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Master thesis

Developing an interactive visual tutorial for Citizen Science

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Developing an interactive visual tutorial for Citizen Science

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Statement of Authorship

Herewith I declare that I am the sole author of the submitted master's thesis entitled:

"Developing an interactive visual tutorial for Citizen Science."

I have fully referenced the ideas and work of others, whether published or unpublished. Literal or analogous citations are clearly marked as such.

Munich, 11.10.2023 Myrto-Panagiota, Bouloukou

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Abstract

The primary research objective of this study is to develop an interactive visual tutorial tailored to the preferences of citizen science enthusiasts. Our overarching goal was to identify the critical features of a visual tutorial that would resonate with the target audience. In addition, we recognize the enormous value of user feedback in refining the tutorial and optimizing its impactful elements. To achieve these goals, we took a multifaceted approach. Firstly, a comprehensive literature review, delving into the citizen science field and exploring interactivity's role in user experience (UX) design, was conducted. This was followed by an online survey focused on identifying user needs and preferences. With the data from these studies, we started developing a citizen science tutorial prototype. Finally, we held a focus group session to gain further insight into improving the tutorial. The findings shed light on the key factors influencing the effectiveness of the tutorial. Simplicity in task design and a well-structured approach emerged as key contributors to user understanding and engagement with the portal. Furthermore, while interactivity has the potential to enhance user engagement, our findings underline the importance of its sensible use. Excessive and redundant interactivity can inadvertently reduce user interest. Considering these findings, we propose a critical need for dedicated research in the area of UX design exclusively for tutorials. The identified gap in this area underscores the importance of delving deeper into the aspects of tutorial design, ultimately contributing to the further development of digital education.

Keywords: Citizen Science, UX design, Visual tutorial, Digital Education, Interactivity, User-Centered design, User Feedback

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List of Abbreviations

CS	Citizen Science
QnA	Questions and Answers

1. Introduction

1.1. Motivation and Problem Statement

Citizen science (CS) involves the broader public in the research procedure voluntarily, attempting to address real-world problems in ways such as "formulating research questions, conducting scientific experiments, collecting and analyzing data, interpreting results, making discoveries, developing technologies, and applications, and solving complex problems" (citizenscience.gov, n.d.). Overall, it is pretty challenging to narrow citizen science down to a single definition since it develops rapidly and has been defined by theoretical, geographical, practical, and societal approaches (Katrin Vohland, 2021). Nevertheless, it has been beneficial for all involved parties, such as the scientists and the users. On the one side, scientific knowledge can be advanced from the huge amount of data that is provided by the users, and on the other side, users can learn how to observe and collect data for scientific purposes (Rick Bonney, 2009).

Furthermore, in most citizen science projects, the research is usually done by amateur scientists or non-professionals collaborating with the scientific community. The challenges may occur due to the needs of the different people participating in the research. Some of them are how the information is communicated and shared, the goal of each participant in the research project, and the educational background of the users (Joseph Roche, 2020). The users' training and preparation for the tasks play a big part in the research and is mostly time-consuming for both the citizen scientists and the researchers. The person in charge of the study should wisely train the users based on specific requirements such as educational background, technology provided, and time limit.

Whereas there are several studies on how to design and develop an interactive citizen science project, there are few insights or research on creating tutorials on how users can interact with the citizen science platform. This thesis aims to effectively develop an interactive web-based tutorial for preparing citizen scientists for their tasks on a scientific project. For this research, influenced by existing citizen science portals, a fiction one will be created for the purpose of the thesis. The tutorial will aim to be simple and understandable for the users and, at the same time, train the users to succeed in their tasks for as little time as possible. Basically, the aim of the tutorial is to understand the extent to which users' involvement in a project has an impact on their engagement with it. Web apps are being preferred for citizen science projects due to the involvement choices and interactivity for the users (Katrin Vohland, 2021). Finally, a user study will be performed to assess the efficiency of the knowledge transfer and the impression of the users for the tutorial.

There is a lot of research and attention on Citizen Science and how to implement and design new projects. However, the perceived quality of citizen science data is one of the sharpest criticisms of citizen science (Alex de Sherbinin, 2021). On the other hand, the vast sampling effort created by many volunteers can act as an equalizer to unsystematic errors in data. It may be even more effective than smaller data sets collected by experts (Schmeller, 2009). Based on these outcomes, it

is presumed that the training of volunteers/amateur users is an integral part of the citizen science process and significantly affects the accuracy of the selected data. This research aims to fill this gap by combining existing knowledge to design an interactive tutorial that will try to encourage more users to use the tutorial and also participate in citizen science by providing as accurate results as possible.

For the purpose of the thesis, the tutorial had to be based on a citizen science portal. To avoid any copyright issues with existing citizen science portals, a fictional one was created. The idea to create the fictional citizen science portal "Urban Green Infrastructure" actually came from recognizing some pressing problems that our cities are facing today. Cities like Munich struggle with problems related to urban growth, so we need to ensure we are looking after the environment and maintaining our green spaces. As cities expand rapidly, it is important to get citizens involved in taking care of these green spaces. The inspiration behind this project comes from the belief that everyday people can make a significant difference in the environment. Our belief is that citizen science can be a powerful force for good, bringing people together to care for our environment. So, by building a customized platform to map and better understand Munich's green spaces, this research is not just adding to what we know about citizen science, it is tackling real problems facing our city. It is about promoting sustainability, engaging the community, and making our urban green spaces even better.

1.2. Related Work

Artemis Skarlatidou (2019) focuses on the interaction between users and computers within the citizen science framework. She explores the needs and requirements of the users, but also the common mistakes that are made on citizen science applications. In her research paper, she sets some design guidelines on developing citizen science applications that make the interaction more enjoyable.

Gareth W. Young's (2020) paper explores how diverse types of users perceive the different city dashboards. An evaluation study was conducted for four different city dashboards (case studies). The study participants were divided into three user categories: novice users, primary and secondary end-users, and advanced users. The main purpose of this paper was to redesign an existing city dashboard based on the feedback and consequently enhance the overall usability and utility of smart city technology.

K. Vohland et al. (2021) book approaches citizen science from various perspectives. Firstly, through a literature review, it explores citizen science and tries to find the best way to describe it. After, it focuses on the participants for citizen science and presents different case studies. Next, citizen science in practice is presented, where the design guidelines and types of platforms that are used for citizen science applications are analyzed. Finally, some final remarks regarding citizen science are presented.

Joseph Roche's (2020) paper shows the potential of citizen science for the volunteers who participate in it. The importance of the user being involved in the learning process is highlighted. Apart from that, some of the challenges of the citizen science process are being identified, which function as indicators for opportunities to develop solutions. Lastly, the author points out that inclusivity and accessibility should be essential for the implementation of the project.

Sung-Joo Choh (2002), in her paper, describes how her team developed an interactive web-based tutorial for teaching sandstone petrology. The tutorial was made to instruct high-school students in an interactive way. The main task is the classification of the folk sandstone, and the interface of the computers tries to mimic the microscope view. The tutorial aims to be used in similar cases when we must display much visual material, like remote sensing applications. The paper refers to the architecture of the tutorial but also the development steps of it.

Alphons J.M. Plasschaert (1997) paper discusses the effects of a multimedia interactive tutorial on learning problem-solving. Combining texts, videos, stills, and sound, an interactive tutorial was developed for the purpose of endodontic problem-solving. The main purpose of the research was to be compared with the traditional teaching method of written information. Students participating in the user study were separated into two learning groups, one group had to learn from written information, and the other from the interactive tutorial. It was revealed that the multimedia interactive tutorial can successfully replace the traditional learning method since there was no significant difference in performance between the two groups.

Christopher L. Aberson (2000), like Plasschaert, attempts to evaluate an interactive web tutorial as a teaching method. The tutorial intends to make students interact with it by drawing samples of the distribution of the mean for the mathematics field. A user study was conducted that involved 111 students. Each student could choose between attending the lecture, completing the tutorial, or doing both. The tutorial was found simple to utilize and comprehend.

Eric Jamet's (2016) article explores whether an interactive tutorial for learning how to use a web service can be refined by using visual cueing. Visual cueing is when different methods, such as color change, flashing, and sudden appearance, are used to point the user's attention in a specific direction. For the research, a user study was conducted that separated the users into two groups, one with cueing effects and the other without any cueing. Both groups were completing the tutorial in a self-paced environment. The study showed that tutorials with visual cueing reduced the time spent on the tutorial and improved the learning of verbal information.

Greg Newman's (2010) article targets how to teach citizen science skills online and what challenges exists. He points out that online training of the volunteers is crucial and necessary for improving the quality of the data from the citizen science project. For his study, static tutorials and multimedia tutorials are compared for tasks such as identification, measuring plots, and using GPS. Surprisingly, the study's outcome was that the online training was not more successful than

the traditional one. Nevertheless, it is suggested that static or interactive training should be combined with other methods for the best results.

1.3. Research Objectives and Questions

The primary objective of this thesis is to create an interactive web-based tutorial for everyday citizen science tasks like data collection and geographical analysis. The tutorial should be built with human-computer interaction standards in mind, and they should assist amateurs in gathering information for the portal. Moreover, this research will gather best practices from existing citizen science portals and will try to apply the best ones in this tutorial. During the course of this master's thesis, we will undertake an in-depth study of existing citizen science portals. This research will involve a diligent process of identifying and recording the most successful approaches and practices found within these platforms. We will then integrate these invaluable insights into the development of our tutorial, effectively absorbing the collective knowledge and insight of the citizen science community.

This research is limited to evaluating the design choices for interactive web-based tutorials, and it will not attempt to design or create guidelines for developing a citizen science project. Neither will generate new cartographic design principles regarding the user interface of the citizen science project. It will focus on better structuring an interactive visual tutorial by considering the users. The proposed research can contribute to the field of cartographic design, specifically UX/UI design, responsive design, and web mapping. This research will help cartographers, user interface designers, and storytellers to begin presenting their work effortlessly for amateurs to understand and interact with.

To be able to conduct this research, it will be divided into three main objectives to navigate the process.

Research Objective 1 (RO1): To identify the users' needs for an interactive visual tutorial.

For this objective, the design process should focus on the needs of the users and on the needs of the project itself.

Research Objective 2 (RO2): To develop a web-based tutorial based on RO1 for citizen science projects.

Based on existing tutorials used on successful citizen science projects, this objective will explore several types of tutorials and try to develop one based on a combination of best practices. It should be kept in mind that the user must interact with the tutorial.

Research Objective 3(RO3): To evaluate and analyze how the users perceived the tutorials and what can be improved.

For the third objective, a user study will be conducted that will focus on what the user thinks about the tutorial. By doing this, feedback will be gathered to identify areas for improvement for future research.

Towards achieving the objectives, three research questions were formulated.

Research Question 1 (RQ1): What differentiates a tutorial for CS than from a regular tutorial?

This question seeks to identify the characteristics that differentiate an interactive visual tutorial from conventional dashboards or portals. It looks at aspects such as narrative structure, user engagement, and other relevant aspects.

Research Question 2 (RQ2): What are the characteristics of a visual tutorial?

The research question aims to delineate the essential characteristics that define an effective visual tutorial. This includes elements contributing to its educational value, usability, and overall effectiveness in conveying complex information.

Research Question 3 (RQ3): How did the user group perceive the tutorial?

It aims to understand how the user group perceived the tutorial. By gathering user feedback through a focus group user study, RQ3 aims to gain deeper insights into users' experiences and attitudes towards the tutorial. The aim is to determine whether the tutorial met users' expectations and made a positive contribution to their learning and to identify areas where adjustments could be made to better meet users' needs.

The central hypothesis of this study is that user preferences for tutorial design, including decisions about multimedia elements and interactivity, have a significant impact on perceived effectiveness and user satisfaction with citizen science tutorials. As the development of effective educational resources in the digital age takes center stage, understanding how users' design preferences shape their learning experiences is paramount. This hypothesis is inextricably linked to the broader investigation of the effectiveness of visual tutorials in the context of citizen science, a domain where active participation and engagement are essential. It also highlights the importance of user feedback as a key element in the iterative improvement of these tutorials. By exploring the complex interplay between user preferences, tutorial design, feedback mechanisms and perceived

effectiveness of citizen science tutorials, this study seeks to shed light on the dynamic relationship between instructional design and user satisfaction in digital education.

1.4. Thesis Structure

The dissertation is divided into 6 chapters.

Chapter 1 introduces the research by outlining the motivation and problem statement, setting clear research objectives, and defining research questions to provide a solid foundation for the study.

Chapter 2 delves into the literature review, starting with an overview of citizen science portals and interactivity. It explores the various levels of citizen science and examines different citizen science platforms. In addition, this chapter examines interactive visual tutorials, providing insights into interactivity, user experience and user engagement, and laying the theoretical foundation for the study.

Chapter 3 elaborates on the chosen research methodology, providing a detailed explanation of the approach adopted to achieve the aims of the thesis, while acknowledging any limitations inherent in the research process.

Chapter 4 provides a brief introduction to the purpose of the case study. It describes in detail the applications used to develop the interactive visual tutorials and provides insights into the online survey and focus group user study, providing a comprehensive overview of the research methodology.

Chapter 5 critically examines the user study results and provides a thorough discussion of the evaluations and findings from the study, which form a critical part of the research findings.

Chapter 6 serves as the concluding chapter, summarizing the key findings and providing an outlook for future research endeavors, thus bringing the thesis to a thoughtful and forward-looking conclusion.

2. Theoretical Background and Related Work

2.1. Citizen Science

Many large-scale research projects required a considerable amount of collected data across a variety of places over spans of years. The collection of data can be achieved through citizen science platforms (Bonney et al., 2009). According to European Union, Citizen Science is where the public becomes included in the scientific process by being the user and provider of the data (Haklay et al., 2021). Basically, the citizens can overtake multiple tasks for the scientific research, such as collecting and reporting observed data, reading about project outcomes, displaying data using Web-based graphs and maps, and analyzing data (Bonney et al., 2009).

Citizen Science holds significance due to distinct reasons. Firstly, it can assist in tackling intricate research questions that would be challenging or unfeasible to resolve through conventional scientific approaches. For example, the involvement of citizens can help researchers to collect more data over a wider geographical area than they would be able to do on their own. Secondly, it can encourage and enable citizens to take part in scientific research and contribute to the creation of new knowledge. Thirdly, it can enhance public comprehension of science and augment scientific literacy. Fourthly, it can endorse environmental and social equity by engaging communities in research that impacts their lives. Lastly, it can offer prospects for interdisciplinary collaboration and innovation (Pettibone et al., 2016).

General, citizen science can help bridge the gap between scientists and the public, while generating valuable scientific data and offering several benefits. These benefits include the ability to inspire new research topics by incorporating fresh ideas, questions, methods, and societal knowledge. Citizen science also generates large datasets that can be used for a variety of purposes and allows for a variety of evaluation capabilities, including photos, scans, and video sequences. In addition, citizen science verifies the practical relevance and applicability of scientific results.

From a societal perspective, citizen science can increase public acceptance of research results, promote general evaluation of research, and generate and communicate socially relevant research topics. Citizen science also allows for the co-creation of transparent research and enables society to take ownership of research. Overall, citizen science can foster collaboration between scientists and the public, promote public engagement with science, and generate valuable data (Pettibone et al., 2016).

2.1.1. Levels of Citizen Science

According to the article "Towards a global participatory platform: democratizing open data, complexity science, and collective intelligence", there are four levels of participation and engagement in citizen science activities (Buckingham Shum et al., 2012):

1. Contributory ("Crowdsourcing"): Participants provide data to a project, but do not typically engage in other aspects of the project.
2. Collaborative ("Distributed Intelligence"): Participants not only provide data, but also engage in other aspects of the project, such as project design or analysis.
3. Co-created ("Participatory Science"): Participants are involved in all aspects of the project, from design to implementation to analysis.
4. Collegial ("Extreme Citizen Science"): Participants are equal partners with professional scientists in all aspects of the project and may even lead the project themselves.

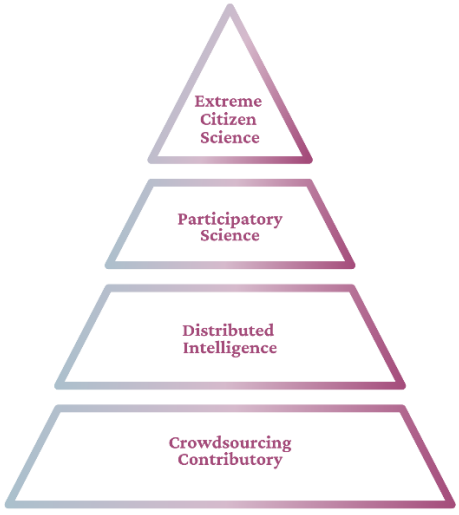

Figure 1: Levels of Citizen Science participation

These levels of participation and engagement are intended to highlight the power relationships that exist between professional scientists and the broader public in citizen science projects. Furthermore, this framework can be helpful for researchers and practitioners who are interested in designing and implementing citizen science projects that are more inclusive and participatory.

2.1.2. Examples of Citizen Science platforms

There are a large number of citizen science platforms in Europe, which can be categorized into five different types (Liu et al., 2021). These types of citizen science platforms are analyzed below:

Type 1: Initiatives for Commercial Platforms for Citizen Science.

Customers can use commercial platforms' services for a fee. For the purpose of facilitating a bilateral market exchange, these platforms frequently bring together a willing buyer and seller. To support citizen science initiatives, these platforms provide a variety of services, including data collection, analysis, and visualization. In contrast, other platforms either provide their services for

free or just enough to cover their costs. It is important to remember that commercial platforms offer their services for profit.

SPOTTERON is an interactive platform for citizen science that enables users to actively participate in scientific research by sharing their observations and data. By utilizing SPOTTERON, individuals can significantly advance environmental and social research while fostering a collaborative approach to solving global problems.

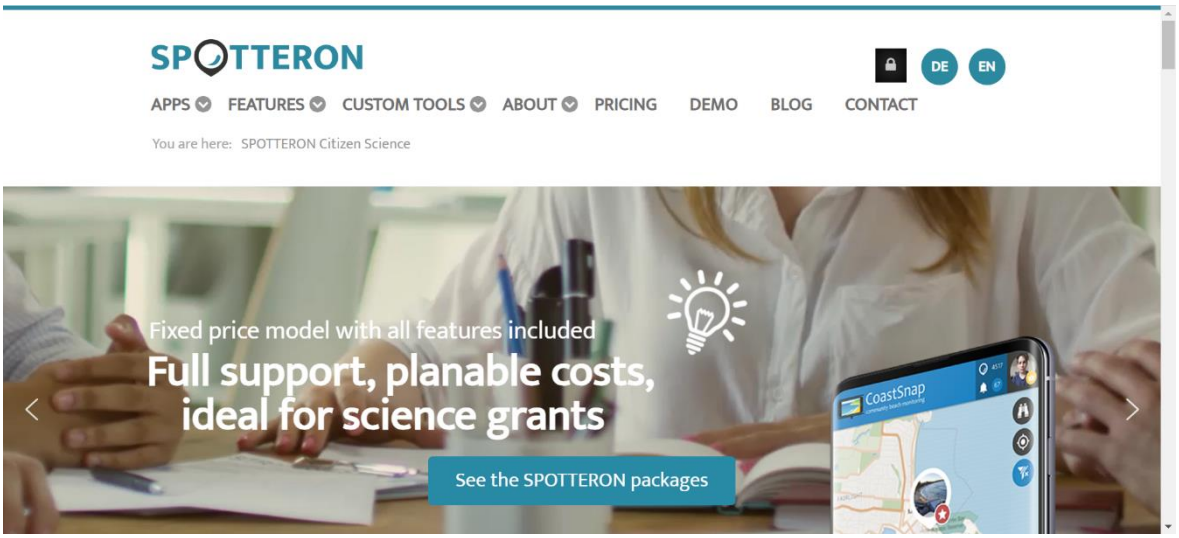

Figure 2: SPOTTERON website screenshot 2023 (https://www.spotteron.net/)

CitizenLab is a robust citizen science platform that enables people to actively shape their communities. It makes it easier to gather insightful opinions and feedback from citizens thanks to its user-friendly interface and a variety of engagement tools. By encouraging teamwork, it empowers communities to jointly develop solutions and make wise choices that successfully tackle regional problems.

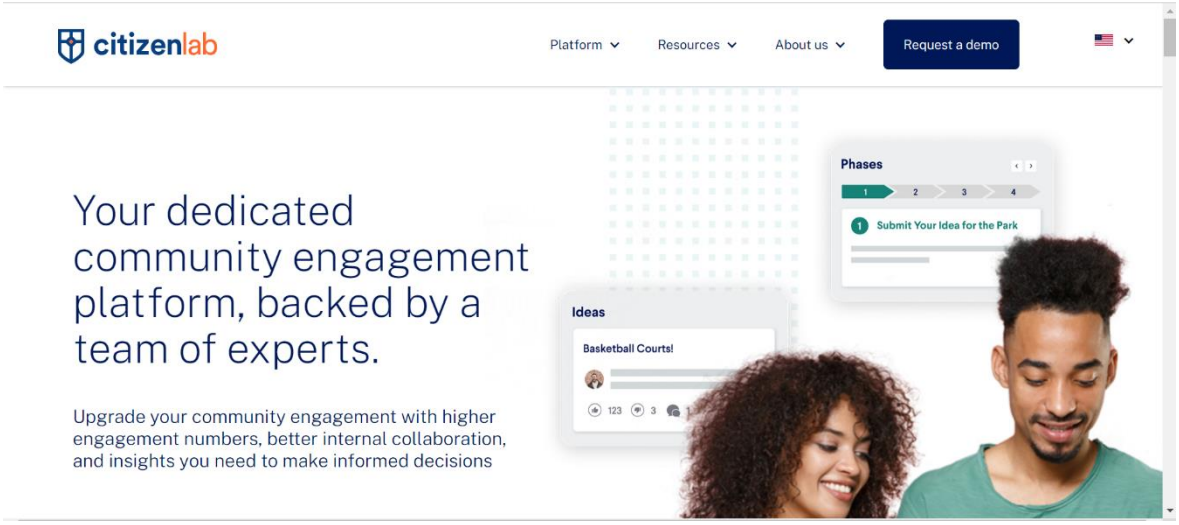

Figure 3: CitizenLab website screenshot 2023 (https://www.citizenlab.co/)

Type 2: Citizen Science Project-Specific Platforms.

A specific citizen science initiative is supported by citizen science platforms for particular projects. These platforms are frequently created by the project team and are customized to the requirements of the project. These platforms offer participants opportunities to interact with the project team and other participants, as well as tools for data collection, management, and analysis. These platforms' potential inability to last past the project's lifespan presents one of their difficulties.

The platform *iNaturalist* allows users to observe and document biodiversity. Users can add their observations of plants, animals, and other organisms to global databases used for research and conservation by recording and sharing their findings.

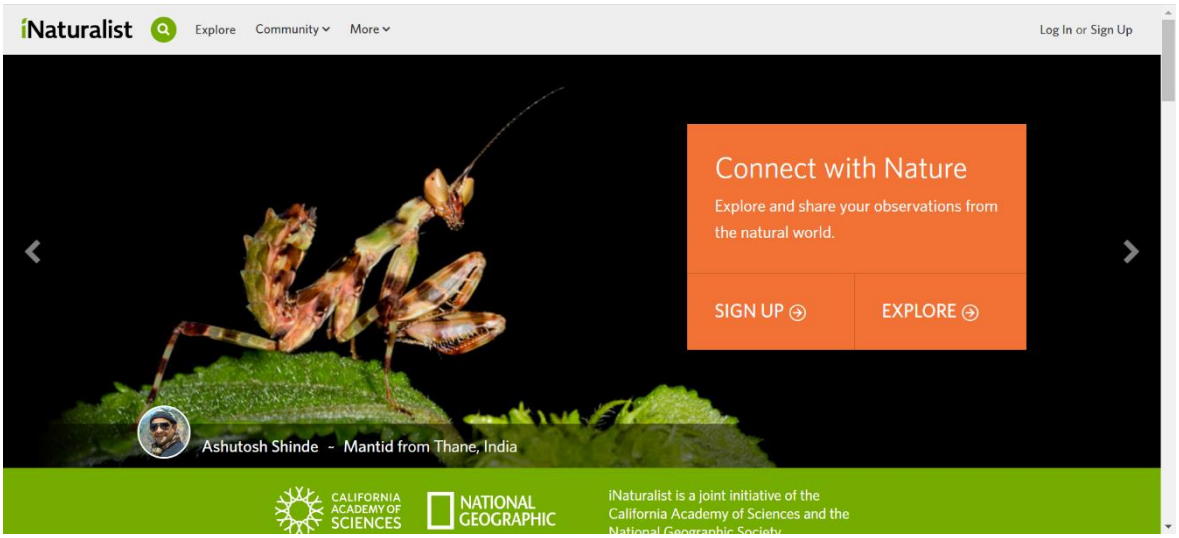

Figure 4: iNaturalist website screenshot 2023 (https://www.inaturalist.org/)

A citizen science platform devoted to bird observation and data gathering is called *eBird*. It makes it possible for birdwatchers to log their observations, track species, and support global bird conservation efforts.

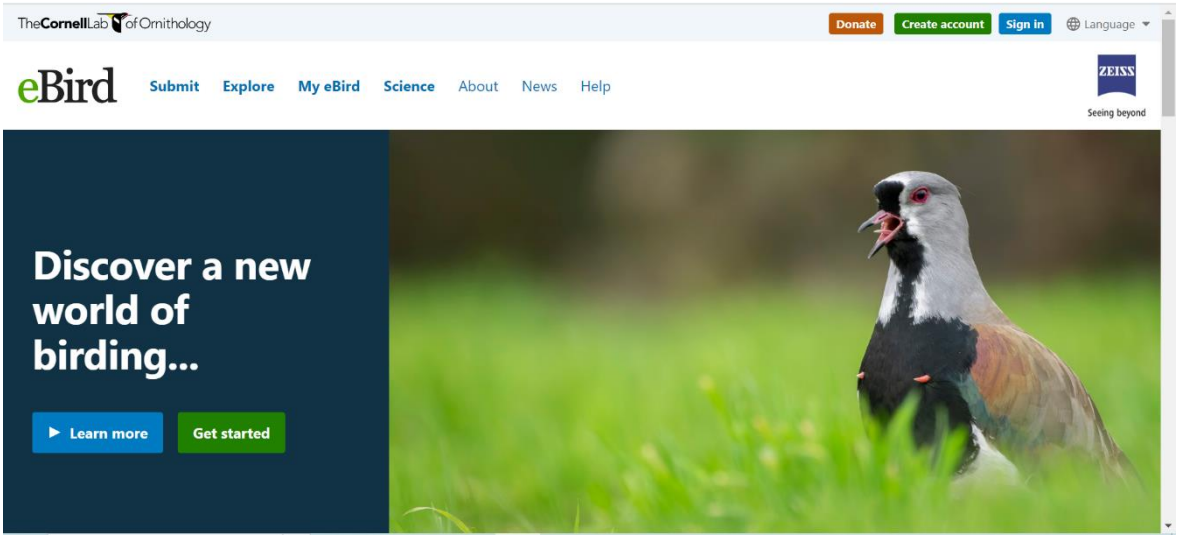

Figure 5: eBird website screenshot 2023 (https://ebird.org/home)

Type 3: Platforms for Citizen Science on Particular Scientific Topics.

Platforms for citizen science focused on particular areas of science are created to aid initiatives for citizen science centered around those areas of science. These platforms frequently give users access to tools and resources for data collection, management, and analysis as well as chances to interact with the scientific community. These platforms have been effective at drawing many people into scientific research and have aided in a number of scientific discoveries.

Zooniverse is one of the largest and most well-known citizen science platforms. It hosts a variety of projects from different scientific fields and lets volunteers participate in research by categorizing images, transcribing texts, or doing data analysis.

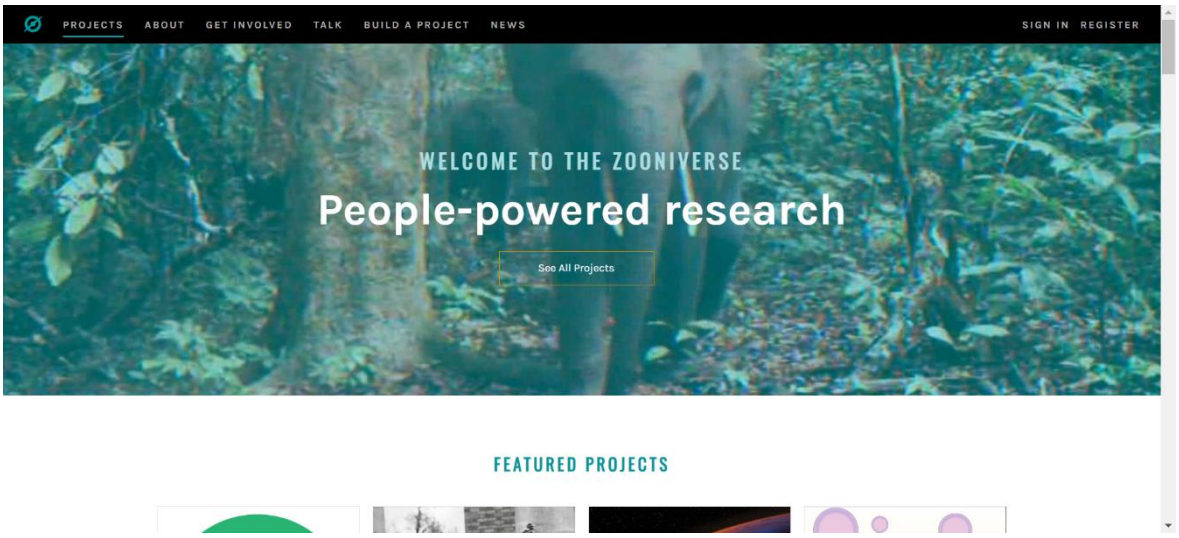

Figure 6: Zooniverse website screenshot 2023 (https://www.zooniverse.org/)

Foldit is an innovative citizen science initiative that makes protein folding fun. To assist researchers in discovering novel configurations and potential drug targets, participants are asked to manipulate protein structures.

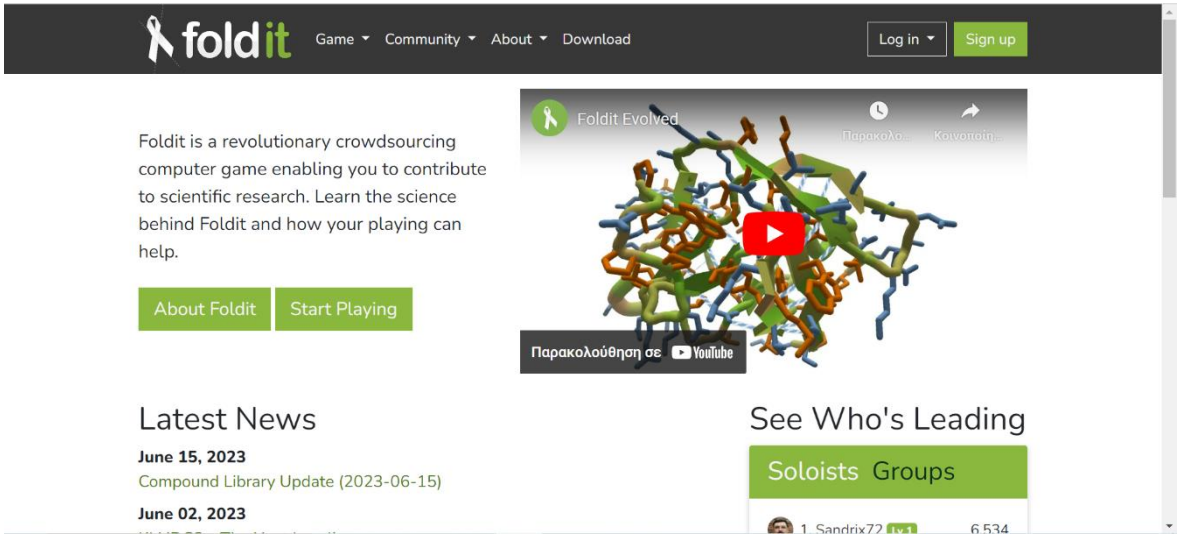

Figure 7: Foldit website screenshot 2023 (https://fold.it/)

Type 4: National Citizen Science Platforms.

With the goal of highlighting the diversity of citizen science projects in the respective countries, various stakeholders are developing national citizen science platforms. These websites act as a clearinghouse for information and activities related to citizen science, and they frequently allow interested people to locate and engage with citizen science projects. These platforms have the potential to increase the visibility and accessibility of science for curious citizens while also giving local, regional, and federal authorities access to the crucial data and information they require on critical issues.

Sensor.Community is a national citizen science platform in Germany that focuses on air quality and noise monitoring and provides a central hub for citizen science activities and information. It provides communities with the tools they need to actively participate in the fight against air pollution and effect positive change by allowing individuals to build their own low-cost air quality sensors and contribute data to a centralized database. It used to be called *Luftdaten.info* and focused only on Germany, but now it is for the entire world.

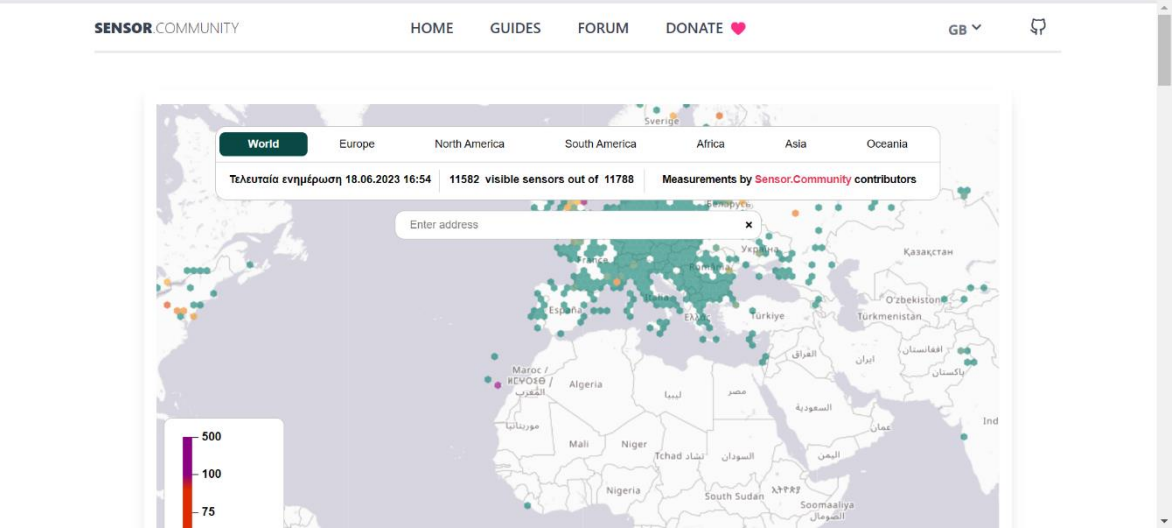

Figure 8: Sensor.Community website screenshot 2023 (https://sensor.community/en/)

Citizen Science Hub is a national citizen science platform in the UK that provides a central hub for citizen science activities and information, as well as opportunities for participants to engage with the scientific community. The platform connects participants and researchers from all over the world and acts as a focal point for citizen science initiatives. It fosters a vibrant and welcoming community of citizen scientists by enabling the seamless exchange of knowledge, data, and experiences.

Figure 9: Citizen Science Hub website screenshot 2023 (https://www.britishecologicalsociety.org/learning-and-resources/engaging-the-public/citizen-science-hub/)

Type 5: Platforms for EU citizen science.

Platforms for EU citizen science are created to assist European citizen science projects. These platforms serve as a focal point for citizen science initiatives.

WeObserve is an innovative platform for citizen science that encourages active involvement in environmental research and monitoring. It empowers people to contribute their observations and data, resulting in significant ecological change by offering easily accessible tools, materials, and a welcoming community.

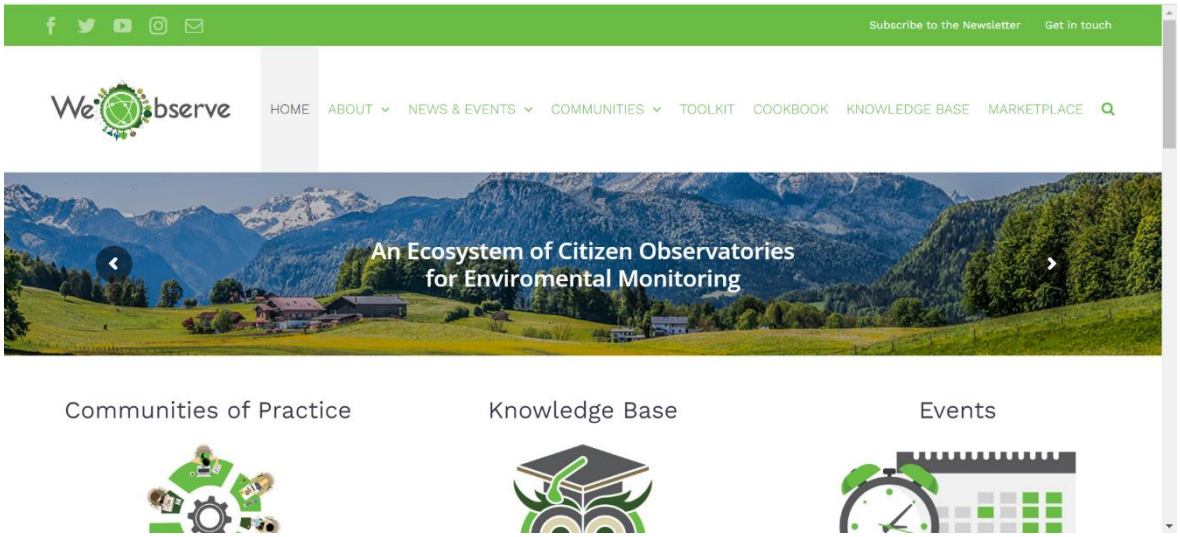

Figure 10: WeObserve website screenshot 2023 (https://www.weobserve.eu/)

D-NOSES is an innovative citizen science platform focused on odor pollution. It enables a collaborative approach to address odor-related challenges and advance environmental justice by involving local communities in data collection and mapping.

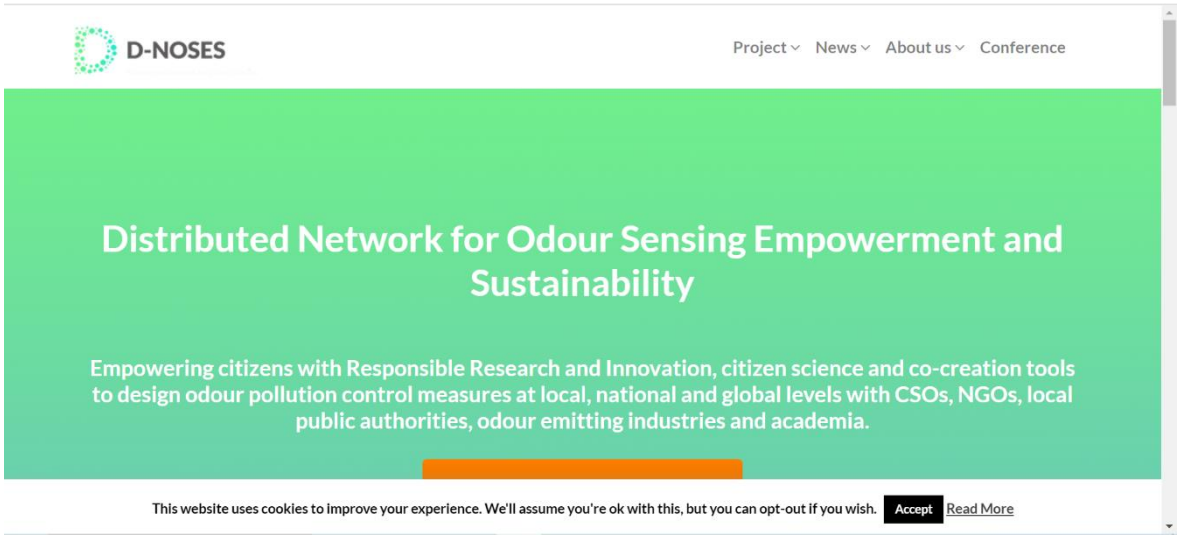

Figure 11: D-NOSES website screenshot 2023 (https://dnoses.eu/)

Apart from the literature sources, the gap in interactive tutorials can be understood from the citizen science tutorial mentioned above. Most of them lack a proper training phase for their participants and usually have a QnA section that the user must find by himself (not so easy for

people without technical efficiency). Moreover, most of the tutorials contain a lot of text and images that are static and can make users lazy to read them. This can have drawbacks such as users not really being trained, skipping the tutorial, and adding data to the forum, thinking they are correct, but lowering the quality and accuracy of the data collected.

For example, iNaturalist website includes several video tutorials alongside the theoretical questions based on the theme of the project. Each video answers a specific question/step of data collection. On the other hand, the Foldit citizen science project is basically a game, but the tutorial doesn't have any interactive elements at all, as it follows the structure of a wiki page with written information for the user to explore.

Considering these categories, our portal will fall into type 2 for project-specific Citizen Science platforms, as it would be exclusive to Munich and would focus on the sustainability of the area and how we can improve the quality and quantity of green spaces.

2.2. Interactive Visual Tutorials

2.2.1.Interactivity

Interaction, as discussed in the paper "What is interaction? (Hornbæk & Oulasvirta, 2017)", refers to the relationship and exchange between humans and computers in the context of human-computer interaction (HCI). According to the paper's authors, the term 'interaction' is both field-defining and surprisingly confusing. While there have been few direct attempts to define interaction, there are distinct and advanced concepts of interaction available in the literature. These concepts include views of interaction as dialogue, transmission, optimal behavior, embodiment, and tool use. Each of these concepts has its own scope and its own understanding of the causal relationships between human beings and computers. For empirical studies and design in the field of HCI, understanding and defining interaction is crucial.

There are four different perspectives on human-computer interaction (Kammersgaard, 1988). These perspectives are:

1. *The systems perspective:* It focuses on the technical elements of the computer system and how it interacts with the user. It includes the hardware, software and network infrastructure that facilitate the interaction. In the systems perspective, it is essential to understand the underlying technology and its influence on the user experience. It is an examination of the system architecture, performance, reliability, and compatibility in order to ensure a seamless and effective interaction.

2. *The dialogue partner perspective:* This perspective looks at the interaction between the user and the computer system as a conversation or a dialogue. It emphasizes the need for effective communication and understanding between the user and the system. Factors

such as natural language processing, user feedback and system responsiveness are considered in the dialogue partner perspective. The aim is to create a more intuitive and human-like interaction experience, in which the computer system can understand the user's input and respond to it appropriately.

3. *The tool perspective:* This perspective treats the computer as a tool that can be used by the user to conduct tasks and achieve goals. It focuses on the usability and functionality of the computer system. The tool perspective considers aspects such as ease of use, efficiency, learnability, and user satisfaction. The aim is the design of interfaces and interactions that are intuitive, efficient, and supportive of the user's workflow. User-centered design methods and usability testing are often used to ensure that the computer system serves as an effective tool for users.

4. *The media perspective:* This is a perspective that sees the computer as a medium through which information is presented and communicated. It considers how different media formats such as text, images, audio, and video affect the user's interaction experience. The media perspective has an emphasis on visual and auditory design, multimedia integration and information presentation. The goal is to use different media elements to effectively communicate information and to create engaging and immersive experiences.

These four perspectives offer different viewpoints that researchers, designers, and users can adopt to understand and approach human-computer interaction. By considering multiple perspectives, one can gain a more comprehensive understanding of the complexities and intricacies involved in the design and use of computer systems.

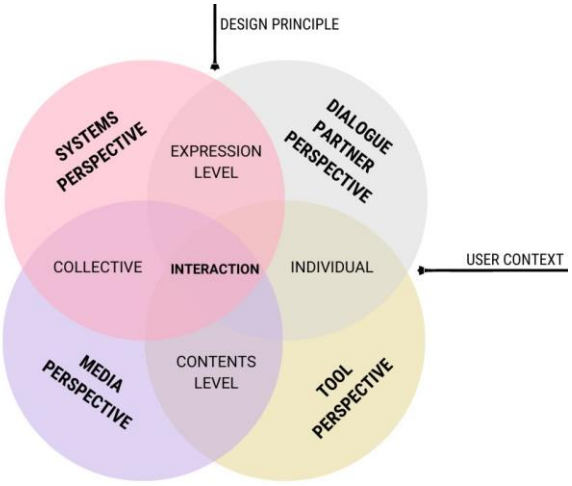

Figure 12: Venn diagram for the four perspectives of interaction

By applying multiple perspectives, the design of computer applications can be improved in several ways. Here are a few examples (Kammersgaard, 1988):

- System and dialogue partner perspectives: By considering both the systems and human-interface perspectives, designers can create computer applications that not only function effectively, but also provide a seamless and intuitive user experience. Understanding the technical aspects of the system (system perspective) ensures that the application is dependable, efficient and compatible. At the same time, considering the human-computer interaction perspective allows designers to focus on effective communication, natural language processing, and system responsiveness, resulting in a more user-friendly and conversational interface.

- Tool and media perspectives: Integrating the tool and media perspectives can lead to the development of visually appealing and engaging computer applications. The tool perspective emphasizes usability and functionality, ensuring that the application serves as an effective tool for users to accomplish their tasks. By incorporating the media perspective, designers can use different media formats (text, images, audio, video) to present information in a compelling and immersive way. This combination enhances the user's interaction experience and facilitates effective information communication.

- Systems and media perspectives: Considering both the systems and media perspectives can result in computer applications that are not only technically robust, but also visually appealing and media rich. The systems perspective ensures that the application is well designed, performs optimally and is compatible with different hardware and software components. At the same time, the media perspective allows designers to use other media formats to present information in an engaging and visually appealing way. This combination creates a seamless integration of technology and media, enhancing the overall user experience.

Interactivity is vital in user experience design because it can have a significant impact on users' judgement, impact and overall satisfaction with a website or application (Hart et al., 2013). When users are able to take an active part in a website through the use of interactive features, it creates a sense of involvement and empowerment. Feeling empowered can lead to more positive website evaluations and increased satisfaction. Interactive elements can also make a website more visually appealing and memorable. They can capture users' attention and make the site more engaging and immersive. This can contribute to a more enjoyable and positive user experience.

In addition, interactivity can improve the usability and functionality of a website. Interactive elements can make it easier for users to navigate, find information and complete tasks. For example, interactive forms with real-time validation or auto-fill suggestions can make the process of filling out a form more user friendly and efficient. Interactivity can also encourage user participation and engagement with site content. Gamification elements such as badges, progress bars or rewards can motivate users to interact with the site and complete tasks. Social media integration can also encourage user interaction and sharing of website content. To summarize, interactivity is essential in UX design because it can enhance users' judgement, affect and overall satisfaction with a website or application. A website can become more visually appealing,

engaging, and memorable through the use of interactive elements. They can also have an impact on usability, functionality, user participation and user engagement.

Based on different websites ('UX Design', 2022). There are several interactive styles that are commonly used in web design to increase user engagement and interactivity. Here are some examples:

1. *Animated elements:* Adding animation to elements such as buttons, icons or images can make them more visually appealing and interactive. Animations can include hover effects, transitions, or micro-interactions that respond to user actions.

2. *Interactive menus and navigation:* Implementing interactive menus and navigation systems can enhance the user experience. This can include drop-down menus, mega menus or hamburger menus that expand to reveal additional options.

3. *Sliders and carousels:* Sliders and carousels allow users to interact with content by scrolling or swiping through images, videos, or other media. This can be useful for presenting multiple pieces of content in a limited space.

4. *Interactive forms:* Incorporating interactive elements into forms, such as real-time validation, auto-fill suggestions, or progress indicators, can make the form filling process more engaging and user-friendly.

5. *Interactive maps:* Integrating interactive maps with features such as zooming, panning and markers can provide users with an interactive and immersive experience, especially for location-based sites or services.

6. *Social media integration:* Including social media sharing buttons or live feeds from social platforms can encourage user interaction and engagement with site content.

7. *Interactive storytelling:* Using interactive elements such as parallax scrolling, interactive timelines or interactive infographics can create a more engaging and immersive storytelling experience for users.

8. *Gamification elements:* Incorporating game-like elements such as badges, progress bars or rewards can make the site more interactive and encourage user participation and engagement.

These are just a few examples of the types of interactive styles that can be used on a web site. Choosing which interactive styles to use should be based on the specific goals, audience, and content of the website. When implementing interactive elements on a website, it is important to consider usability, user preferences and the overall user experience.

2.2.2. User Experience design (UX)

User Engaging (UE) and User Experiencing (UX) are closely related terms (O'Brien & Toms, 2008). UE refers to how people are attracted to use interactive products and explains how and why applications engage users within a session, making the interaction exciting and enjoyable. UX, on the other hand, includes UE but is broader in scope, covering why people adopt and continue to use a particular design over many sessions and even years. In other words, UE focuses on the short-term experience during the interaction, while UX considers the longer-term experience and the factors that influence users' adoption and continued use of a design.

Users are critical to the design of a product because they are the ones who will ultimately interact with and use the product (Sutcliffe, 2016). Designing with users in mind ensures that the product meets their needs, preferences, and expectations, leading to a more prosperous and satisfying user experience. Here are some reasons why users are important for design:

- User-centered design: Designing with users in mind follows the principle of user-centered design, which emphasizes the involvement of users throughout the design process. By understanding users' goals, tasks and preferences, designers can create products that are intuitive, easy to use and effectively meet users' needs.

- Meeting user needs: Users have specific needs and requirements that a product should fulfil. By conducting user research and gathering feedback, designers can gain insight into what users expect from the product. This information helps to design features, functionality and interfaces that meet user needs, increasing the chances of user satisfaction and adoption.

- Improve the user experience: User experience (UX) plays an essential role in the success of a product. By considering users' perceptions, emotions and interactions with the product, designers can create a positive and engaging user experience. This includes factors such as usability, aesthetics, interactivity, and overall satisfaction.

- Differentiation from competitors: In a competitive market, the user experience can be a unique selling point for a product. By focusing on creating an exceptional user experience, designers can differentiate their product from competitors and attract more users.

In summary, involving users in the design process and considering their needs and preferences will result in a product that is easier to use, meets user expectations and provides a positive user experience. Ultimately, designing with users in mind increases the chances of product success and user satisfaction.

The book chapter "Design for User Experience and Engagement" by (Sutcliffe, 2016) presents illustrations of effective user engagement design in the context of art galleries. A comparative experimental study was conducted on three websites evaluating their interactive features such as interactive guides, animations, and 3D effects. The study aimed to assess the impact of these design features on the user experience, and the results showed that the features implemented did indeed improve the overall user experience.

Although the three websites shared the same domain of art galleries, they differed in terms of their interactive features. For example, egocentric navigation positioned the user's perspective within the interactive environment, while animated pop-ups extended the conventional mouseover effect by incorporating scripted animations triggered by mouse actions. Hypermedia navigation, on the other hand, adhered to the basic principles of web-based interaction.

In conclusion, the key to successful user engagement design is to develop interactive products that are not only user-friendly, but also engaging and entertaining. This can be achieved by integrating an understanding of user psychology into the design process and by experimenting with different interactive features to determine the most effective approaches for the target audience.

2.2.3. Examples of Interactive Visual Tutorials

Interactive visual tutorials are a valuable tool for increasing learner engagement and facilitating understanding of complex topics. This chapter presents the following examples of such tutorials:

- **Codeacademy**

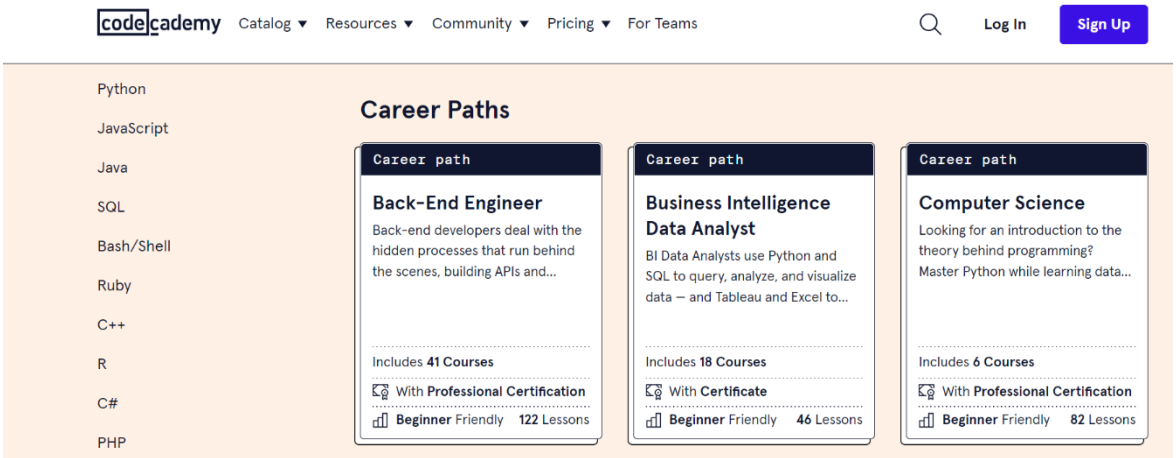

Figure 13: Codeacademy tutorial, screenshot 2023(https://www.codecademy.com/catalog/all)

Codecademy provides a dynamic learning environment characterized by interactive coding tutorials. These tutorials feature a live coding interface that allows learners to actively participate

in the learning process by writing and executing code in real time. The platform also provides instant feedback and helpful hints to help users master programming languages such as Python, JavaScript and more. Each tutorial is about a specific programming language. The tutorial is being divided based on the career path that an individual is interested in. That way it is easier for the user to decide which tutorial is more beneficial for him.

- **Khan Academy**

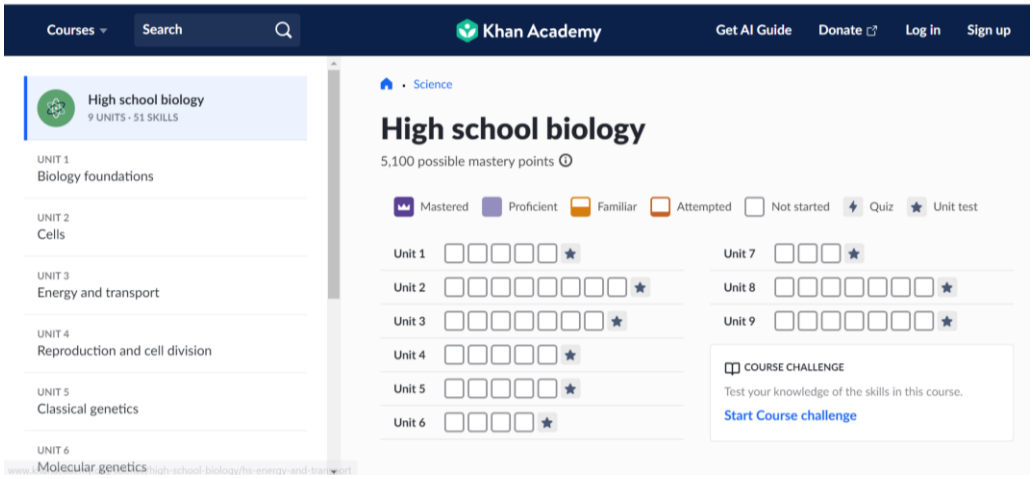

Figure 14: Khan Academy, screenshot 2023 (https://www.khanacademy.org/science/high-school-biology)

Khan Academy offers a wide range of interactive tutorials in subjects such as mathematics, science, and computer programming. These tutorials use a pedagogical approach that integrates step-by-step visual explanations and interactive exercises to promote a comprehensive understanding of the subject matter. Each tutorial is for a specific grade on a specific subject and then it is divided on units to make it more structured for the student.

- **Duolingo**

Figure 15: Duolingo tutorial, screenshot 2023(https://blog.duolingo.com/duolingo-101-how-to-learn-a-language-on-duolingo/)

Duolingo is emerging as a prominent language learning application that uses interactive visual tutorials to facilitate the acquisition of new languages. Users engage in language practice in multiple areas, including speaking, listening, reading, and writing, through gamified lessons and interactive exercises that are thoughtfully designed to promote proficiency. Duolingo is a notable example for gamified elements because it implements a dashboard with users points until today, you get free prizes if you do well and there are also quests between friends.

- **Brilliant**

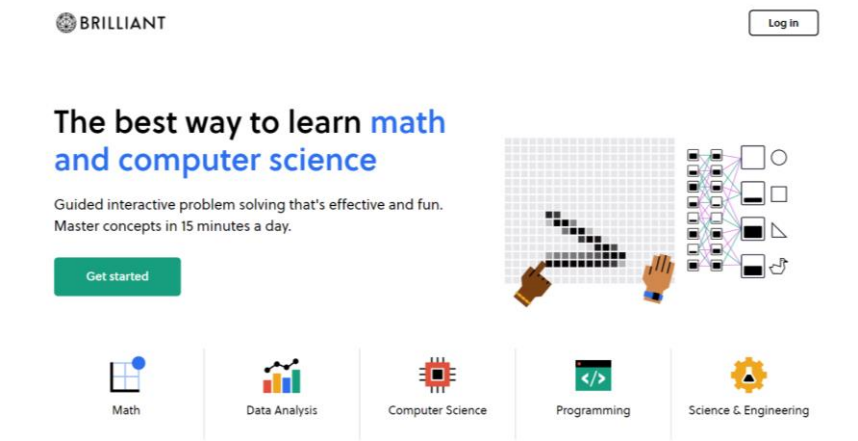

Figure 16: Brilliant tutorial, screenshot 2023(https://brilliant.org/)

Brilliant is characterized by the provision of interactive visual tutorials covering areas such as math, science, and engineering. These tutorials allow users to explore complex concepts using interactive diagrams, simulations, and direct exercises. The platform actively cultivates problem solving and critical thinking skills through guided courses.

- **Adobe Creative Cloud Tutorials**

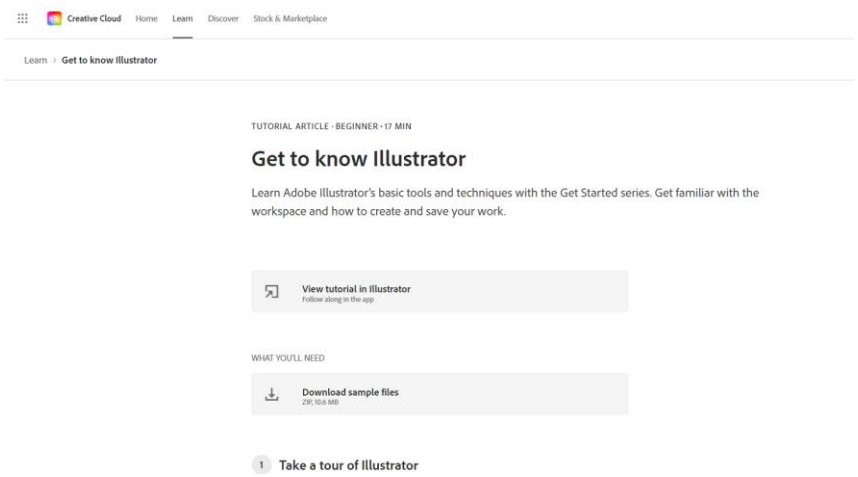

Figure 17: Adobe Creative Studio Tutorial, screenshot 2023(https://creativecloud.adobe.com/learn/illustrator)

Adobe is adding interactive visual tutorials to its suite of software products, including Photoshop, Illustrator and Premiere Pro. These tutorials include comprehensive step-by-step instructions, video demonstrations, and interactive features to help users become more proficient in using these software tools. The tutorial is accessible through a page in the menu of Adobe Creative Cloud website.

Taken together, these examples of interactive visual tutorials cater to a wide range of learner interests and preferences, making knowledge acquisition and skill development a more accessible and enriching endeavor.

3. Methodology

3.1. Introduction

The methodology chapter serves as the methodological backbone of this study. It provides a clear plan for how we approach our investigation. Its primary purpose is to explain the methodological choices that underpin our study, to explain their appropriateness in the context of our research questions, and to provide the reader with a guide to the chapters that follow. In this chapter, we will delve into the details of our choice of research methods, the justification for their selection and an overview of the structure of this research.

3.2. Research design

The research design of this study is a mixture of quantitative and qualitative methods. This design has been carefully chosen to suit our research questions and objectives. The quantitative component allows us to collect structured data, facilitating statistical analysis to uncover patterns and correlations within the dataset. Meanwhile, the qualitative component allows us to delve into the rich layers of participants' experiences and perceptions, providing a deeper understanding of the phenomenon. This integration of methods serves as an optimal strategy to comprehensively address our research objectives by triangulating various sources of evidence.

Our research is driven by three fundamental questions: (1) What differentiates a tutorial for CS from a regular tutorial? (2) What are the characteristics of a visual tutorial? (3) How did the user group perceive the tutorial? These questions serve as the pillars of our research and guide our exploration of how to develop an interactive web tutorial for Citizen Science projects. To address these research questions, we will use different approaches, combining online survey and focus group interviews. These approaches allow us to collect both quantitative and qualitative data, facilitating a holistic exploration of online interactive tutorials for Citizen Science.

For the first research question, the approach taken included a literature review and an online survey. For the literature review part, Citizen Science was further explored by combining different literature sources on interactive tutorials and citizen science portals. Basically, we tried to understand the level of participation in CS, the distinct types of CS portals and to gather a good amount of related work from previous research projects. The online survey was conducted based on the results of the literature review. The results of the survey will serve as a basis for refining our tutorial approach and tailoring it to better meet the needs of users.

To address the second research question, our research focused on human-computer interaction and what are the essential components of a visual tutorial. By combining the results of the online survey and the research, a prototype design of the tutorial was created using ArcGIS products. Basically, we created a map-based citizen science portal, and we embedded the interactive tutorial

on it. For the third question we focus on the evaluation of the master thesis product. For this purpose, a focus group was held with a small group of people interested in citizen science portals. The participants could express their opinion on the result of the tutorial while exploring it. We tried to explore usability, navigation, design, content, and overall user experience of the interactive tutorial with the use of open-ended questions.

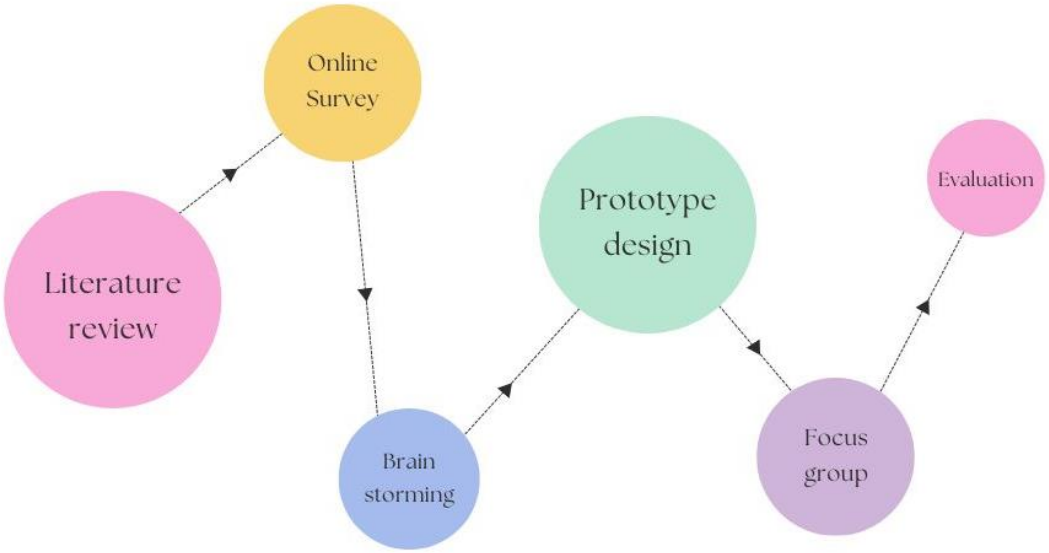

Figure 18: Methodology flowchart

3.3. Limitations

Although we chose to use a mix of numbers and stories in our research, there are some drawbacks that we need to be aware of. One limitation is that because we are using both numbers and ideas, our interpretations may be influenced by subjective opinions, even though we tried our best to remain objective. The research had some limitations that might make it difficult to say that our findings apply to everyone. Firstly, we could not include as many people as we would have liked in the online survey part of our study and the focus groups, because it was difficult to find so many participants. This means that the conclusions we draw may not apply to a larger group.

During our research we encountered some unexpected problems for which we had not planned. This type of research can be quite time-consuming, which may be difficult for students with limited time and resources. One big problem was that everything took longer than we thought because of not having an adequate number of online surveys replies as we mentioned before but also not being able to gather proper literature sources related to the research objectives. This threw our research schedule out of plan. We had to make some changes on the methods chosen to handle this research and formulate the research objectives according to that. This made the research

process take a bit longer than we originally thought. But despite these challenges, we stayed focused on doing good research and making sure our study was conducted ethically and carefully.

4. Case Study

4.1. Introduction

As mentioned in the previous chapters, this thesis is about building an interactive visual tutorial for citizen science. To make this more realistic and to deal with real websites, it is better to be addressed on an existing portal. For the purpose of the research, we created a fictional portal and embedded the tutorial into it. We did not choose an existing portal because of copywriting issues. Apart from that, by designing it myself, I was able to systematically check certain aspects and have freedom to make design choices. The name of the CS portal is "Urban Green Infrastructure Project" and focus on urban green spaces in Munich. The reason for this decision is that polygon shapes (such as green spaces) are usually easier and more understandable to locate on a map than lines or points (roads/trees). It is also in line with sustainability, which is crucial to reducing the impact of climate change.

The focus of the portal is to map green infrastructure in Munich area, which in our case includes the following three categories: urban forests, green roofs, and community gardens. As a user/visitor to the platform, you will have the opportunity to venture out into your local neighborhood, armed with a sense of purpose and simple data collection tools. Once you have done this, you will enter the data into the portal. Through the efforts of users, we will collect valuable information on the location, size, and health of green spaces, providing essential insights for urban planning, biodiversity conservation and climate adaptation strategies.

4.2. Online survey

4.2.1. Introduction

In the dynamic field of digital education and interactive content, it is vital to gain an in-depth understanding of user preferences and valuable insights into the effectiveness of educational materials. To address this need, it was decided to use online survey as a strategic research tool in this chapter. In a world where technology continues to shape the contours of how we engage with information and acquire knowledge, interactive visual tutorials have emerged as an influential educational resource. These tutorials are meticulously designed not only to disseminate knowledge, but also to create immersive and engaging learning experiences. However, the effectiveness of these tutorials depends on the depth of insight we have into the needs, expectations, and preferences of our users.

The decision to use online survey as the methodological cornerstone for this user study is underpinned by several compelling factors such as: online surveys provide a flexible means of data collection that transcends geographical constraints; the use of online surveys allows for the efficient collection of substantial amounts of data in a relatively compressed timeframe; and finally

online surveys provide participants with the invaluable cloak of anonymity, thereby fostering an environment conducive to open and honest responses. Through the strategic use of online surveys, we aim to tap into the collective wisdom of our user community and gain valuable insights that will inform the refinement and development of interactive visual tutorials. By identifying user preferences, we aim to tailor our educational resources more closely to the needs and expectations of our users, enriching their learning experience.

4.2.2. Data Collection

The first part of the research is to understand users' needs and expectations for a citizen science portal and the tutorial for it. To do this, we collected qualitative and quantitative data through an online survey. The survey was created in Google Forms taking into consideration the results of the literature review. It consists of five parts and 32 questions in total. The parts of the online survey are the following:

- Demographic information (age, education, familiarity with CS).
- Previous participation in CS projects.
- Motivation to participate in CS.
- Tutorial for CS.
- Suggestions/improvements for CS projects.

The online survey consisted of open questions, multiple choice questions and rating scale questions.

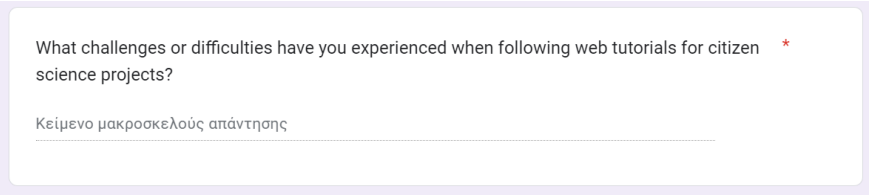

Figure 19: Example of open question

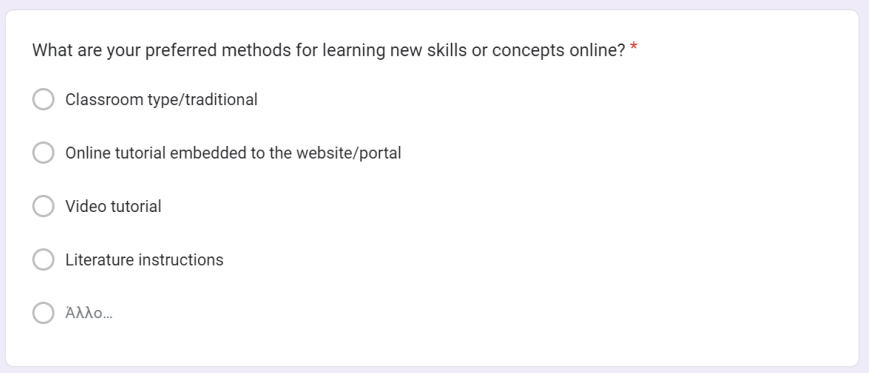

Figure 20: Example of multiple-choice question

4.2.3. Data Analysis

The survey was published on 25 May 2023 and was open for answers until 7 July 2023. It managed to collect thirty-two responses. The data from the online survey was processed and analyzed using Tableau software. The outcome of the analysis varies from bar charts and pies to tree maps and world bubbles. The method we used for analysis is aggregation, so we can combine distinctive characteristics of the users with their subjective opinions.

- Demographic information

For the first part of the online survey, we wanted to compare how the demographic information of the participants (age/ field of work/ gender) is related to their familiarity with Citizen Science projects. Out of curiosity, we also wanted to find out why people had not participated in CS research before.

According to Figure 21: Population pyramid, we have achieved a good balance between males and females completing the survey for the 14-25 age group. In the other two age groups, there are twice as many women as men.

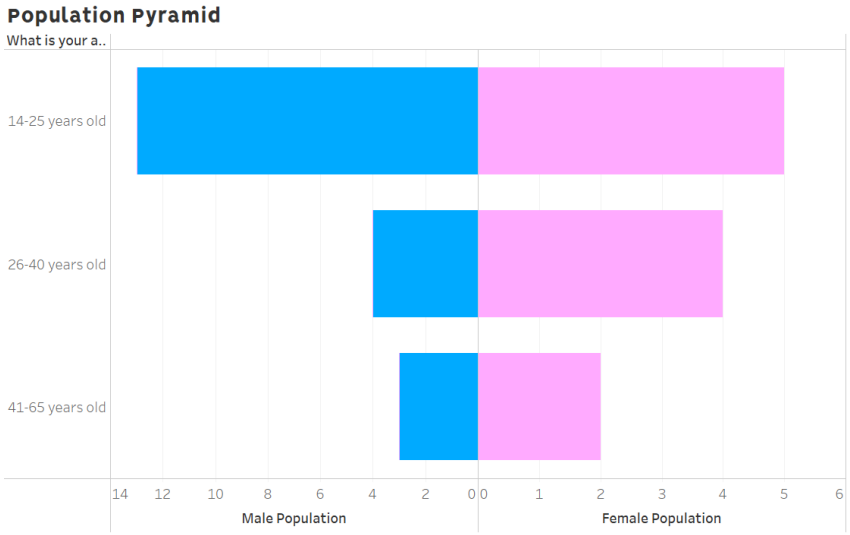

Figure 21: Population pyramid

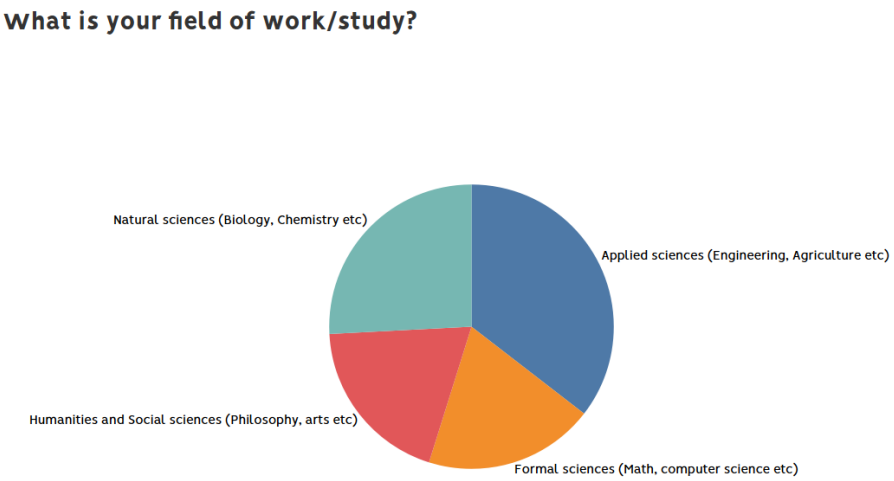

Figure 22: Field of work/study

In the Figure 22: Field of work/study, we can see that most of the people who completed the survey belong to the Applied Sciences category and the rest are evenly distributed among the other three categories. Following this, the Figure 23 and Figure 24 show the distribution by age groups and fields of study, respectively, on how familiar the participants are with the Citizen Science. It is obvious that younger people are more familiar with CS than older age groups. Moreover, there is no significant difference between the fields of study, but it can be said that people with an applied science background are slightly more familiar with CS.

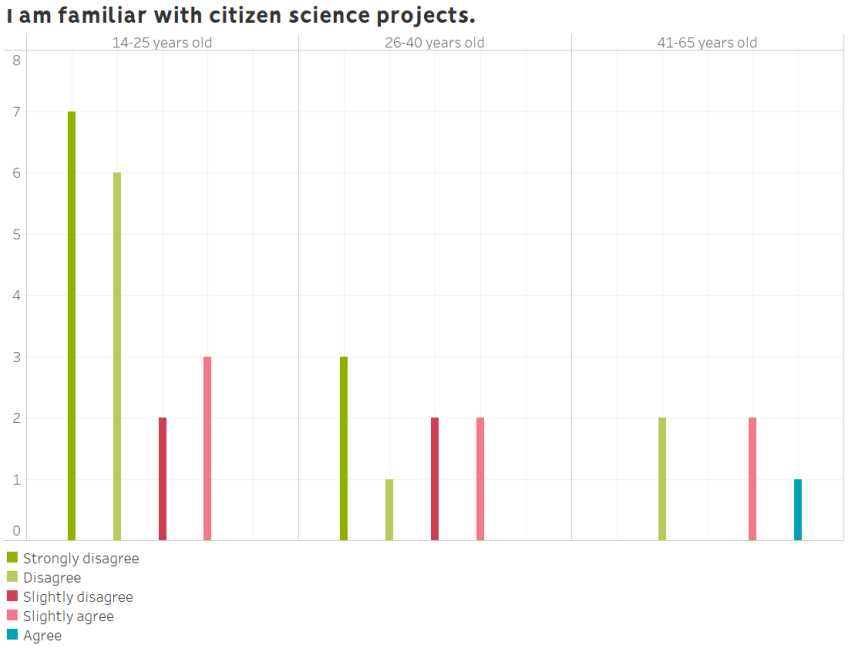

Figure 23: Familiarity with CS - part1

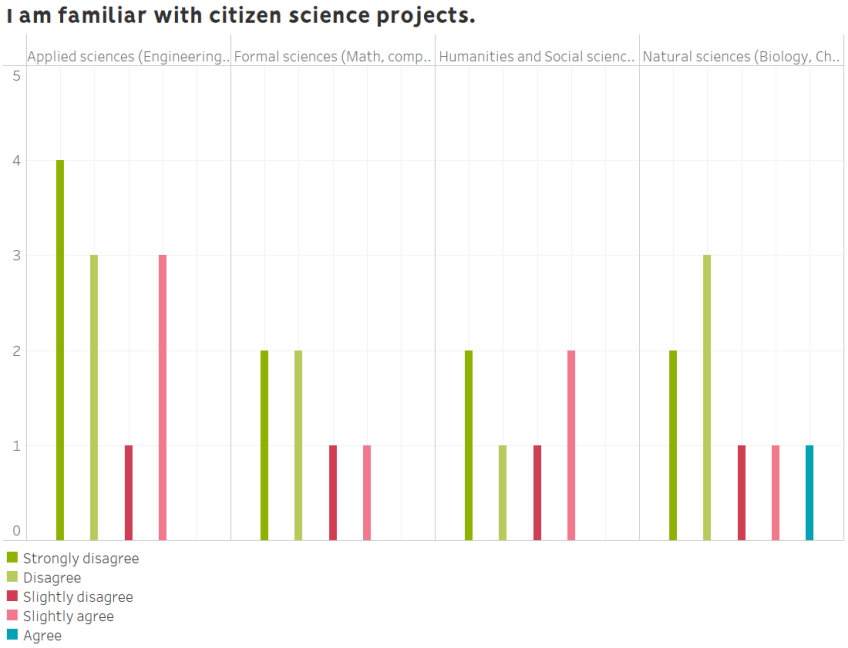

Figure 24: Familiarity with CS - part 2

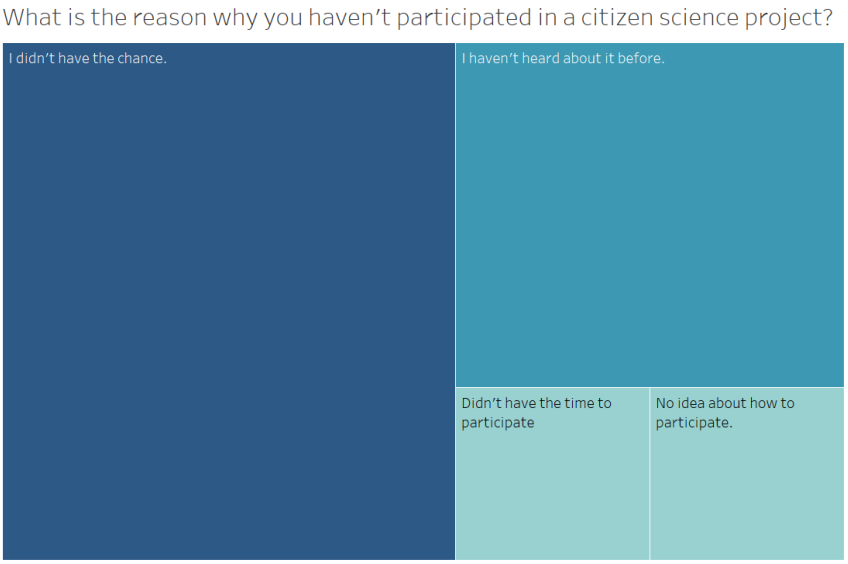

Figure 25: Reasons why you haven't participated in CS project.

The Figure 25 shows the reasons why people haven't participated in a Citizen Science project. The main ones are that they haven't had the chance, or they have never heard about it before. This result tells us that although Citizen Science is a science that involves citizens rather than experts, it is not so well known among users. According to the responses to the online survey, we can assume a division between amateurs and experts based on their familiarity with citizen science projects. Our small group of participants doesn't allow us the luxury of considering more parameters for the division. So, we can say that people who have participated in a CS project and are familiar with it are considered experts, while the rest can be placed in the amateur group.

- Participation in CS projects

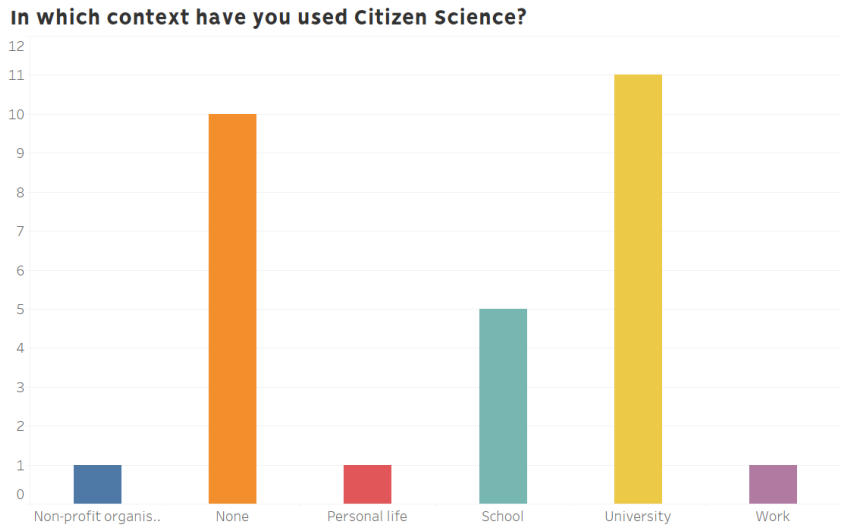

Figure 26: In which context have you used CS?

Most of the participants were involved in a CS project during their school or university years, while a significant percentage of them never experienced any CS activity.

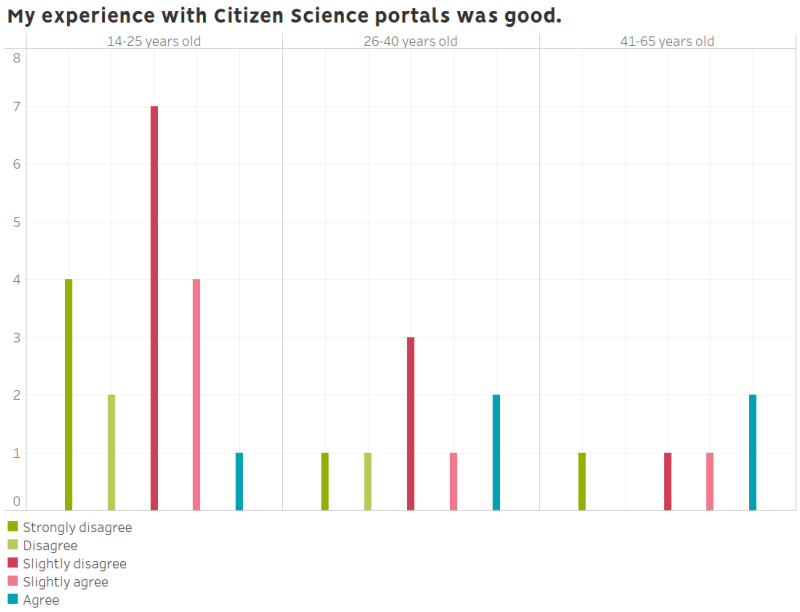

Figure 27: How would you rate your experience with CS portal -part 1.

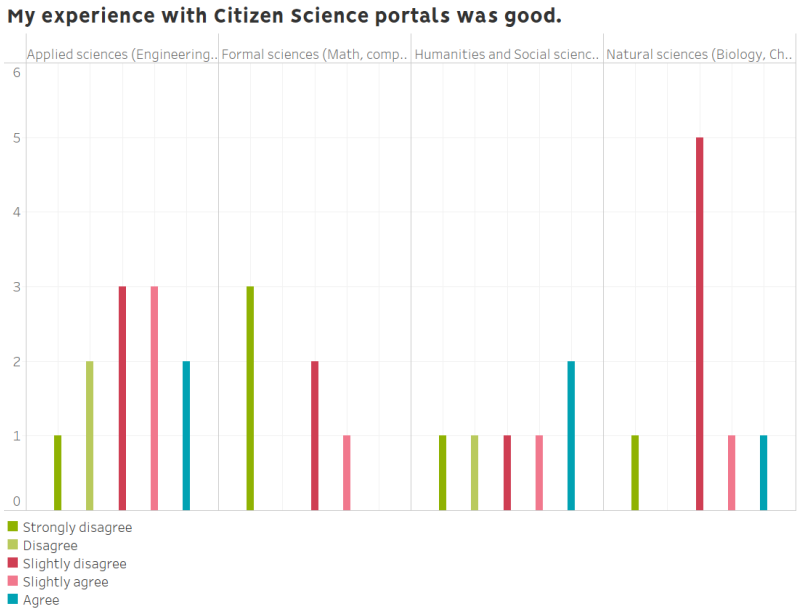

Figure 28: How would you rate your experience with CS portal -part 2.

The figures above (Figure 27, Figure 28) show how participants rated their experience with the Citizen Science Portal. The first figure shows this in relation to the age of the participants and the second in relation to the field of study/work. It can be seen that the majority of the people in both of the figures show a slight degree of dissatisfaction with the citizen science portals. The figure that stands out is that younger age groups seem to be more discontent with CS portals.

- Motivation to participate.

A particularly key factor for a successful citizen science project is the motivation of each participant. For our thesis, we want to understand the motivations of the users and how they react in a tutorial according to their motivation for the whole project.

Figure 29: What motivates you to engage in CS.

The first main reason is related to knowledge and science, with the majority of participants believing that by participating in such a project they will contribute to science. The next two reasons are climate change and helping friends (possibly meaning that the coordinator of the project is their friend).

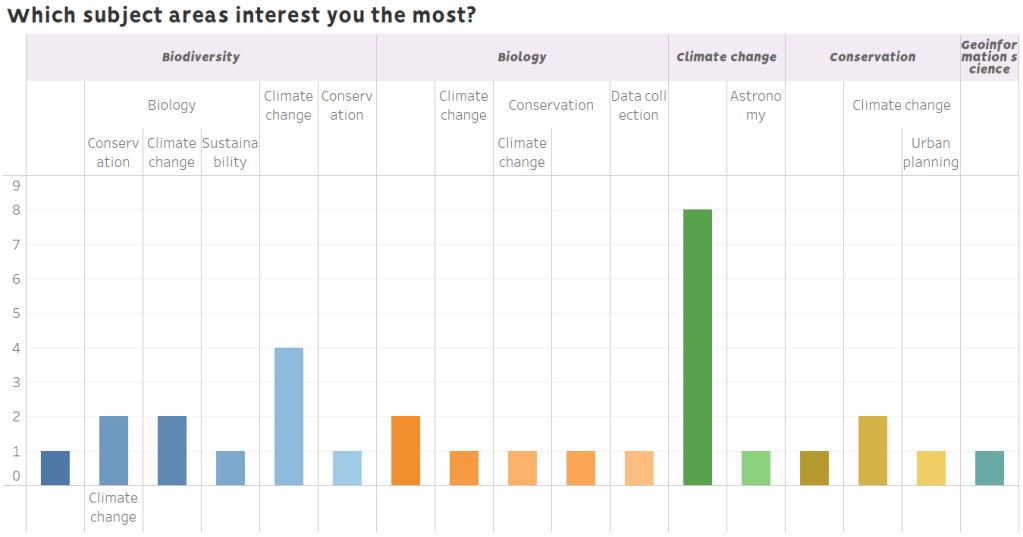

Figure 30: Which subject areas interest you the most?

As we said in the methodology chapter, for the purposes of our study we need to create a fictional citizen science portal. In order to make it more fun for the users, the survey included a question about which citizen science topic was preferred. The Figure 30 shows that climate change is by far the most popular topic among users.

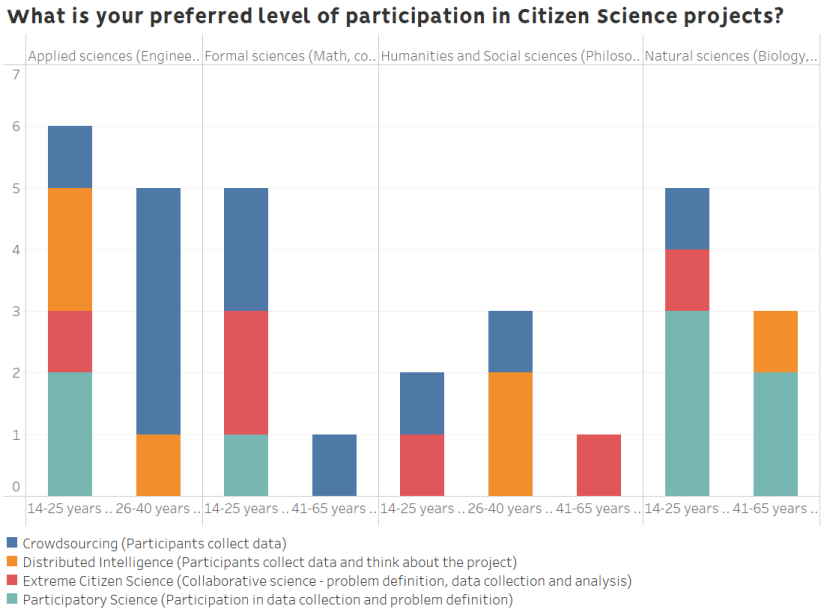

Figure 31: What is your preferred level of participation in CS projects - part 1.

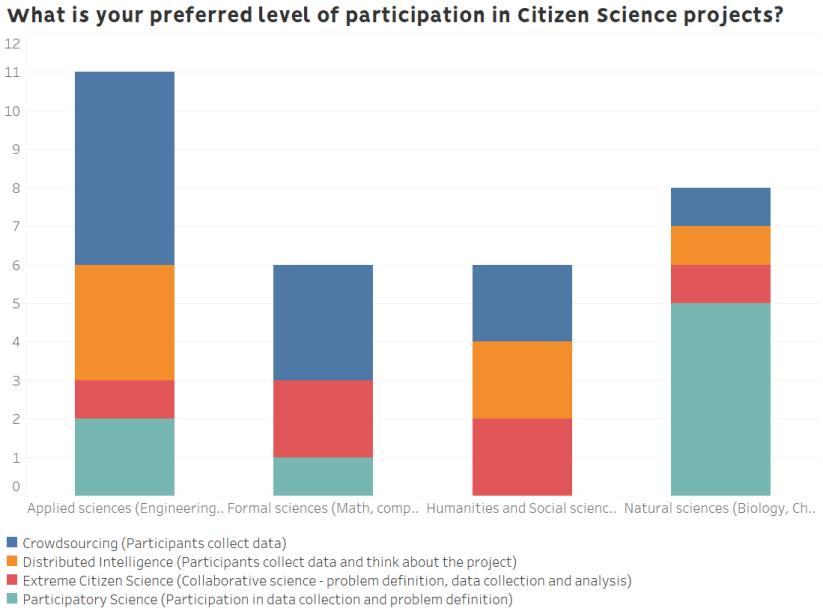

Figure 32: What is your preferred level of participation in CS projects - part 2.

In chapter 2 we look at the diverse levels of participation in citizen science. For this online survey, we asked participants to choose which level of participation they preferred. The Figure 31 shows the preferred level as a function of age and field of work, and the Figure 32 shows the preferred level as a function of field of work only. It is interesting that people with technical backgrounds

prefer crowdsourcing or participatory science, while people with theoretical backgrounds prefer extreme citizen science.

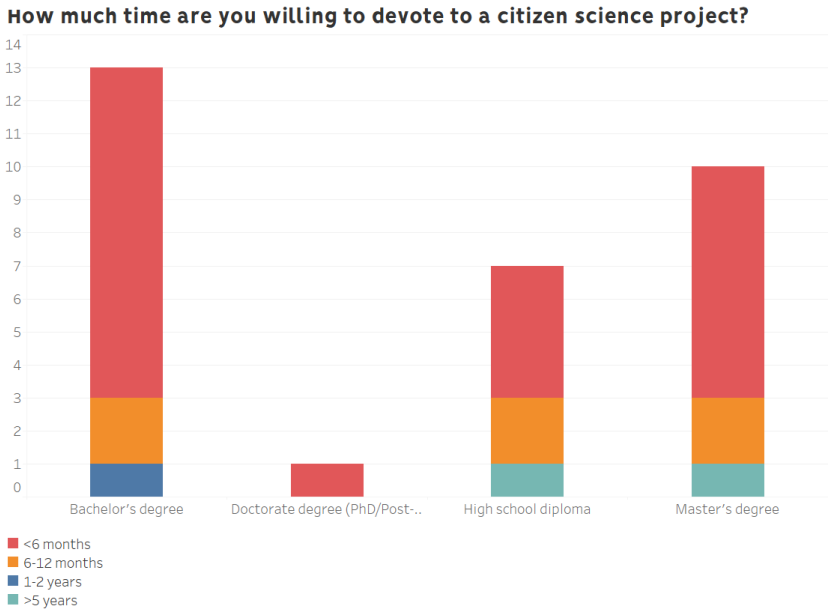

Figure 33: How much time are you willing to devote to a CS project? -part 1.

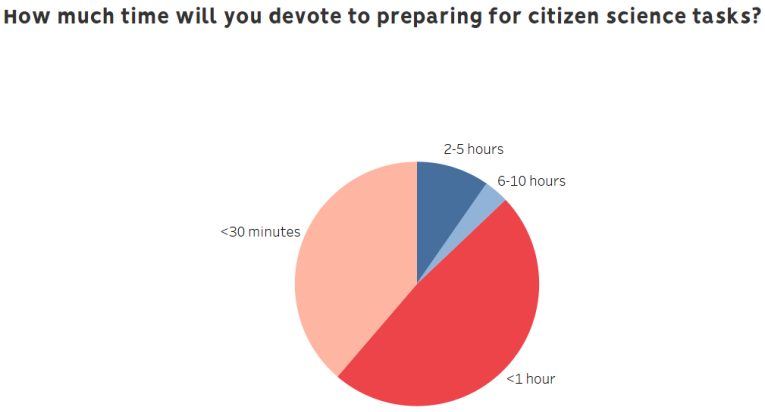

Figure 34: How much time are you willing to devote to a CS project? - part 2.

Another essential element of a successful citizen science project is that the data is accurate and truthful. To achieve this, participants should be willing to invest time in the project and not just collect data without care. To this end, our online survey includes a question about how much time they are willing to devote to the project. The results include in a pie chart (Figure 34) showing the amount of time spent on citizen science tasks. Overall, almost half of users are willing to spend no more than 1 hour on a project, while a small percentage are willing to spend 6-10 hours on the tasks. Regarding the time for the whole project (from the definition of the idea to the results), the bar chart (Figure 33) shows the time in relation to the level of education of the participants. The

majority of them are willing to spend less than 6 months. In the case of bachelor's students, no more than 1 year is possible, while master's students and high school students are willing to commit themselves to a long-term project (>5 years).

- Tutorial for CS.

This section focuses on how users imagine an interactive visual tutorial for citizen science. For example, what are their expectations, what challenges have they faced with existing tutorials. As we can see in the Figure 35, the majority of users are positive about having a tutorial before collecting data for a project.

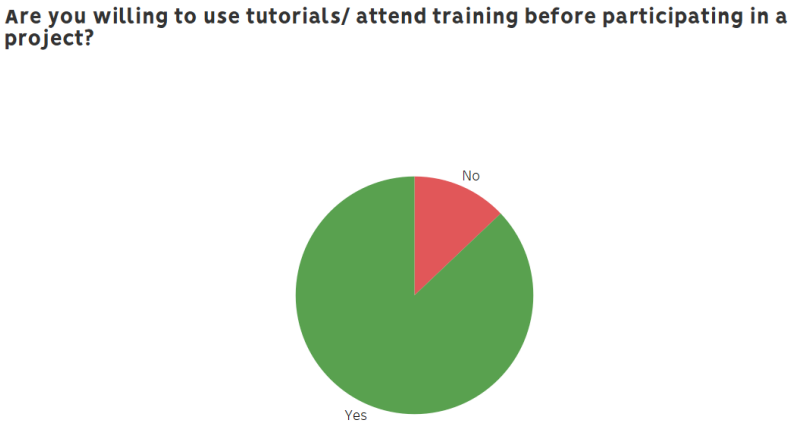

Figure 35: Are you willing to attend a tutorial before participating in a project?

To better understand whether the preferred method of learning is based on experience or just taste, we aggregate the result with prior participation in a tutorial.

Figure 36: What are your preferred methods for learning new skills online?

From the Figure 36, we can see that people who have never participated in a tutorial prefer traditional teaching methods, while people who have participated in a tutorial are more interested in interactive online methods.

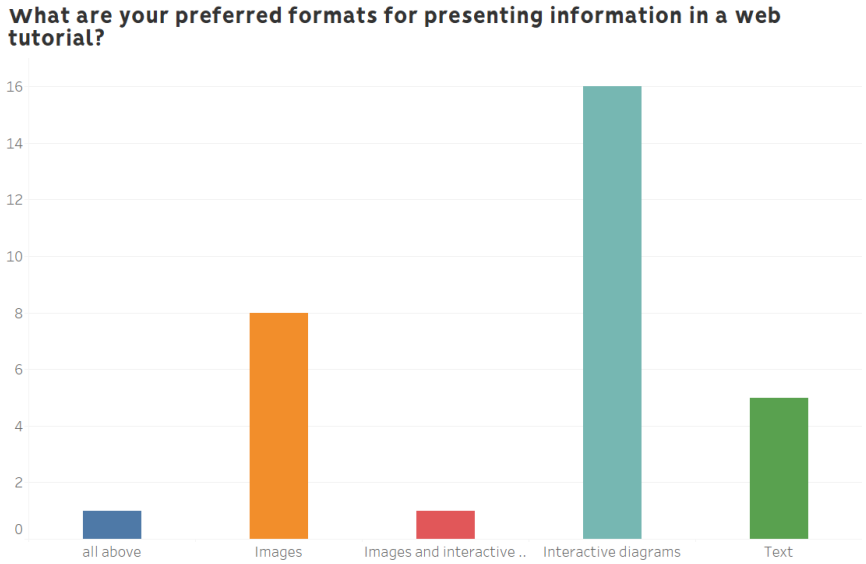

Figure 37: What are your preferred formats for presenting information in a web tutorial?

From Figure 37 ,By far the most popular format for presenting information is interactive diagrams. This gives us a nice opportunity to embed an interactive infographic page into the portal.

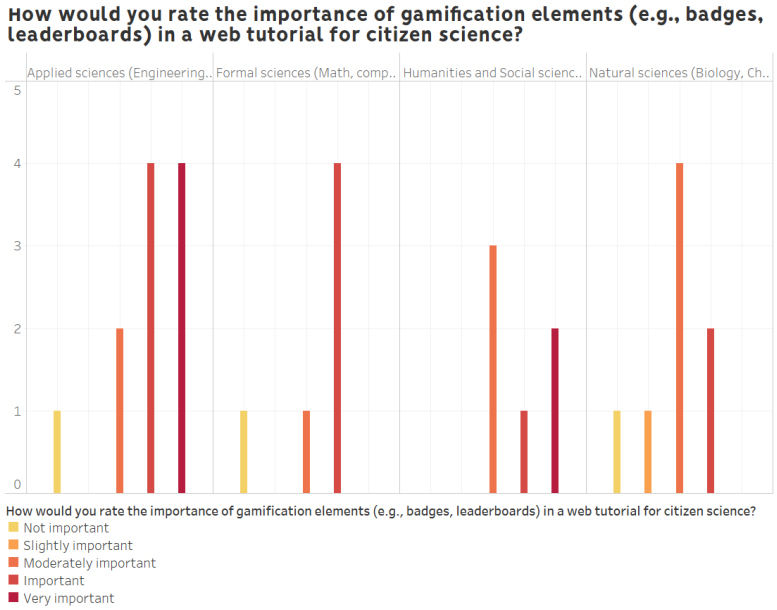

Figure 38: How would you rate the importance of gamification elements? - Part1

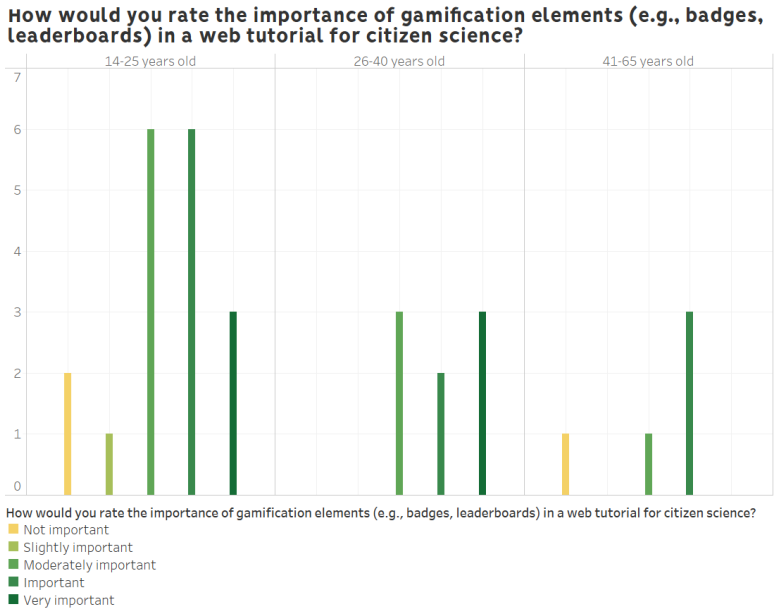

Figure 39: How would you rate the importance of gamification elements? – Part2

The figure shows whether users consider gamification elements important according to their age or educational background. It shows that gamification elements are considered moderately important across all age groups and academic backgrounds.

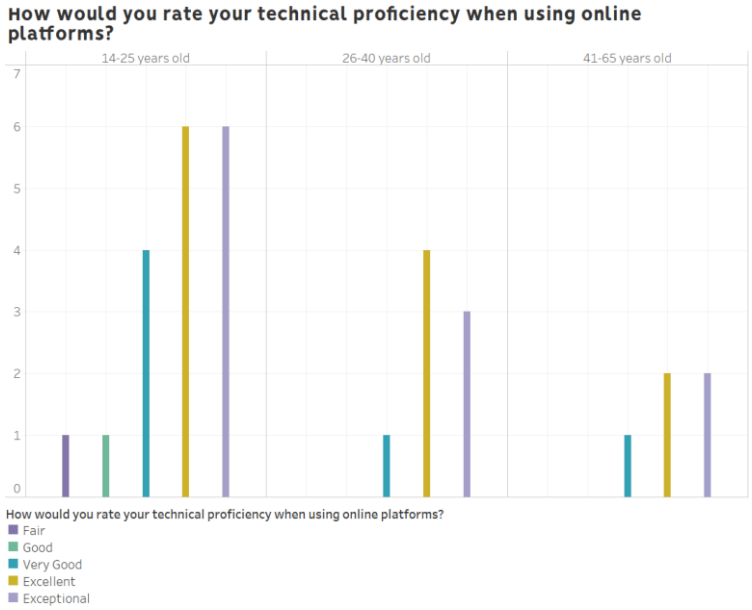

Figure 40: How would you rate your technical proficiency when using online platforms? - Part1

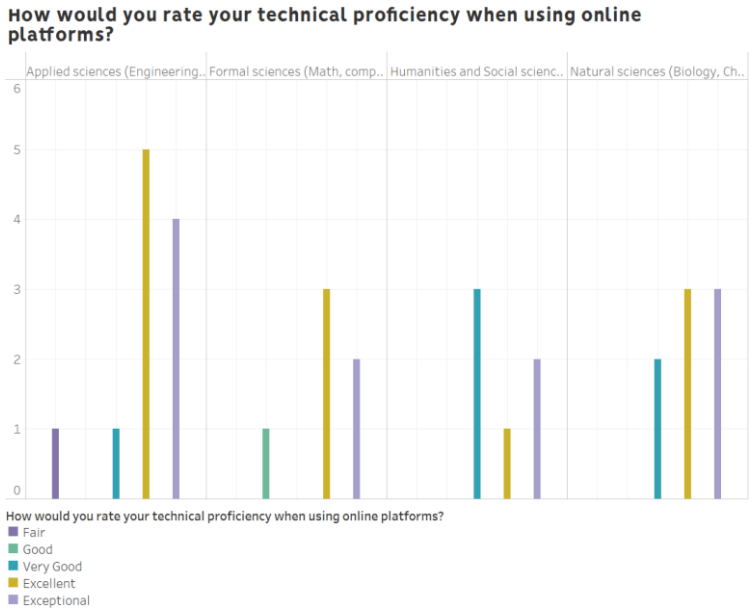

Figure 41: How would you rate your technical proficiency when using online platforms? - Part2

From the Figure 40 and Figure 41, we can see that most of our study participants have a basic knowledge of how to use online platforms.

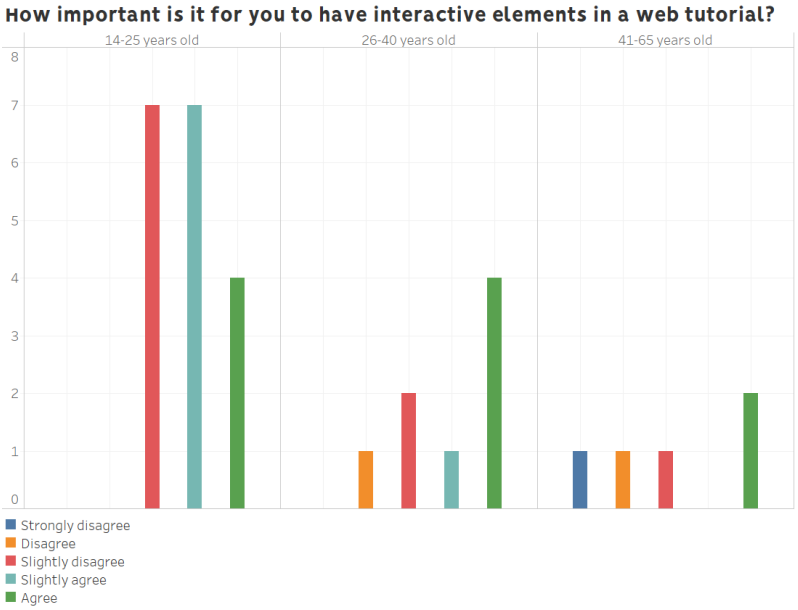

Figure 42: How important is for you to have interactive elements in a web tutorial?

The Figure 42 illustrates the importance of interactive elements for a tutorial. While younger users think it is particularly important, some users in the 26-40 age group feel it is not important. The options for the structure of the web tutorial are linear progression, modular sections, and user-driven exploration. Linear progression is a structured sequence in which information is presented in a predetermined order, with each section or lesson building on the previous one (*What Is Linear Structure in Web Design?*, 2022). Modular sections divide the tutorial into self-contained modules, allowing users to explore specific topics independently. It offers flexibility, making it suitable for learners with different interests or skill levels (Admin, 2022). User-driven exploration allows learners to choose their own learning path and is more suitable for advanced users (*What Is User-Driven Design?*, 2021). The Figure 43 combines the preferred structure with prior participation in a tutorial. The linear progression structure is preferred by half of the users.

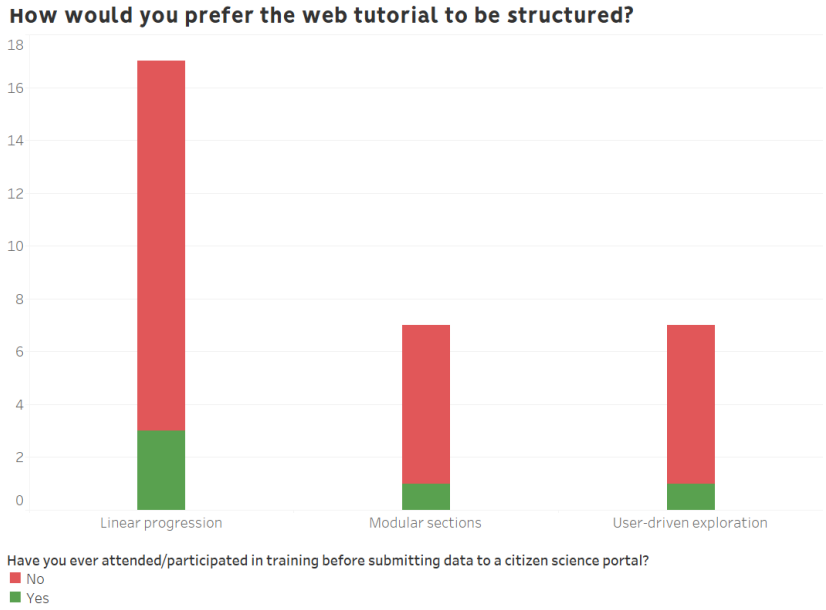

Figure 43: How would you prefer the web tutorial to be structured? – Part 1

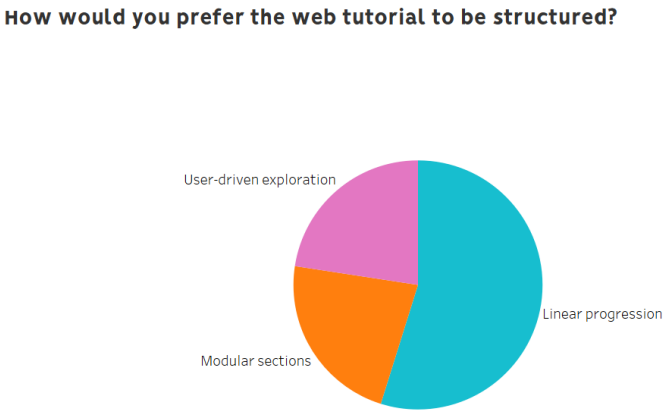

Figure 44: How would you prefer the web tutorial to be structured? – Part 2

- Suggestions/Improvements for CS projects.

This section of the online survey will allow us to gather information about any suggestions or improvements we can consider for the existing web tutorials for citizen science projects.

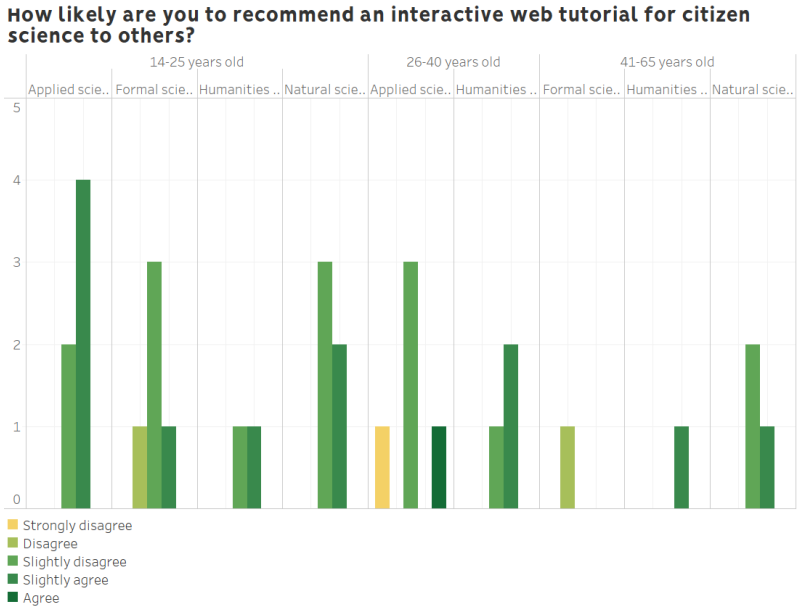

Figure 45: How likely are you to recommend an interactive web tutorial for citizen science to others?

As we can see in the Figure 45, most users wouldn't be so positive about recommending a web tutorial to others.

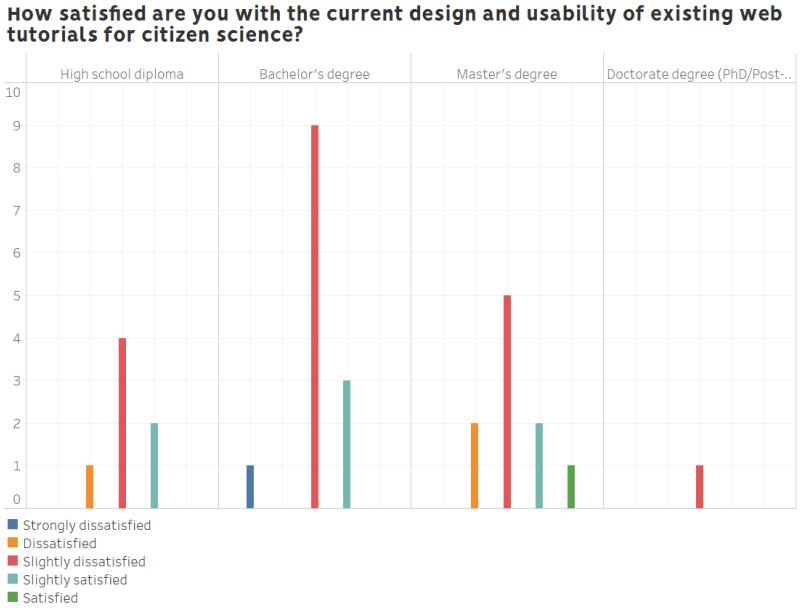

Figure 46: How satisfied are you with the current design of web tutorials for CS? - Part 1

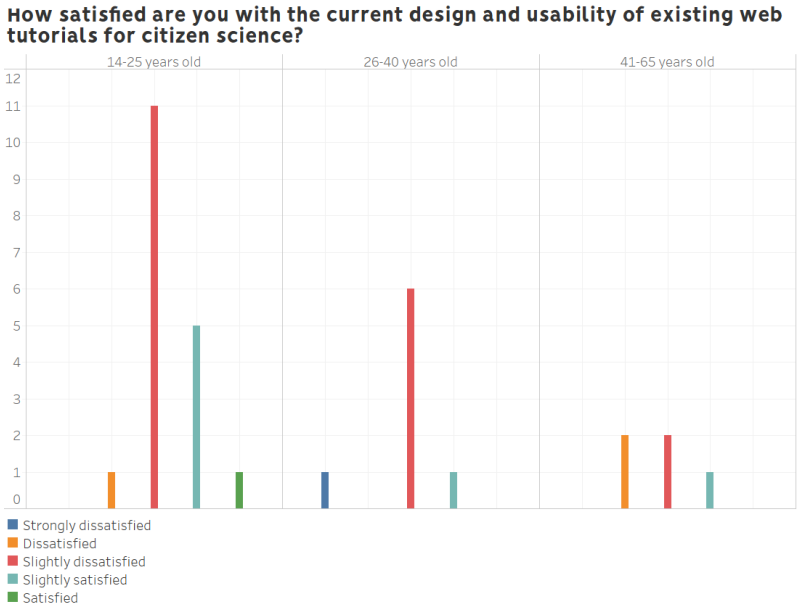

Figure 47: How satisfied are you with the current design of web tutorials for CS? - Part 2

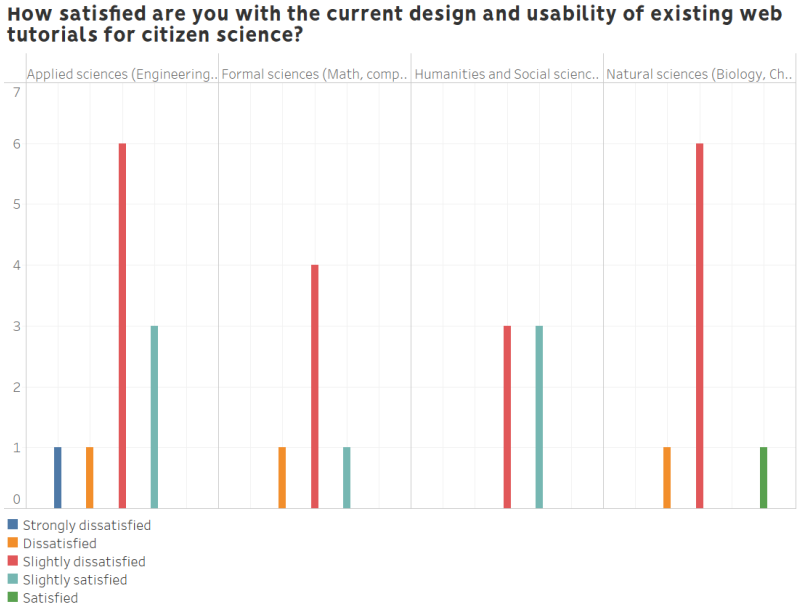

Figure 48: How satisfied are you with the current design of web tutorials for CS? - Part 3

The figures above (Figure 46, Figure 47, Figure 48) give the answer to why you shouldn't recommend a web tutorial to others. Basically, across all academic backgrounds and age groups, people are dissatisfied with existing web tutorials. This dissatisfaction arises from pre-existing problems or user challenges with existing tutorials for participants. The Figure 49 highlights the challenges people face when following a web tutorial. The main challenge is that the information provided in the tutorial is usually too complicated and advanced for a new user. In addition, the lack of interaction or opportunity to ask questions is a problem for some people.

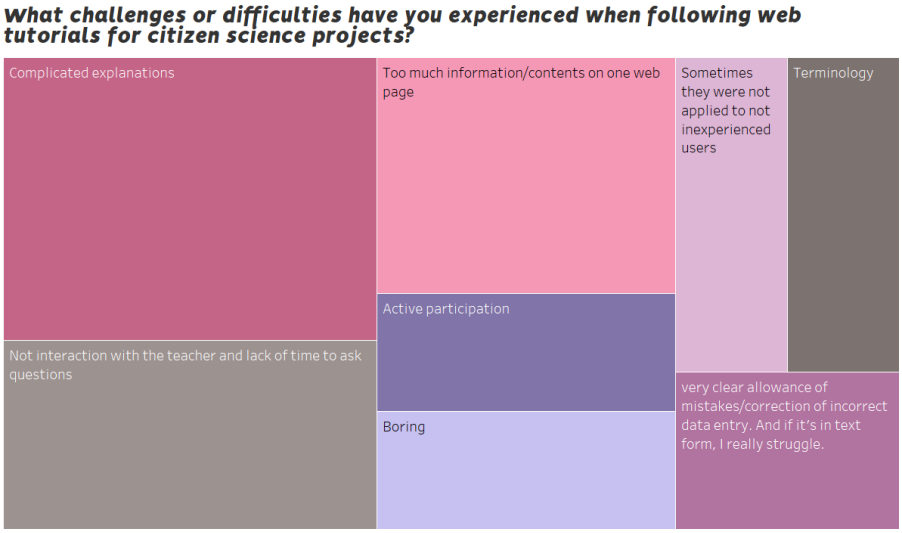

Figure 49: What challenges have you experienced when following web tutorials for CS projects?

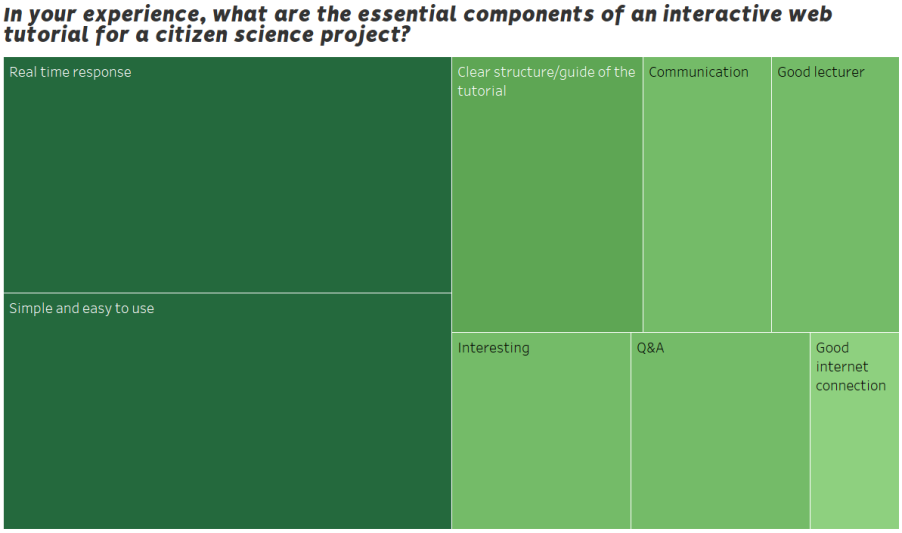

Figure 50: Essential components of an interactive web tutorial for CS.

From the Figure 50, the top three essential components of a web tutorial are to be simple and easy to use, to be interactive, and to have a clear structure that can guide the user. So, from these results we understand the significance of UI and UX of the web tutorial. After collecting the negative aspects of the existing tutorials, we asked what could be improved. Some of the ideas we collected are shown in the Figure 51.

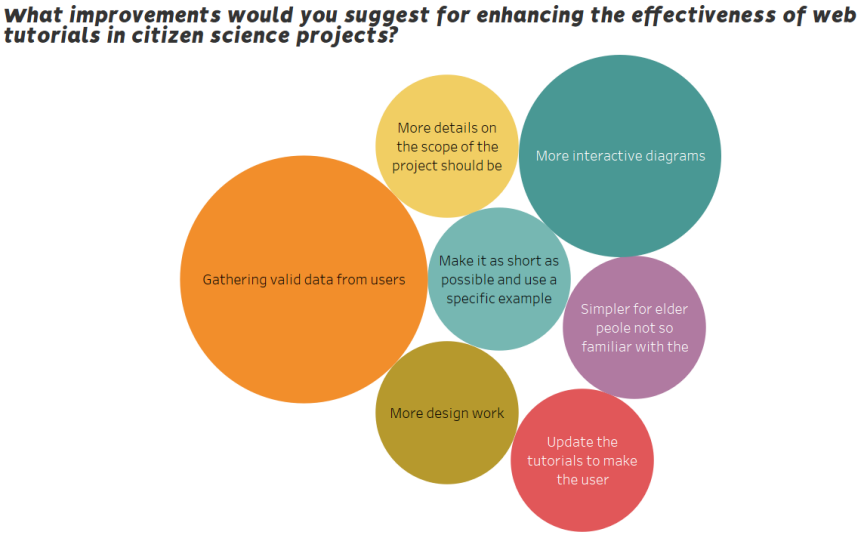

Figure 51: Suggestions/Improvements for enhancing effectiveness of web tutorials for CS.

4.2.4.Limitations

The online survey has several limitations, including a small sample size of 32 participants, mainly in the 14-25 age group, potential age bias, limited demographic diversity and potential response bias.

First, the most obvious limitation is the relatively small sample size of 32 participants. This size may limit the generalizability of the findings to a wider population beyond the specific age group surveyed. The results may not fully represent the diversity of perspectives that exist within a larger user base. Secondly, focusing primarily on participants aged 14-25 may introduce an age bias into the survey results. The preferences and experiences of younger users within this age group may differ significantly from those of older users interacting with the same visual tutorials. Consequently, the results may not accurately reflect the needs and preferences of all potential users.

Next, with a small sample size, the potential for response bias increases. Participants within a small group may be more likely to give similar answers, or answers that they think the researcher wants to hear, rather than expressing their true opinions and preferences. Limited sample size can affect the statistical power of the analysis, making it difficult to detect statistically significant differences or relationships between variables. This limitation could affect the ability to draw strong and reliable conclusions. Secondly, a smaller sample size may also limit the depth of qualitative insights gained from open-ended survey questions or comments. It may be difficult to capture the full range of qualitative data needed to understand the nuances of user preferences and experiences.

Finally, due to limitations in sample size and demographics, caution should be exercised when attempting to generalize survey findings beyond the specific context and age group examined in

the study. While these limitations should be acknowledged, they do not negate the value of our online survey. Rather, they provide valuable insights into the scope and applicability of your research findings and can guide future studies with larger and more diverse samples.

4.3. Prototype Design

4.3.1.Mock-up design

Creating a visually appealing and functional website is a complex endeavor, where user experience and aesthetics must harmonize seamlessly. The first step in achieving this is to create mockups. Mockups are the preliminary visual representations of a website that serve as blueprints for the final product. They are the bridge between the abstract ideas conceived during the design phase and the tangible, interactive web pages that users engage with. In essence, they are the foundation upon which successful web pages are built. For the design of the tutorial, it was necessary to gather our abstract ideas and try to organize them as mockups.

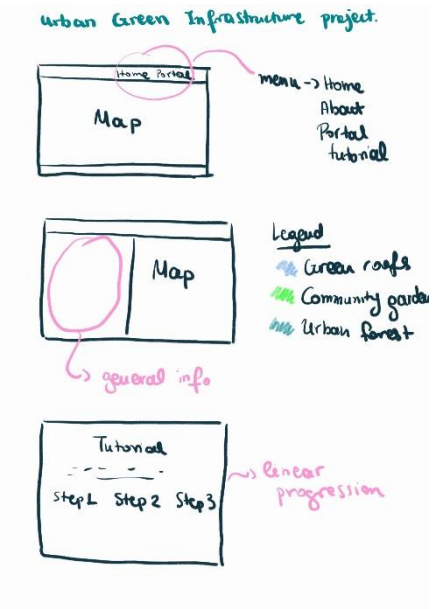

Figure 52: Mock up 1

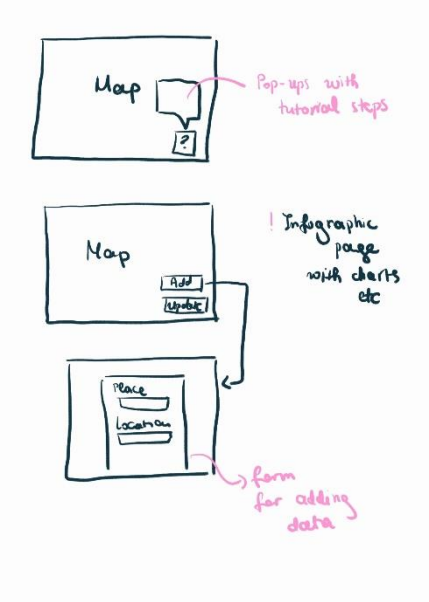

Figure 53: Mock up 2

4.3.2.Tools

In today's world of research and data analysis, the triumph of a thesis depends heavily on the toolbox at our disposal. This chapter takes a closer look at the software and applications that were the backbone of this dissertation journey. These tools made significant contributions to the research process, each offering distinct features and functions that, when combined, drove the progress of this study. The tools that have been used in the thesis are the following ones.

- **ArcGIS Experience Builder**

ArcGIS Experience Builder emerged as the backbone of this research, enabling the creation of interactive, web-based experiences that convey complex geographic information in an intuitive way. It facilitated the development of interactive web applications that weave together maps, charts, images, and textual content. These characteristics made it the best choice to host our citizen science portal and tutorial.

- **ArcGIS Online**

ArcGIS Online was used to create and publish the map used in our portal. This platform provided a central repository for all the spatial data sets, maps and applications used throughout the research process. A folder was created for the master's thesis projects, containing everything used for the tutorial.

- **ArcGIS Survey123**

ArcGIS Survey123 was our tool of choice for collecting field data. Its intuitive form builder allowed us to quickly create our customized survey and link it to the map. This tool facilitated the efficient collection of field data, such as the location and shape of the green space. It gives us the ability to gather insights directly from the field, enriching our analysis with real-time information and increasing the accuracy of our research. In addition, the data is displayed on the map as soon as it is collected.

- **ArcGIS Dashboards**

ArcGIS Dashboards played a vital role in transforming raw data into actionable insights. Its dynamic and interactive dashboards provided a visual canvas for displaying key findings and trends. We used the power of ArcGIS Dashboards to create real-time graphs and indicators of our collected data. In addition, we could easily display the dashboard on the ArcGIS Experience Builder website.

- **Canva**

Canva's easy-to-use interface helped us communicate our message effectively. All the graphics used in the thesis and in the final design of the citizen science portal and tutorial were created on Canva. Canva was also useful for editing the videos and turning them into gifs for the tutorial needs.

- **Quizmaker**

To engage the audience and reinforce key concepts, Quizmaker was used to develop interactive quizzes and assessments. These quizzes not only evaluated the audience's understanding, but also acted as a teaching tool, reinforcing the key messages of the research. Quizmaker was also used to add gamification elements to the portal by embedding a quiz. At the end of the quiz, users are graded and ranked.

In conclusion, it's worth noting how these tools, namely ArcGIS Experience Builder, ArcGIS Online, ArcGIS Survey123, ArcGIS Dashboards, Canva and Quizmaker, played a pivotal role in shaping the course of our thesis journey. Each of these tools brought their own strengths and unique capabilities to the table, and together they created a body of work that was not only informative and engaging, but also visually stunning.

4.3.3.Final design

In this section it is presented the outcome of our design process, an interactive web tutorial that addresses our research objectives. This final design represents the practical implementation of the research. It is the product of our efforts to create an effective learning tool.

- Color selection

Our choice of a vibrant green color palette for our portal is in line with our broader theme of urban green infrastructure. The choice of this color scheme was intentional as it symbolizes the lush, environmentally friendly aspects of our urban environments. Green represents sustainability, growth, and harmony with nature, all of which are central to our mission to promote a greener future.

Figure 54: Color palette for portal

- Imagery and Graphics

Graphics and images play a significant role in driving engagement on a website. Well-chosen graphics can evoke emotion, simplify complex concepts, and guide users through content. In essence, graphics and images are the artistic language that helps bridge the gap between your website and its audience, creating a memorable and engaging online experience. When someone enters the portal, the first thing they notice is the Figure 55. It was created as a logo/banner image for the website, to give the user a slight idea of what the portal is all about.

Figure 55: Portal banner

In addition, quite simple icons were used to represent the different actions on the website. For example, if a user wishes to open the tutorial for help, he or she can click on the question mark (?). (Figure 56)

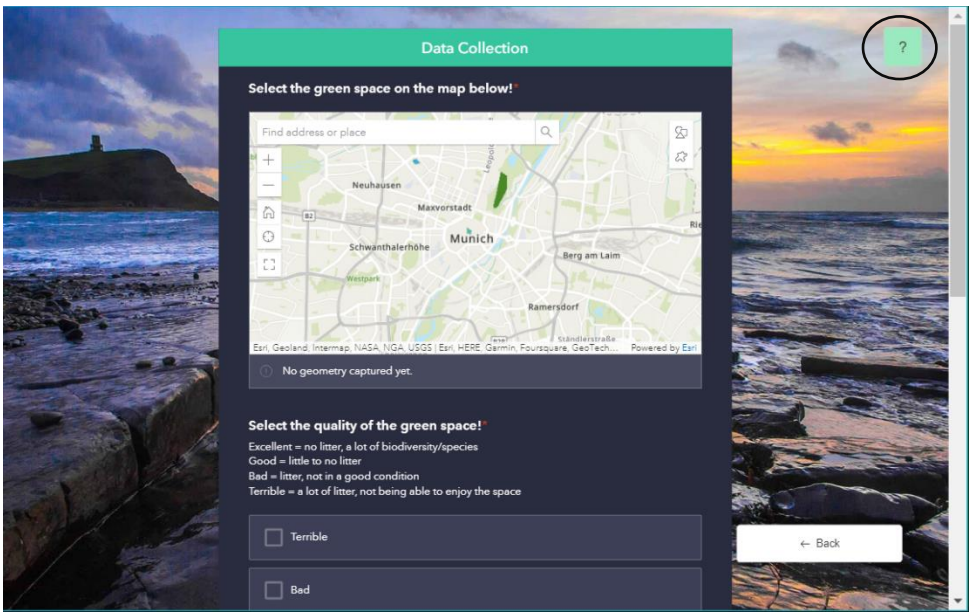

Figure 56: Questionmark icon

Here is another graphic used in the tutorial. A title for the tutorial was created by combining the theme of the portal (green spaces -> sustainability -> trees/roofs) and the word tutorial. (Figure 57)

Figure 57: Graphic example

- User Interface

In this section, we will provide an in-depth look at the user interface (UI) of our interactive tutorial, highlighting its design elements and how they contribute to the user experience.

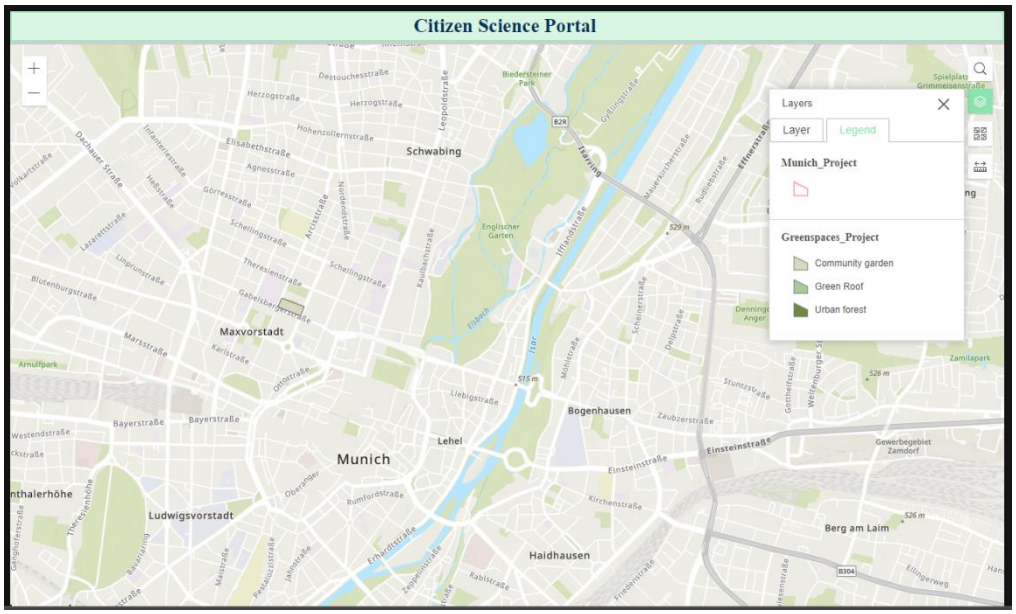

Figure 58: First draft of the portal

The Figure 58 shows an initial design created for the portal. At this point, the title of the portal wasn't finalized, and the main goal was to create a simple map interface for the tutorial. The map remained as it was until the tutorial was completed.

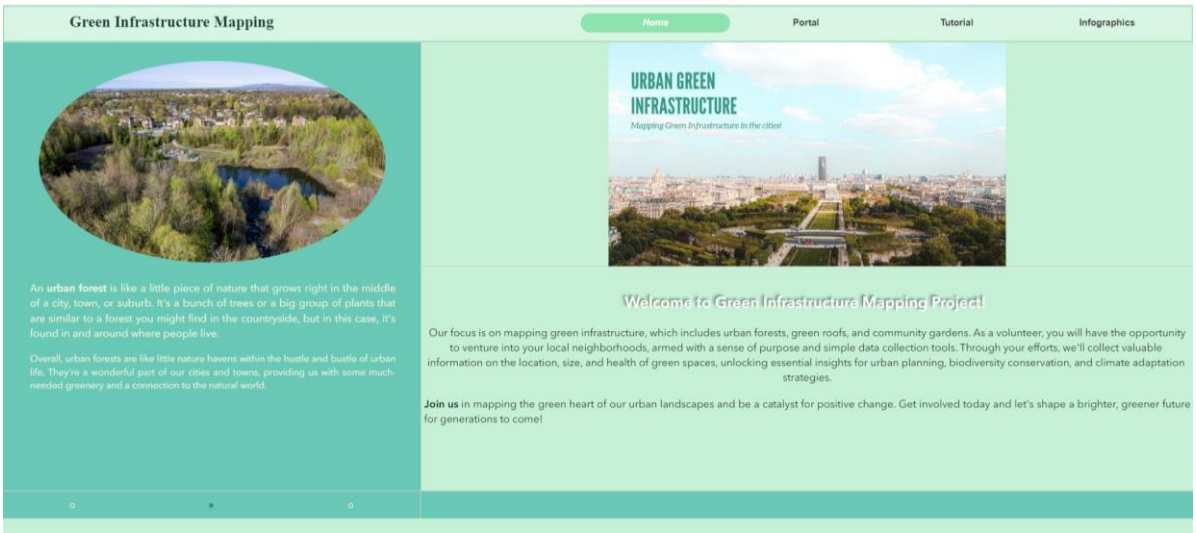

Figure 59: Home page

The homepage of the portal is divided into two parts. The right part is an introduction to the theme of the portal and the left part is a presentation of the three categories of data to be collected. The information is presented in a slideshow view (Figure 59).

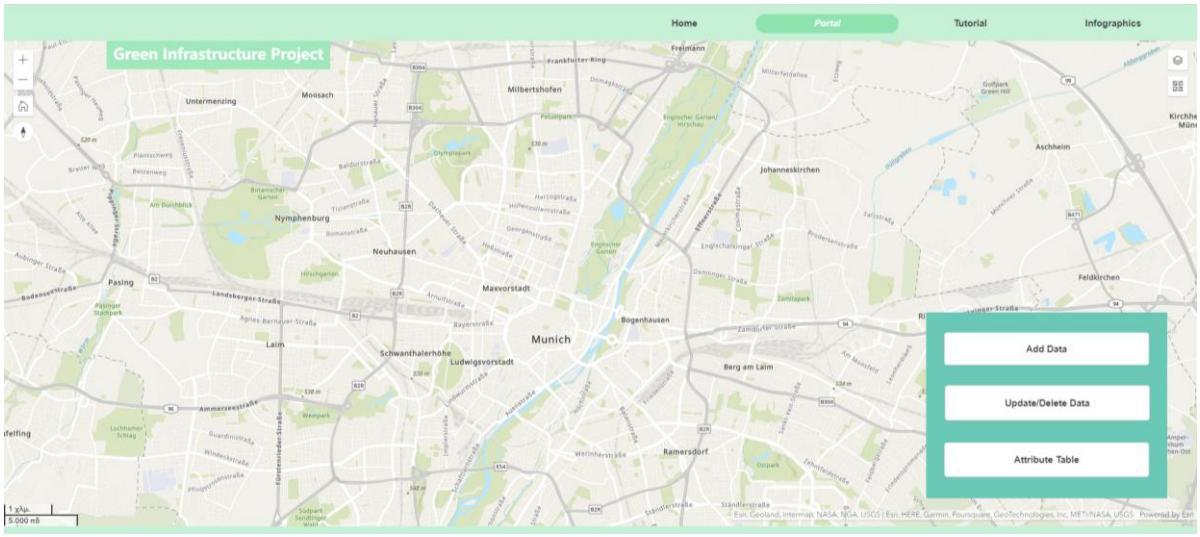

Figure 60: Portal interface

The portal page contains the map interface, which includes the map, zoom functions, scale, legend, layers, and base map selection. In addition, on the bottom right of the page you'll find options to add data, update/delete data or view the attribute table if you want to download the data for later use (Figure 60).

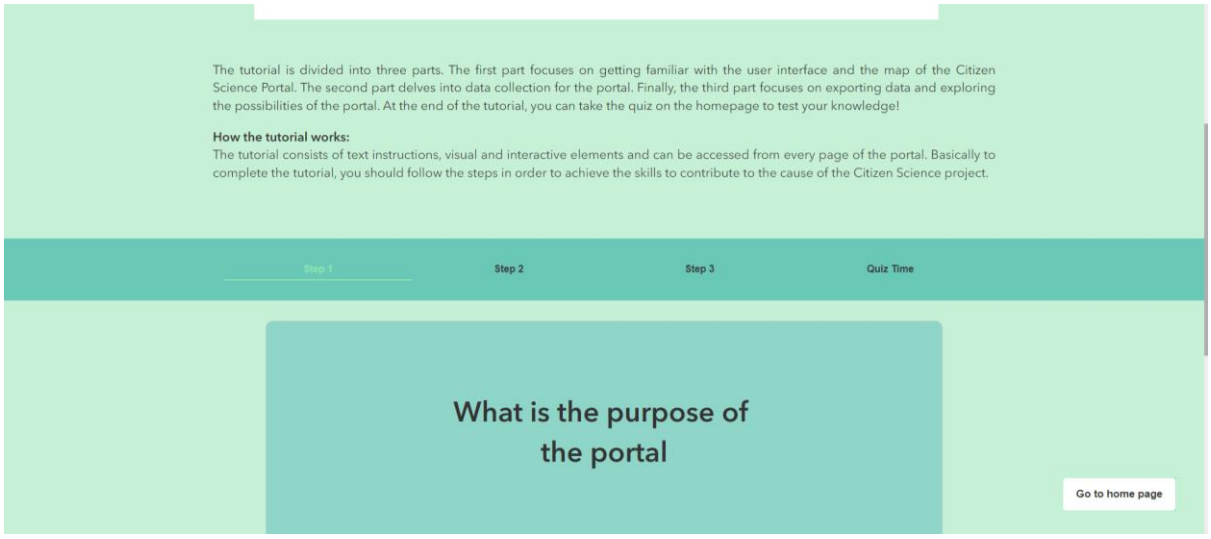

Figure 61: Tutorial steps part 1

The tutorial is on a separate page from the portal. It consists of 3 steps and the last one is a test to see how well you have understood the purpose of the portal and how well you have learnt how to collect data in the right way (Figure 63). In each step of the tutorial, there are two sub-steps that the user must follow. They are displayed in cards that open interactively when you move the mouse over them (Figure 62). Each card is divided into two parts, one part is a gif showing the steps that are described in text on the other part.

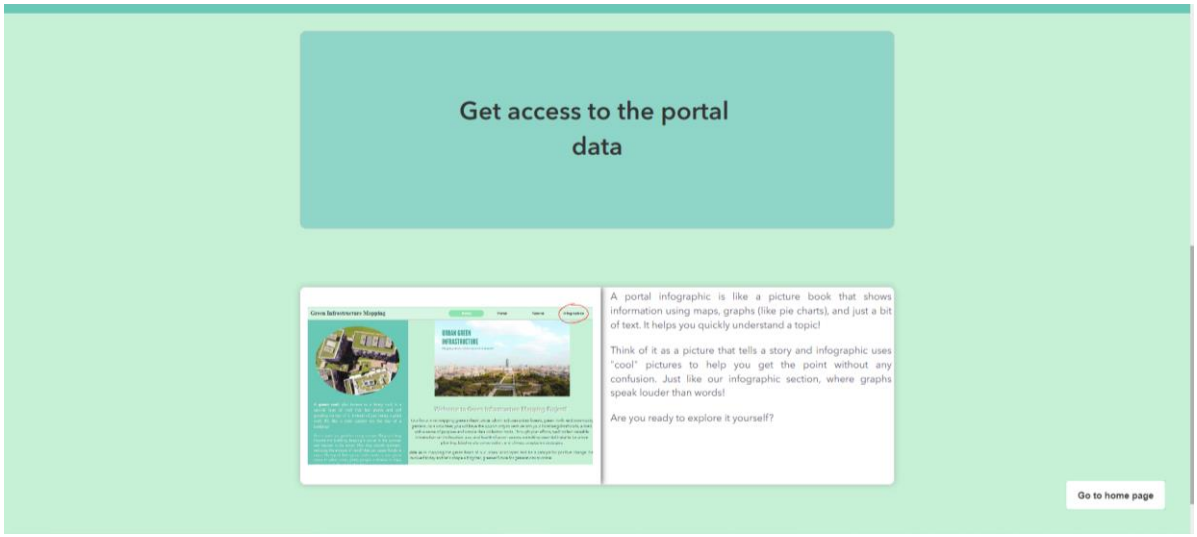

Figure 62: Tutorial steps part 2

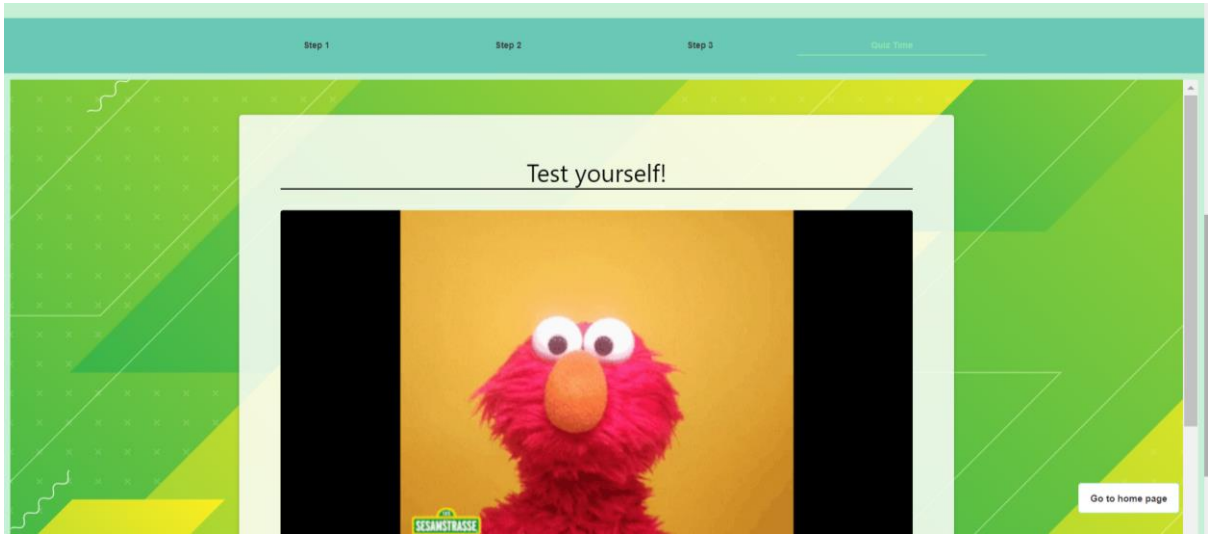

Figure 63: Quiz

Finally, to increase user engagement and interest in the portal's purpose, we created an infographics page, as shown in the Figure 64. The infographics contain the map, a pie chart with the 3 categories of data and some indicators related to the collected data.

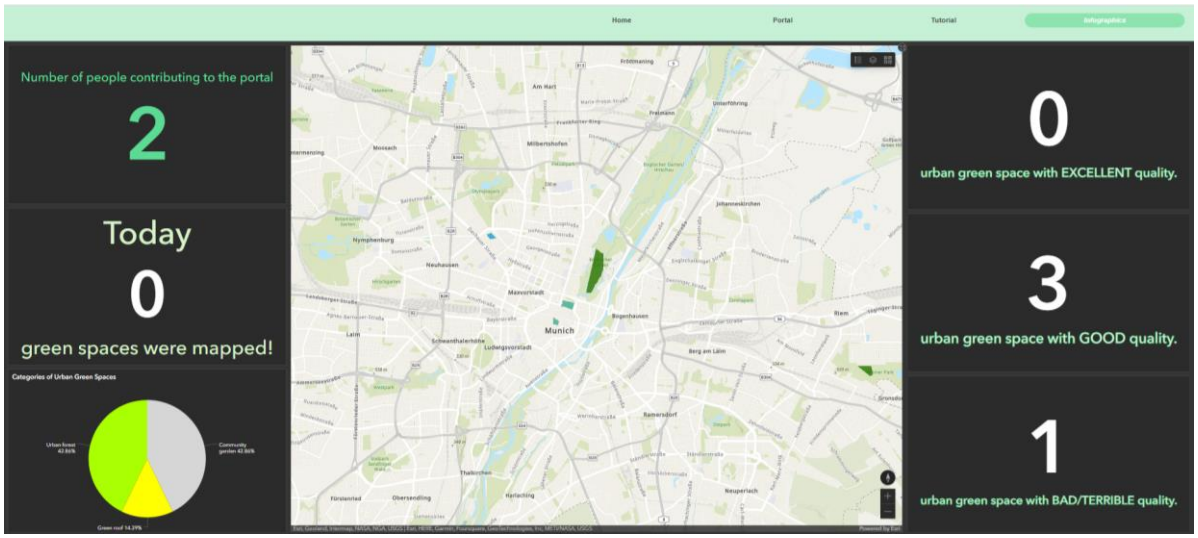

Figure 64: Infographics page

This chapter has provided an in-depth look at the design elements and visual aspects of our interactive tutorial. Our examination of color selection and user interface has shown how these design choices contribute to the effectiveness of our learning tool.

4.4. Focus group

4.4.1.Introduction

In the pursuit to evaluate the effectiveness and usability of the "Urban Green Infrastructure" Citizen Science Portal, a key phase of this research involves engaging directly with end users through a comprehensive focus group study. This chapter highlights the invaluable insights and perspectives gained from this user-centered approach. The focus group user study serves as a critical tool for evaluating the effectiveness and usability of the interactive visual tutorial designed for the citizen science platform. Through open discussion, participant feedback, and task-based evaluation, we aim to gain a deeper understanding of how this tutorial is resonating with its intended audience, identify areas for improvement, and ultimately collect suggestions for the tutorial to better meet the needs of citizen scientists and urban enthusiasts alike. This collaborative and participatory methodology aligns seamlessly with the core principles of citizen science, placing end-users at the center of the innovation process and ensuring that every Citizen Science portal truly empowers individuals to meaningfully contribute to its goal.

4.4.2.Planning and Preparation

The selection of participants for the focus group was a critical aspect of ensuring the validity and relevance of the research. The aim was to assemble a diverse group of individuals who could provide rich and varied insights into the research topic, which focused on the evaluation of the interactive visual tutorial in terms of usability and accessibility. Participants were selected based

on their experience with citizen science portals and familiarity with technology. Ultimately, a group of 6 participants was selected, each bringing unique insights and experiences to the focus group discussion. The careful selection process aimed to provide feedback on the research findings.

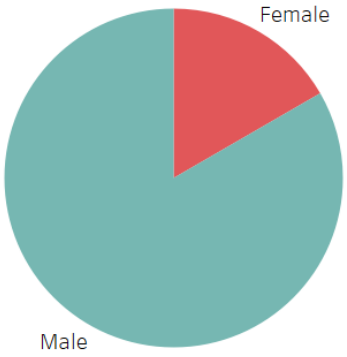

Figure 65: Gender Pie of focus group participants

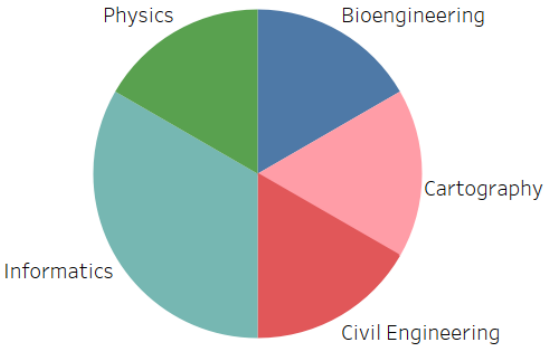

Figure 66: Educational background of focus group participants

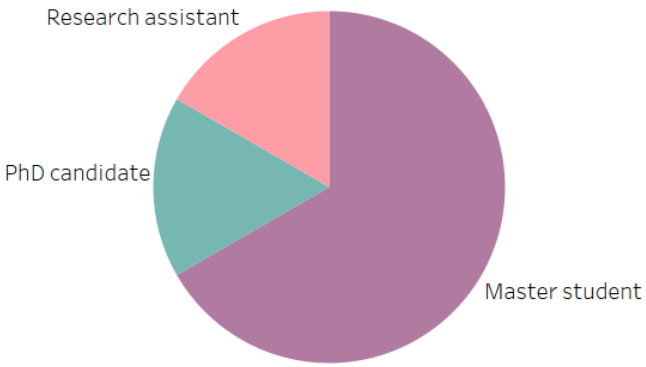

Figure 67: Status of focus group participants

The focus group discussions were held in a central and convenient location for the participants. The TUM main campus library was chosen. In particular, a well-equipped group study room was booked for this purpose. This location was chosen for its accessibility and comfort, ensuring that participants could engage in open discussions without distractions. The focus group discussion took place on Sunday 24/9/2023 from 12:30 to 14:00 to accommodate the availability of our participants, as the majority of them are master's and PhD students with busy daytime schedules. A detailed timetable was drawn up for each session, with the first 10 minutes devoted to an introduction, establishing ground rules, and obtaining informed consent. The following 35 minutes were towards completing tasks for the tutorial and giving their insights. After the break, the next 30 minutes were devoted to structured discussions, guided by a set of pre-determined questions. The final 5 minutes were used to summarize key points, address any questions or concerns from participants, and express gratitude for their valuable contributions.

	Focus group schedule
12:30-12:35	Greetings and Brief Introduction (purpose and goal of focus group)
12:35-12:40	Icebreaker activity: Participants introduce themselves
12:40-12:50	Overview of the portal and the tutorial
12:50-13:15	Task-based evaluation
13:15-13:20	Short Break
13:20-13:50	Group Discussion (Participants share their thoughts)
13:50-14:00	Closing Remarks and Thank you

Table 1: Focus group schedule

4.4.3.Data Collection and Analysis

A multi-faceted approach, including task-based assessment, participants thinking aloud during tasks and open-ended responses, was used to collect data for this study. To ensure thorough documentation and analysis, each session was carefully recorded using an iPhone 14. The purpose of this recording was to enable in-depth examination and interpretation of the data collected during the subsequent stages of analysis and evaluation. This robust methodology was critical in capturing a holistic view of the participants' experiences and insights into the tutorial.

The participants were divided into two groups of 3 and asked to complete 3 tasks. Before starting the tasks, each group should spend about 8-10 minutes practicing the tutorial and thinking about what they need to do to contribute to the portal. One participant commented that the portal reminded him of a CS project on the Greek island of Crete about olive trees. According to the participants, the most exciting part of the tutorial was the quiz. They all wanted to answer the questions and found the use of the photos/gifs quite entertaining. One drawback for them was that the time starts from the moment you sign your name and not after. The tasks were completed sequentially and not simultaneously. The first task was to add data to the portal for a green space

of their choice. The second task was to update or delete data from the portal and the last task was to download information from the portal and explore the infographics section.

For the first task, both teams were worried about how to find data as they were not so familiar with the 3 categories of the portal. They tried to change the base map (as indicated in the tutorial) to a satellite base map so that they could more easily see the green spaces in Munich and their quality. In addition, most of the participants found the fonts of the portal a bit too small and needed to enlarge the screen. Despite this, both teams manage to complete the task in around 10 minutes. For the second task, participants decided to update the existing polygon as they found it difficult to find the shape on the first attempt to add the data. There was some confusion with this task as people did not remember that they had to select the polygon and then press 'Edit Data'. Finally, the last task was quite easy for both teams. They were able to download the data they had collected from the portal without any problems.

The final and most important part of the user study is the group discussion. This is the moment when the user can share their thoughts about the tutorial with the other users. Participants were asked seven questions about the usability, design and user experience of the tutorial. The questions are as follows:

-Please share your thoughts on the overall design and visual appeal of the tutorial/website.

“The tutorial should be bigger (zoom)… I couldn’t read normally… text was small.”

“The design was for the phones, right?”

“You should add points that lead to the tutorial maybe, otherwise you have to find yourself where to go.”

“It would be nice if website recognizes the edges of the area.”

The participants' comments revolved around the tutorial's user interface. Two participants felt that it should have been designed in a linear way, by accessing individual points, rather than as a user driven exploration. In addition, participants felt it was a mobile design, whereas it was a website. All participants wanted larger text for the website. Last but not least, they think that when you add data, the green area should be detected automatically.

-What did you like most about the tutorial/website? What did you find most useful?

“Quite clear to introduce what tasks and functions you have to deal with… it is very clear … simple, quickly.”

“If you break the tasks … like if you do one task successfully then you go to the next one… go one by one. “

All participants agreed that the tutorial was easy to follow and quick to complete. So, it wasn't tiring for them to take part. Also, the instructions were noticeably clear to them about how the portal worked and what they needed to do. They also liked that the theme of the portal was focused on sustainability and climate change. If we go back to the results of the online survey, we can see that again most people are in favor of climate change issues. Finally, they really liked the structure of the tutorial, which followed the step-by-step guide.

-Were there any features or content you felt were missing or could be improved?

“For the quiz I would like to see what the correct answer is.”

People did not say much about this question. They were mostly focused on the quiz, where the correct answers were missing after the quiz. From this reaction we can say that the gamification element increased their engagement with the portal as it was the only thing they remembered very well.

-Did you encounter any unexpected or confusing elements while using the tutorial?

“The tasks weren’t that hard.”

“Maybe the most confusing is to understand why we are using Citizen Science.”

All participants agreed that some technical problems were to be expected, but as far as the tasks were concerned, the tutorial was not too difficult to follow.

-Did the use of graphics, images, or multimedia elements enhance your understanding of the content?

“When you press here, this white is kind of lazy… it is kind of boring.”

“Also, the videos somewhere in the tutorial were too small to see.”

“You should give a bit more space not put it all the way to the edge.”

“You picked really nice colors in general.”

There were many suggestions from the participants regarding the visual design of the tutorial. First of all, regarding the color palette, they thought the choice of colors was really nice, but they wanted to be followed all the way. For example, the white background on the flashcards in the tutorial, they thought it could be green because white can sometimes be "lazy to the eye" and boring. They also said that the gifs were in a small frame to be helpful. Basically, they asked for a bigger frame to cover the whole tutorial web page to make it easier to read.

-In your opinion, how well does the tutorial meet the needs of its target audience or user group?

“When we tried to add data, the map is a topological map which doesn’t help to distinguish what the green area is.”

“I would say it is helpful...”

“Yes, I agree. It is understandable.”

“If I was not physically in this user study, I wouldn’t be possible to find the categories.”

All the comments from the participants were that the tutorial was helpful to learn, understandable, easy, and tailored to the needs of the portal tasks. Some suggestions from the participants regarding some of the drawbacks are as follows It is difficult to find the data if you are not physically there, so we can see that a responsive design for mobile devices is needed for the tutorial. Some users think that someone older with less technical skills might find it difficult. Two participants suggested a few things for navigation, like showing where the user has to go now, which is basically related to some of the previous comments that user-driven exploration is not the best for the tutorial. Last but not least, to be able to change the base map everywhere in the tutorial, because when you fill in the data you cannot change the base map within the form.

-What are your thoughts on the interactive elements?

“Why do you have these kinds of things? Flashcards you know... I don’t like this stuff.”

“I agree... without flashcards you can use bigger pictures as well … more readable.”

Overall, they believe that interactivity is important for a website so that the user can engage with it. They also had some insights into the interactive elements of the tutorial. First of all, they liked the pop-up videos at each step, but they think that there should also be a bigger one with a longer duration that covers all the steps at once. Also, one participant suggested that the flashcards were a bit redundant as the interactivity was not needed in this part.

4.4.4.Limitations

The present study has several limitations that need to be acknowledged. Firstly, the pool of participants consisted of only six individuals, all of whom were acquaintances and aged between 22 and 30 years. This limited sample size and homogeneity could potentially affect the generalizability of the findings, as the perspectives of a broader and more diverse population may not have been adequately represented. In addition, the familiarity between the participants and the moderator of the user study (author of thesis) may have introduced a social desirability bias, potentially affecting the authenticity of their responses.

Furthermore, due to time constraints and the pressure of submission deadlines, it was not possible to conduct a follow-up focus group session or to use the personal think-aloud method with each participant. These methodological limitations may have hindered the depth of insight that could have been gained from a more extensive data collection process. Future research in this area should aim to address these limitations by including a larger and more diverse pool of participants, as well as allowing for a more comprehensive data collection approach to increase the robustness of the study's findings.

5. Results

This chapter presents the results of an extensive research effort aimed at addressing the three fundamental research objectives established at the beginning of this study. The preceding chapters have explored the theoretical underpinnings, methodological approaches, and data collection processes, all of which converge at the critical intersection of analysis and interpretation. Through a careful examination of the data, this chapter aims to provide comprehensive insights and conclusive answers to the research questions posed at the beginning of this study. By synthesizing the findings, this chapter seeks to shed light on the insights that have emerged about CS and tutorials.

5.1. Research Objective 1

The main objective of this study is to investigate and understand users' requirements for an interactive visual tutorial in order to improve the educational experience in a digital environment. In pursuit of this goal, we must identify the specific needs and preferences of users of interactive visual tutorials. This objective serves as the cornerstone for unravelling how these tutorials can best serve their intended audience.

Research Question 1 (RQ1): What differentiates a tutorial for CS than from a regular tutorial?

Within Research Objective 1, RQ1 explores the characteristics that distinguish an interactive visual tutorial from a conventional tutorial. By addressing RQ1, we aim to lay the groundwork for understanding the essential elements that contribute to the effectiveness and appeal of interactive visual tutorials in citizen science education. The answers to RQ1 will provide invaluable insights into how these tutorials can be tailored to meet the specific needs of their users, thus fostering an environment conducive to effective learning and knowledge retention.

The summary of the findings from both the extensive literature review and the online survey conducted has revealed a unanimous preference among users for the inclusion of interactive and gamification elements within educational tutorials, regardless of their age or educational background. This convergence of user sentiment underscores the universal appeal of interactive learning tools in the digital education landscape. Such elements not only encourage engagement, but also contribute significantly to the overall effectiveness of these tutorials in conveying complex information and enhancing the learning experience.

In addition, the research findings have highlighted the three most important attributes that users prioritize when engaging with tutorials. Primarily, simplicity emerges as a key factor that resonates across user demographics. Users consistently express a preference for tutorial interfaces that are intuitively designed, minimize complexity, and ensure accessibility for learners of all levels. Ensuring simplicity in a tutorial, especially for non-technical users, is of paramount

importance. Simplicity is the key to accessibility, allowing people with diverse levels of prior knowledge to engage effectively with the material. Clear and concise explanations, intuitive interfaces and step-by-step guidance are essential components of simplifying the learning experience.

Secondly, the desire for real-time responsiveness within tutorials stands out. Users value the immediate feedback and interactivity that real-time features provide, as it allows them to gauge their progress, correct mistakes promptly and remain actively engaged throughout the learning process. In addition, the inclusion of problem-solving exercises plays a vital role in increasing engagement. These exercises encourage active participation, critical thinking, and the application of newly acquired knowledge, transforming the tutorial into an interactive learning journey. By combining simplicity with problem-solving elements, tutorials not only become more accessible, but also foster a dynamic and engaging learning environment that appeals to a wider audience, regardless of their technical background.

Finally, a clear and well-defined structural framework emerges as another critical element. Users value tutorials that present information in a logical and organized manner. A clear structure not only helps to understand complex concepts, but also facilitates efficient navigation, allowing users to find specific content effortlessly. Taken together, these findings highlight the importance of user-centered design principles in the development of interactive visual tutorials for computer science education. By emphasizing simplicity, real-time responsiveness, and a clear structural layout, educational content creators can meet the needs of learners.

CHARACTERISTICS	CITIZEN SCIENCE TUTORIAL	REGULAR DASHBOARD/PORTAL
User Engagement	✓	✗
Training and Guidance	✓	✗
Active Contribution to research	✓	✗
Access to Information	✓	✓
Specific Scientific Project	✓	✗

Figure 68: Difference between CS tutorial and regular portal

In terms of purpose and focus, a citizen science tutorial is primarily designed to train and actively engage volunteers, often referred to as citizen scientists, in scientific research projects. Its main objective is to provide step-by-step guidance to equip participants with the necessary knowledge

and skills to actively participate in data collection, analysis, and research activities specific to particular scientific projects. In contrast, a regular portal or dashboard typically serves a broader range of purposes, such as providing access to various information, data, resources, or services, without a specific focus on active engagement in scientific research.

In terms of user engagement, citizen science tutorials are deliberately designed to encourage active participation in scientific endeavors. They often include interactive elements, training modules, and comprehensive guidance on data collection, creating an environment that encourages users to actively contribute to scientific research. Conversely, interaction with a regular portal or dashboard tends to be more passive, focused on tasks such as accessing information or using services, without a primary focus on active user engagement in scientific activities.

Scientific contribution is a key differentiator. Citizen science tutorials aim to empower users, especially citizen scientists, to make substantive contributions to scientific research efforts. They focus on providing the necessary knowledge and skills for data collection and submission, thereby contributing to the advancement of scientific knowledge. On the other hand, while regular portals or dashboards may provide valuable information or tools, they generally lack a specific focus on enabling users to actively contribute to scientific research initiatives.

The aspect of training and guidance is another notable difference. Citizen science tutorials are known for their comprehensive training and guidance provisions. They ensure that users understand research protocols, data collection methods and scientific objectives by providing step-by-step instructions and a wealth of resources tailored to participants. In contrast, while regular portals or dashboards may provide information and resources, they typically do not offer the same level of structured training or guidance that is commonly found in citizen science tutorials. In addition, citizen science tutorials are often linked to specific scientific research projects or initiatives that require public participation. These tutorials are carefully designed to meet the specific needs and objectives of these projects. In contrast, regular portals or dashboards cover a wide range of topics or services and may not be inherently linked to specific scientific research efforts.

Finally, in data collection and reporting, citizen science tutorials provide detailed instructions on how to collect and report data according to specific research protocols. They often guide users on how to ensure data quality and accuracy, which are paramount for scientific research. Conversely, mainstream portals or dashboards may provide access to data, but typically do not offer the same level of guidance and structure when it comes to collecting and reporting data for scientific purposes. These distinctions highlight the unique characteristics and specialized objectives of citizen science tutorials compared to regular portals or dashboards and underscore their role in facilitating active citizen participation in scientific research.

5.2. Research Objective 2

The aim of this research objective was to use the results and findings of Research Objective 1 (RO1) to develop an interactive web-based tutorial specifically tailored to citizen science projects. This objective recognized the growing importance of citizen science in various fields, where the active participation of volunteers plays a crucial role in data collection and research efforts. By creating a web-based tutorial, the aim was to empower individuals interested in participating in citizen science initiatives by providing them with accessible resources, guidance, and training materials. This tutorial seeks to facilitate their involvement, improve their understanding of project objectives, methodologies, and data collection techniques, and ultimately contribute to the success and impact of citizen science efforts.

Research Question 2 (RQ2): What are the characteristics of a visual tutorial?

To advance the field of citizen science and increase volunteer participation, Research Question 2 (RQ2) was addressed, which focuses on elucidating the basic characteristics of an effective visual tutorial. This research question is a critical component of a broader initiative to empower and educate individuals interested in citizen science projects. Building on the valuable insights gained from an online survey, this thesis presents a prototype citizen science tutorial that serves as a practical embodiment of RQ2. The prototype not only allows for an exploration of the specific visual elements and instructional design principles conducive to effective learning, but also allows for the collection of user feedback to inform and refine the development of the tutorial.

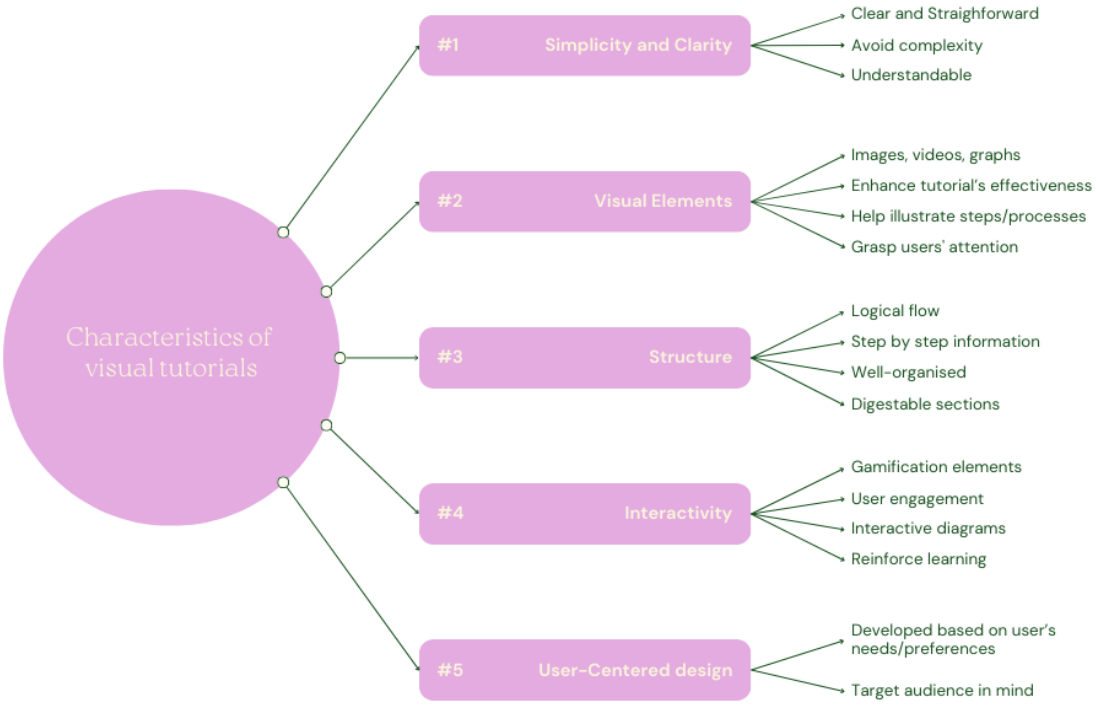

Figure 69: Characteristics of visual tutorials

In developing the prototype for this thesis, a global approach was taken, taking into account several critical features that define an effective visual tutorial. First, the overriding principle of clarity and simplicity was maintained as the cornerstone of the tutorial's design. Information was meticulously presented in a clear and straightforward manner, avoiding the pitfalls of unnecessary complexity and jargon, thus ensuring accessibility and comprehension for users of varying backgrounds and levels of expertise.

Visual elements, including images, diagrams, charts, and videos, were carefully integrated to enhance the effectiveness of the tutorial. These visual aids played a key role in explaining complicated concepts, describing step-by-step procedures, and explaining complex processes, thereby facilitating a deeper understanding among users. The engagement factor of the tutorial was further enhanced by the inclusion of graphics. This strategic use of engaging visuals not only grabbed users' attention, but also maintained their interest throughout the learning journey, fostering a more immersive and rewarding educational experience.

An emphasis on structure and organization was also paramount, ensuring that the tutorial had a logical flow. Information was meticulously arranged in a step-by-step format, and complex topics were artfully broken down into digestible sections. This meticulous structuring functioned as a guiding compass, allowing users to navigate seamlessly through the tutorial, enhancing their learning experience. Interactivity was another key aspect incorporated into the prototype. In order to actively engage users and deepen their understanding, the tutorial included interactive elements such as quizzes and interactive diagrams.

In addition, the guiding principle of user-centered design was at the center of the tutorial's development. Every aspect of the design, from the choice of visual elements to the instructional content, was carefully crafted with the needs, preferences, and prior knowledge of the target audience in mind. This approach was designed to ensure that the tutorial resonated with users on a personal level, promoting greater accessibility and effectiveness. Taken together, these features resulted in a prototype that embodies the ideals of clarity, engagement, structure, interactivity, and user-centered design. This overall approach not only illustrates the creation of an effective visual tutorial, but also underlines a commitment to advancing the field of citizen science education and promoting informed and engaged participation in this vital field.

5.3. Research Objective 3

In the quest to fully evaluate the effectiveness and usability of the tutorial prototype developed in this study, a critical juncture was reached with the initiation of a focus group. This crucial stage represents the practical manifestation of the research objective to "evaluate and analyze how users perceived the tutorials and what can be improved". The focus group, consisting of six participants, was carefully structured to include both task-based evaluations and in-depth discussion sessions. This approach allowed for a multi-faceted exploration of users' perceptions, experiences, and feedback, shedding light on the strengths, weaknesses and areas for improvement of the tutorial.

Research Question 3 (RQ3): How did the user group perceive the tutorial?

According to the results of the focus groups presented in Chapter 5, users showed a commendable level of ease in navigating through the tutorial. In particular, they expressed a strong sense of clarity about the purpose of the tutorial and the specific tasks they were required to complete. This clarity was perceived as a significant benefit that greatly enhanced their overall experience. Participants praised the tutorial for its simplicity, emphasizing that the tasks were presented in an accessible and straightforward manner. In addition, the effectiveness of the tutorial in conveying information was widely acknowledged, with users highlighting its ability to cater for a wide range of users and learning styles. The consensus among participants was that the tutorial successfully struck a balance between simplicity and comprehensiveness, a feature that contributed greatly to its overall positive reception.

Feedback from focus group participants not only shed light on the visual design elements of the portal and tutorial, but also underlined the importance of accessibility and inclusivity for all users in the design process. The positive reception of the colors, graphics and images not only contributed to the aesthetic appeal, but also resonated with the notion that design decisions should be made with a broad and diverse user base in mind. Participants' recognition that the colors chosen were not only visually appealing but also well suited to the theme of the citizen science project highlighted the careful consideration of thematic coherence.

In addition, participants' appreciation of the images and gifs within the tutorial, although accompanied by a request for larger visuals, highlighted the importance of visual aids in enhancing the learning experience. Inclusive design principles advocate considering the needs and preferences of diverse users, including those who may rely more heavily on visual cues to understand and engage with content. In essence, the feedback provided by the focus group participants highlighted the necessary relationship between design aesthetics and inclusivity. It reinforced the notion that while visual elements should be aesthetically pleasing, they should also be optimized for accessibility to ensure that the portal and tutorial are welcoming and effective for all users, regardless of their abilities or learning styles. This underlines the commitment to creating an inclusive educational environment that meets the needs of a diverse audience.

During the focus group discussions, participants expressed a strong interest in the integration of feedback mechanisms within the tutorial to enhance their overall learning experience. Specifically, they expressed a desire for features such as a progress bar and quizzes that provided immediate feedback on their answers. Participants recognized the value of progress tracking as a means of monitoring their progress through the tutorial, allowing them to gauge their understanding and navigate their learning journey more effectively. At the same time, the idea of interactive quizzes, designed to provide answers and explanations following user responses, was seen as a valuable tool for reinforcing understanding and encouraging active engagement. Their request for these feedback mechanisms underlines the importance of real-time assessment and self-assessment

tools in educational resources, as they facilitate a more interactive and dynamic learning environment.

Finally, participants provided valuable information about balancing interactives in tutorials, in particular how they felt about certain interactive elements. While recognizing the benefits of interactivity, there was a consensus among participants that some interactive elements, such as flashcards, may have been somewhat excessive and occasionally irrelevant to the intended purpose of the portal. Their feedback indicated a preference for a more measured approach, suggesting that an excess of such features could potentially distract from the core learning objectives. Participants expressed a desire for a simplified learning process with fewer but more relevant interactive elements. This perspective highlights the importance of aligning interactivity with instructional goals, ensuring that interactive features are purposeful and enhance the learning experience without overwhelming users with redundant elements.

Considering the participants, the graph (see Figure 69) showing the characteristics of visual tutorials looks like this:

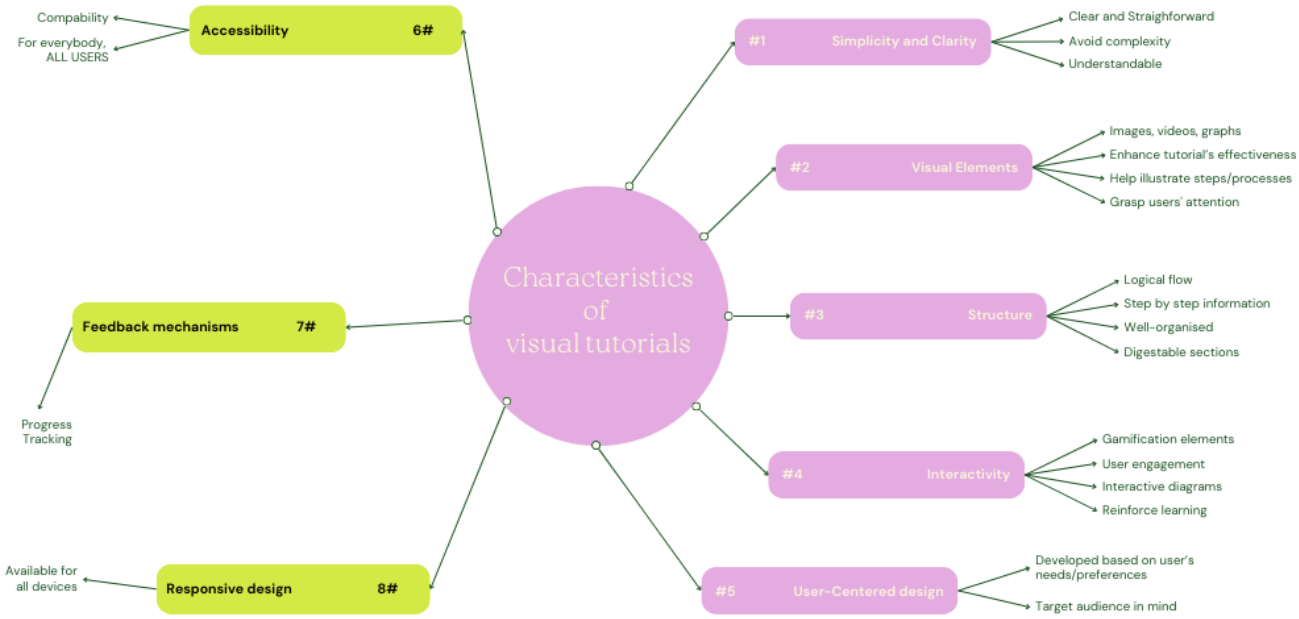

Figure 70: Characteristic of visual tutorials after feedback

The text with a yellow-greenish background are the characteristics that were added after the collection and analysis of the focus group feedback.

6. Conclusions

6.1. Discussions

The results highlight that effective visual tutorials for citizen science should emphasize interactivity, simplicity, structured step-by-step guidance and the strategic inclusion of visual elements and graphics. In addition, participants highlighted the importance of real-time feedback, accessibility of the tutorial to a diverse user base, and the need for responsive design across different devices. Taken together, these findings underscore the importance of a multifaceted approach to citizen science tutorial design that addresses user preferences and promotes an inclusive and engaging learning experience.

The hypothesis that user preferences significantly influence the perceived effectiveness of citizen science tutorials emerged as a central theme of this study. While the initial excitement surrounding interactive elements in the pre-prototype online study was evident, the subsequent user testing phase revealed a more subtle perspective. Participants found that an excess of interactive elements could become redundant, highlighting the delicate balance required in tutorial design. In particular, the inclusion of gamification elements consistently emerged as an effective strategy, receiving positive feedback in both the preliminary online study and the focus group sessions. These findings are consistent with previous research, particularly studies such as the study for virtual Citizen Science (Simperl Elena et al., 2018), which suggest that gamification elements contribute to the increased effectiveness of tutorials. This highlights the multifaceted relationship between user preferences, interactive elements, gamification, and the overall perceived effectiveness of citizen science tutorials.

The results of this study provide valuable insights into the design and effectiveness of citizen science tutorials. They provide a comprehensive understanding of how user preferences affect the perceived effectiveness of such tutorials, shedding light on the delicate balance required in tutorial design. The findings, including the importance of interactive elements and the effectiveness of gamification, have practical implications for the development of future citizen science educational resources. Furthermore, the identification of a gap in UX design for tutorials highlights the need for further research and best practice in this area, contributing to the wider field of instructional design and digital education. Overall, these findings are not only meaningful in the specific context of citizen science but are also relevant for the design and optimization of online tutorials and educational materials in various domains.

In acknowledging the limitations of the study, it is important to recognize that the focus group sessions involved a relatively small sample of only six participants. While this number may be seen as a drawback in terms of statistical representation, the insights and feedback gathered from these participants proved to be extremely valuable. Their in-depth discussions and perspectives provided rich feedback that allowed for a detailed exploration of user preferences and perceptions of citizen science tutorials. Despite the small group size, the quality and depth of the insights

provided by these participants were instrumental in shaping the findings of the study and providing practical guidance for refining the educational resources.

6.2. Future Work

In terms of future work, the findings from the user study and focus group sessions provide a promising direction. It is advisable to implement the suggested improvements to the tutorial, considering the valuable user feedback received. Integrating these improvements into the design and content of the tutorial has the potential to increase its overall effectiveness, usability, and engagement. Subsequent rounds of user testing can then be conducted to assess the impact of these refinements. This iterative approach ensures that the tutorial remains responsive to user needs and provides an opportunity to gauge the evolving perceptions and preferences of the user base. Through these ongoing iterations, the tutorial can continue to evolve into a more effective and user-centered educational resource.

In addition, an interesting direction for future research lies in the area of user experience (UX) design specific to tutorials. Although tutorials play a vital role in various educational contexts, there is a noticeable gap in the literature regarding UX design principles for tutorials. Conducting comprehensive research into the strategies, principles, and best practices for creating tutorials that optimize the user experience can make a significant contribution to the field of educational technology. This research can cover various aspects including interface design, interactivity, accessibility, and the incorporation of multimedia elements. By highlighting the details of designing tutorials that resonate with users across different domains, this line of research can provide valuable guidance to instructional designers, educators and researchers seeking to create more effective and engaging learning resources.

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APPENDIX A: Online Survey

This appendix can be accessed here: Online Survey

APPENDIX B: Online Survey Replies

This appendix can be accessed here: Online Survey Replies

APPENDIX C: Citizen Science Tutorial

This appendix can be accessed here: Citizen Science Tutorial

APPENDIX D: Focus Group Consent form

This appendix can be accessed here: Consent Form

APPENDIX E: Focus Group Transcripts

This appendix can be accessed here: Audio Transcripts