link for users to explore in-depth information about each pioneer.

About : This page provides information about the project, its objectives, and the creator. It explains the motivation behind the project, the primary, secondary, and tertiary objectives, and information about the creator, Ajay Pradeep Mahadeven. It also provides links to the creator's social media and personal website.

Contact : This page provides information on how to get in touch with the website administrators for any queries or feedback related to the website. Users can use the provided contact form or other contact methods to contact the administrators.

Page	Description
Home	The website's main page introduces the pioneers in Computer Science.
Chat with EVA	Allows users to interact with EVA, a personal assistant trained to answer questions about the pioneers of computer science.
Browse By Name	Allows users to browse the pioneers by their names.
Browse By Field	Allows users to browse the pioneers by their expertise.
Browse By Country	Allows users to browse the pioneers by their country of origin.
Birth Places of Pioneers (Map)	Provides a map showing the birthplaces of the pioneers. This feature is only available on tablets or devices with larger screens.
Road Map	Provides a timeline of pioneers in computer science, showcasing their achievements based on the year.
About the Project	Provides information about the project, its objectives, and the creator.
Contact Information	Provides information on how to contact the website administrators for any queries or feedback related to the website.
Search Bar	Allows the user to search for a pioneer from any page except the Home Page, where a search bar is one of the main functionalities.

Table 2.1: Pages and Search contained in the PICS website header

The header on the PICS website is a clear example of how a well-designed title can enhance the user experience, providing easy access to critical information and additional resources.

Figure 2.1: Header of the Website (Home Page)

Figure 2.2: Header of the Website (other pages)

Chapter 3

Footer

3.1 Introduction

This chapter will introduce the use of a footer in website design, specifically focusing on the PICS website.

3.1.1 Use of a Footer

The footer is a section located at the bottom of each page. It typically contains information secondary to the web page's primary content but is still crucial for the user. The footer is where users expect to find specific types of information, such as contact information, links to privacy policies and legal information, social media icons and copyright notices.

The footer is crucial to a website's navigation system, providing users quick access to important pages and information. It benefits first-time users getting to know a website and returning users who need to find specific information quickly.

Page	**Description**
Privacy Policy	Outlines the website's privacy policy, explaining what data is collected and how it is used.
Copyright Information	Provides information about the website's copyright policy.
Takedown Policy	Provides information on what to do if a user believes that any content on the website violates their intellectual property rights.
Accessibility Statement	Provides an overview of the website's accessibility features.
Disclaimer	Provides a disclaimer about the information contained in the website.

Table 3.1: Pages contained in the PICS website footer

3.2 Footer on the PICS Website

On the website, the footer contains links to several important pages :

Privacy Policy: This page outlines the website's privacy policy, explaining what data is collected and how it is used. It reassures users that no personal information is collected, and any collected data is not linked to the user's identity.

Copyright Information: This page provides information about the website's copyright policy. It explains that the content on the website is licensed under a Creative Commons Attribution-Non Commercial-ShareAlike 4.0 International License and MIT License.

Takedown Policy: This page provides information on what to do if users believe that any content on the website violates users' intellectual property rights. It provides a step-by-step guide on how to report such content.

Accessibility Statement : This page provides an overview of the website's accessibility features. It explains the efforts made to make the website accessible to the widest possible audience.

Disclaimer : This page provides a disclaimer about the information contained on the website. It clarifies that while efforts are made to keep the information current and correct, there are no guarantees of completeness, accuracy, reliability, suitability, or availability of the website's information, products, services, or related graphics.

The footer on the PICS website is a clear example of how a well-designed footer can enhance the user experience, providing easy access to important information and additional resources.

Figure 3.1: Footer of the Website

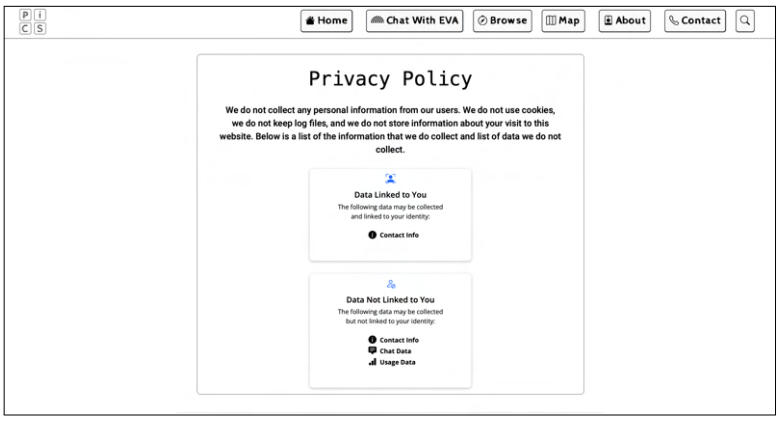

Figure 3.2: Privacy Policy Page

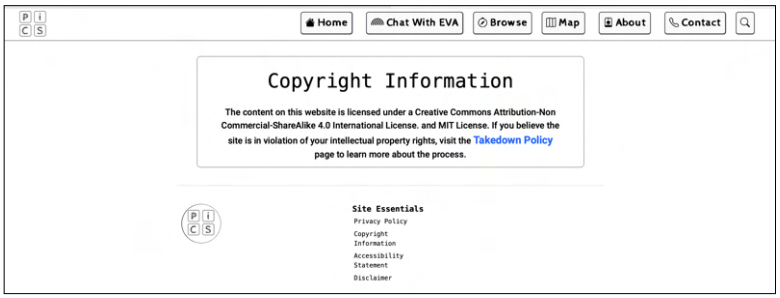

Figure 3.3: Copyright Information Page

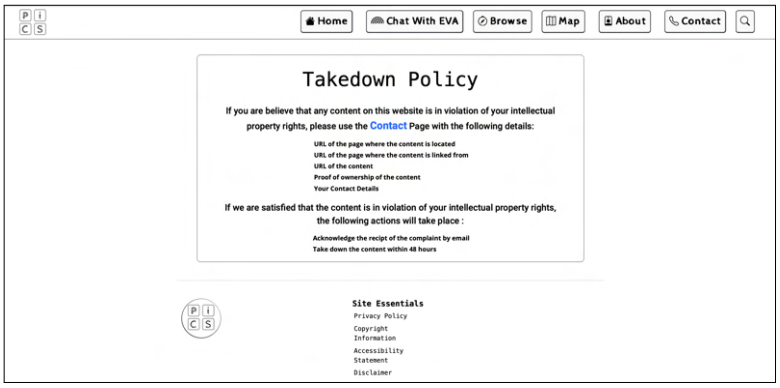

Figure 3.4: Take-down Policy Page

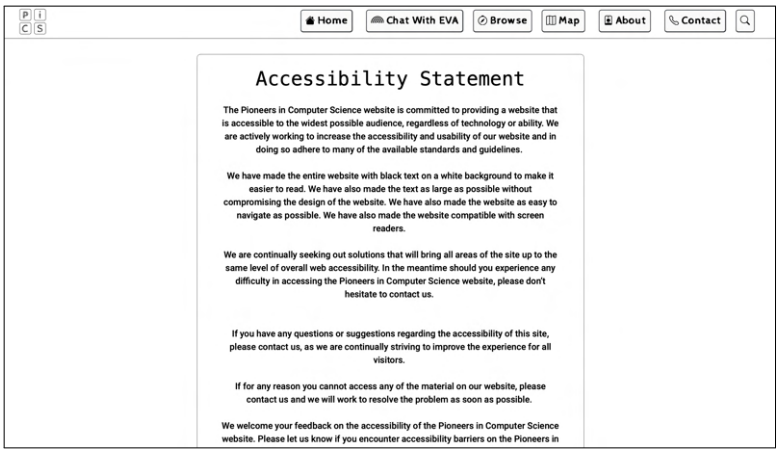

Figure 3.5: Accessibility Statement Page

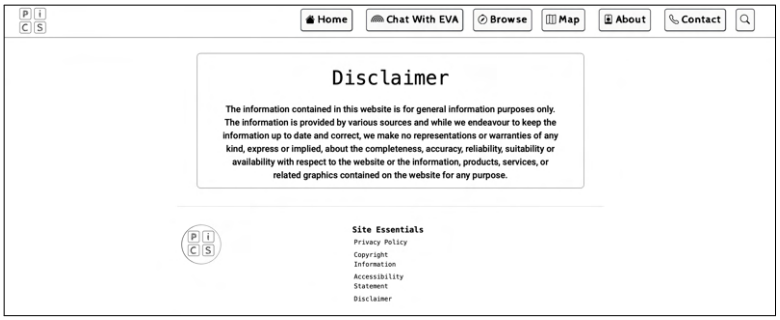

Figure 3.6: Disclaimer

Chapter 4

About Page

Link: About Page

4.1 Introduction

The "About the Project" page on the Pioneers in Computer Science (PICS) website provides detailed information about the project, its objectives, and the creator. This page is essential for users who want to understand the motivation behind the creation of the website, the goals it aims to achieve, and the person behind its development.

4.2 Description

The "About the Project" page begins with a brief introduction to the project, explaining that it is a tribute to the pioneers in computer science. It highlights the importance of recognizing the contributions of these pioneers, who have laid the foundation for the digital world we live in today.

The page then outlines the objectives of the project, which are categorized into primary, secondary, and tertiary objectives. The primary aim is to provide a comprehensive resource about the pioneers in computer science. The secondary purpose is to inspire the next generation of computer scientists. The tertiary objective is to contribute to the open-source community.

The page also provides information about the creator of the project, Ajay Pradeep Mahadeven. It includes a brief bio and links to his online profiles and personal website. This section allows users to learn more about the person behind the project and to connect with him on various platforms.

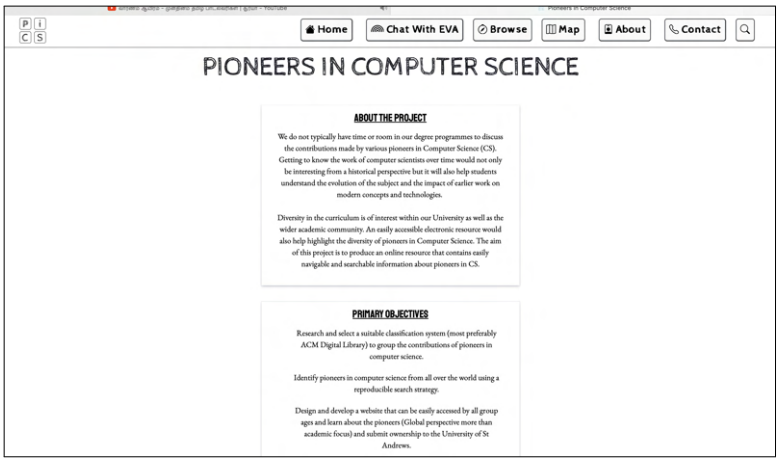

Figure 4.1: About (start) Page of the Website

Figure 4.2: About (end) Page of the Website

Chapter 5

Contact Page

Link: Contact Page

5.1 Introduction

The "Contact Information" page on the Pioneers in Computer Science (PICS) website is a crucial resource for users who have queries, feedback, or require assistance related to the website. This page provides various methods for contacting website administrators, ensuring that users' concerns or inquiries are addressed promptly and effectively.

5.2 Description

The "Contact Information" page provides clear instructions for contacting the website administrators. It emphasises that users are welcome to contact us for any queries or feedback related to the website.

The contact form allows users to send a message directly from the website, while an email address allows users to send a detailed message from their personal or work email account. Social media handles provide an alternative way for users to reach out, especially those active on these platforms.

The "Contact Information" page is an essential part of the PICS website, ensuring that users have a direct line of communication with the website administrators. This open line of communication helps to improve the website's user experience, as users can provide feedback, report issues, or ask questions, knowing that their input is valued and will be addressed.

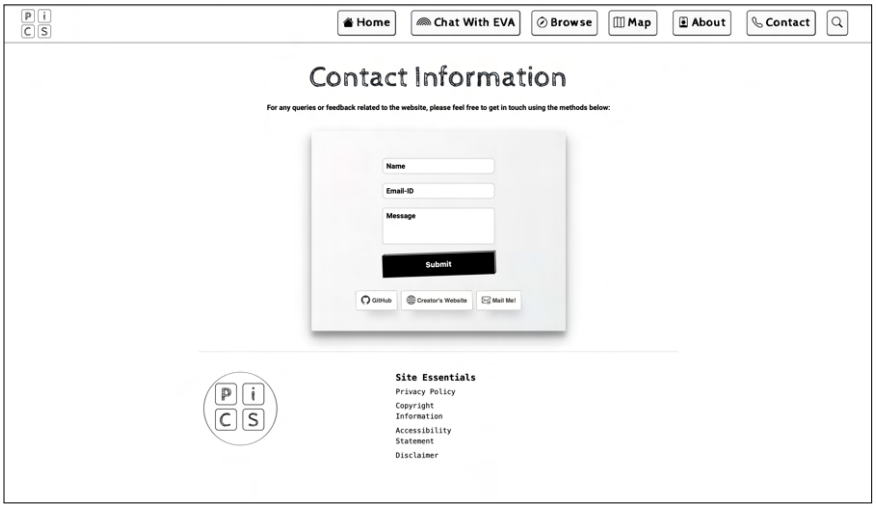

Figure 5.1: Contact Page

Chapter 6

Map Page

Link: Map Page

6.1 Introduction

The "Birth Places of Pioneers (Map)" page on the Pioneers in Computer Science (PICS) website is a unique feature that offers a geographical perspective on the pioneers in the field of computer science. This page allows users to visualize the birthplaces of these pioneers, providing an engaging and interactive way to explore the information.

6.2 Description

The "Birth Places of Pioneers (Map)" page presents a world map that marks the birthplaces of the pioneers in computer science. Each marker on the map represents a pioneer, and clicking on a marker reveals more information about the pioneer, such as their name, a brief description of their contribution to computer science, and a link to learn more about them.

However, it's important to note that this feature is only available on tablets or devices with larger screens. Users with smaller devices should switch to landscape orientation to check if the feature is enabled.

The map provides a unique way to explore the pioneers in computer science, allowing users to see where they were born and learn more about their contributions. It adds a layer of interactivity to the website, making the learning experience more engaging and enjoyable.

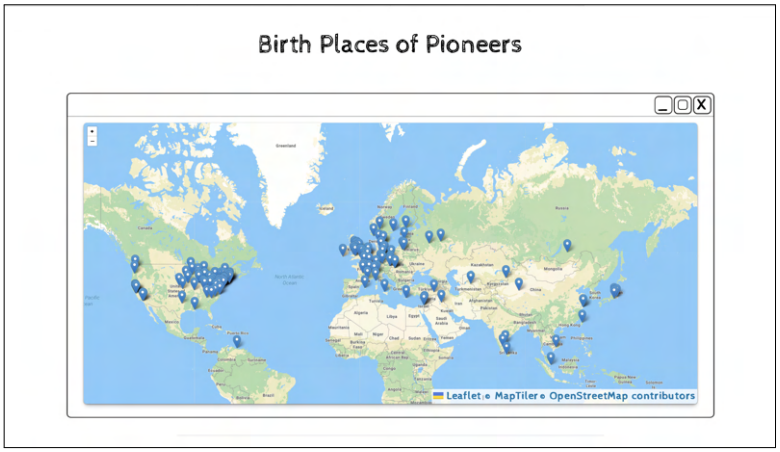

Figure 6.1: Map Page

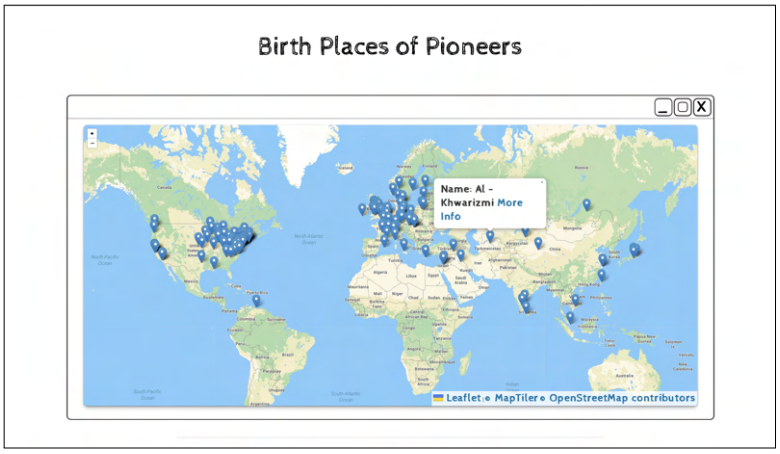

Figure 6.2: Map Page with Marker clicked by the user

Chapter 7

Road Map Page

Link: Road Map Page

7.1 Introduction

The "Road Map" page on the Pioneers in Computer Science (PICS) website is a feature that presents the achievements of computer science pioneers in a timeline format. This page provides a chronological perspective on computer science's evolution, highlighting these pioneers' critical contributions.

7.2 Description

The "Road Map" page presents a timeline of pioneers in computer science, showcasing their achievements based on the year. The timeline starts from the year 830 with Al-Khwarizmi, whose work led to the term "algorithm", and continues through the centuries to include pioneers like Charles Babbage, Ada Lovelace, and many others.

Each entry on the timeline includes the year of the achievement, the pioneer's name, a brief description of their contribution, and a "Learn More" link. The "Learn More" link directs users to a page with more detailed Information about the pioneer.

The timeline provides a visual representation of the progression of computer science over the years, highlighting the significant contributions of each pioneer. It offers an engaging and informative way for users to understand the history and evolution of computer science.

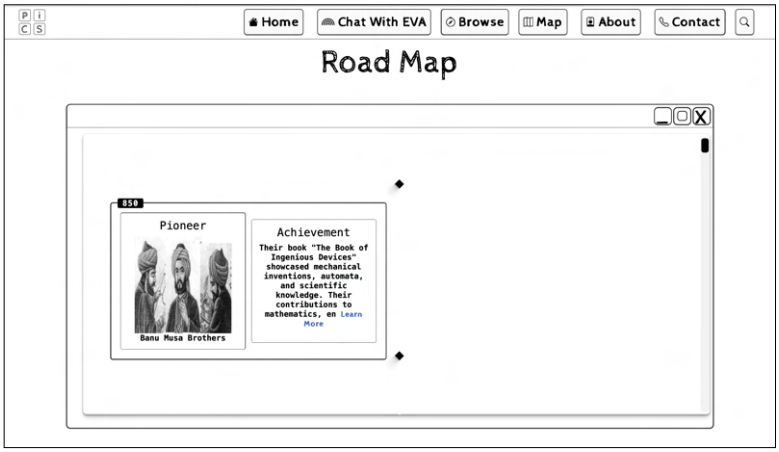

Figure 7.1: Information presented on the left of the Road Map

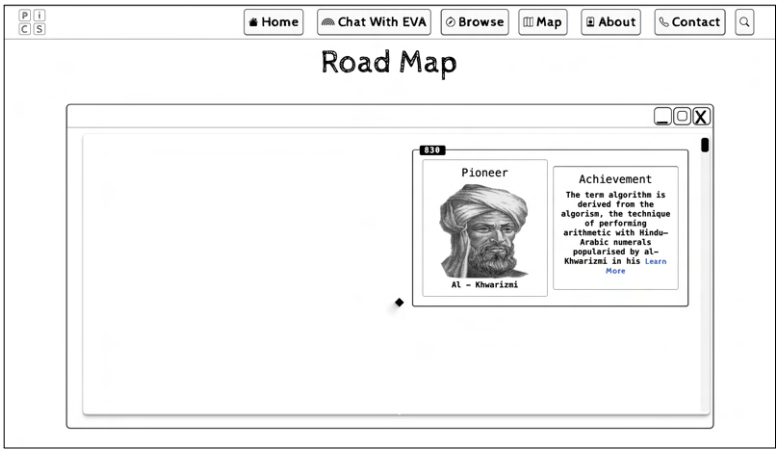

Figure 7.2: Information presented on the right of the Road Map

Chapter 8

Chat with EVA Page

Link: Chat with EVA Page

8.1 Introduction

The "Chat with EVA" page on the Pioneers in Computer Science (PICS) website is an interactive feature that allows users to engage in a conversation with a chatbot named EVA - "Electronic Virtual Assistant". EVA is designed to answer questions about computer science pioneers, providing users with an engaging and personalized way to explore the information on the website.

8.2 Description

The "Chat with EVA" page presents a chat interface where users can interact with EVA. Users must type their questions into the chat box and press enter to start a chat. EVA will respond conversationally, providing information about computer science pioneers based on the user's query.

The page also includes several important disclaimers and notes. Users are reminded to be responsible with their questions, as all questions and responses are stored in the database for fine-tuning the chatbot. However, this data is assumed to be anonymous and no personal information is stored.

The page also clarifies that the chatbot is a work in progress and is not perfect. It is based on the training data and will be improved over time. The chatbot's responses do not reflect the creator's views or opinions, and the chatbot is designed based on information available until September 2021.

The "Chat with EVA" page provides a unique and interactive way for users to learn about the pioneers of computer science. It enhances the user experience by delivering personalized responses to user queries, making learning more engaging and enjoyable.

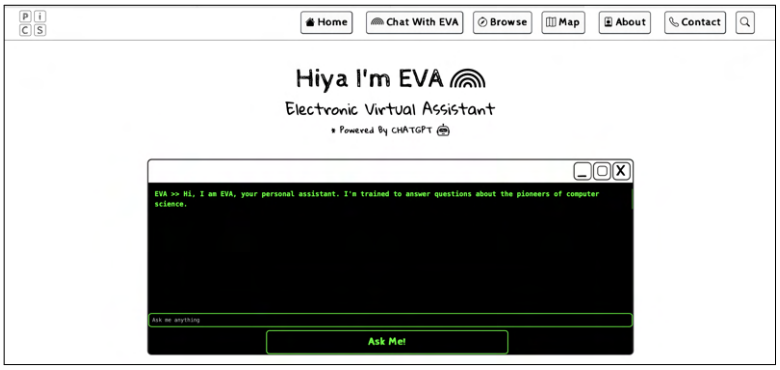

Figure 8.1: EVA Page

Figure 8.2: EVA's Generated Response to User Queries

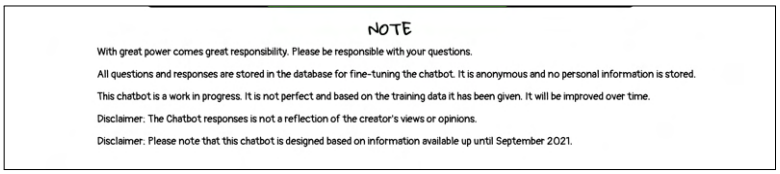

Figure 8.3: EVA Page Disclaimer

Chapter 9

Browse

Link: Browse By Country
Link: Browse By Field
Link: Browse By Name

9.1 Introduction

The "Browse" options on the Pioneers in Computer Science (PICS) website provide users with a structured approach to explore the information about the pioneers in computer science. These options, which include "Browse By Name", "Browse By Field", and "Browse By Country", allow users to navigate the information based on their specific interests or needs. This chapter provides an introduction and description of these browsing options.

9.2 Description

Browse By Name

This page allows users to explore the pioneers based on their names. It provides an alphabetical list of all the pioneers featured on the website. Users can select a name to view more detailed information about the pioneer, including their contributions to the field of computer science and other relevant details.

Browse By Field

This page allows users to explore the pioneers based on their expertise. The fields could include various areas within computer science, such as programming, hardware, theory of computation, etc. Users can view a list of pioneers who significantly contributed to that area.

Browse By Country

This page allows users to explore the pioneers based on their country of origin. This could be useful for users interested in learning about the pioneers from a specific country or region. Users can select a country to view a list of pioneers who were born in that country.

The "Browse" options on the PICS website provide a user-friendly and organised way to explore the vast information available about the pioneers in computer science. Whether users want to learn about a specific pioneer, analyse contributions within a particular field, or understand assistance from a specific country, these browsing options cater to a wide range of user needs and interests.

Figure 9.1: Browse By Country Page

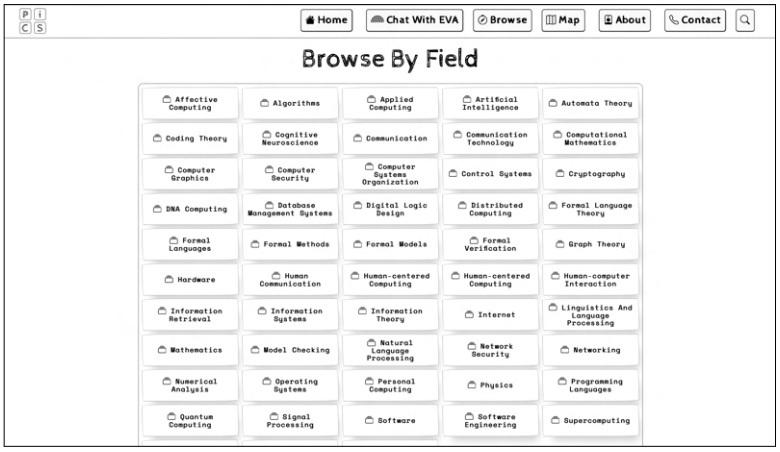

Figure 9.2: Browse By Field Page

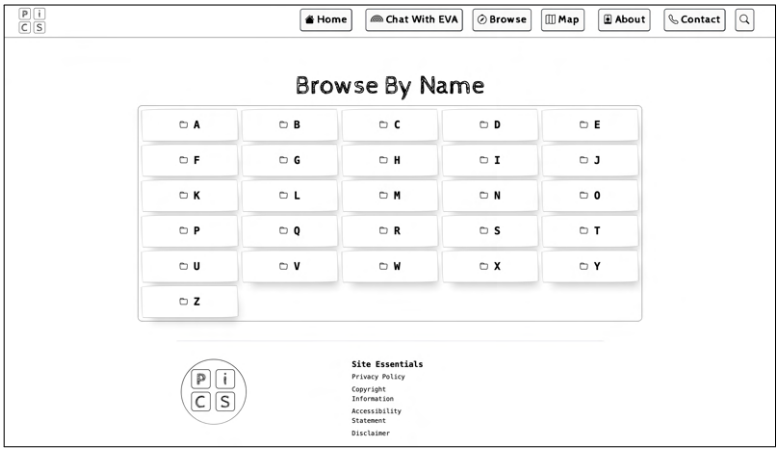

Figure 9.3: Browse By Name Page

Chapter 10

Search Results Page

Link: Example

10.1 Introduction

The "Search Results" page on the Pioneers in Computer Science (PICS) website is a dynamic feature that displays the results of a user's search query. This page is designed to help users find specific information on the website quickly and efficiently.

10.2 Description

The "Search Results" page presents the results of a user's search query. Each result includes the name of a pioneer and a brief description of their contributions to the field of computer science. A "Learn More" link also directs users to a page with more detailed information about the pioneer.

For example, if a user searches for "Alan Turing", the search results page will display information about Alan Turing, including his fundamental contributions to theoretical computer science, such as the Turing machine computational model, the conceiving of the stored program concept, and the designing of the high-speed ACE design.

The number of results found is also displayed at the top of the page, giving users an idea of how many pioneers match their search query.

The "Search Results" page is a valuable tool for users looking for specific information on the PICS website. It provides a quick and efficient way to find and explore information about specific pioneers in computer science.

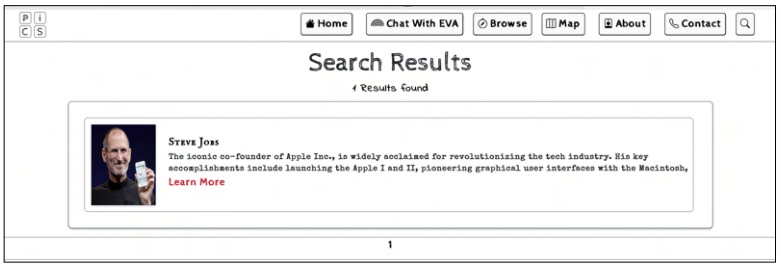

Figure 10.1: Search Results for Steve Jobs

Chapter 11

Pioneer Page

Link: Example

11.1 Introduction

The "Pioneer Information" page on the Pioneers in Computer Science (PICS) website is a dedicated page that provides comprehensive information about a specific pioneer in the field of computer science. This page offers an in-depth understanding of the pioneer's contributions to the area.

11.2 Description

The Information" page presents detailed information about a specific pioneer. For example, if a user navigates to the page of Steve Wozniak, they will find information regarding his life, achievements, and contributions to computer science.

The page is structured into several sections:

About

This section provides a brief biography of the pioneer, including their background, career highlights, and significant contributions to the field of computer science.

Achievements

This section outlines the pioneer's critical achievements in computer science. It includes creating significant technologies, contributions to the industry, and any awards or recognition they have received.

Contributed Year

This section provides the year and century when the pioneer made their first significant contribution.

Classification (ACM Library)

This section presents the classification of the pioneer's contributions as per the ACM Computing Classification System. Each classified field serves as an interactive button. When a user clicks on a specific field, they are directed to a list of other pioneers who have made significant contributions in the same field.

Birth Place

This section offers information about the pioneer's place of birth. It features two interactive buttons for enhanced user experience. One button, when clicked, presents a list of all pioneers originating from the same place. The other button allows users to view the pioneer's birthplace on a map, providing a geographical context to their origin.

References & Research Tools

This section consolidates sources and tools for users to explore the pioneer's life and contributions. Citations back information and images for credibility. The unified approach offers a seamless experience for users.

Figure 11.1: Start Content of the Pioneer Page

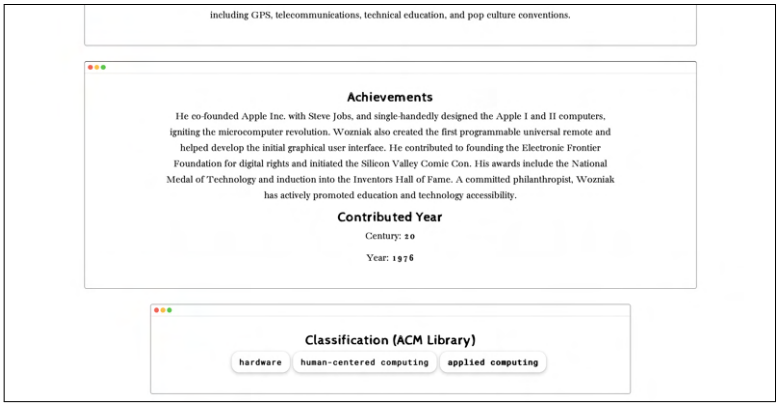

Figure 11.2: Middle Content of the Pioneer Page

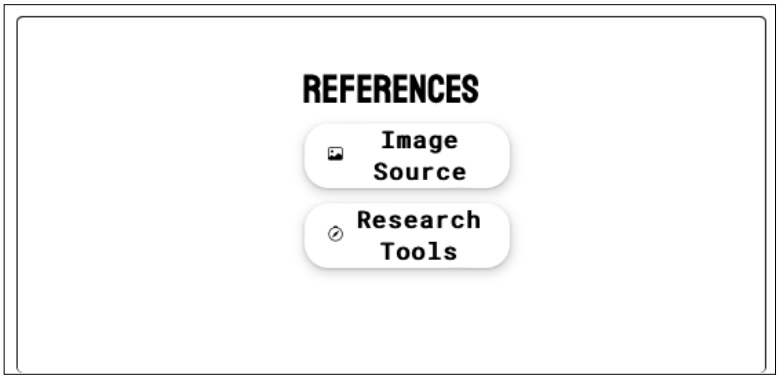

Figure 11.3: End Content of the Pioneer Page

Chapter 12

Responsiveness

12.1 Introduction

The Pioneers in Computer Science (PICS) website is designed to focus on responsiveness, ensuring that users have a seamless and efficient browsing experience across various devices and screen sizes. This section provides an overview of the website's responsiveness for all the linked pages.

12.2 Description

Home

The home page is designed to adapt to different screen sizes, ensuring the content is easily readable and navigable whether users are on a desktop, tablet, or mobile device. The carousel container is disabled in small devices.

Chat with EVA

The chat interface on this page is responsive, adjusting to the device's size to provide an optimal chat experience.

Browse By Name/Field/Country

These pages adjust the layout and size of the list of pioneers to fit the screen size, ensuring that users can easily navigate and select from the list regardless of their device.

Birth Places of Pioneers (Map)

This page provides a map that adjusts to the screen size. However, the map feature is only available on tablets or devices with larger screens. Users with smaller devices should switch to landscape orientation to check if the feature is enabled.

Road Map

The timeline on this page is not designed to be responsive; it is disabled for smaller screen devices and only viewable on laptops or larger screen sizes.

Map

The content on this page adjusts to fit the screen size for tablets and larger screens but is disabled for smaller screen devices.

About

The content on this page adjusts to fit the screen size, ensuring that the text is easily readable on any device.

Contact

The contact form on this page is responsive, adjusting to the screen size to provide an optimal form-filling experience.

Search Results

The layout of the search results adjusts based on the screen size, ensuring that users can easily read and navigate the results on any device.

Pioneer Information

The information layout adjusts to the screen size, ensuring users can easily read about the pioneer on any device.
The PICS website's responsive design ensures users have a consistent and user-friendly experience across all devices. It adjusts the layout, size, and arrangement of the elements based on the screen size and orientation, providing an optimal browsing experience for all users.

Figure 12.1: Portrait View of Home Page (Mobile Devices)

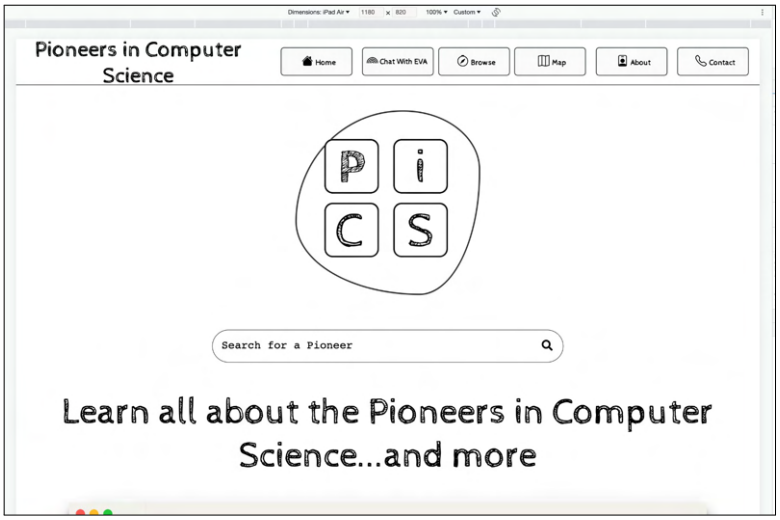

Figure 12.2: Landscape View of Home Page (Tablets)

Chapter 13

Conclusion

We have reached the end of this user manual for the Pioneers in Computer Science (PICS) website. This guide has provided users a thorough overview of the website's features, functionality, and navigation.

The PICS website is a rich resource for anyone interested in the pioneers of computer science. Its user-friendly design, interactive features, and wealth of information make it an engaging and informative platform for learning about the pioneers who have shaped the field of computer science.

Remember, the website is designed to be responsive, ensuring a seamless browsing experience across various devices. Whether users are exploring the pioneers by name, field, or country, chatting with EVA, or delving into detailed information about a specific pioneer, the PICS website offers many ways to engage with the content.

We hope this user manual has helped guide users through the website's features and functionality. Enjoy exploring the PICS website and discovering the pioneers who have made significant contributions to the world of computer science!

Last Updated : **August 14, 2023**

Appendix P

Code for the Map Feature

```
<div class="map" id="map">
    <script>
        const key = '****************';
        const map = L.map('map').setView([49.2125578,
            16.62662018], 3); //starting position
        L.tileLayer(`https://api.maptiler.com/maps/streets-v2/{z
            }/{x}/{y}.png?key=${key}`,{
          tileSize: 512,
          zoomOffset: -1,
          minZoom: 1,
          attribution: "\u003ca href=\"https://www.maptiler.com/
              copyright/\" target=\"_blank\"\u003e\u0026copy;
              MapTiler\u003c/a\u003e \u003ca href=\"https://www.
              openstreetmap.org/copyright\" target=\"_blank\"\
              u003e\u0026copy; OpenStreetMap contributors\u003c/a
              \u003e",
          crossOrigin: true,
        }).addTo(map);

        <% pioneers.forEach(function(pioneer) { %>
        var marker = L.marker([<%= pioneer.latitude %>, <%=
            pioneer.longitude %>]).addTo(map);
        marker.bindPopup("<b><a>Name: <a/></b><a> <%= pioneer.
            name %></a><b><a href='/pioneer/<%= pioneer.name %>'>
             More Info</a></b>");
        <% }); %>
    </script>
</div>
```