Cartography M.Sc.

Master thesis

Blazing the Trail

Creating a Customisable Web Map for Yellowstone and Grand Canyon National Parks

Vanessa Henkes

Technical University of Munich
TECHNISCHE UNIVERSITÄT WIEN Vienna University of Technology
TECHNISCHE UNIVERSITÄT DRESDEN
UNIVERSITY OF TWENTE. ITC

2023

Blazing the Trail

Creating a customisable Web Map for Yellowstone and Grand Canyon National Parks

Vanessa Henkes

Enschede, The Netherlands, September, 2023

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.

SUPERVISOR:
Univ.-Prof. Dr., M. F.- B., Franz-Benjamin Mocnik

REVIEWER
Dipl.-Ing. Dr., L. F., Florian Ledermann

THESIS ASSESSMENT BOARD:
[Prof. Dr., K. M.-J., Menno-Jan Kraak (Chair)]

Master Thesis

Blazing the Trail

Creating a Customisable Web Map for Yellowstone and Grand Canyon National Parks

International Master of Cartography
Written with ITC, Netherlands

Written by:
Vanessa Henkes
7th of September, 2023

Supervision by:
Franz-Benjamin Mocnik

UNIVERSITY OF TWENTE.

Declaration of Authorship

Herewith I declare that I am the sole author of the submitted Master's thesis entitled: "Blazing the Trail – Creating a Customisable Web Map for Yellowstone and Grand Canyon National Parks". I have fully referenced the ideas and work of others, whether published or unpublished. Literal or analogous citations are clearly marked as such.

Vienna, 7th of September, 2023 Vanessa Henkes

Acknowledgement

I want to express my heartfelt thanks to everyone who played a crucial role in helping me complete this master's thesis.

First and foremost, I'm deeply grateful to my friends for their unwavering support, both emotionally and intellectually, throughout this academic journey. Your encouragement and our insightful discussions have been invaluable, broadening my perspectives in ways I never expected. I'd like to extend a big thank-you to my supervisor, Franz-Benjamin Mocnik, for being an outstanding mentor. Your guidance and expertise have been a guiding light in shaping this research. A special shoutout goes to my dog, Rosie. You were my loyal companion during those long hours of research and writing. Your presence brought comfort and company at all times. To my sister, thanks for believing in me and constantly sending funny and cute videos to brighten my days. I also want to thank my flatmates for their patience, understanding, and friendship during this intense research period. Your tolerance for my late-night rants and the occasional morale boost truly kept me going. Lastly, I can't forget the online community that provided an abundance of knowledge, resources, and inspiration, especially when it came to learning JavaScript from scratch.

To all of you, mentioned here or not, who contributed in various ways to this thesis, I want to convey my heartfelt thanks. Your support, in all its forms, has been invaluable in helping me reach this milestone.

Abstract

This thesis aims to establish a versatile map interface that caters to the distinct needs and preferences of visitors in the contexts of Yellowstone and Grand Canyon National Parks. The research initiates by developing a temporary web map for Yellowstone National Park using a trial-and-error approach. The study culminates in a user analysis that examines the interface's intuitive features, usefulness, and aesthetics. Despite the limitation of having only 20 participants, the research's findings have significant implications for refining the interface. The recommendations shared by participants underline the importance of enhancing interface features, including incorporating aspects such as hiking trails and environmental factors, for example, crowd density and optimal viewpoints. The study finds evidence of a preference for customisation, highlighting the significance of offering both personalised filtering and predefined map settings. The research reveals that interface comprehension is generally favourable but specific areas of ambiguity, such as button functionality and element visibility, were identified. Furthermore, participants' expectations are aligned with the actual element functionalities, validating the initial design's coherence and inherent user-friendliness. The scope of the study goes beyond interface intricacies to explore the broader utility of the map, revealing its effectiveness in proactive trip planning and spontaneous exploration. It can assist in pinpointing attractions and aiding tourism entities. Of notable importance is the perceived usefulness for travel planning, thus supporting the primary goal of the project. These findings reveal the mutually beneficial relationship between user engagement and design innovation, providing valuable insights into adaptable map interface development. To reinforce these scientific findings, the study advocates a circular conceptual framework that includes Knowledge, Preparation, Application, Evaluation, and Review stages, thereby mapping out a systematic process for developing adaptable and user-friendly map interfaces. Incorporating user feedback into actionable design paradigms emphasises the iterative nature that underpins interface evolution. This study provides a prototype for crafting user-centric interfaces that enhance the experiential dimension of trip planning. The framework provides a first foundational foothold while anticipating the accommodation of technological shifts and evolving user preferences, fostering sustained user engagement, and immersive exploration within natural enclaves such as national parks.

Keywords: adaptable interface, user-centric, national parks, conceptual framework

I. List of Figures I
I.I. In Text I
I.II. Appendix II
II. List of Tables II
III. List of Abbreviations III
1. Introduction 1
1.1. Research Motivation 1
1.2. Research Questions 2
1.3. Thesis Outline 4
2. Literature Review 5
2.1. Motivation 5
2.2. Adaptation 10
2.3. Accessibility 13
2.4. User Experience/User Interface Design 14
2.5. Design 16
2.6. Hiking Formulas/Algorithms 17
2.7. Framework 20
3. Study Sites 21
3.1. Yellowstone National Park 21
3.1.1. Exploration and Establishment 21
3.1.2. Geography and Geology 22
3.1.3. Activities 23
3.2. Grand Canyon National Park 24
3.2.1. Exploration and Establishment 24
3.2.2. Geography and Geology 25
3.2.3. Activities 27
3.3. Similarities and Differences between the parks 27
4. Methodology 30
4.1. Data acquisition and processing 30
4.2. Website Development 31
4.2.1. Basics 31

4.2.2.Filtering 32
4.3. User Study 33
4.4. Framework 35
5. Results 36
6. Analysis 45
6.1. Discussion 45
6.1.1.Filtering — Sub-Section One 46
6.1.2.Design — Sub-Section Two 49
6.1.3.Overview — Sub-Section Three 51
6.2. Conceptual Framework 53
6.2.1.Knowledge 54
6.2.2.Preparation 54
6.2.3.Application 55
6.2.4.Evaluation 56
6.2.5.Review 56
6.2.6.Contributions and Limitations 57
7. Conclusion 58
8. Future Work 59
9. References 60
10. Appendix A
10.1.NPS Park Maps A
10.2.Progress Screenshots B
10.3.Conceptual Framework E

I. List of Figures

I.I. In Text

Figure 1: Conceptual outline of visitor identities and corresponding authors **9**
Figure 2: Conceptual outline of motivational factors within visitor identities and corresponding authors **10**
Figure 3: Study Site Map **29**
Figure 4: Pie Chart showing the age demographic of the participants **36**
Figure 5: Pie chart showing the device used by participants **36**
Figure 6: Bar chart visualising answers to "Are you satisfied with the options for specific activities to choose from (eg. Photography)" **37**
Figure 7: Bar chart visualising clusters of answers to "Why were you satisfied/dissatisfied?" **37**
Figure 8: Bar chart visualising answers to "Would you wish for additional options to adapt the map to"? **38**
Figure 9: Bar chart visualising cluster of answers to "What kind of options would you like to see?" **38**
Figure 10: Bar chart visualising answers to "Do you feel represented by the categories in the predefined settings?" **39**
Figure 11: Bar chart visualising answers to "Which filtering process did you prefer to use?" **40**
Figure 12: Bar chart visualising clusters of answers to "Why did you prefer that one?" **40**
Figure 13: Bar chart visualising answers to "When you opened the website, did you immediately understand how to use it — of were there some difficulties?" **41**
Figure 14: Bar chart visualising clusters of answers to "What confused you? (Which elements?)" **41**
Figure 15: Bar chart visualising answers to "Would you benefit from an onboarding tutorial - as in a step by step guide through the first interaction with the map?" **41**
Figure 16: Bar chart visualising answers to "Did you expect any element of the interface to do something different than it finally did?" **41**
Figure 17: Bar chart visualising clusters of answers to "Which elements seemed to do something different than expected?" **42**
Figure 18: Bar chart visualising clusters of answers to "What would you change to make the design more intuitive?" **43**
Figure 19: Bar chart visualising cluster of answers to "At any point, were there issues with loading the map content?" **43**
Figure 20: Bar chart visualising clusters of answers to "What do you believe this map could be useful for?" **44**
Figure 21: Bar chart visualising clusters of answers to "How useful do you believe this map is for the purpose of planning a trip?" **44**
Figure 22: Conceptual Framework for creating adaptable web map interfaces **53**

I.II. Appendix

App. 1: Official map of Yellowstone NP (NPS, 2023a) **A**
App. 2: Official map of Grand Canyon NP (NPS, 2015) **B**
App. 3: Progress Screenshot of the map — first working filtering example **B**
App. 4: Progress Screenshot of the map — first example of the filtering window **C**
App. 5: Progress Screenshot of the map — Addition of Grand Canyon NP, a "Switch NP" button to navigate between the parks, and highlighted park entrances (as suggested through the user study) **C**
App. 6: Progress Screenshot of the map — refined explanation of the predefined map categories **D**
App. 7: Progress Screenshot of the map — refined filtering window for individual settings **D**
App. 8: Conceptual Framework for creating adaptable web map interfaces **K**

II. List of Tables

Table 1: Hiking categories after Shenandoah NP (NPS, 2023d) **19**

III. List of Abbreviations

API - Application Programming Interface

AVANTI - Adaptive and Adaptable interactions for multimedia Telecommunication applications

CNNIC - China Internet Network Information Center

GUI - Graphical User Interface

ISO - International Standardisation Organisation

LBS - Location based Services

MIDE - Método de Información de Excursiones or Medium Itinerary Displacement Effort

NP - National Park

NPS - National Park Service

NYT - New York Times

POI - Point of Interest

SRTM - Shuttle Radar Topography Mission

TCM - Travel Cost Model

US - United States

USGS - United States Geological Survey

WCAG - Web Content Accessibility Guidelines

YVO - Yellowstone Volcanic Organisation

1. Introduction

Every year, thousands of people visit the National Parks in the US. In 2022 alone, 312 Million visitors were recorded, an increase of about 5% compared to 2021. For 2023, the National Park Service (NPS) has requested a budget of $3.1 Billion to maintain and renew the parks, with $279.8 Million allocated solely to Visitor Services, for visitors to have an experience to remember. The main philosophy of the NPS is to “preserve the natural and cultural resources and values of the National Park system, unimpaired, for the enjoyment, education, and inspiration of this and future generations” (2022). With this in mind, maps of the National Parks have been created since the designation of Yellowstone as a National Park in 1872 (NP; Butcher, D., 1969). Both web maps and static maps of most of the parks exist, free for use. The majority of these cartographic visualisations of the parks include points of interest (POIs), trails for hiking, areas for camping, restaurants, and diners (NPS, 2023a). They are designed to be used by any and all visitors, in an easily understandable way. The standard design of these maps is the same for all parks. They take into account accessibility to ensure everyone has a good experience there, and all the aforementioned elements are present on all the maps.

1.1. Research Motivation

The main objective of this research is to **develop a user-specific web map taking into account visitors’ motivations, identify platial differences between the parks, analyse how these influence the design, and create a corresponding framework that can and should be accessible and replicable.**

More specifically, these sub-objectives will serve as a guide through the thesis.

To develop a user-specific web map that takes into account visitors’ motivations.

This objective aims to develop a web map that is tailored to the specific motivations of visitors of Yellowstone NP and Grand Canyon NP. This will involve conducting a user study to understand the needs and preferences of visitors and designing a map that meets those needs.

To identify the platial differences between the parks and how they influence the design of the map.

This objective involves exploring how the parks differ in terms of their cultural significance and natural environment, taking into account factors like topography, flora, and fauna, and cultural significances. To achieve this objective, it will be necessary to analyse the platial differences and other physical characteristics of the parks, and determine how to represent them on a map effectively. This will involve examining factors like the types of landscapes found within the parks, the presence of unique plant and animal species, any present cultural or historical landmarks, and the sense of place. By analysing these differences, we can gain a deeper understanding of what makes each NP unique and identify potential ways of representing them on an interactive web map.

To create an accessible and replicable framework for generating user-specific web maps.

This objective is to create a framework for generating user-specific web maps that can be used by other researchers in the field. This will involve identifying key elements that are needed for such a framework and developing a set of guidelines that can be followed easily.

The primary audience for this thesis are cartographers and researchers, utilising the results and guidelines of this research, that will be included in the framework. Additionally, the audience of the web maps will be potential visitors to Yellowstone NP and Grand Canyon NP. The aim of this research is to develop a representative framework, which will enable others to produce similar maps, promoting wider accessibility, and to create user specific web maps of the two parks. It should be noted that this research does not aim to expand on existing theories of visitor motivations or update NPS design principles. Rather, it will build upon current design principles in order to develop a tailored and user-friendly interface. Limitations of the research include these omissions and the potential for biases in the user study.

1.2. Research Questions

To meet the aforementioned objectives, the following research questions are going to be answered throughout the course of the thesis.

RQ1: How can the motivations for visiting a National Park be incorporated into the design of a user-specific web map?

The research question aims to explore how the motivations for visiting a NP can be integrated into the design of a user-specific web map. Designing a map that caters to the diverse interests and preferences of visitors can enhance the experience. The goal is to identify key factors for motivation, design principles, and methods for evaluating and refining the map.

To achieve this, the following sub-questions will be answered:

I. *What are the key factors that motivate visitors to visit National Parks?*

II. *How can these factors be incorporated into the design of the web map, using the best practices and design principles for creating user-specific National Park web maps ?*

III. *How can user feedback and evaluation be used to refine the web map design and better align it with the motivations and needs of National Park visitors?*

RQ2: How do the platial differences between the National Parks affect the design of the map, and what specific adjustments are needed to accurately represent each park on the map?
The research explores how the variation in size, shape, topography, and sense of place between Yellowstone and Grand Canyon NP influence the design of a map. Since the two parks differ significantly not only in their physical characteristics, such as topography, vegetation, and geology, but also in the overlying aspect of place, a one-size-fits-all approach to mapping may not be appropriate. Therefore, the question seeks to identify the differences and ascertain specific adjustments that can contribute to the development of the maps. More specifically, the following question will be investigated:

I. *What are the key platial differences between the two NPs that require different cartographic strategies?*

II. *How do the differences in the physical features affect the visual representation of each of the parks?*

RQ3: How can the necessary components of this project be made accessible and replicable for others to use? This research question aims to investigate how the necessary components of a project can be made accessible and replicable for others to use. By developing a framework that outlines the necessary steps and components for disseminating the project, the research can contribute to advancing knowledge and innovation in the field, promoting collaboration.

To accomplish this, the following question will be resolved:

I. *What are the key components of the project that need to be made accessible and replicable?*

II. *How can a framework be developed to guide the dissemination and replication of the project?*

1.3. Thesis Outline

The thesis is divided into eight sub-sections, beginning with an introduction to the project, which includes the research motivation and research questions. The introduction is followed by a literature review, which provides the necessary knowledge base for the creation of the adaptable interface and the conceptual framework, answering RQ1.I, and RQ3.II. This is followed by a detailed description and differentiation of the study site, providing information about Yellowstone and Grand Canyon NP. The methodology chapter will outline the research design, including the creation of the map interface and the development of the user study. The Results chapter will present the results of the user study, followed by an analysis including a discussion of the results and a conceptual framework for creating adaptable, intuitive map interfaces. Finally, a conclusion will summarise the findings of the thesis and future work will provide an outlook for any necessary future research and testing.

2. Literature Review

2.1. Motivation

When planning to create an adaptable interface on the web, to give potential visitors to a national park such as Yellowstone, one first has to understand the motivations and preferences of those visitors. The first step in creating such an understanding is to acquire the underlying knowledge of the drivers of human behaviour. Within the tourism industry, researchers often analyse the economical benefits and put less of an in-depth view on the social circumstances of why a tourist may visit a destination (Simková, 2013). Psychology and the theories therein can also be applied to this situation. For instance, Villamira (2001) indicated that psychology in tourism is based on general psychology. Here, inquiries about the drivers that make a tourist travel, the needs and preferences of the latter and the decision-making process of tourists are being done. Similarly ,Ryglová et al. (2011) state that a tourist's behaviour is based on social, emotional, motivational and cognitive aspects. Another key aspect is the role of the mental image of the destination (Simková, 2001). A tourist's motivation to visit a destination is influenced, for instance, by prior experiences, expectations, and (dis)satisfaction, which in turn influence the mental image. All these factors also pour into the general analysis of a tourist's needs and preferences when visiting a national park. Whether they have visited the park before, may influence which parts of it, they will make part of another trip. Additionally, any good or bad experiences with similar destinations may influence a tourist's mental image, and drive them to make a decision on whether to visit a national park, based on those experiences. Therefore, comprehending these factors can aid in creating a versatile interface catering to the needs of every tourist.

Studies are being conducted every year by the NPS (2023b), quantifying the demand for a national park. One reason to do this is to explore the benefits of visitation so as to conduct cost analyses. These analyses are used to determine budgetary considerations regarding "expansion, upgrades, or maintenance" (Benson et al., 2013, p. 918). The second reason is to determine visitor characteristics and parameters that affect park demand. The latter is ultimately comprised of visitor demographics and preferences. Benson et al. (2013) conducted a travel cost analysis with a subsequent clustering of user groups for Yellowstone NP, not only estimating park demand but building upon those results and investigating how benefits may vary based on the type of visitor. In general, travel cost models (TCM) are used to evaluate demand for recreational sites. Since such an analysis cannot be built on a market price of any kind, Benson et al. (2013, p. 918) used the "implicit price paid by a visitor to a recreational site" as the travel cost in this scenario. Additionally, the TCM took into account demographics such as age, gender, income and driving time, creating a number of factors on which to base the number of visits an individual makes to the recreational sites (Loomis, 2008).

A common problem within such studies of the benefits for the tourists is the heterogeneity of tourists. Therefore, Benson et al. (2013) included a cluster analysis of the visitor's activities. Five clusters were created, based off of the similarity of the activities the visitors participated in (Wilson and Thilmany, 2006). The clusters are as follows: "Do It All Adventurists", "Windshield Tourists", "Value Picnickers", "Creature Comfort Seekers" and "Backcountry Enthusiasts". The "Do It All Adventurists" group, experience everything there is and showed participation in activities higher than average. "Windshield Tourists" are more inclined to look at "roadside exhibits, photography and paints" (Benson et al., 2013, p. 922). As the name says, "Value Picnickers" are most likely to picnic in the park, as opposed to "Creature Comfort Seekers", who are more likely to eat at restaurants. The "Backcountry Enthusiasts" focused solely on backpacking, rather than participate in specific activities, with the exception of rock climbing.

Their results can be used to explore visitor preferences and motivations, so as to incorporate them into the filtering algorithm. However, to create an adaptable interface where a tourist can completely make their own decisions on what to see on the map, more factors have to be included. A general understanding of the preferences and needs of visitors is crucial in creating an adaptable interface for such visitors to use. These factors can then be included in the interface to provide the user with everything they might need to plan a trip to a national park. Another study, aiming to understand what motivate tourists to visit several national reserves in Kenya, provided eight segments of motivational factors. Beh et al. (2007) conducted a 49-item survey at campsites and lodging locations in each of the three national reserves. To include tourists from as many backgrounds possible, the survey was available in six languages. This way, the aforementioned problem of heterogeneity (Benson et al., 2013) was addressed. The survey consisted of motivation indicators, asking participants to rate the importance of motivations on a Likert scale from one to seven. Additionally, visitor demographics were gathered, such as age, country of citizenship, and education level. Using an explanatory factor analysis to identify motivational factors and a K-means cluster analysis to identify visitor segments, Beh et al. (2007) came to the following conclusions. The main motivation factors were identified as Escape, Culture, Personal Growth, Mega-Fauna, Adventure, Learning, Nature, and General Viewing, in order of cumulative percentages. The cluster analysis resulted in three clusters: Escapists, Learners and Spiritualists, respectively. Additionally, the specific activities that comprised the motivation factors were analysed. For instance, within the domain "Escape", visitors reasoned their motivation as avoiding responsibilities, relaxing physically, and having a change from everyday routine. The motivation factors were also shown in a graph of differences, showcasing which factors were most correlated to which of the three segments. All segments showed similar motivation factors for general viewing, nature and culture. While Learners and Escapists were less likely to have been motivated by personal growth, Spiritualists were. Similarly, Escapists were motivated by factors such as Escape and Adventure, while Learners were more motivated by Learning, Nature, and Mega-Fauna. All in all, Beh et al. (2007) outlined an additional number of factors to include in the adaptable interface.

Cini et al. (2012) conducted a study specifically of overnight visitors to a national park. In this case, South Africa's Kruger National Park was chosen as the study site. Visitors were asked to fill in a questionnaire that included a 23-item scale of reasons for visiting the park. These reasons ranged from intrinsic motivations, such as fascination with the park, or the ability to explore it in many directions, to spending time with friends and family and loyalty to the park. Results from the study show that it seems people are mainly motivated intrinsically to visit a national park. Going on holiday to a national park is a way for people to extend their capabilities and getting away from their day-to-day routine. These findings corroborate what Beh et al. (2007) found, as escape is once again found to be one of the biggest motivational factors for visiting a national park. Kamri et al. (2013) outlined additional factors in a similar study, surveying visitors to Bako National Park in Malaysia. Here the factors with which most people strongly agreed with included to feel independent, to challenge skills and abilities, and to develop skills. Kamri et al. (2013) also outlined motives for visiting from previous research, which included to relieve tensions, to enjoy sights, sounds, and smells of nature, and to feel free from society's restrictions.

A slightly different approach to determine motivations of visitors was done by Rowe and Nickels (2011). Using the "Identity-Related Visitor Motivation Model" that was generated as part of a collaboration between the Association of Zoos and Aquariums of the United States and researchers Falk, Heimlich, and Bronnenkant (2008); visitor's motivations were documented at zoos, aquariums, and informal education settings. Rowe and Nickels (2011) present several studies that formulate the so-called "entry-narrative" and how they may be directly related to a visitor's identity. Pekarik and Doering (1996) and Pekarik, Doering, and Karns (1999) came to the conclusion that visitors enter museums with an "entry-narrative". It is made up of three parts: "(a) a basic framework or fundamental way that they as individuals construct and contemplate the world, (b) information about the specific content area organized according to that basic frame- work, and (c) personal experiences, emotions, and memories that verify and support this understanding." (Rowe and Nickels, 2011, p. 163)

Circling back to visitor's perceptions and satisfaction as mentioned by Simkova (2001), Doering and Pekarik (1996) found that entry narratives are directly related to the visitor's experiences and (dis)satisfaction. They conclude that the entry narrative is a concept, that is dynamic and will change with experiences. Later, Falk (2006, 2009, 2011) documents that entry narratives may be closely related to the underlying motivations of the visitor and subsequently their identity.

Here, Falk differs between "Identity" and "identity". "Identity" covers the traditional categories, for instance, gender, race, or national origin, whereas "identities" are "highly contextualised ways of being and being recognised as particular kinds of people engaged in particular kinds of activities" (Rowe and Nickels, 2011, p. 163). Following the analysis of the difference of the two, Falk et al. (2008) determined five situation-related identities of people on visits to the zoo or aquarium: explorers, facilitators, professional hobbyists, experience seekers, and spiritual pilgrims (later renamed to rechargers). Explorers are driven by curiosity and possess a genuine interest in uncovering more about the subject or content presented within the institution. On the other hand, facilitators visit with a social motivation, focusing primarily on the experience and learning of the others in their group. For professional hobbyists, there is a strong connection to the museum's content, and their visits are usually driven by a desire to fulfil specific content-related objectives related to their profession or hobby. Experience seekers view the museum as an important destination, deriving satisfaction mainly from the experience of "being there" and having accomplished the visit. Meanwhile, spiritual pilgrims seek a restorative, spiritual, or contemplative experiences, perceiving the museum as an escape from their every-day world. Following the user study, Rowe and Nickels (2011) found that explorers and facilitators were the main representative motivations at the aquarium and marine tour. Meanwhile, professional hobbyists were the primary motivation type at the science centre. Only few aquarium visitors, and marine tour visitors, were experience seekers. The least displayed motivation factor among all three locations were the rechargers, however there were significantly more in the aquarium, than the other two areas.

Apart from the singular identities, Rowe and Nickels (2011) also used further research to determine whether visitors belonged to singular motivation factors, or whether they would fit into more than one, or none. The latter categories were called dual-dominant motivation and non-dominant motivation respectively, based on Packer and Ballantyne's (2002) assumption that visitors have a mixture of motivations, with some of them being more important than others. While all three locations showed around 50% of the visitors with non-dominant motivations, the number of dual-dominant motivated visitors ranged from 3.6% to 8.6% at the science centre and aquarium respectively. Finally, Rowe and Nickels (2011) found seasonal differences, however they were not able to state why the motivations shifted.

This somewhat different study shows similar motivational factors as the ones centred around national parks around the world, so it may be applicable here as well. These studies show that not only is there a growing interest in visitor motivations, but also that there is a very wide range of factors and tourist identities that play a key role in creating an adaptable interface (see **Figures 1** and **2** for an overview). Each of the motivational factors gives insight into why people visit places such as national parks, and this insight can be used to create a filtering algorithm, that takes them into account, building an intuitive interface that can be tailored to each visitor's needs and preferences. See the following concept map for an overview of the similarities between the studies.

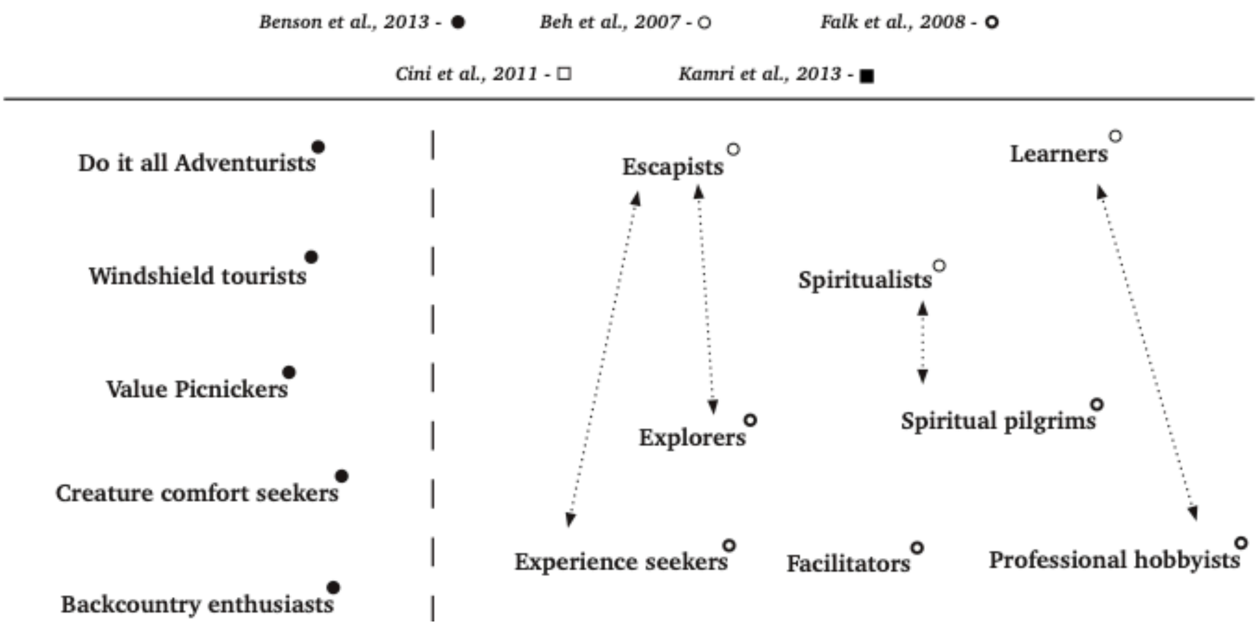


Figure 1: Conceptual outline of visitor identities and corresponding authors

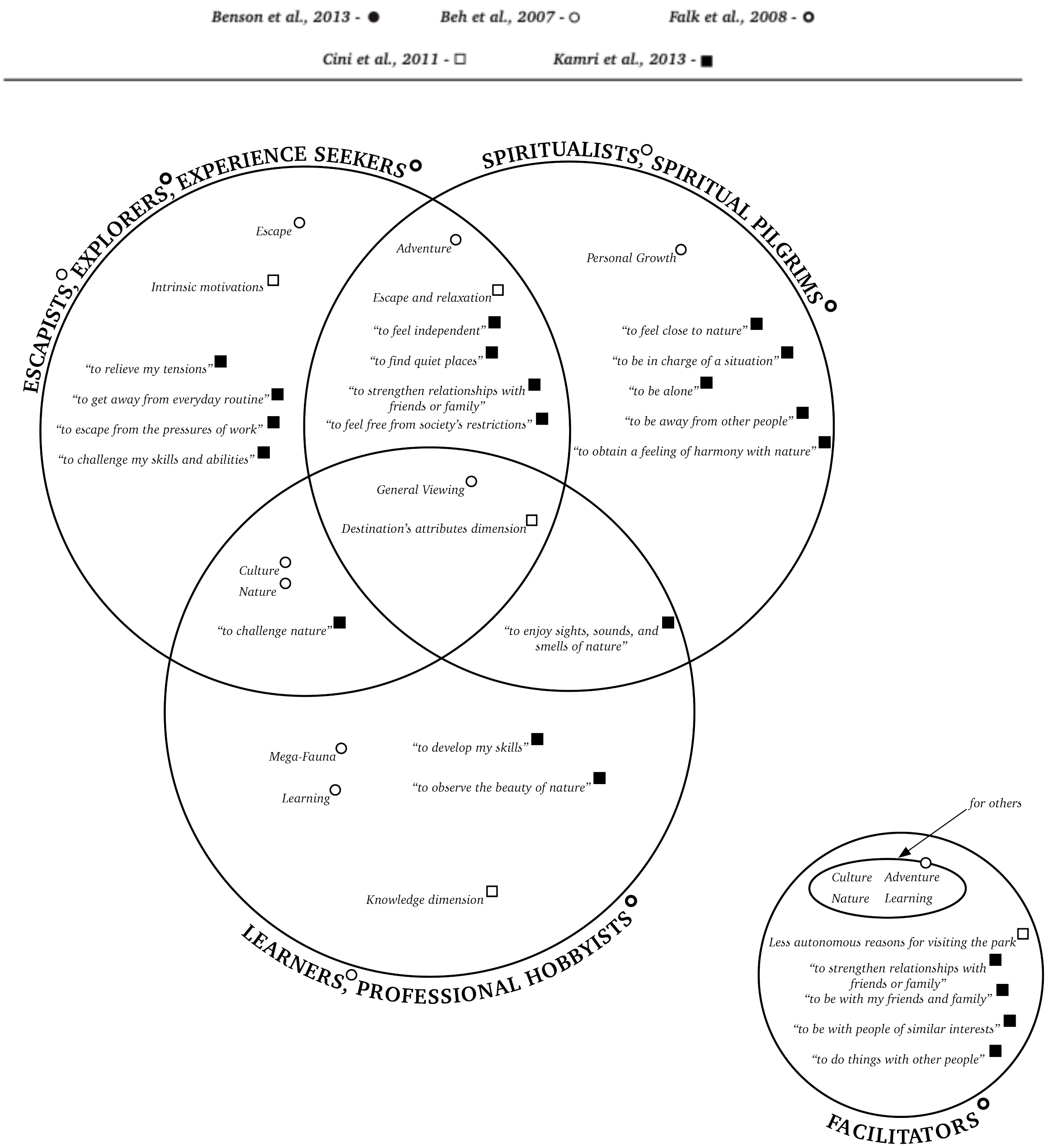


Figure 2: Conceptual outline of motivational factors within visitor identities and corresponding authors

2.2. Adaptation

Apart from understanding why visitors visit a NP, and using that understanding in creating an interface tailored to potential visitors' needs and preferences, the interface itself and its adaptable nature are important. The early 2000s generated an upward trend of affordable devices, such as mobile phones and computers, and with that also came more research into domains such as location based services (LBS) or graphical user interfaces (GUI; Reichenbacher, 2013). The latter warrants more and more researchers to analyse how to create the optimal GUI, providing a benefit to the user. Part of such research also ventures into understanding the complexity of GUIs, and managing it, so it is intuitive for the user. Moreover, user studies show that individuals use different functions of an interface than others, even when they are doing similar tasks, suggesting the need for personalisation (Greenberg, 1993). Generally, Reichenbacher (2013) states, adaptation methods can be seen as the middle piece between geoinformation and the visualisation thereof, according to their usage situation. Ultimately, it comes down to providing the user with the opportunity to make their own decision, or have provided a dynamic systematic approach, and base the visualisation of geoinformation on those decisions. Before diving into the best practices for adaptation in cartography, one has to understand the difference between adaptable and adaptive systems.

Adaptable and adaptive interfaces can be seen as the two main approached to personalisation (Findlater et al., 2004), and differ with respect to who controls such customisation. Adaptive interfaces will adjust an interface dynamically, with the intention to support the user, whereas adaptable interfaces rely on the user to use certain mechanisms that result in adaptation. In short, adaptable interfaces are user-controlled, and adaptive interfaces are system-controlled. According to Weld et al. (2003), such techniques can be seen as the only scalable approaches to personalisation. However, it is also possible to use a mixed-initiative adaptation that uses both adaptive and adaptable methods. One example for this is the AVANTI (**A**daptive and **A**daptable i**n**teractions for multimedia **T**elecommunication appl**i**cations project). The project aims to provide mechanisms for delivering information to all potential users, including those that may have an impairment or disability, providing equitable access to any user. Stephanidis et al. (1998, p. 6) refer to adaptability as the "process of selecting/modifying (aspects of) the user interface during initiation of each interaction session, according to user characteristics that are known prior to the interaction" and adaptivity as "the process of selecting/modifying (aspects of) the user interface dynamically, according to dynamic user characteristics and situation that are detected at run-time". This means, the adaptable part of the interface requires input by the user, while the adaptive part will use what the system can provide to it, even before the adaptable part gains such input. This way, researchers within the AVANTI project created a system that can provide the user with the opportunity to make their own changes to the representation of information, while keeping it simple enough, by using such adaptive processes in the background.

Deciding which adaptation method is most applicable to the project includes a basic understanding of the differences in usage situation. There is a difference between what will be referred to as static and mobile situations, namely users who will use an application, or website at home or those who will use it while on the move. Studies show that the visiting behaviour greatly differs between desktop and mobile users. Albers & Kim (2000) for example, found that browsing behaviour and the search for information changes. Additionally, there are differences in levels of user experience and satisfaction, according to Wu & Bi (2016). In general, the proportion of mobile users is far greater than that of desktop users. According to the China Internet Network Information Center (CNNIC; 2018), mobile users increased from 95.1% in 2016 to 97.5% in 2017, and while this only covers the population of China, one may assume that the general trend toward mobile instead of desktop is a world-wide phenomenon. Jiang et al. (2018) attribute this trend to the phone's portability that enables people to use it whenever and wherever they want. Time also plays a role. In their clickstream analysis, Jiang et al. (2018) found that mobile users spend less time on a website than desktop users do. In this case, if an adaptable interface will be used, the functionalities will have to be front and centre. However, maybe an adaptive interface is the better choice here, to keep the user from leaving the site, because they may be overwhelmed by having to make a choice. In general, these studies suggest, that considerations have to be made when creating an interface that utilises adaptation methods. For instance, the general functionalities should work in both static and mobile usage situations, but they may be represented differently on either device.

Apart from the usage situation, mobile and desktop devices differ in screen size, resolution and more. While the screen size for a mobile phone is, on average, between 5.8 to 6.2 inches (14.7 to 15.7cm), with resolution ranging from 750 x 1334 to 1440 x 2560 (iPhone 6 and Google Motorola Nexus 6 respectively; Apple, 2023; Kelly, 2014), a Desktop screen is much larger, and will therefore also fit much more content. Additionally, functionalities such as hovering over something on the map, is not possible on a phone, which is why one has to be aware of such differences, and let them flow into the process of making the content applicable for both desktop and mobile users. Some researchers have been analysing how adaptive and adaptable interfaces are impacted by the screen size. Findlater and McGrenere (2008) found that high-accuracy adaptive menus have a larger positive impact on performance on smaller screens. They do note however, that with a high-accuracy menu, the user may not be aware of the full set of items, therefore making it more challenging to use. In general, an understanding of the differences between the devices will provide a helping hand in the build of a website, and one should make sure to take those differences into account to create the best possible outcome for potential users.

The comprehensive examination of user adaptability concerning web interfaces and maps has received limited scholarly attention. This research gap underscores the potential contribution of this thesis, which seeks to offer valuable insights in this area. Existing research has predominantly concentrated on establishing a foundational understanding of adaptive interfaces, with a specific emphasis on applications like search engines and various browsing methodologies. In contrast, the primary objective of this thesis is to bridge this existing body of research with the domain of touristic decision-making, specifically addressing how individuals plan trips to national parks.

2.3. Accessibility

Any potential visitor should be able to use all functions available, so the map also has to be accessible for people with disabilities, such as visual impairments. Not only are there several policies in place, but also best practices. Apart from a web designer's personal thoughts about accessibility of their site, government and educational institutions require websites to follow guidelines (Foley, 2002). Such guidelines have been established by the World Wide Web Consortium, which "develops standards and guidelines to help everyone build a web based on the principles of accessibility, internationalisation, privacy and security" (w3.org), the latest version being published in December 2008. The guidelines are comprised of four principles: perceivable, operable, understandable, and robust. Each of the principles is followed by specific guidelines, aimed at providing an accessible website. For instance, perceivable is defined as "information and user interface components must be presentable to users in ways they can perceive". Underlying guidelines include to provide text-alternative for non-text content, or to make content distinguishable, for example, through use of colour or enhanced contrast. Each of the guidelines comes with an explanation and section on how to implement them and how to understand them in more detail. Finally, to conform to the Web Content Accessibility Guidelines 2.0 (WCAG), levels of conformance have to be satisfied. The levels range from "NA" to "AAA" with "NA" being not-accessible, and "AAA" being the highest level of accessibility. Each of the levels required a certain amount of guidelines to be met within the website, or in an alternate version of the website. The consortium does note, that it is not recommended that the highest level of conformance be required for entire websites, as it is impossible to satisfy all applicable guidelines for some content. Since establishing these guidelines, many countries across the world recognise them as a reference for legal requirements, and since 2012, the International Organisation for Standardisation (ISO) acknowledges the WCAG 2.0 as a standard for accessibility (ISO, 2019).

To produce a website that satisfies as many of the guidelines as possible and implements an accessibility policy, Foley (2002) proposes a four-step process. The first step is the identification and adoption phase. In this phase, the standard that will need to be met, will have to be identified and adopted. Such standards may include federal standards, local standards or organisational standards. The next phase is validation. Here, existing sites should be checked against the adopted standard, providing insight into which issues will have to be addressed. The next step is to establish an approach with which the design will be made accessible, ultimately aiming to standardise the structure of the site. Finally, the implementation of the adopted accessibility standards and approaches is done. Foley notes, that accessibility should not be seen as an extra step in the workflow, but as an integral part of the process.

Additionally, while providing an interface that is accessible, it is just as important to provide such an interface without it having an impact on non-disabled users. The best practice for an accessible GUI is to aim for equity. While practitioners voiced concerns at first, about possible negative consequences for non-disabled users (Ellcessor, 2014), studies show, that accessible interfaces have a positive effect on users who do not have any impairment (Schmutz et al., 2018). As part of this research, the overlap between accessibility and usability are widely discussed. Some authors believe usability to be a concept that includes accessibility as a subset, specifically saying that while usability is an issue for everyone, accessibility is only an issue for people with impairments (Thatcher et al., 2002). Some other authors contend that successful utilisation is contingent upon the presence of accessibility as a fundamental requirement (Shneiderman, 2003; Schmutz et al., 2018), basically saying the accessibility is the concept of which usability is a subset. Empirical research indicates that the two are similar concepts, ultimately saying that neither is a subset of the other, but rather that the two are each their own domain with overlapping concepts but different roots (Schmutz et al., 2018; Petrie et al., 2004). As for the benefits of accessible websites for non-disabled users, Schmutz et al. (2018) conducted a user study with only non-impaired users and found that users who used a website with level “AA” of conformance gave higher satisfaction ratings than those who used a website with level “NA”, independent of their age. Research such as this one therefore suggests that accessibility is beneficial to both user with and without disabilities.

2.4. User Experience/User Interface Design

Another factor that influences a user’s satisfaction and ultimately use of an adaptable interface is how intuitive the design is. A domain that studies how humans interact with computer systems is human-computer interaction (HCI). Within HCI studies, emphasis is often laid on what constitutes a good user interface design. Stone et al. (2005, p. 6) say, that a good user interface design “encourages an easy, natural, and engaging interaction between a user and a system […]”. What that means, is that an interface should cater to a user’s needs and support them in whatever tasks they may be undertaking. To accomplish that, there are various design options that can be considered. For instance, Toepoel and Funke (2018) examined the differences between using sliders, buttons, or visual analogue scales in a survey environment. They found that sliders that require a “drag-and-drop” action were less favoured than radio buttons, big buttons, and visual analogue scales. When considering the choice between buttons and sliders, it becomes evident that the overall functionality of the element plays a crucial role. However, limited research exists regarding the effectiveness of specific GUI widgets within a map environment. This thesis aims to address this gap in knowledge and shed light on the subject.

Not only what kind of menu items one chooses to include in the interface, but also the location and size are crucial in providing the user with an intuitive design. Gestalt laws provide some insight into perceptual organisation and grouping of elements (Stone et al., 2005). They are made up of five separate laws, namely: proximity, similarity, closure, continuity, and symmetry. The law of proximity states that elements placed closely together appear as groups rather than random elements. Similarity means that elements of the same colour or shape appear to belong together. The law of closure means that wherever people see an incomplete element, such as a circle with a gap, they will fill in the gap. The law of continuity states that when presented, for instance, with two lines of dots crossing each other, we see them as such, rather than as a random set of dots. Finally, the law of symmetry states that individuals tend to see regions bounded by symmetrical borders as coherent figures. (Wertheimer, 1923)

Further design principles, complementing the Gestalt laws, are simplicity, structure, consistency, and tolerance (Stone et al., 2005). Simplicity emphasises how important it is to keep the user interface as simple as possible, while communicating clearly in the user's language. To do this, designers should use controls that are known by the user. Keeping an interface simple also includes using descriptive link text. The principle of structure states to organise the user interface both in a meaningful and useful way. Users' perceived related features should be prominently grouped together on the user interface, ensuring clear and close associations between them. With consistency, the importance of uniform placement, appearance, and behaviour is emphasised. If something is presented in a certain way once, users expect it to be the same throughout the entire interface. Finally, tolerance, as a design principle, underscores the significance of crafting the user interface in a manner that mitigates the potential for user errors. Stone et al. (2005) note, however, that errors are not always the fault of a bad user interface. A lack of domain knowledge, poor communication or stress can also cause errors. Implementing both the Gestalt laws and these design principles, to the extent that is possible, can help in providing the user with an intuitive layout.

If in the process of doing a user study and subsequently reviewing it, does it become clear that a tutorial of some sort may be useful, a so-called "onboarding" can be added to the interface, when the user first opens the website. However, Joyce (2020) notes that individuals prefer a clear "how to use" rather than having to go through a tutorial. A workaround for this may be to provide the user with the option to skip the tutorial, and as is common in apps nowadays, give the user the opportunity to select the option for the system to remember that the tutorial isn't needed anymore.

As mentioned before, the design should also consider screen size, to stop several items from overlapping and making the website unusable on other devices, other than the one it is programmed for.

2.5. Design

The NPS has produced maps and other print media for their parks since its establishment in 1916. All publications, be it maps, brochures, and other visual media, come from the NPS Publications Program at Harpers Ferry Center in West Virginia. A collaborative effort between writers, graphic designers and cartographers there, they produce maps for the 390 holdings in the NPS system (Patterson, 2010). Any publication reflects the visual identity of the NPS, which includes the arrowhead logo. The design of the maps, while always similar, has changed throughout the years. For instance, until the early 2000s, base maps for most cartographic representations were done by hand, while nowadays they are produced entirely from digital sources (Patterson, 2002). Within the term "realism", which, in the artistic sense, Merriam-Webster Dictionary defines as "the theory or practice of fidelity in art and literature to nature or to real life and to accurate representation without idealisation", cartographically realistic maps are produced. Patterson (2002) does note, that all maps are idealised representations, however he also states that maps may appear more realistic than others.

When delving into the historical context of NPS maps, it becomes evident that modern maps are a culmination of diverse influences. In the 1950s, Hal Shelton, an employee at the United States Geological Survey (USGS), contributed to this evolution by crafting small-scale plan maps of the United States. These maps were designed to aid air travellers in gaining a general sense of orientation. Shelton's artistic renderings combined landcover details with shaded relief, effectively emulating the visual experience passengers would encounter from an aircraft's vantage point. Before that, Eduard Imhof, in 1938, crafted his magnum-opus — a depiction of Walensee in Switzerland. Encompassing approximately 9.6 square meters, this masterpiece stands as a testament to the pinnacle of freehand cartographic artistry, skilfully capturing a sense of realism that continues to resonate. Parallel to Imhof's approach, contemporary NPS maps do not strive for photorealism. Rather, they present a stylised interpretation of the world, offering visitors a curated perspective that may not mirror reality precisely but instead aligns with their expectations and desires. This blending of history and aspiration has helped NPS maps go beyond simple representation and transform into creative guides that invite exploration.

As a cartographer for the NPS, Patterson (2002) proposes four principles for cartographic realism in map design. One such principle involves the thoughtful use of lines, which serve as a fundamental element in graphical expression. However, an excessive reliance on lines, often observed in prehistoric cave art and children's drawings, as well as in map-making, can lead to visual clutter and distraction. To achieve a more organic and realistic feel, it is recommended to rasterise vector elements in software like Photoshop. This process not only reduces artificiality but also opens the door for creative manipulation through filters applied exclusively to pixels. Furthermore, the modulation of tones plays a pivotal role in replicating the subtle tonal variations found in natural landscapes, such as water bodies, ice fields, and deserts, ensuring their accurate representation. Lastly, introducing texturised elements like graphical noise and embossed textures to specific areas, like cliffs, forests, and rasterised lines, imparts a tactile quality that closely mimics the textures found in nature. By integrating these principles—careful line usage, rasterisation, tone modulation, and texturisation—maps can attain a harmonious balance between visual appeal and true-to-life representation.

In addition to design considerations, a notable emphasis is placed on the intrinsic characteristics of each individual park. This involves a deliberate selection of specific focal points, such as prominently visited sectors or areas, that hold distinctive significance within a park's context. In the case of Glacier Bay National Park in Alaska, cartographic representation prioritises the dynamic phenomenon of glacier retreat, thereby encapsulating the evolving natural dynamics of the park's glacial landscape. Such dedicated mapping efforts work to clarify the distinctive characteristics and subtle features found in each NPS location. This practice contributes to a comprehensive grasp of their unique identities and significance.

2.6. Hiking Formulas/Algorithms

Determining the estimated time it will take to hike a trail, and the difficulty of them, is vital not only for the safety of NP visitors, but also to determine which map elements to include, based on the visitor's preferences or decisions in the filter of the website. There are several formulas to determine hiking time, the first of which was proposed in 1892 by Naismith: "allow one hour per three miles on the map and an additional hour per 2,000 feet of ascent". Decades later, Langmuir (1984) extended it to include downhill hiking. Many more have proposed formulas to include factors such as terrain. The following section will analyse some of them chronologically.

In 1892, W. W. Naismith wrote in the Scottish Mountaineering Club Journal about a recent excursion and came to the conclusion: "This [aforementioned excursion details] tallies exactly with a simple formula, that may be found useful in estimating what time men in fair condition should allow for easy expeditions, namely, an hour for every three miles on the map, with an additional hour for every 2,000 feet of ascent." (Naismith, 1892) Metrically this would amount to 5 km an hour and an additional hour for every 600 m of ascent. The most notable primary extensions to this formula were proposed by Aitken and Langmuir in 1977 and 1984 respectively, accounting for downhill hiking and different terrain.

Another significant formula was presented by Waldo Tobler in 1993. Tobler, known for his extensive contribution to the field of geography and more, was an avid hiker himself, and published his proposal for a hiking time function in 1993. His function, as opposed to that of Naismith is an exponential function and combines speed and slope, where v = speed in km/h, g = slope (equal to vertical rise) and the constant $e = 2.71818$.

$$v = 6e^{-3.5|g+0.05|}$$

The NPS proposed their own formula for categorising trails in Shenandoah NP. Their formula determine hiking difficulty, using a numerical rating.

$$\sqrt{(elevationgain * 2 * distance)}$$

The square root produces a numerical rating, that determines the difficulty in one of five categories. Those range from easiest to very strenuous, with a numerical rating as seen in **Table 1**. In addition to the categories, the NPS estimate a walking pace of 1.5 mph for easy trails, 1.4 mph for moderate trails, 1.3 mph for moderately strenuous hikes, and 1.2 mph for strenuous and very strenuous hikes. Authors of the formula note that it is imperfect, since trails with a short distance, but high elevation gain may still fall into the category "easy", although in reality they are more likely to fit into "moderate". Moreover, the formula does not take into account other factors such as "fitness, exploration, rest, and contemplation" (NPS, 2023d).

Category	Explanation	Numerical rating
Easy	"A hike that is generally suitable for anyone who enjoys walking. Mostly level or with a slight incline. Generally less than 3 miles."	< 50
Moderate	"A moderate hike is generally suitable for novice hikers who want a bit of a challenge. The terrain will involve moderate incline and may have some steeper sections. Generally 3 to 5 miles."	50 - 100
Moderately strenuous	"Moderately strenuous hikes will generally be challenging for an unconditioned person. The terrain will involve a steady and often steep incline. Generally 5 to 8 miles.	100 - 150
Strenuous	"Strenuous hikes will challenge most hikers. The hike will generally be longer and steeper, but may be deemed "Strenuous" because of the elevation gain. Generally 7 to 10 miles."	150 - 200
Very strenuous	"Only well-conditioned and well-prepared hikers should attempt very strenuous hikes. The hike will generally be long and steep, and may include rock scrambling, stream crossings, and other challenging terrain. Generally 8 miles and over."	> 200

Table 1: Hiking categories after Shenandoah NP (NPS, 2023d)

Apart from mathematical formulas, there are also more "contextual" methods. They are not only related to the distance or the slope, but also to the general terrain, the required physical effort, risks in the natural environment and route navigation. A method that takes all of these factors into account is the MIDE ("Método de Información de Excursiones" or "Medium Itinerary Displacement Effort"). Version 1.0 was first carried out in 2002, authored by Alberto Paris Roche. Its aim is to provide a system for hikers to communicate, evaluate and express the demands of routes they have taken, therefore unifying assessments of the difficulties of hikes. It has also been conceived as a tool to prevent accidents in a natural environment. The MIDE consists of two pieces of information: the baseline information, and the assessment information. Part of the baseline or reference information are a description of the excursion, the type of route, elevation gain and loss, and specific technical difficulties. Assessment information includes aspects such as environment, itinerary, movement, and effort. Each of these aspects is assessed on a scale from one to five, according to the manual of procedures. The manual also specifies symbols for specific technical difficulties, like "rappel", "climbing steps", and "snow slopes", where the latter is separated into very likely and possible.

2.7. Framework

The final part of this thesis, is to comprise findings and put them into a written framework, or taxonomy, to promote reproducibility and collaboration among researchers in similar fields. A framework, as such, will be defined as: 'a navigational tool and stabilising force in research, acting as a unifying ecosystem that enables researchers to purposefully unify all elements of a study. This process elucidates the relationships, disparities, intersections, conflicts, and the contextual factors influencing both the research environment and the examination of phenomena within it', after Ravitch and Riggan (2016). Such frameworks or taxonomies are used in a variety of fields, including health care and entrepreneurship. To create such a conceptual outline, researchers use many different approaches. For instance, Gunasekaran (1999), did both a classification and review of previous research in his field of study, and created a conceptual model along key dimensions that were outlined in the review. Similarly, Nguyen (2009) also did a literature review, but made a distinction between empirical research and case studies. Elsbach and Stigliani (2018) also went for a literature approach and presented their findings in a framework of hierarchical order, where each stage builds upon the stage before. While also basing their framework on literature, Petrie et al., (2018) used a somewhat different approach, in that they specifically utilised information found through primary studies, that had done testing. All these studies, from a wide range of fields of study, have one thing in common, which is the literature review approach. However, they all also note another important thing. After having presented the frameworks and having explained them thoroughly, all researchers note, that further testing and input from other researchers is not only a possibility, but rather a necessity. That leads to the conclusion that to produce a comprehensive framework that covers parts of or even a whole domain, not one single study is able to summarise it all. The collaboration of the scientific community is of great importance here.

3. Study Sites

The following chapter will provide a brief overview of the exploration, establishment, geography, geology and possible activities of Yellowstone and Grand Canyon NP. The final section of the chapter will analyse the similarities and differences between the parks, both physically and platially. This analysis will help in the development of the final web map, answering RQ2.I and RQ2.II.

3.1. Yellowstone National Park

3.1.1.Exploration and Establishment

Yellowstone NP was the first national park to be established in the United States (US). Even before its establishment in 1871, several explorations and ventures into the territory were done. According to the book “Yellowstone National Park: Its Exploration and Establishment”, the greater Yellowstone area was discovered by Lewis and Clark as part of their famous expedition across the US between May 1804 and September 1806. However, despite their tremendous interest in geography, anthropology and geology, they were not the first to take notice of the unusual nature around the Yellowstone River. On September 8th, 1805, Governor James Wilkinson describes in a letter an area called “yellow stone” by the native population of the region. He later received more information of the area in the form of a buffalo pelt map that was supposedly presented to him from Native American sources. The map was later given to President Thomas Jefferson, who placed it in his Virginia home. According to a letter that was forwarded to Jefferson, the map included several branches of the South-Western part of the Missouri River, and a volcano. Unfortunately, the map is believed to have been a victim of the fire of the Rotunda at the University of Virginia after it was transferred there.

In Codex N of the original journals of Lewis’ and Clark’s expedition, several notes can be found detailing some of the thermal features of the region. Notably, accounts from the Native American population are included in these notes, describing a frequently heard noise, “like Thunder, which makes the Earth tremble”. These notes are believed to have been added upon the expedition’s return to St. Louis in 1806. Clark also used information that came to him after the return of the expedition to create a map of the region, amending it continuously for around six years. This map, supposedly the first of its kind, was based on reports from John Colter, a former member of the expedition party of Lewis and Clark, who had stayed behind in the mountains. He made a winter journey through the Yellowstone region. His remarks were passed onto Clark, and made it possible for him to add several features of the so-called “terra incognita”. The depiction of two lakes, Lake Biddle (known today as Lake Jackson) and Eustis Lake (known today as Yellowstone Lake), and the river make for proof, that John Colter had discovered at least one of the thermal areas of what is Yellowstone NP today. Similar to the buffalo pelt map, Clark's manuscript map was lost later on.

An era following the exploration era of the west of the US, made possible through the purchase of Louisiana from France on April 11th, 1803 is referred to as the fur-trade era. Between 1818 and 1842, fur-trade dominated the exploration of the Yellowstone area. As part of this era, discoveries such as the Teton Range, what was then described as "Boiling fountains having different degrees of temperature [], one or two were so very hot as to boil meat" were made. Several discoveries were made, creating a more general knowledge of the area than before. It was not until much later, though, that the suggestions to turn the greater Yellowstone area into an established national park gained some traction and were considered before Congress. 1871 marked a year with multiple explorations of the Yellowstone area, and before they had even returned with notes and the collected specimen, cabins were raised and roads established. Increased interest in the region resulted in the suggestion, on October 28th 1871, to let Congress pass a bill, essentially preserving the basin "as a public park forever", by Judge Kelley, who was associated with the Northern Pacific Railroad Company. The bill was finally passed in March 1872 with 115 yeas, 65 nays and 60 abstaining members of Congress. At first, the establishment of the park was met with mixed reviews in Montana: "In our opinion, the effect of this measure will be to keep the country a wilderness, and shut out, for many years, the travel that would seek that curious region if good roads were opened through it and hotels built therein." (Rocky Mountain Gazette, 1872). What followed was a political "mud-slinging contest" between the local newspapers. Today, Yellowstone National Park is still one of the most prominent parks of the national park system, having the seventh-most visits of the parks in 2022 with more than three million visitors. (Begley Bloom, 2023)

3.1.2. Geography and Geology

Located in the north-west of Wyoming, also crossing the state lines to Montana and Idaho, Yellowstone NP is a unique area, spanning across 3,472 square miles (8,991 km2; NPS, 2023e). It forms the centre of the Greater Yellowstone Ecosystem, which is one of the biggest almost intact temperate-zone ecosystem on Earth. The established area of the park, preserved its geothermal sites, that contain around half of the world's active geysers. Once development of the western territories of the US increased, Yellowstone NP "became a sanctuary for the largest concentration of wildlife in the lower 48 states." (NPS, 2019)

The vast diversity of the region includes several lakes, rivers, vegetation and hydrothermal features, as well as the Grand Canyon of the Yellowstone River. Vegetation alone includes more than 1160 different species, ranging from hundreds of wildflowers, nine conifers, to three species endemic to Yellowstone. In general, the vegetation is typical for a region such as the Rocky Mountains, and has elements of the Great Plains and Great Basin forts mixed in. Over 80% of the park is covered by forests. Other vegetation communities are sagebrush steppe, wetlands and hydrothermal plants, which are supported by the hydrothermal areas of the region. Apart from vegetation, Yellowstone NP is home to a wide variety of wildlife. Among them are almost 300 species of birds, 67 species of mammals including 2 bear-species, and 16 species of fish. The bird species include songbirds, waterfowl and raptors, many of which are migratory. Mammals include around 1,063 grizzly bears, as estimated in 2021 and many black bears. Since 1995, grey wolves are back in the park, and as part of the preservation of their long-term viability, the park has provided a place for research. Other notable species are bobcats, coyotes, Canada Lynx, cougars, and river otters. Among the ungulate species are bison, moose and elk, and mountain goats. Of all those animals, the Bison is the only one, that has lived in the area since prehistoric times, which makes Yellowstone NP the only place in the US to have such a long-lasting heritage. All animals roam freely through the park, and visitors are warned about how to safely photograph them when visiting the park. (NPS, 2019)

Geologically, Yellowstone is of significance, as it is a natural geologic laboratory of active Earth processes. Shallow magma sources result in volcanic activity, and more than 10,000 hydrothermal features, among which are around 500 geysers, more than half of the world's total. According to National Geographic's 2021 Documentary "Yellowstone — America's National Parks" the super volcano that once created the landscape that is part of the park's territory today, will explode again. The pressure that powers the geysers of Old Faithful, for instance, blows water up to 150 feet into the air, every 60 to 90 minutes. The area is monitored continuously by the Yellowstone Volcano Observatory (YVO), a consortium of nine federal and state agencies. The YVO provides both monitoring of the Yellowstone Plains, and hazard assessment of volcanic, seismic, and hydrothermal activity. Even though, the locale poses a risk of some kind, it makes for a magnetic property of the park for visitors from all over the world. People come because of the volcano, and because of the nature it created some 640,000 years ago. (NPS, 2021)

3.1.3. Activities

The first national park, not only of the US, but also of the world, provides a diverse portfolio of activities for visitors. Ranging from hiking the traditional trails of the Native American population, to experiencing wildlife in its natural habitat, tourists have the opportunity to participate in several activities, either by themselves, or with the help of a park ranger. The NPS provides guided tours with snowmobiles or snow-coaches in winter, and horseback rides in summer. Visitors have the opportunity to explore the park by themselves, watching wildlife, camping, or fishing. Throughout the year, they can also attend indigenous cultural events. To learn more about the park itself, tourists can participate in a ranger program, and kids can become junior rangers or explore the scientific mysteries of the park as young scientists. (NPS, 2023e)

3.2. Grand Canyon National Park

3.2.1. Exploration and Establishment

It is estimated that people have been living in and around the canyon for more than 12,000 years. The Ancestral Pueblo people suddenly departed the canyon around 1250, making way for the Havasupai people that have lived in the canyon that bears their name for hundreds of years.

To this day, eleven Native American tribes have significant connections to the canyon. While Spanish colonisers first saw Grand Canyon in the sixteenth century, it was Lt. Joseph Ives who first ventured into the canyon. In 1857 an expedition was done up the Colorado River. They sidetracked into the area of what is the Grand Canyon today to determine whether it was feasible to run a railroad through it. Upon his return, Ives said: "It can be approached, only from the south, and after entering it there is nothing to do but leave. Ours is the first and will doubtless be the last party of whites to visit this profitless locality." (True West Magazine, 2016) Later, he doubled down on his opinion of the area: "The region . . . is, of course, altogether valueless. It can be approached only from the south, and after entering it, there is nothing to do but leave. Ours has been the first and the last party of whites to visit this profitless locality. It seems intended by nature that the Colorado River, along the greater portion of its lonely and majestic way, shall be unvisited and undisturbed." (McKee, 1933)

The canyon was not greatly visited until artistic depictions and journal's brought it to the attention of the US, which, at that point, had begun to be curious about their western territories. By the mid-1860s, mineral claims began to pour into the region, establishing a competitive mining industry by the mid-1890s. Privateers looking for gold, silver, copper and other valuable minerals began claiming areas in and along the rims of the canyon. With the increased interest in mining also came a need for reliable water sources. With the establishment of a permanent tourist camp in 1886, tourists also began visiting the Grand Canyon. The Colorado River was viewed as the perfect source for water and hydroelectric power and by 1893, developers began thinking about building dams in the area. It wasn't until 1923, that a first river expedition was done, aiming to locate the best sites to build dams on the Colorado River. The USGS identified 29 sites, and finally began construction on the Boulder Dam downstream of what is today's park territory. The dam was later renamed into the Hoover Dam that to this day powers the greater region around Las Vegas (Bureau of Reclamation, 2017). Increased strain on the region came with the Cold War. Due to a higher demand in metals that would be used for the production of nuclear weapons, new mining grounds were sought after. Originally a copper mine, the Orphan Mine near today's visitor centre on the south rim, was acquired in 1953 after it had not been profitable. In 1956, mining began for uranium. Due to the noise, and the "unsightly machinery" the park service closed half of the south rim trail. It is estimated, that until the closure of the mine in 1969, 500,000 tons of high-grade uranium ore were excavated. Still today, the site is fenced, and residual radiation poses threats to the visitors. With the closure of this and several other mines, the mining industry slowly backed out of the canyon, though leaving behind much of their equipment. As of 2023, according to the New York Times, President Joe Biden is expected to create a new national monument that would permanently ban uranium mining, protecting around a million acres around the Grand Canyon. Former President Barack Obama had made a designation in 2011, that had temporarily banned uranium mining in the area, which would run out by 2032. (NYT, 2023; NPS, 1988)

The first preservation efforts started in 1893. Then President William Henry Harrison made the Grand Canyon a national reserve. With the name came growing popularity, and by 1901 a new railroad into Grand Canyon Village brought tourists to the park even faster. Grand Canyon Village, to this day, is the start of most visitor's journeys into Grand Canyon NP. Later, after a camping trip into Yosemite valley, President Theodore Roosevelt became inspired to expand federal protection of the area, and subsequently signed five more NPs into existence, and declared the Grand Canyon a National Monument in 1908. On February 26th, 1919 President Woodrow Wilson signed the NP into law. According to National Geographic, 37,000 people visited in the first year. Today, Grand Canyon NP receives over 200 million guests each year. Many of the areas that are part of the NP today, were conjoined with the area much later. The park, as it is today, has only been like this since the 1970s, when two adjacent national monuments, parts of Glen Canyon and Lake Mead National Recreational Areas, and other federal and state lands were added to the park (NPS, 2017).

3.2.2. Geography and Geology

The story of how the Grand Canyon came to be starts about 2 Billion years ago, with the deposition of sedimentary rocks. Millions of years of accumulation created the layers of rocks, one can still see today. With these layers, geologists are able to discern when the sediments were deposited there, and what the climate looked like at the time. For instance, the area was once covered by a shallow sea, which is why there are layers of oceanic sediment. Other layers show evidence of having been deposited in a drier climate in the form of windswept sand dunes. At the time of the accumulation of sedimentary rocks, the area was located around sea level. Between 50 and 70 million years ago, tectonic plates began shifting. The Pacific and North American plates collided, forcing one underneath the other in a process also called “Subduction” (USGS, 2016). This resulted in the formation of the Colorado Plateau. The South Rim of the canyon is around 7000 feet (2133 m) above sea level. After the uplift of the region came the so-called downcutting. Five to six million years ago, the Colorado River began flowing the course it does today. Since such downcutting happens faster when the body of water is at an incline, it comes as no surprise that the Colorado River starts at around 14,000 feet and drops about 7 feet per mile as it flows to the Gulf of California, Mexico, carrying soft sedimentary rocks to and through the canyon. Finally, erosion created the look of the canyon we see today. Ice wedging, the process when water freezes in cracks and then breaks them apart, is one of the weathering processes that can be attributed to the generation of the canyon. Additionally, there are two wet seasons at the Grand Canyon, one in winter and one with Monsoon season that bring a lot of precipitation with it. The North Rim is around 1,000 feet higher than the South Rim, so it is more impacted by such heavy rainfalls. While rain at the south rim flows away from the canyon, it flows towards and into the canyon at the north rim. (Pearson, 2019)

Apart from the impressive geology of the canyon, the NP is home to a wide variety of species. About 447 known species of bird use the Grand Canyon, which is why is was designated a Globally Important Bird Area. Moreover, around 48 species of reptiles and 10 species of amphibians call the canyon their home. Of the 91 species of mammal, Bison, Elks, and Bighorn Sheep are by far the largest. Additionally, Grand Canyon NP is home to one of the highest diversities of bats in the United States, with a total of 22 different species. (NPS, 2017)

Unfortunately, the canyon’s history with mining and hydroelectric power has permanently changed the environment. Species of plant and animals that once thrived here, are now in danger of extinction (Grand Canyon Trust, 2019). Today, climate change also plays a role. Higher temperatures and droughts bring more wildfires to the region every year, posing as one of the biggest challenges for park management. According to Pearson (2019), fire ecologists estimate, that of all the burned forest between 1919 and 2006, 95% burned after 1992, when the NPS implemented their wild land fire policy. Apart from its impact on nature, it also affects the population of exotic species in the park, such as Buffaloes. With the diminution of grasslands, they were forced to find cooler climates and now permanently reside in the forests of the North Kaibab, south of Grand Canyon Village.

3.2.3. Activities

At Grand Canyon, visitors have the opportunity to explore both the South Rim and the North Rim of the canyon, although the North Rim has seasonal openings. At the South Rim, which is open year round, visitors can explore the history of the canyon at visitor centres and the visitor centre theatre. Tourists can hike the trails or cycle along some of them. The Desert View drive invites visitors to enjoy the scenery from the road. There are also guided mule tours and rafting trips on the Colorado River. On the North Rim, there are additional visitor centres and visitors are invited to participate in ranger programs. Additionally, visitors can go for a day's hike or trail rides along the canyon. The park service specifically encourages visitors to "travel green" to help reduce carbon emissions and keep the environment healthy (NPS, 2023c).

3.3. Similarities and Differences between the parks

Yellowstone and Grand Canyon National Parks exhibit pronounced disparities in physical characteristics, including topography, vegetation, and geology, alongside their distinct "sense of place." These differences and commonalities between the parks play a pivotal role in shaping their cartographic representations, impacting how maps are utilised not only for navigation but also as guides for prospective park visits.

In terms of physical attributes, Yellowstone NP dwarfs Grand Canyon NP, covering 3,472 square miles (8,991 km^2) and 1,904 square miles (4,931 km^2), respectively (**Figures 3**, and **App. 1** & **2**). Furthermore, their shapes are disparate, with Yellowstone NP assuming a square configuration and Grand Canyon NP stretching linearly along the course of the Colorado River. Consequently, achieving an optimal zoom level in a single map becomes essential, balancing the need to encompass critical features of both parks without overwhelming users with frequent adjustments. Notably, Yellowstone's geothermal features, including geysers and a super volcano, form the core of its tourist appeal, while the Grand Canyon itself dominates the visitor experience in the latter. Cartographically, these divergent characteristics necessitate distinct representations – Yellowstone's geothermal features lend themselves to point features, while the Grand Canyon's canyon and river require line features. Thus, the parks' physical differences primarily influence the scale and extent of map coverage, resulting in unique cartographic challenges that culminate in maps that capture the singular essence of each park on one singular map.

Geographical disparities are paramount in shaping cartographic approaches. The desert environment of Grand Canyon NP demands a nuanced portrayal of arid topography, emphasising the rugged landscape and the profound chasm sculpted by the Colorado River. Conversely, Yellowstone NP's verdant surroundings necessitate meticulous mapping of its diverse ecosystems, showcasing dense forests, expansive meadows, and the striking geothermal features. These geographical contrasts guide decisions regarding colour schemes, shading techniques, and altitude renderings, harmonising with each park's distinct geographical identity.

Historical accounts contribute another layer to map representations. Yellowstone's association with the Lewis and Clark expedition inspires maps that pay homage to this historical legacy, urging cartographers to incorporate expedition routes and significant landmarks to invoke the spirit of exploration. Conversely, Lieutenant Ives' revelation of the Grand Canyon calls for an alternative cartographic approach, one that underscores the canyon's monumental scale and perhaps echoes Ives' personal astonishment. These historical nuances inform the selection of symbols, annotations, and design elements, weaving the parks' narratives into their maps. Furthermore, conservation disparities wield influence over map narratives. Yellowstone's distinction as the world's first national park, preserving much of its pristine condition, demands an illustration that accentuates its natural beauty and the harmonious coexistence of diverse wildlife. In contrast, human engineering and resource extraction in Grand Canyon National Park necessitate a cartographic portrayal that acknowledges the park's magnificence while underscoring the adverse impact of human activities on its landscape. This may entail incorporating annotations or overlays to communicate the delicate equilibrium between preservation and utilisation.

The "sense of place" experienced by park visitors is a vital aspect that influences map usage. Yellowstone's vast, untamed wilderness and geothermal marvels evoke a sense of wonder and adventure, attracting visitors seeking tranquility, nature's grandeur, or the thrill of geysers. This sense of place, deeply rooted in ecological diversity and geothermal phenomena, influences map utilisation, extending beyond mere navigation to encompass the essence of exploration. In contrast, Grand Canyon National Park inspires humility through its awe-inspiring canyon, captivating visitors with nature's immense power and beauty. Visitors often arrive seeking reflection, solace, or the challenge of navigating its intricate trails. Consequently, cartographic representations of the Grand Canyon must convey not only the physical landscape but also the emotional resonance of the experience, serving as guides to ensure meaningful exploration. Another influential factor in map usage is visitors' intended experiences within the parks, ranging from driving through and stopping briefly at wayside exhibits to engaging in extensive backcountry exploration. One noticeable disparity in visitor experiences between Yellowstone and Grand Canyon National Parks relates to the nature of the hikes commonly pursued. Yellowstone offers a diverse range of hiking experiences, with trails traversing forests, meadows, and varying terrains, accommodating both leisurely strolls and more strenuous uphill climbs. In contrast, Grand Canyon NP's primary attraction, the massive canyon itself, often leads visitors to undertake hikes that involve descending into the canyon along challenging and steep trails. This stark difference underscores the need for map representations that cater to these distinct hiking experiences, ensuring visitors can navigate and make the most of their park exploration effectively. These varying intentions significantly impact the way visitors interact with and rely on maps. However, it may be challenging to depict the different platial and spatial features of each park within one map.

In conclusion, the interplay of spatial and platial distinctions between Yellowstone and Grand Canyon National Parks reverberates through the art of cartography. These distinctions underpin map design choices, symbology, and thematic emphasis, offering cartographers a rich palette of elements to work with, facilitating the creation of maps that reflect the individual character, history, and conservation legacy of each park. These cartographic depictions transform into dynamic narratives, inviting viewers to engage deeply with the unique essence of each park, transcending static visuals and serving as more than mere guides, but as gateways to transformative journeys within these landscapes.

Figure 3: Map highlighting Yellowstone and Grand Canyon NP

4. Methodology

4.1. Data acquisition and processing

For the data acquisition, GeoJSON data was taken from the NPS open data website. This included trails, boundaries, and points of interest (POI) of Yellowstone and Grand Canyon NP. Additionally, elevation data was taken from the USGS Earth Explorer, in the form of satellite images from the Shuttle Radar Topography Mission (SRTM). All satellite images were of the same resolution, so they could be merged in a later step to perform further analyses. Since data required by the final basemap, such as topography or landcover, is included when adjusting a MapBox style, no further data was needed at this point.

Once data acquisition and a review was done, the processing of the data began. First the trails were dissolved into the actual trails, since the original layer by the NPS included hundreds of segments of each trail, instead of one vector line. This was done using QGIS (Version: 3.30) and the incorporated toolbox algorithm. The trail data did not originally include elevation data, which was needed for the following steps. Using the “v.drape” algorithm, the vector lines of the trails and the mosaic of the SRTM satellite images were located on top of each other and elevation data were derived from there, using the “nearest” sampling method. At this point, it became clear that the lengths of the trails according to QGIS, and those according to the official NPS website differed slightly. Due to timely constrictions, it was not possible to go through the NPS website for each of the over 400 trails, so the measurements from QGIS were used. Once all trails had all the necessary data, the vectors were converted to csv format and moved to excel, to do further processing. Since the original trail data did not include any considerations for the difficulty or hiking time, they had to be calculated. Using the previously outlined hiking function by Naismith, the estimated hiking time was calculated for each of the trails, except the spur trails. Most of them are much shorter than a mile, and have no elevation data due to that shortness, so they were left out of the calculations, as any derived estimations may not have been very accurate. For the difficulty rating, the Shenandoah NP formula was used. Each of the trails, again excepting spur trails, was assigned to one of the categories ranging from one to five, depending on their elevation gain and distance. With this data added to the GeoJSON of the trails, the base was done to integrate it on the website.

4.2. Website Development

4.2.1. Basics

The website development process centred around the use of Visual Studio Code for coding tasks and initially only involved Yellowstone NP. The first step involved incorporating a Mapbox basemap, facilitated by the MapBox GL JS library in the form of a globe, to keep the projection as close to reality as possible. The user interface was then carefully constructed to feature popup menus and intuitive buttons, each aligned with distinct filtering methods, further outlined under 4.2.2. Following this, algorithmic development became the focal point. Layers were seamlessly integrated using GeoJSON files from a GitHub repository. A dynamic bounding box was created based on user input to govern the display of trails and POIs, with specific considerations for trail length and user-defined activities.

The amalgamation of these algorithms was achieved through a central button labelled "Apply Filter". This button harmonised all underlying processes, offering a unified user experience. Similar algorithms were extended to predetermined maps based on Benson et al.'s (2013) user groups. The subsequent phase encompassed styling refinements. CSS was employed to align the visual appearance of custom buttons with the native Mapbox GL JS zoom controls. A well-integrated legend and custom icons inspired by NPS visuals further enriched the website. Trail labelling was implemented through strategically positioned labels following cartographic guidelines, and popup windows provided comprehensive trail information. Similarly, POIs were enhanced through popup windows.

The website's accessibility was addressed by adapting the interface for various devices and making sure that text-to-speech was possible. Adjustments were made to ensure optimal window sizes for desktop and mobile users, with provisions for tablet screens. The Mapbox style was customised to align with the NPS design and colour scheme. Additional enhancements included an "About" button linking to the GitHub repository and real-time NPS alerts integrated through an "Alerts" feature. In summary, the website development encompassed a systematic process, ranging from initial basemap integration to algorithmic implementations and styling considerations. This multifaceted approach contributed to the creation of a user-centric platform suitable for both desktop and mobile users, seamlessly integrating spatial data visualisation and user-driven functionalities. In a final step, the website was included in the GitHub repository and deployed using vercel, a free frontend cloud service for deploying websites. In later iterations of this process, after the user study results had been analysed, features of the Grand Canyon were added, and a button to navigate between the parks was implemented. Images in Section 10.2 provide a visual reference and offer transparency into the iterative steps involved in crafting the cartographic representations for Yellowstone and Grand Canyon National Parks[1].

4.2.2. Filtering

The user had the opportunity to make several decisions regarding their upcoming trip. In order to ensure a comprehensive filtering process, various factors were considered. These factors included the length of stay (1), the desired amount of activity (2), specific activities the user wished to participate in (3), and their preferred entrance to the park (4). The relationship between factors (1) and (2) became evident, as the length of stay and desired activity level directly influenced the selection of trails to be displayed. A deliberate process was carried out to determine which trails would be suitable for different scenarios, such as a two-day trip with intense activity versus a one-day trip with minimal activity. To address factor (1), a bounding box was established, correlating to the area a user could reasonably cover within their designated length of stay. This bounding box served to restrict the display of trails and POIs on the map. Factor (2), on the other hand, was determined based on multiple trail attributes, including trail length, elevation gain, estimated hiking duration, and pre-defined hike categories. A sliding scale was utilised for factor (2), ranging from "not very active" to "very active," with a detailed breakdown of its calculation provided in the accompanying table.

Incorporating factor (4) into the aforementioned considerations, the map's extent was dynamically adjusted to focus on the user's preferred entrance location, displaying relevant map elements accordingly. The bounding box derived from factor (1) was centred at the entrance chosen in factor (4). Factor (3) contributed additional POIs and required map elements within the extent defined by factor (1). Additionally, users were given the flexibility to select from pre-defined settings aligned with Benson's (2013) visitor clusters, facilitated through a separate filtering window. All the decisions made within this process were based on the the literature reviewed in Section 2.1. Including all aforementioned factors encompassed the development of a specialised algorithmic framework, followed by the validation of its effectiveness through an extensive user study.

[1] The product can be found at this URL: "https://blazing-the-trail-thesis.vercel.app".

4.3. User Study

The user study is a both qualitative and quantitative questionnaire, aiming to answer the last two sub-research questions of *RQ1*.

RQ1: How can the motivations for visiting a National Park be incorporated into the design of a user-specific web map?

I. *What are the key factors that motivate visitors to visit National Parks?*
II. *How can these factors be incorporated into the design of the web map, using the best practices and design principles for creating user-specific National Park web maps?*
III. *How can user feedback and evaluation be used to refine the web map design and better align it with the motivations and needs of National Park visitors?*

In addressing RQ1, a comprehensive evaluation approach was undertaken, integrating both user feedback gathered through the questionnaire and insights derived from relevant literature. Through meticulous analysis of responses obtained from the user study, Research Question 1.III, emerged with particular significance, focusing on participants' affiliations with national parks as a prime criterion for participation. The questionnaire itself was meticulously structured, strategically divided into four subsections to enhance user experience by mitigating information overload. This segmentation facilitated focused exploration while promoting seamless navigation.

The initial sub-section established an informative welcome and context-setting tone, acquainting participants with the master thesis's objectives and study aims. Subsequently, demographics were tactically probed, encompassing age, prior visits to Yellowstone NP, and the device employed to interact with the map. Notably, the device query served as a valuable diagnostic tool, instrumental in isolating potential issues if a specific device exhibited recurrent problems or misconceptions. Moreover, age-related data facilitated an evaluation of potential age-group disparities in interface engagement and functionality comprehension. Lastly, the differentiation between respondents who have previously visited Yellowstone NP and those who have not aimed to illuminate potential contrasting insights, thereby contributing to a comprehensive understanding of user perspectives.

Transitioning to Sub-section Two, meticulous inquiry was directed toward the user's engagement with the filtering processes, underscoring the user's satisfaction with filtering "algorithms." A Likert scale format effectively gauged contentment with activity options, encompassing activities such as photography and horseback riding. Encouraging qualitative feedback, participants were invited to elucidate their responses, fostering deeper insights. Further exploration of user preferences entered on potential adaptation options for the map, subsequently inviting participants to articulate specific desired adaptations. Notably, a comparison of user affinity with predefined settings against the customised filtering approach was strategically employed to unveil optimal user experiences. The subsequent inquiry into preferred filtering methods, accompanied by justifications, provided rich contextualisation for preferences. Finally, participant-driven suggestions for additional predefined categories reflected an open-ended approach, offering participants a platform to influence potential enhancements.

Sub-section Three navigated the user experience within the design realm. Inquisitively probing the intuitiveness of the interface, participants were queried about immediate understanding upon opening the map and any encountered confusion. In-depth insights were gained by soliciting feedback on issues experienced and gauging the desirability of an onboarding tutorial. Discrepancies between expectations and encountered elements were thoughtfully explored, yielding actionable insights into design refinement. Participants' suggestions for enhancing the interface's intuitiveness further enriched the evaluation's scope.

The final sub-section, titled "Overview", encapsulated broader inquiries, commencing with a technical assessment of the platform's operational performance. The exploration of potential use-cases beyond the intended purpose engaged participants in speculative yet illuminating considerations. The ensuing evaluation of the map's perceived usefulness for its intended purpose substantiated its alignment with user expectations. Notably, the final question provided an expansive canvas for participants to offer unanticipated suggestions and insights, encapsulating diverse perspectives.

Upon submission, participants were notified of their response's successful recording. Furthermore, participants were offered the opportunity to remain updated of project developments, thus promoting sustained engagement and commitment. In effect, this questionnaire facilitated the multifaceted exploration of RQ1, offering a platform for comprehensive user evaluation of the web map that was built through a trial-and-error approach. As an additional source for evaluating whether the map functioned the way it was supposed to, Microsoft Clarity was installed. This tool tracks every session and includes things such as the amount of dead-clicks, whether there was endless scrolling, JavaScript errors, and quick backs, among many other statistics.

4.4. Framework

The final stage of the project was to produce a framework for creating adaptable maps, such as this one, and finding the best practices to do so. Answering RQ3.I and RQ3.II in the process, the framework is based primarily on the answers from the user study, since they gave an insight of what is important to the user, which subsequently is vital for the developer of such a website to include, and on the outcome that was the trial-and-error approach to this project. Additionally, inspiration was taken from several other scientific frameworks, to find a structure that would promote the understanding and collaboration with other researchers that are part of one or more of the domains this thesis touched upon. Mainly, the framework includes guidelines, how to create such an adaptable interface, and how to proceed with user evaluation once a first draft has been created. The conceptual framework consists of five stages that encompass the journey to a finished project: Knowledge, Preparation, Application, Evaluation and Review. This conceptual analysis in the form of the framework can be found in Section 6.2 and a standalone version of the framework can be found in Section 10.3.

5. Results

The following chapter will show the results of the user study, and the Microsoft Clarity plugin. The survey was available to fill for six weeks, to give participants enough time to potentially come back to the survey in case they wanted to. After that period of time, 20 answers were collected. The results of the Likert scales were analysed through statistical measures such as mean, variance, and standard deviation. For the open-ended short answer questions, a cluster analysis was done, creating custom coding schemes for each question and calculating the frequency of each code. Answers were assigned to possible coding schemes, and multiple coding schemes could fit for one answer. Finally, all answers were visualised using bar charts.

First, all participants were asked to answer some questions on demographics. The 20 participants were aged between 19 and 36, with most participants in the age group from 23 to 27 (**Figure 4**).

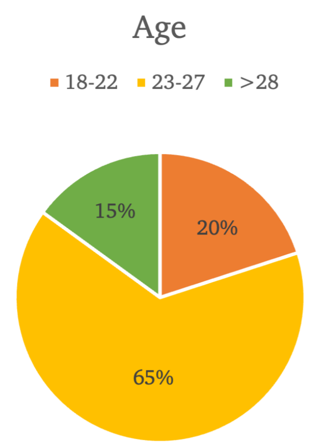


Figure 4: Pie chart showing the age demographic of the participants

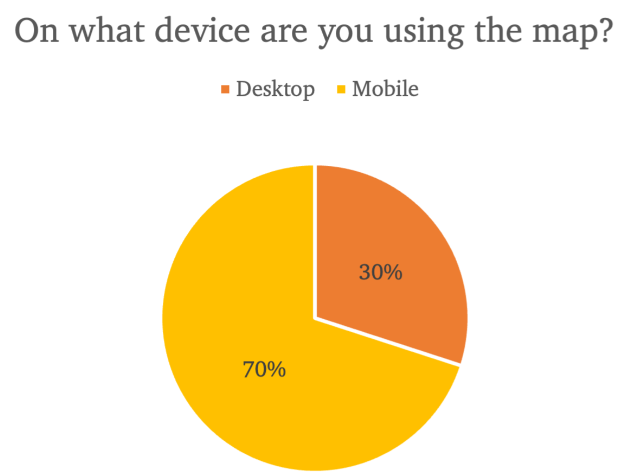


Figure 5: Pie chart showing the device used by participants

The second question asked whether they had been to Yellowstone NP before. Only two participants had. Finally, they were asked what device they were using to test the map, to find out whether there were any issues relating to that. Most people did the user study on their mobile phones (70%) and only 30% of participants used a desktop (**Figure 5**).

After participants were asked to take a look at the map, test its abilities and asked to answer some questions on demographics, they were asked whether they were satisfied with the options for specific activities to choose from. Those activities include, for instance, photography, lodging, and horseback riding. Here, the mean was 3.75, on the likert scale ranging from one to five, from "Not at all" to "Very". The variance of the answers was calculated to be 0.69, with a standard deviation of 0.85 (**Figure 6**). The follow up question "Why were you satisfied/dissatisfied?" was answered by 18 participants (**Figure 7**). From the answers, six major coding schemes could be identified: "No active options", "too little options", "I would like more information", "I like the POIs filtering", "Options covered everything", and "More specific". Since some of the answers did not include explanations as to what the participant meant, only speculation is possible. To keep this at a minimum, unclear answer were compared to the participants' other answers to the short-answer questions, aiming to determine what it was they meant. For instance, one participant stated they were dissatisfied because there were no active options. From a developer's point of view, this could mean that none of the options were active upon opening the website. A person without the knowledge of a developer may use "active" in this case to describe options to be active, such as hiking, rafting, or cycling. In this case, the participant used active in later answers as well, in the context of being active. Two participants saw too little options in general, while four participants desired more information. This information ranged from things to see on the trails to available ranger programs on set dates. One participant simply stated they liked the POIs filtering. The most frequented reason for satisfaction was because the options covered everything, with eight participants answering this. Seven participants wished for more specific options, for example, watching animals, or "must have" photos.

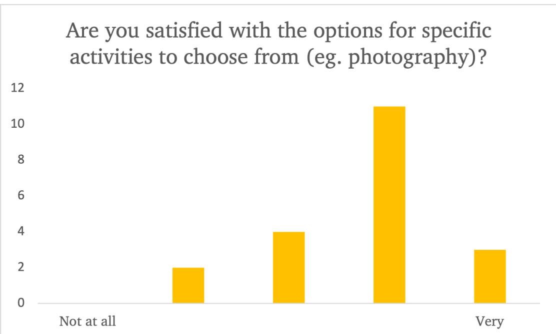


Figure 6: Bar chart visualising answers to "Are you satisfied with the options for specific activities to choose from (eg. Photography)?"

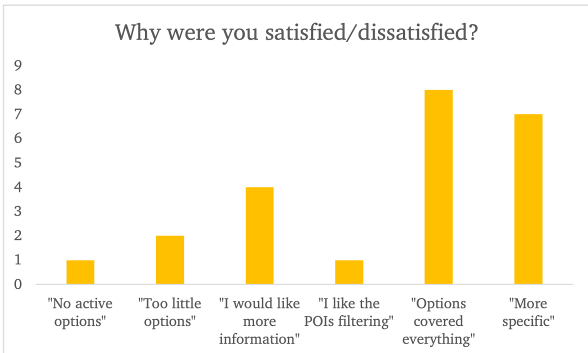


Figure 7: Bar chart visualising clusters of the answers to "Why were you satisfied/dissatisfied?"

The answers to the question inquiring whether they would wish for additional options to adapt the map to, has a mean of 3.3 on the Likert scale ranging from one to five, “Not at all” to “Definitely” (**Figure 8**). The variance was calculated to be 1.71 and the standard deviation is 1.34. When asked to specify what kind of options participants would like to see, five coding schemes emerged: “Specific activities and interests”, “atmosphere, ambience”, “being active”, “routes for running, cycling”, and generally more options (**Figure 9**). Nine participants answered they would like to see specific activities and interests, such as, the option to select a home-base to start from, or different kinds of accommodation like hotels and trailer parks. Three participants mentioned they would prefer to include options for atmosphere and ambience, such as the crowdedness of a location or “beautiful view” filters. “Being active” was again suggested, as five participants answered they would like options for choosing trails based on length and elevation or more activity based options such as mountain biking and kayaking. Similar to those answers were those under “routes for running, cycling”, where four participants would like to see options specifically for cycling routes. Finally, five participants wanted generally more options, for instance, bird watching, fishing, and different methods of transportation.

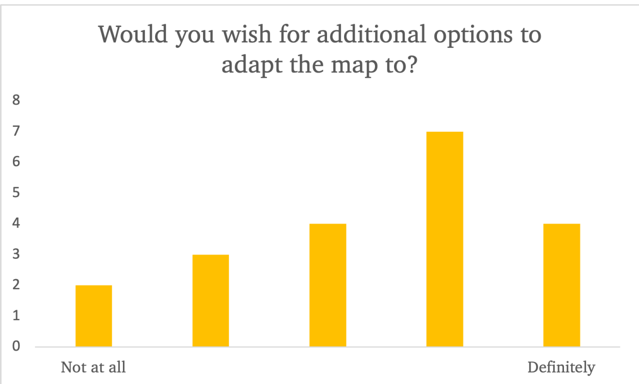


Figure 8: Bar chart visualising answers to “Would you wish for additional options to adapt the map to?”

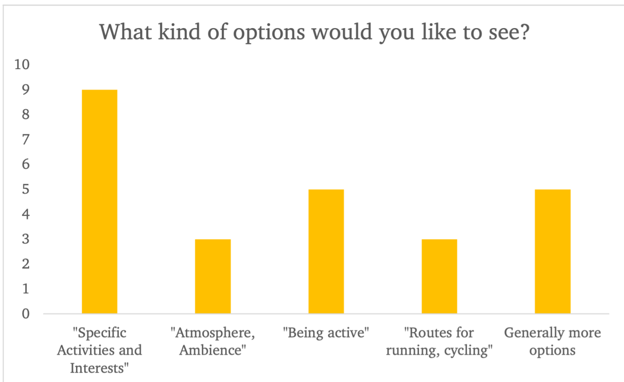


Figure 9: Bar chart visualising clusters of answers to “What kind of options would you like to see?”

Next, participants were asked wether they felt represented by the categories in the predefined settings. Reiterating those categories are based off Benson et al.'s (2013) cluster analysis and include: "Do it all Adventurer", "Windshield Tourist", "Value Picnicker", "Backcountry Enthusiast" and "Comfort Creature". Of the 20 participants, the mean lays at 3.75, the variance at 0.49 and the standard deviation at 0.72 (**Figure 10**).

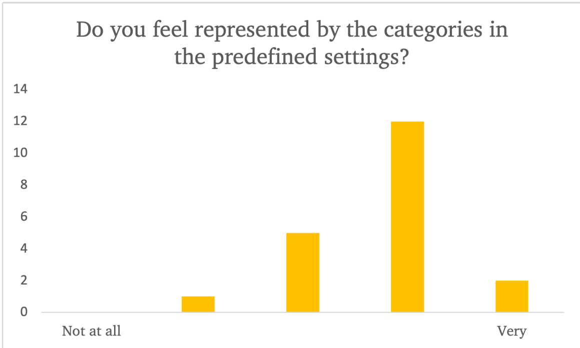


Figure 10: Bar chart visualising answers to "Do you feel represented by the categories in the predefined settings?"

The following question, inquired which of the two filtering mechanisms the participants preferred (**Figure 11**). Here the mean was calculated to be 3.6, indicating participants slightly more preferred to use individual settings. The variance was 2.14 and the standard deviation 1.50. Clarifying why they preferred that process, participants has answers within seven categories: "Describe the mood", "Useful to have both", "I like to choose", "More specific", "Individuality", "Easier", "Don't want to miss anything" (**Figure 12**). Answers underneath "Describe the mood" actually show that one preferred the predefined settings, while the other preferred the individual settings, but for similar reasons. Five participants stated that it is useful to have both options. Two participants simply stated they liked to choose, one preferring the predefined settings and one the individual settings. Five participants preferred the individual settings because they can be tailored more specifically to their unique interests. Most participants stated individuality as the main reason why they preferred the individual settings. Nine people stated that it allowed them to be more creative, and is more specific to their interests. Three participants answered that it was easier to use. Two of them preferred the predefined settings, explaining that they were clear and easy to identify with, while the third person answered that "it is is easier to just select what I want individually", preferring the individual settings. Finally, one participants said they do not want to miss anything by filtering it, preferring the predefined settings.

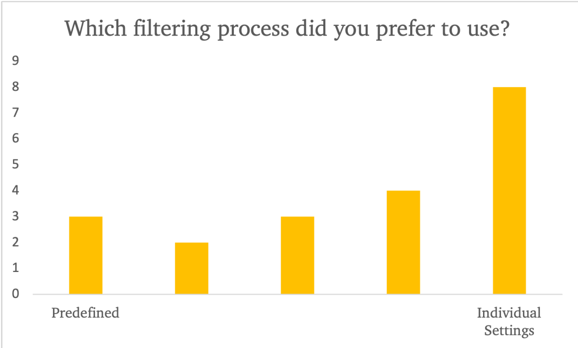


Figure 11: Bar chart visualising answers to “Which filtering process did you prefer to use?”

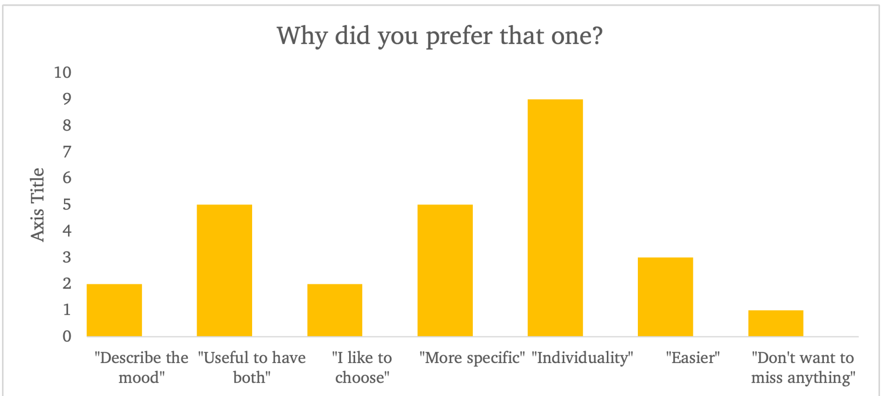


Figure 12: Bar chart visualising cluster of answers to “Why did you prefer that one?”

The final question of the first section of the user study was “What additional categories would you like to see for the predefined settings?”. Unfortunately, this question seems to have been confusing for most participants. Only half the participants answered the question, and of those answers, two people answered in the expected way, stating they would suggest a “hikers” category or something related to landscapes. The other participants seem to have missed that this question was about the predefined categories after Benson et al. (2013), suggesting option for the individual settings such as “read and relax” or “semi-active”. No bar chart could be created here, since no real trend could be made out of the answers.

For the first question of the second section of the user study, participants were asked whether they immediately understood how to use the website upon opening it or not. The mean was calculated to be 3.55, the variance 1.34, and the standard deviation 1.19 (**Figure 13**). Five clusters could be identified from the answers the question, clarifying the previous one: “Clicking and nothing happened”, “took a second to realise importance of the buttons”, “Legend was hidden at first”, I thought they were settings for map appearance”, “It’s easy to navigate” (**Figure 14**).

Seven participants stated that they clicked things and nothing happened, mainly citing “the black dots” and that they did not understand to define parameters first. Six participants stated that they did not realise the importance of the buttons at first. Some of these participants additionally explained, that they did not understand how exactly the selection in the individual settings changed the map content. Three participants noted that the legend was hidden at first, and that sliders should have labels. One person thought the settings were to change the map’s general appearance. Finally, two people stated they believe the map to be easy to navigate.

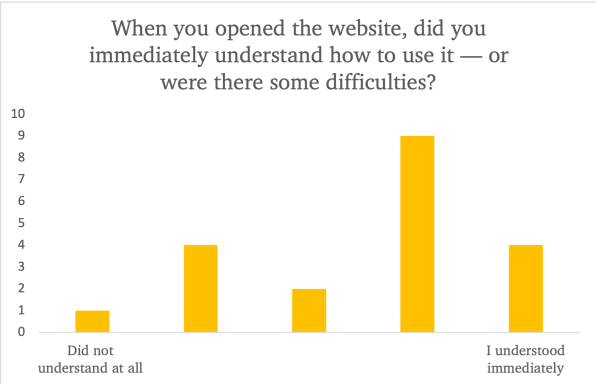


Figure 13: Bar chart visualising answers to “When you opened the website, did you immediately understand how to use it — or were there some difficulties?”

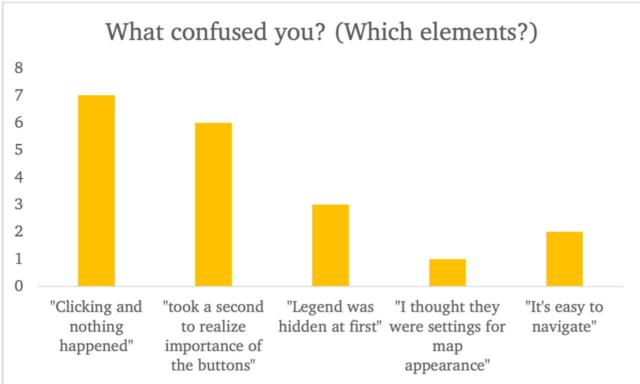


Figure 14: Bar chart visualising cluster of answers to “What confused you? (Which elements?)”

Participants were also asked if they thought they would benefit from an onboarding tutorial. Here, the mean was 3.35, the variance 1.93, and the standard deviation 1.42. From the bar chart only a slight delineation towards an onboarding process can be made out (**Figure 15**). To further inquire about any possible confusion with the interface itself, participants were asked whether they expected elements to something different than they did. Here, the mean was 1.55, the variance 0.75, and the standard deviation 0.89 (**Figure 16**).

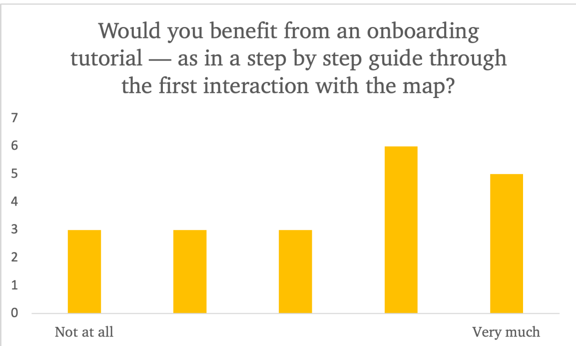


Figure 15: Bar chart visualising answers to “Would you benefit from an onboarding tutorial — as in a step by step guide through the first interaction with the map?”

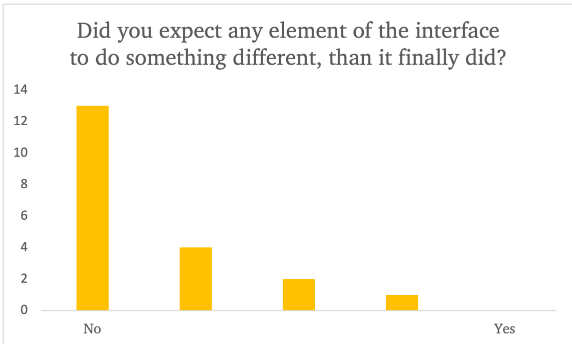


Figure 16: Bar chart visualising answers to “Did you expect any element of the interface to do something different, than it finally did?”

From the question clarifying which elements, five categories could be determined: “No close button”, “opens windows on top of one another”, “black dots”, “expected more information” and “None” (**Figure 17**). One participants noted, that when opening the alerts API (Application Programming Interface), there is no extra button for closing, but rather a second click on the “Alerts” button closes the window. Another participant remarked that the filtering windows open on top of one another instead of closing one when the other is opened. Two participants noted, that clicking on the “black dots”, which are the POIs before filtering, does not give the user any additional information. Six participants expected more information in general, such as opening hours or more general labels of the basemap. Eleven participants had no suggestions.

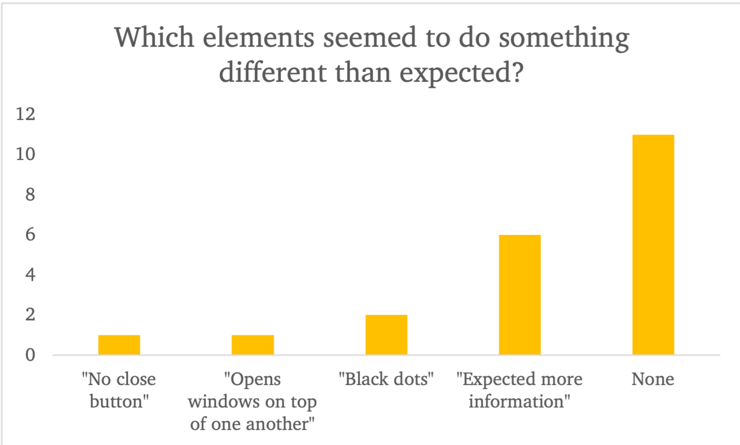


Figure 17: Bar chart visualising clusters of answers to “Which elements seemed to do something different than expected?”

For the final question of sub-section two of the survey, eight different categories could be made out for clustering the answers: “Assemble buttons differently”, “PC vs. Mobile issues”, “Bigger points while zooming in”, “should be explained briefly”, “Highlight entrances”, “metric system”, “more information”, and “Basemap” (**Figure 18**). Three participants suggested to assemble buttons differently, both within the filtering window and the buttons on the map itself. Two participants had problems with rotating the map on a PC and hovering over items as opposed to clicking on them. Moreover, one person suggested that when zooming in, the points also become bigger, rather than staying the same size. Four participants would like explanations to the filtering mechanisms, for instance, explaining the predefined categories there without linking the paper, and describing what exactly the different menus, sliders and buttons in the individual settings do. Three participants suggest to highlight the entrances for better visibility and one person suggested to include metric measurements as well, since many international tourists are not familiar with the imperial system. Five participants wanted more information in general, both on the basemap and within the filtering mechanisms. Finally, three participants suggested to improve the basemap with different colouring contrasts, labels, and generally more elements.

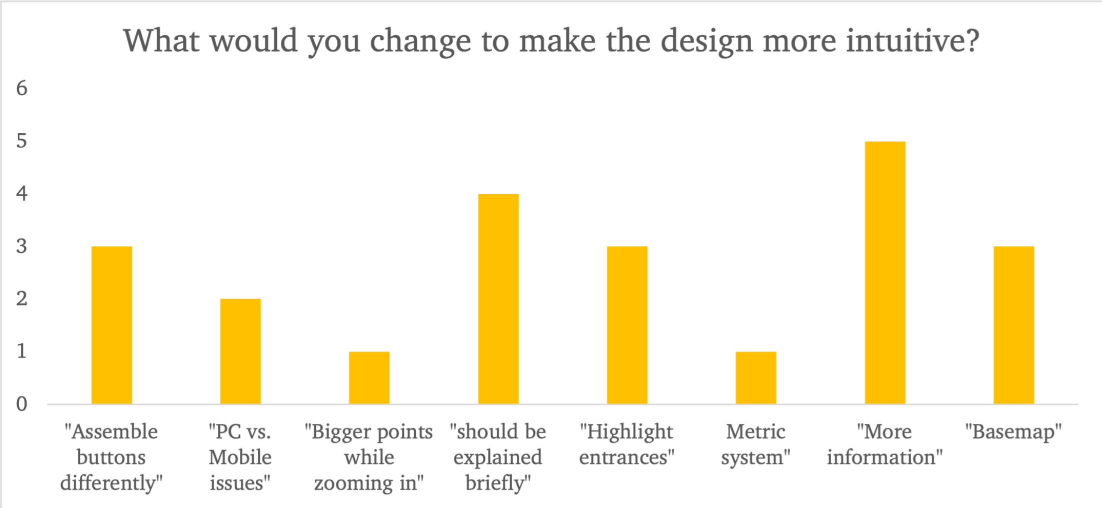


Figure 18: Bar chart visualising clusters of answers to "What would you change to make the design more intuitive?"

The first question of the final section inquired whether there were issues with loading the map at any point. 18 participants did not experience any issues with loading, while two participants noted, that sometimes the map "took a few seconds". They did however state, that this did not inhibit the general functionality or use of the map (**Figure 19**).

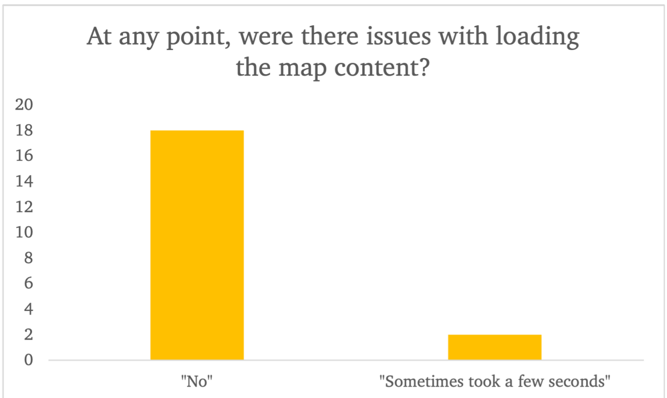


Figure 19: Bar chart visualising clusters of answers to "At any point, were there issues with loading the map content?"

The next question was asked to see what kind of usefulness participants attributed to the website (**Figure 20**). Here, six different categories could be determined: "Planning in advance", "Spontaneous", "Specific to my interests", "Identify POIs to visit", "Finding tourist attractions", and "for tourism agency". 13 participants thought the map to be useful for planning trips to the NP in advance or planning a holiday. Three participants believed that it could also be useful for spontaneous trips or spontaneously changing plans while already in the park. Three participants stated that the map would be useful for finding things to do, specific to their interests. Two participants found that it was useful to identify POIs to visit, and two more participants believe the map to be useful for finding tourist attractions in the park. Finally, one participant stated that the map could be useful for a tourism agency.

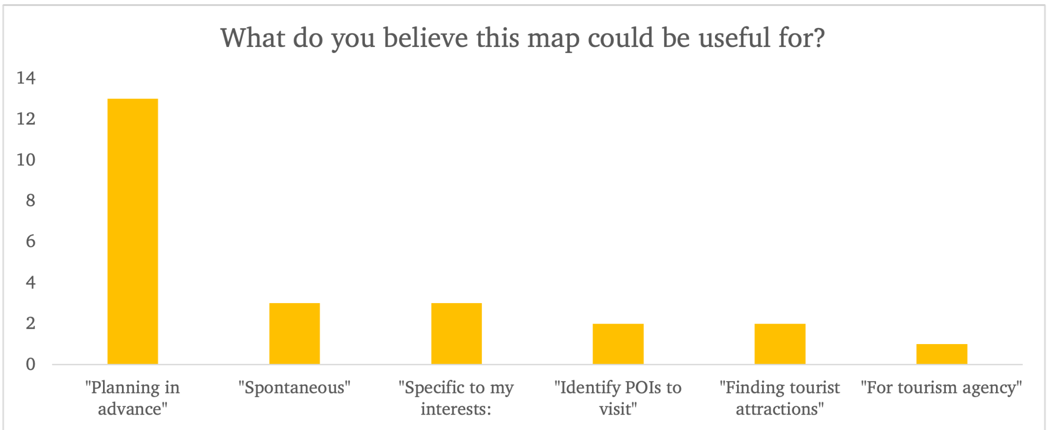


Figure 20: Bar chart visualising clusters of answers to "What do you believe this map could be useful for?"

The second to last question inquired how useful they believed the map to be, for the purpose of planning a trip to Yellowstone NP (**Figure 21**). The mean was calculated to be 4.1 for the Likert scale from one to five, "Not at all" to "Very". The variance was 1.09, and the standard deviation 1.07. Only one participant chose "not at all". Finally, participants were asked for any additional remarks or suggestions that had not been covered by the previous questions of the user study. These suggestions could not be clustered, since every participant had something else to say. In general, participants stated they would like more colour, pictures or links to other websites, the option to save or download the map once the filtering is done, and an improved front end development. Apart from one question, all questions were understood and answered thoughtfully by the participants.

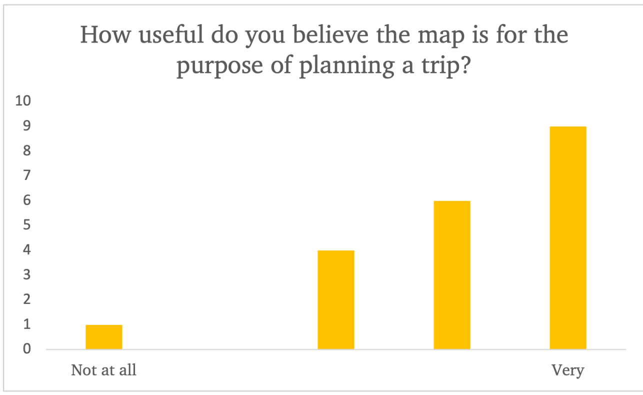


Figure 21: Bar chart visualising clusters of answers to "How useful do you believe the map is for the purpose of planning a trip?"

From the Microsoft Clarity dashboard, several insights could be taken. Of all the sessions done in the timeframe of the user study, 68.42% had so-called dead-clicks, which happens when people click on something on the website and nothing happens. 2.63% had rage-clicks, which is what it is called when a person rapidly clicks on the same item or in the same small area. 10.53% of the sessions had quick-backs. This happens when a person navigated to a page and then quickly returns to the previous page. No JavaScript errors and no excessive scrolling were found in any of the sessions.

6. Analysis

6.1. Discussion

The following sections will discuss the findings presented in Section 6, split into the sub-sections of the questionnaire. Additionally, participants provided demographic information that adds contextual depth to the study. Age distribution ranged from 19 to 36, with most participants being in the 23-27 age range. Age does not seem to have had any impact on the use of the map. Device usage indicated a predominant mobile preference, with 70% utilising mobile devices and 30% opting for desktop. There were no distinct differences in the answers between mobile and desktop users, except for some minor functionality issues on the desktop interface. A minority (2 of 20) had prior experience visiting Yellowstone National Park, which is why no comparative analysis could be done regarding answers from participants who had and who had not visited the park before. The results from the Microsoft Clarity plugin indicate issues with dead-clicks, since 68.42% of the session had some. In combination with some of the answers from the user study, this leads back to several POIs not providing any additional information when clicking on them. When further expanding the web development of the map, this feedback will be taken into account in the form of informative pop-ups. Upon further analysis, sessions with quick-backs, showed that participants clicked on the explanatory link to the Benson et al. (2013) paper and quickly navigated back to the map. This in combination with some of the answers to the questions in the user study indicates that participants would much rather prefer an explanation of the predefined settings there, as opposed to having to read through a scientific research paper.

6.1.1.Filtering — Sub-Section One

Having reviewed the results of the user study, some conclusions can be drawn. Generally, the amount of participants is limited. Optimally, a user study aiming to evaluate such a project should include more participants. While opinions differ on the optimal sample size, a comprehensive review by MT Collins et al., suggests a minimum between 51 and 82 for mixed-methods approaches (2006). Due to timely constrictions, and the added difficulty to initially find participants that had potentially visited Yellowstone NP before, it was not possible to find more participants for the user study. For future studies however, and to evaluate this project even further, more people should be found and asked to participate.

The first question of the user study, asked whether they were satisfied with the options to choose from in the individual settings. The mean satisfaction was calculated to be 3.75, indicating an overall moderate level of satisfaction with the options. The relatively low variance value of 0.69 suggests that the responses were clustered around the mean, implying a consistent pattern of satisfaction. Additionally, the standard deviation of 0.85 further supports this observation, indicating that the majority of responses were within one standard deviation from the mean. This suggests a relatively stable and uniform perception of satisfaction among the study participants. The clustering analysis revealed six distinct clusters capturing participants' sentiments and preferences regarding the available options. The "No active options" cluster, represented by one response, indicated dissatisfaction due to the absence of interactive elements. Two responses fell into the "Too little options" cluster, reflecting participants' desire for a broader range of choices. Four participants were grouped into the "I would like more information" cluster, expressing their need for additional details about the presented options. One response aligned with the "I like the POIs filtering" cluster, highlighting satisfaction with the point-of-interest filtering feature. A substantial majority of participants, represented by eight responses, belonged to the "Options covered everything" cluster, indicating an overall contentment with the comprehensiveness of the provided choices. Additionally, seven participants were categorised within the "More specific" cluster, expressing their preference for even more targeted options. This segmentation underscores the diverse range of user preferences and requirements. Building upon these findings, the subsequent inquiry into the reasons behind satisfaction or dissatisfaction provided deeper insights into participants' motivations, shedding light on the factors influencing their perceptions.

Inquiring further into participants' preferences, the study investigated whether participants would welcome the inclusion of additional options to customise and tailor the map interface. The analysis of responses revealed a mean score of 3.3, indicating a moderate level of interest in additional options. The variance of 1.71 suggests a notable dispersion of responses around the mean, potentially reflecting differing degrees of enthusiasm among participants. The standard deviation of 1.34 further confirms the variability in attitudes toward the addition of new customisation features. This outcome implies that while some participants may be relatively more receptive to additional options for map adaptation, others might hold reservations or exhibit stronger preferences for the current set of choices. In response to the query about desired additional options for map customisation, participants provided insights into their specific preferences. The clustering analysis revealed distinct thematic clusters among the responses. The largest group of participants, represented by nine responses, expressed an interest in “specific activities and interests” underlining the importance of tailoring options to match individual hobbies and passions. A separate cluster, consisting of five responses, was centred around “atmosphere and ambience” highlighting a desire for additional filters regarding the atmosphere of a place, for instance, whether a location is crowded, or has a beautiful view. “Being active” emerged as another distinct theme, with three responses indicating a preference for options that encourage physical engagement. Similarly, three participants sought “routes for running and cycling”, emphasising the importance of fitness-oriented choices. Lastly, five participants fell into a cluster that sought “generally more options”, suggesting an overall desire for a diverse range of customisation possibilities. Together with the answers for (dis-)satisfaction with the options, these findings underscore the significance of catering to diverse user interests and needs, providing a foundation for potential feature expansion and customisation to enhance user satisfaction and engagement.

Examining participants’ sense of representation by the predefined map categories, the study yielded insightful findings. Participants were queried regarding their level of alignment with the predefined categories after Benson et al. (2013). The mean score of 3.75 suggests a moderate to high level of perceived representation among the participants. The relatively low variance of 0.49 further indicates a consistent consensus among respondents, underlining a shared sentiment of alignment with the predefined map categories. The corresponding standard deviation of 0.72 reaffirms this observation, showcasing a relatively tight clustering of responses around the mean. These statistics suggest that a significant majority of participants feel adequately represented by the existing categories, highlighting the success of the predefined options in capturing the diversity of user preferences.

Participants were further asked to indicate their preference, between the individual filtering and the predefined maps. The mean preference score of 3.60 signifies a moderate preference leaning towards the individual filtering option. The variance of 2.14 indicates a relatively broader distribution of preferences across the sample, reflecting a diversity of inclinations. The standard deviation of 1.50 further underscores this variation, indicating that while some participants strongly favoured one mechanism, others exhibited a more balanced or nuanced preference. These statistics highlight the importance of providing both options to accommodate differing user needs and inclinations. Investigating why participants preferred one filter over the other, the study delved into deeper insights provided by their explanations. Among those who favoured individual filtering, nine participants expressed a desire for “more specific” options, underlining their inclination for tailored selections that closely align with their unique preferences. A separate cluster of five participants highlighted the “usefulness of having both” mechanisms, underscoring their appreciation for the flexibility and choice offered by the dual approach. An equal number of participants (five) emphasised their preference for “more specific” choices, reaffirming the value of customisation and personalisation. “Individuality” emerged as a prominent theme, with nine participants expressing a preference for options that align with their distinct preferences and interests. Additionally, “easier” navigation was cited by three participants as a key driver of their preference. Two participants noted a preference for options that “describe the mood”, indicating an affinity for choices that evoke specific atmospheres. Lastly, one participant indicated a preference for individual filtering to ensure they “don’t want to miss anything”, further underscoring the significance of customisation in enhancing user satisfaction. The moderate mean preference score for individual filtering suggest its appeal, potentially attributed to users’ desire for personalised customisation. On the other hand, the diversity in responses underscores the value of retaining both mechanisms, ensuring that users can tailor their map experience in a manner that resonates with their preferences. Additionally, the clusters provide an understanding of the factors that influence the users preferences.

While seeking participants’ input on potential enhancements to the predefined settings, the analysis yielded a limited number of usable responses, with a majority of participants potentially misunderstanding the question’s intent. Two participants provided suggestions that align with the scope of the inquiry. One participant proposed the addition of a category catering to “hikers”, suggesting an interest in options tailored specifically for hiking enthusiasts. Another participant indicated a desire for a category related to “landscapes” highlighting an inclination for choices that emphasise the scenic beauty and visual appeal of the surroundings. Despite the challenge in gathering substantial suggestions, these responses provide insights into users’ potential preferences for new predefined categories that encompass outdoor activities and aesthetics. The scarcity of applicable responses underscores the importance of precise phrasing in survey design to elicit targeted feedback. Moving forward, these insights could potentially inform future expansions of the predefined settings to encompass a broader spectrum of user interests and needs, however, further testing should be done beforehand to understand the importance of those categories.

All in all, the first sub-section of the questionnaire did yield some insights into user preferences and the need to adjust or change various elements of the map, to make them more user friendly. Participants exhibited that both individual settings and predefined maps are valuable for the website, with a slight preference toward the individual settings. Participants shared suggestions for further enhancement of both mechanisms, ranging from generally more information to specific changes to the options provided. These insights will be taken into account in the further stages of the web development of the map.

6.1.2. Design — Sub-Section Two

The study examined participants' first impressions and ease of navigation on opening the site, and sought to determine their level of immediate understanding. Analysis of the responses provided insights into users' initial interactions with the interface. The mean score of 3.55 indicates a generally positive perception of ease of understanding the functionality of the site. The relatively low variance of 1.35 suggests a consistent consensus among participants, underlining a shared sense of clarity and accessibility. The corresponding standard deviation of 1.19 supports this observation, indicating that participants' experiences were relatively closely clustered around the mean. Taken together, these descriptive statistics suggest that a significant proportion of participants felt reasonably confident in their ability to quickly navigate and understand the features of the website on first contact. This positive feeling about the website's usability underlines the importance of intuitive design and serves as a testament to the effectiveness of the interface's layout and instructional cues. The further analysis of participant responses revealed distinct thematic clusters that shed light on specific points of confusion. Seven participants highlighted "clicking and nothing happened" as a source of confusion, pointing to potential issues related to user interaction or responsiveness. An additional six participants noted that it "took a second to realise the importance of the buttons", suggesting that initial comprehension of certain elements required a brief adjustment period. Three participants mentioned that the "Legend was hidden at first", indicating an initial difficulty in accessing a crucial explanatory component. A smaller cluster of two participants indicated that they initially "thought the settings were for map appearance", which could indicate potential ambiguity in the labelling or presentation of certain map features. On a positive note, two participants emphasised that they found the website "easy to navigate", indicating an overall positive user experience. These clusters offer valuable feedback to refine the user interface design, optimise the visibility of essential components, and ensure seamless user interactions. Addressing these specific points of confusion can contribute to enhancing user satisfaction and facilitating a smoother navigation experience for all users.

The analysis of responses, inquiring whether participants would benefit from an onboarding tutorial, guiding them step-by-step through the first interaction with the map, revealed a mean score of 3.35 indicating a moderate to positive interest in the idea of an onboarding tutorial. The variance of 1.93 suggests a range of preferences among participants, reflecting differing levels of perceived need for guided assistance. The corresponding standard deviation of 1.42 further emphasises this variation, suggesting that while some participants strongly believe in the value of a tutorial, others may view it as less essential. These statistics collectively underscore a generally favourable disposition toward the concept of an onboarding tutorial, albeit with varying degrees of enthusiasm. Tailoring the tutorial to address specific areas of confusion, as highlighted in previous responses, can enhance its effectiveness and provide users with a more seamless and informative initial experience. For those who do not see it as important to have an onboarding tutorial, users could be given the opportunity to skip such a tutorial, without having to click through it entirely.

Examining participants' preconceived expectations and subsequent experiences with the website's elements, the study aimed to uncover any disparities between anticipated and actual functionalities. The analysis of responses revealed noteworthy insights into participants' perceptions. The mean score of 1.55 indicates that participants generally had low expectations of elements behaving differently than they ultimately did. The low variance of 0.75 suggests a relatively consistent alignment between participants' expectations and the actual outcomes, reflecting a shared understanding of the website's functionalities. The corresponding standard deviation of 0.89 further reinforces this observation, indicating that participants' expectations were closely clustered around the mean. These findings collectively indicate a high degree of congruence between participants' initial assumptions and the realised behaviour of website elements. This alignment is indicative of the effectiveness of the website's design and functionality, as well as participants' ability to accurately anticipate how elements would function. Digging deeper into the aspects that participants found confusing during their interaction with the website, the study revealed distinct clusters that illuminated particular pain points. Analysis of responses unveiled a cluster of participants (six responses) who indicated confusion related to "black dots", suggesting potential issues with the functionality of the elements. An additional cluster (with two responses) highlighted the confusion arising from the "opening of windows on top of one another" indicating a concern with overlapping or layered content. One response noted the absence of a "close button" for the "Alerts" window, hinting at a challenge related to navigation or dismissal of certain elements. Similarly, a single participant pointed out that they "expected more information", suggesting a desire for additional context or content. A significant cluster of participants (eleven responses) indicated that "none" of the elements specifically confused them, signifying an overall positive user experience in terms of clarity and comprehensibility. These thematic clusters provide valuable feedback to identify specific pain points, allowing for targeted improvements to enhance user understanding and streamline navigation within the website.

Finally, exploring participants' constructive feedback on refining the design for enhanced intuitiveness, the study gleaned insights into several areas for potential enhancement. A significant number of participants (five responses) underscored the importance of "more information", emphasising the value of providing comprehensive details to enrich the user experience. Four participants advocated for "brief explanations", highlighting a need for concise yet informative content that aids in understanding the website's features. An additional cluster (three responses) suggested the incorporation of a "metric system", reflecting a desire for accommodating international users through alternative units of measurement. "Highlighting entrances" emerged as another key theme, with three participants emphasising the significance of clearly indicating access points for improved navigation. Two participants pointed out "PC vs. Mobile issues", indicating the need for an improved responsive design. A cluster of three participants highlighted the potential benefit of "bigger points while zooming in", enhancing visibility and interaction at varying levels of zoom. "Assembling buttons differently" was suggested by three participants to optimise the arrangement of interface elements. Lastly, one participant proposed improving the "basemap".

In conclusion, the clusters derived from participants' feedback, coupled with the statistical analysis, culminate in a comprehensive grasp of users' viewpoints on enhancing the website's design. By embracing these suggestions and aligning them with principles of intuitiveness and user-centred design, a more seamless and engaging interface can be created.

6.1.3. Overview — Sub-Section Three

Examining participants' experiences with loading map contents, the final section of the user study provided insights into the website's general performance. Participants were asked about any potential issues encountered during content loading, revealing distinct clusters that shed light on their loading experiences. The majority of participants (18 responses) reported a seamless loading process, affirming the website's efficiency in promptly delivering content. Conversely, a smaller cluster (two responses) noted intermittent delays, suggesting occasional instances where loading took a few seconds longer. These clusters collectively underscore the website's effectiveness in swiftly presenting map contents to the majority of users. The infrequent occurrences of minor delays highlight the importance of fine-tuning loading times to ensure a consistently smooth user experience, which can be addressed in further iterations of the website development.

Participants' perspectives on the map's practicality provided insights into its multifaceted purposes. A significant cluster (13 responses) identified the map as a tool for "planning in advance", highlighting its capacity to assist users in trip preparation. Another cluster (three responses) emphasised the map's relevance in facilitating "spontaneous" decision-making, reflecting its adaptability to on-the-spot exploration. An additional cluster (three responses) underscored the map's ability to cater to "specific interests", enabling users to customise their experiences to match their unique preferences. Participants recognised the map's potential for "identifying points of interest (POIs) to visit", streamlining the process of locating notable destinations. Similarly, the map's efficacy in "finding tourist attractions" received acknowledgment from two participants, underscoring its role in guiding visitors to notable landmarks. Finally, one participant acknowledged the map's applicability to the needs of a "tourism agency", suggesting its potential as a resource for travel industry professionals. These clusters collectively illuminate the diverse and versatile utility of the map, positioning it as an asset for a range of user scenarios and enhancing its significance within the broader context of travel and exploration.

Continuing the exploration of participants' perspectives, the study turned to their assessment of the map's usefulness for trip planning. With a mean score of 4.10, participants expressed a consistently positive perception of the map's usefulness in trip planning. The low variance of 1.09 underscores the relatively uniform agreement among participants, reflecting a shared sentiment of the map's value in this context. The corresponding standard deviation of 1.07 further supports this observation, indicating participants' viewpoints were closely clustered around the mean. These statistics collectively signify a consensus among participants regarding the map's efficacy as a valuable tool for trip planning.

In the final question, participants shared their perspectives through suggestions and remarks, offering a diverse range of insights. Recommendations included incorporating visuals like pictures or links for better route comprehension, and a desire for a user-ranked trail system. One participant expressed strong enthusiasm for the project's potential expansion. Feedback ranged from colour enhancement suggestions to pinpointing inaccuracies in trail distances. Ideas for future development encompassed highlighting roads and refining the custom filter pop-up. Constructive criticism addressed front-end aesthetics, while others found satisfaction with the existing map. Valuable insights touched on the absence of a save option, emphasised data maintenance for competitive edge, and advocated for comprehensive paths suggestions. Overall, participants' input provides a multifaceted view, guiding potential enhancements and affirming the map's utility for trip planning and exploration. Taking into account all the results, suggestions and remarks from the participants, the map for Yellowstone NP is then improved, and Grand Canyon NP is added to the map.

6.2. Conceptual Framework

From the trial-and-error approach and the analysis of the results of the user study, a conceptual framework is created for the creation of adaptable map interfaces in the domain of National Park tourism. In an effort to promote collaboration among researchers and cartographers, the following sections will summarise an approach to such a project from start to finish. The sections build upon one another in a circular motion (**Figure 22**), starting with "Knowledge". A stand-alone version of the framework can be found in Section 10.3.

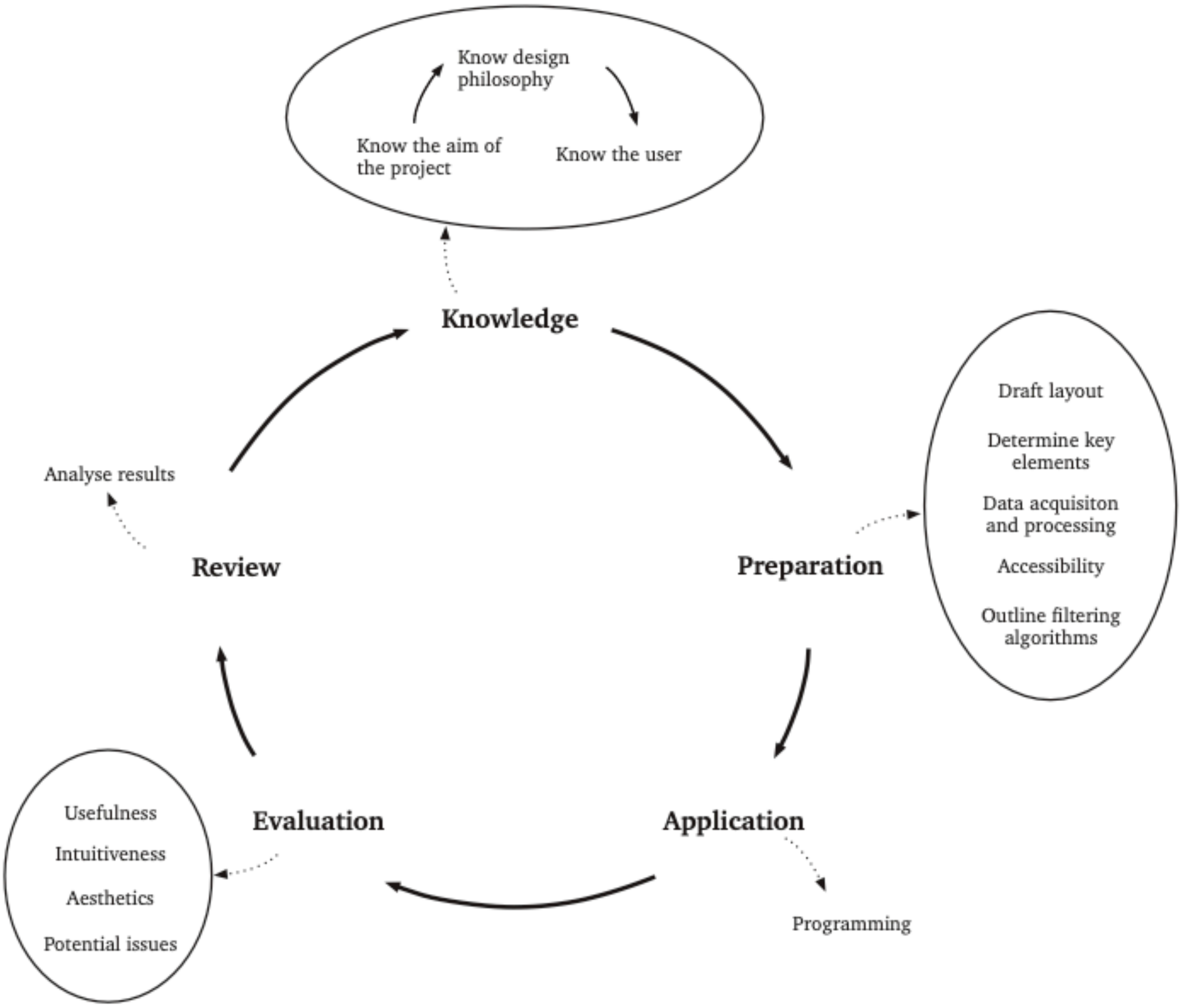


Figure 22: Conceptual Framework for creating adaptable web map interfaces

6.2.1.Knowledge

What became apparent in this project, was that a significant amount of knowledge is required to begin thinking about the layout and the intricate algorithms of the map interface. This knowledge is split into multiple sections. The first piece of knowledge that is vital, is to know the aim of the project. In case a project is created for a specific company or should be based on other designs, the company's philosophy should be researched profusely. In the case of this project, the design was meant to resemble that of the paper maps created by the NPS. To achieve that, the philosophy of the NPS had to be understood, and the particular design philosophy as well. Since maps created by the NPS usually have a basemap that includes a relief and the landcover of the region, those facts have to be known and taken into account in later steps of the development of the map interface. Additionally, when creating an adaptable interface, as opposed to an adaptive interface, it is important to understand the needs and preferences of potential users. In the case of a NP, visitors may require different elements on the map, as opposed to public parks or city squares. Once the aim of the project and preferences and needs of the visitors are somewhat clear, one can commence with the next phase.

6.2.2. Preparation

This pivotal stage involves the seamless translation of acquired insights into actionable design strategies. By crafting an initial draft and an outline of the map's layout, key elements can be identified, serving as a foundation for project overview and time allocation. The trial-and-error approach employed in this project highlights the importance of delineating the website's layout, aiding decisions on element placement for optimal user interaction. A strategically outlined layout, preceding the "Application" phase, expedites interface development by minimising the need for later adjustments. A salient consideration is the integration of accessibility guidelines, especially for inclusivity. Existing mandates or custom approaches should be adhered to, with Foley's (2002) framework in Section 2.3 offering guidance for creating an accessible interface. Such guidelines extend to the subsequent data acquisition and processing phase, encompassing the addition of alternative text to images, guided by, for instance, WCGA 2.0 principles. Crucially, data procurement and processing draw from insights gleaned in the knowledge stage. For instance, this project's examination of hiking formulas, detailed in Section 2.6, informed the determination of optimal functions – a pivotal component of this preparation stage. Another key part of this stage is the creation of an outline of filtering algorithms. The centrepiece of the map, the adaptable user interface, requires the creation of such filtering algorithms to tailor the map to each user individually.

6.2.3. Application

Using the layout drafted in the previous stage, the interface can now be programmed. This stage involves translating design concepts into a functional map interface, focusing on aspects such as visual aesthetics, user interaction, and intuitive navigation. Concepts for user interaction, which were researched in the "Knowledge" stage, can now be applied. For instance, in this project, research was done on how to make a web interface responsive for multiple screens. This is increasingly vital as more users rely on mobile phones instead of desktop screens. The interface and the basemap must both be aesthetically pleasing to the user. It is important to follow cartographic principles for user-friendly design in this case. Furthermore, the previously outlined design principles and philosophies, such as the NPS design philosophy, will be applied here. Several options are available to create a basemap. Existing open-source libraries like Leaflet, or proprietary software solutions such as MapBox which was used for this map interface, can be utilised. Depending on the underlying basemap, a JavaScript environment will have been created in which further development of the interface should occur. To illustrate, when integrating with MapBox, the interface was built using MapBox GL JS. By employing such implementations consistently, it can be ensured that the final website performs seamlessly. Another crucial aspect in the "Application" stage is to offer easy-to-use navigation between GUI elements. Studies reveal that users anticipate buttons to be in specific locations on the interface, and they can get perplexed if it is not found there. For example, a button to exit a window is frequently positioned in the top-right corner. If such a button is located elsewhere or missing completely, it could confuse the user. Furthermore, considerations need to be made, regarding the first load of the website:

If one of the filtering windows is already open, should we assume the user knows how to use it?
Is it wise to have the legend already open, or will it cover other map interface elements that would otherwise be visible?
Is the website user-friendly, or would potential users need an onboarding tutorial to guide them through their first interaction with the map?

Initially, the approach to this stage will be to create a functional interface and then move on to the next phase. Because of the cyclical nature of the framework, the developer will revisit this stage and modify the user interface based on the new knowledge and suggestions gained from the final stages of evaluation and review.

6.2.4.Evaluation

As the initial version of the web map is developed through research and trial-and-error methods for creating the map interface, it is crucial to conduct a thorough evaluation of the interface. The initial step is to identify the type of evaluation required. For projects of this nature, a mixed-methods approach has been demonstrated as optimal, since it entails employing both qualitative and quantitative measures while assessing the website interface. To establish quantitative measures, utilising Likert scale-type questions is recommended, as it enables the user to provide ratings for their experience with the website on a scale, instead of writing a comprehensive answer. Adding open short-answer questions to such queries enables users to explain the reason they gave the scale rating, thereby contributing a qualitative evaluation method. At this stage, it is crucial to develop questions that the user can comprehend as intended. Two questions in this project proved too complicated for participants, rendering their answers useless for the review process. Questions should be phrased in a way that can be understood by those who lack knowledge in interface design. To prevent over-complication for the user, detailed software descriptions or complex scientific words must be avoided in a user study. Furthermore, questions must consider all elements of the interface to perform a comprehensive evaluation that assesses intuitiveness, aesthetics, usefulness, and potential issues. Lastly, the user study must be implemented. Depending on the map's content, obtaining feedback from experts in the relevant field can be advantageous. It is crucial to allocate ample time between the implementation of the user study and publishing the final project, since finding a sufficient amount of participants can be time-consuming. Although the results obtained from a user study having limited participants, like this one, will have limitations, they can still offer insights into the fields mentioned earlier. Furthermore, obtaining feedback about the website's performance through third-party software, such as Microsoft Clarity, can be beneficial. This free plugin captures any website's sessions and provides insights into dead-clicks, quick-backs, and possible JavaScript errors.

6.2.5. Review

After obtaining adequate responses from the user study, the results need reviewing and analysing. Various data analysis methods are available depending on the type of questions asked during the user study. Bar charts depicting the answer frequencies and statistics like the mean, variance, and standard deviation are useful in the case of Likert scale questions. In qualitative questions, like those in this user study, which further inquired about the participants' Likert scale ratings, clustering analysis can be helpful. By establishing clusters for each question and examining the frequency with which answers align with those clusters, it is possible to gain insights into the issues that are most critical to the users. The significance of these issues may assist in determining which ones should be tackled first when returning to the "Application" phase. After completing the "Review" stage and obtaining a thorough understanding of the website's successes and areas that require improvement, one should update the "Knowledge" section and begin the process afresh. The iterative circular process enables continuous improvements and optimisations over time.

6.2.6. Contributions and Limitations

The conceptual framework outlined in this study makes notable contributions to the domain of adaptable map interface development by offering a systematic and user-centric approach that harmoniously integrates user preferences, design considerations, and iterative feedback. Through the use of literature, the trail-and-error approach to the thesis and the results of the user study, a conceptual framework could be created, therefore answering RQ3.II. By delineating a circular process encompassing Knowledge, Preparation, Application, Evaluation, and Review stages, this framework provides a comprehensive guide for creating adaptable and intuitive map interfaces. However, certain limitations and challenges emerged during the study and implementation process. For instance, while participant feedback significantly enriched the design, the study's sample size was limited, potentially impacting the generalisability of findings. Additionally, the interpretation of qualitative responses introduced subjectivity. Furthermore, the integration of complex data processing algorithms necessitated technical expertise, potentially posing barriers for less experienced developers. Addressing these limitations, future researchers could expand sample sizes for broader insights, consider other approaches for more robust analyses, and develop user-friendly tools to facilitate algorithmic integration. Despite these constraints, the conceptual framework's potential to enhance map interfaces is evident, guiding future innovations with valuable insights and lessons from this endeavour.

7. Conclusion

In conclusion, this thesis strived to create an adaptable map interface for Yellowstone and Grand Canyon NP. Upon completing a preliminary web map of Yellowstone NP, with a trial-and-error approach, a comprehensive user study gave insight into the intuitiveness, usefulness, and aesthetics of the interface. Although results are limited due to a rather small sample size of 20 participants, they could still contribute to the review of the interface. Despite a distinction of 70% and 30% of mobile and desktop user respectively, there were no distinguishable variations in the responses. Several overlapping suggestions between participants showed the importance of adding additional options such as hiking and atmospheric factors like crowdedness or where to see a beautiful view. Though the answers highlighted a slight preference towards customisation, the user study also showed that it is important to provide the user with both individual filtering settings and predefined map options, since participants valued the individuality of the filtering settings, but also the somewhat easier to use predefined options. Additionally, participants generally found the interface easy to understand, though specific areas of confusion were identified, such as button comprehension, and element visibility. There was some interest in an onboarding tutorial to a varying degree among participants. Furthermore, their expectations aligned well with the actual functionality of the elements, signifying that the preliminary design was coherent and intuitive already. Specific constructive feedback and suggestions provided comprehensive insights into enhancing the intuitiveness of the interface, including larger points during zooms, and optimally assembling buttons.

The study also explored the map's broader utility, revealing its effectiveness for planning in advance, and also spontaneity, identifying points of interests, and assisting tourism agencies. Participants perceived a high usefulness of the map for trip planning, which supports the initial purpose of the project. These findings illuminate the dynamic relationship between user engagement and design evolution, contributing to the landscape of adaptable map interface development. By formulating a circular conceptual framework spanning Knowledge, Preparation, Application, Evaluation, and Review stages, a comprehensive guide emerged for creating adaptable and intuitive map interfaces. The synthesis of user feedback into actionable design strategies exemplified the iterative nature of interface development. This study's contributions extend to fostering innovation, providing a blueprint for creating user-centric interfaces that elevate trip planning experiences. As technology evolves and user needs shift, the framework stands as a first foundation, fostering user engagement, satisfaction, and effective exploration of natural landscapes, such as national parks.

8. Future Work

Future work includes the implementation of several extra features to the web map that could not be done due to timely restrictions. Since the user study only involved the preliminary map for Yellowstone NP, and Grand Canyon NP was added only once the user study was done, more user-centred research is required to understand whether the design of the two maps is adequate, now that a first round of results, suggestions, and remarks was taken into account. Platial similarities and dissimilarities were taken into account based off of a short review of both parks, and implemented using a trial-and-error approach, therefore further research into the cartographic depiction of these parks with the adaptable interface in mind will need to be done in the future. Additionally, filtering algorithms were created with the values for Yellowstone NP in mind, since the parks do greatly differ in topography and relief, research should be done to determine whether it is feasible to use the same algorithms, or whether they should be adjusted to each NP. While many suggestions from the user study were taken into account, some of them could not be implemented in time. Future work on the map should include providing the user with the opportunity to save the map as a pdf or png file and building an onboarding tutorial to help users with the first interaction with the map. Additionally, the map, as it is programmed right now, uses separate algorithms and buttons for the national parks. With more time and resources, one may take into consideration to build the website, so that more parks can be added more easily, without creating a new button and filtering algorithm every time.

Future research endeavours should aim to enhance and refine the conceptual framework through rigorous testing and expansion. Currently anchored in research focused on national parks in the United States, its generalisability could be bolstered by investigating users' preferences and requirements in various global national parks. Furthermore, broadening the scope to encompass diverse settings like urban city centres or public parks would contribute to its broader applicability. The overarching goal is for the conceptual framework to transcend specific contexts, becoming a versatile tool applicable to a wide array of destinations. Ultimately, this study aspires to usher in a new era of map interface design, where the foundation is rooted in users' aspirations and preferences, thus enhancing both accessibility and enjoyment of diverse destinations.

9. References

Albers, M. J., & Kim, L. (2000). User Web browsing characteristics using palm handhelds for information retrieval. 18th Annual Conference on Computer Documentation. Ipcc Sigdoc 2000. Technology and Teamwork. Proceedings. IEEE Professional Communication Society International Professional Communication Conference and ACM Special Interest Group on Documentation Conferenc, 125–135. https://doi.org/10.1109/IPCC.2000.887269

Apple. (2023). iPhone 6 - Technical Specifications. https://support.apple.com/kb/sp705?locale=en_GB

Begley Bloom, L. (2023, February 27). The 15 Most Visited National Parks In America (And The Least). Forbes Magazine. https://www.forbes.com/sites/laurabegleybloom/2023/02/28/the-15-most-popular-national-parks-in-america-and-the-least/?sh=60b061f86192

Beh, A., & Bruyere, B. L. (2007). Segmentation by visitor motivation in three Kenyan national reserves. Tourism Management, 28(6), 1464–1471. https://doi.org/10.1016/j.tourman.2007.01.010

Benson, C., Watson, P., Taylor, G., Cook, P., & Hollenhorst, S. (2013). Who Visits a National Park and What do They Get Out of It?: A Joint Visitor Cluster Analysis and Travel Cost Model for Yellowstone National Park. Environmental Management, 52(4), 917–928. https://doi.org/10.1007/s00267-013-0143-4

Cini, F., Kruger, S., & Ellis, S. (2013). A Model of Intrinsic and Extrinsic Motivations on Subjective Well-Being: The Experience of Overnight Visitors to a National Park. Applied Research in Quality of Life, 8(1), 45–61. https://doi.org/10.1007/s11482-012-9173-y

Collins, K. M. T., Onwuegbuzie, A. J., & Jiao, Q. G. (2006). Prevalence of Mixed-methods Sampling Designs in Social Science Research. Evaluation & Research in Education, 19(2), 83–101. https://doi.org/10.2167/eri421.0

Doering, Z. D., & Pekarik, A. J. (1996). Assessment of Informal Education in Holocaust Museums. Institutional Studies Office - Smithsonian Institution.

Ellcessor, E. (2014). : Web Accessibility Myths as Negotiated Industrial Lore. Critical Studies in Media Communication, 31(5), 448–463. https://doi.org/10.1080/15295036.2014.919660

Elsbach, K. D., & Stigliani, I. (2018). Design Thinking and Organizational Culture: A Review and Framework for Future Research. Journal of Management, 44(6), 2274–2306. https://doi.org/10.1177/0149206317744252

Falk, J. H. (2006). An Identity-Centered Approach to Understanding Museum Learning. Curator: The Museum Journal, 49(2), 151–166. https://doi.org/10.1111/j.2151-6952.2006.tb00209.x

Falk, J. H. (2011). Contextualizing Falk's Identity-Related Visitor Motivation Model. Visitor Studies, 14(2), 141–157. https://doi.org/10.1080/10645578.2011.608002

Falk, J. H. (2016). Identity and the Museum Visitor Experience (0 ed.). Routledge. https://doi.org/10.4324/9781315427058

Falk, J. H., Heimlich, J., & Bronnenkant, K. (2008). Using Identity-Related Visit Motivations as a Tool for Understanding Adult Zoo and Aquarium Visitors' Meaning-Making. Curator: The Museum Journal, 51(1), 55–79. https://doi.org/10.1111/j.2151-6952.2008.tb00294.x

Findlater, L., & McGrenere, J. (Eds.). (2004). CHI 2004: Connect: conference proceedings: April 24-29, Vienna, Austria: Conference on Human Factors in Computing Systems: Vienna, Austria, April 24-29. Association for Computing Machinery.

Findlater, L., & McGrenere, J. (2008). Impact of screen size on performance, awareness, and user satisfaction with adaptive graphical user interfaces. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 1247–1256. https://doi.org/10.1145/1357054.1357249

Foley, A., & Regan, B. (2002). Web Design for Accessibility: Policies and Practice. Educational Technology Review, 10.

Greenberg, S. (1993). The computer user as toolsmith: The use, reuse, and organization of computer-based tools. Cambridge University Press.

Gunasekaran, A. (1999). Agile manufacturing: A framework for research and development. International Journal of Production Economics, 62(1–2), 87–105. https://doi.org/10.1016/S0925-5273(98)00222-9

Haines, A. L. (1974). Yellowstone National Park: Its Exploration and Establishment. US National Park Service.

ISO. (2019). ISO/IEC 40500:2012 Information technology—W3C Web Content Accessibility Guidelines (WCAG) 2.0 (40500:2012). https://www.iso.org/standard/58625.html

Jiang, T., Yang, J., Yu, C., & Sang, Y. (2018). A Clickstream Data Analysis of the Differences between Visiting Behaviors of Desktop and Mobile Users. Data and Information Management, 2(3), 130–140. https://doi.org/10.2478/dim-2018-0012

Joyce, A. (2020). “Mobile Tutorials: Wasted Effort or Efficiency Boost?”. https://www.nngroup.com/articles/mobile-tutorials/

Kamri, T., & Radam, A. (2013). Visitors’ Visiting Motivation: Bako National Park, Sarawak. Procedia - Social and Behavioral Sciences, 101, 495–505. https://doi.org/10.1016/j.sbspro.2013.07.223

Kanno-Youngs, Z., & Friedman, L. (2023, August 7). Biden to designate Monument near Grand Canyon, preventing Uranium Mining. https://www.nytimes.com/2023/08/07/us/politics/biden-grand-canyon-arizona-national-monument.html

Kelly, G. (2014, October 14). Motorola Nexus 6 Official: Everything You Need To Know. Forbes Magazine. https://www.forbes.com/sites/gordonkelly/2014/10/15/motorola-nexus-6-everything-you-need-to-know/?sh=1f7f81507e34

Lais, G. (1992). Wilderness Accessibility for People with Disabilities—A Report to the President and the Congress of the United States on Section 507 (a) of the Americans with Disabilities Act. National Council on Disability.

Langmuir, E. (1984). Mountaincraft and Leadership.

Loomis, J., Tadjion, O., Watson, P., Wilson, J., Davies, S., & Thilmany, D. (2009). A Hybrid Individual—Zonal Travel Cost Model for Estimating the Consumer Surplus of Golfing in Colorado. Journal of Sports Economics, 10(2), 155–167. https://doi.org/10.1177/1527002508320136

Martin, S. (2019). Impact Report 2019—The Grand Canyon's next generation of conservation leaders. Grand Canyon Trust.

McKee, B. (1933, November). Grand Canyon Nature Notes. 8(8). http://npshistory.com/nature_notes/grca/vol8-8e.htm

Naismith, W. (n.d.). Scottish Mountaineering Club Journal. https://books.google.at/books?id=mTjuAgAAQBAJ

National Geographic (Director). (2021). Yellowstone—America's National Parks.

Nguyen, L., & Shanks, G. (2009). A framework for understanding creativity in requirements engineering. Information and Software Technology, 51(3), 655–662. https://doi.org/10.1016/j.infsof.2008.09.002

NPS. (1988). Colorado River Management Plan.

NPS. (2015). Grand Canyon National Park [Map]. NPS.

NPS. (2016, May 10). J. C. Ives visits the Grand Canyon. https://truewestmagazine.com/article/j-c-ives-visits-the-grand-canyon/

NPS. (2017, January 20). Wildlife—Grand Canyon. https://www.nps.gov/grca/learn/nature/wildlife.htm

NPS. (2019, September 10). Wildlife—Yellowstone. https://www.nps.gov/yell/learn/nature/wildlife.htm

NPS. (2021, February 2). Geology—Yellowstone. https://www.nps.gov/yell/learn/nature/geology.htm

NPS. (2022a). National Park Service Budget Report. National Park Service.

NPS. (2022b, February 16). Visitation. https://www.nps.gov/subjects/socialscience/visitation.htm

NPS. (2022c, December 29). Blind/Low Vision. https://www.nps.gov/subjects/accessibility/blind-low-vision.htm

NPS. (2022d, December 30). About Us. https://www.nps.gov/aboutus/index.htm

NPS. (2023a). Yellowstone National Park [Map]. NPS.

NPS. (2023b, March 13). Socioeconomic Monitoring Visitor Surveys. https://www.nps.gov/subjects/socialscience/socioeconomic-monitoring-visitor-surveys.htm

NPS. (2023c, July 24). Things to do—Grand Canyon. https://www.nps.gov/grca/planyourvisit/things2do.htm

NPS. (2023d, July 28). How to Determine Hiking Difficulty. https://www.nps.gov/shen/planyourvisit/how-to-determine-hiking-difficulty.htm#:~:text=Shenandoah%27s%20Hiking%20Difficulty%20is%20determined,root%20is%20the%20numerical%20rating.

NPS. (2023e August 7). Things to do—Yellowstone. https://www.nps.gov/yell/planyourvisit/things2do.htm

Packer, J., & Ballantyne, R. (2002). Motivational Factors and the Visitor Experience: A Comparison of Three Sites. Curator: The Museum Journal, 45(3), 183–198. https://doi.org/10.1111/j.2151-6952.2002.tb00055.x

Paris Roche, A. (2002). MIDE.

Patterson, T. (2002). Getting Real: Reflecting on the New Look of National Park Service Maps. Cartographic Perspectives, 43, 43–56. https://doi.org/10.14714/CP43.536

Pearson, B.E. (2019). These Dismal Abysses": An Environmental History of Grand Canyon National Park. Journal of Arizona History 60(4), 395-436. https://www.muse.jhu.edu/article/744822.

Pekarik, A. J., Doering, Z. D., & Karns, D. A. (1999). Exploring Satisfying Experiences in Museums. Curator: The Museum Journal, 42(2), 152–173. https://doi.org/10.1111/j.2151-6952.1999.tb01137.x

Petrie, H., Hamilton, F., & King, N. (2004). Tension, what tension?: Website accessibility and visual design. Proceedings of the International Cross-Disciplinary Workshop on Web Accessibility - W4A, 13. https://doi.org/10.1145/990657.990660

Petrie, K., Joyce, S., Tan, L., Henderson, M., Johnson, A., Nguyen, H., Modini, M., Groth, M., Glozier, N., & Harvey, S. B. (2018). A framework to create more mentally healthy workplaces: A viewpoint. Australian & New Zealand Journal of Psychiatry, 52(1), 15–23. https://doi.org/10.1177/0004867417726174

QGIS (3.30). (n.d.). [Computer software]. https://www.qgis.org/en/site/

Ravitch, S. M., & Riggan, M. (2017). Reason & rigor: how conceptual frameworks guide research (Second edition). SAGE.

Realism. (n.d.). In Merriam Webster. https://www.merriam-webster.com/dictionary/realism

Reichenbacher, T. (2003). Adaptive Methods For Mobile Cartography. Proceedings of the 21st International Cartographic Conference (ICC), 1311–1322.

Rocky Mountain Gazette. (1872). Wilkinson and Ronan.

Rowe, S., & Nickels, A. (2011). Visitor Motivations Across Three Informal Education Institutions: An Application of the Identity-Related Visitor Motivation Model. Visitor Studies, 14(2), 162–175. https://doi.org/10.1080/10645578.2011.608006

Ryglová, K., Burian, M., & Vajčnerová, I. (2011). Tourism – business principles and opportunities in practice. Praha: Grada Publishing, ISBN 978-80-247-4039-3.

Schmutz, S., Sonderegger, A., & Sauer, J. (2018). Effects of accessible website design on nondisabled users: Age and device as moderating factors. Ergonomics, 61(5), 697–709. https://doi.org/10.1080/00140139.2017.1405080

Shneiderman, B. (2002). Promoting universal usability with multi-layer interface design. ACM SIGCAPH Computers and the Physically Handicapped, 73–74, 1–8. https://doi.org/10.1145/960201.957206

Šimková, E. (2014). Psychology and its Application in Tourism. Procedia - Social and Behavioral Sciences, 114, 317–321. https://doi.org/10.1016/j.sbspro.2013.12.704

Stephanidis, C., & Salvendy, G. (1998). Toward an Information Society for All: An International Research and Development Agenda. International Journal of Human-Computer Interaction, 10(2), 107–134. https://doi.org/10.1207/s15327590ijhc1002_2

Stone, D. L., & Open University (Eds.). (2005). User interface design and evaluation. Elsevier: Morgan Kaufmann.

Thatcher, J. B., & Perrewe, P. L. (2002). An Empirical Examination of Individual Traits as Antecedents to Computer Anxiety and Computer Self-Efficacy. MIS Quarterly, 26(4), 381. https://doi.org/10.2307/4132314

The Bureau of Reclamation. (2017, February 8). Hoover Dam Historical Information. https://www.usbr.gov/lc/hooverdam/history/storymain.html

Tobler, W. (1993). Three presentations on geographical analysis and modeling. NATIONAL CENTER FOR GEOGRAPHIC INFORMATION AND ANALYSIS.

Toepoel, V., & Funke, F. (2018). Sliders, visual analogue scales, or buttons: Influence of formats and scales in mobile and desktop surveys. Mathematical Population Studies, 25(2), 112–122. https://doi.org/10.1080/08898480.2018.1439245

University of Nebraska. (n.d.). Lewis and Clarks Journals. https://lewisandclarkjournals.unl.edu

USGS. (2016, September 12). EarthWord—Subduction. https://www.usgs.gov/news/science-snippet/earthword-subduction#:~:text=Subduction%20occurs%20when%20an%20oceanic,plate%20and%20slides%20beneath%20it.

Villamira, M. A., & Bracco, F. (Eds.). (2001). Psicologia del viaggio e del turismo (1. ed). UTET libreria.

W3C. (n.d.). World Wide Web Consortium. W3.org

Weld, D., Anderson, C., Domingos, P., Etzioni, O., Gajos, K., & Wolfman, S. (2003). Automatically Personalizing User Interfaces. IJCAI International Joint Conference on Artificial Intelligence.

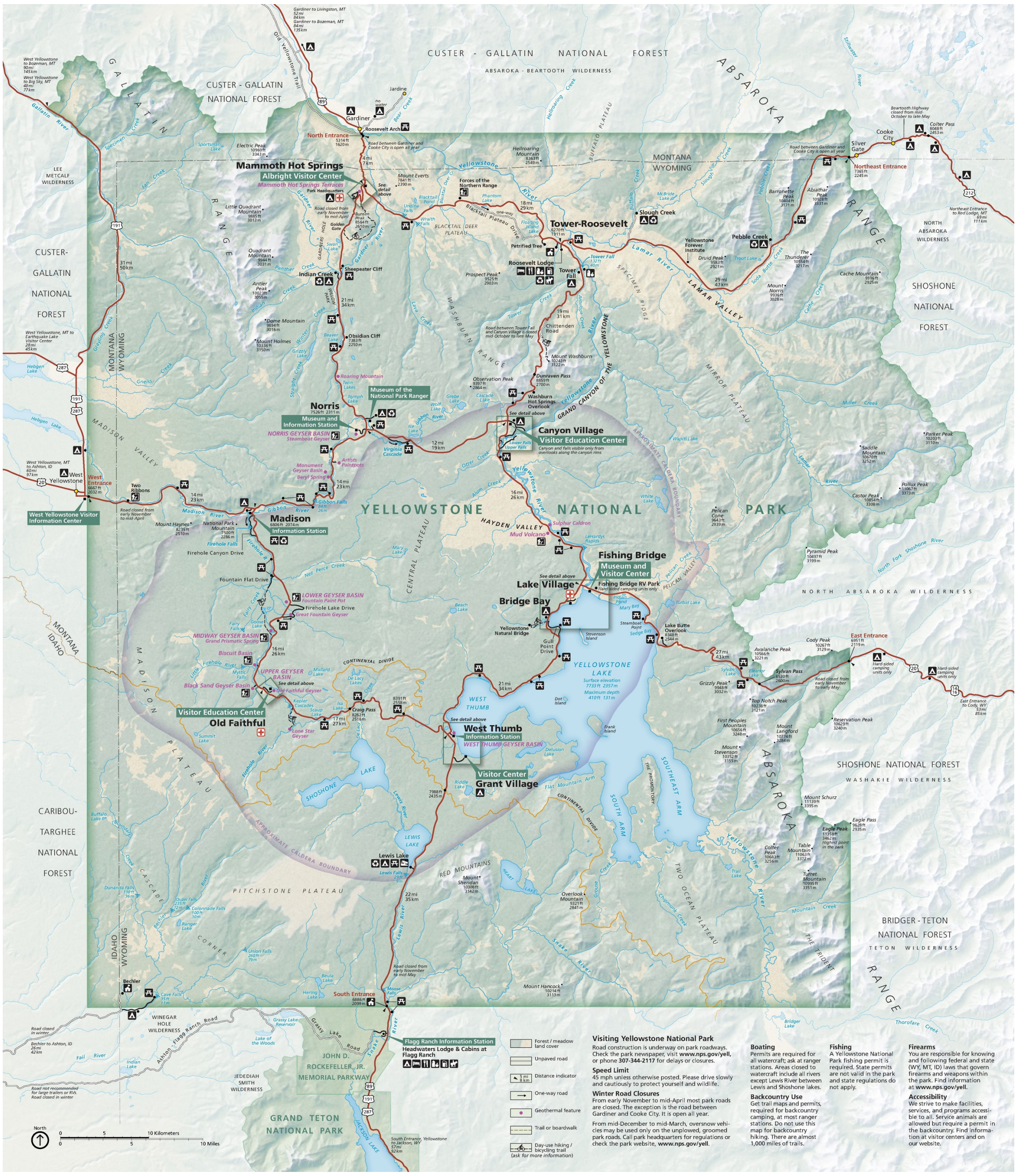
Wertheimer M. Untersuchungen zur Lehre von der Gestalt, II. Psychologische Forschung. 1923; 4:301–350. (Translated extract reprinted as “Laws of organization in perceptual forms.” In W. D. Ellis (Ed.), (1938). A source book of Gestalt psychology (pp. 71–94). London, U. K.: Routledge & Kegan Paul Ltd.).

Wilson, J., & Thilmany, D. (2006). Golfers in Colorado: The role of golf in recreational and tourism lifestyles and expenditures. Journal of Travel and Tourism Marketing, 20(3/4), 127–144.

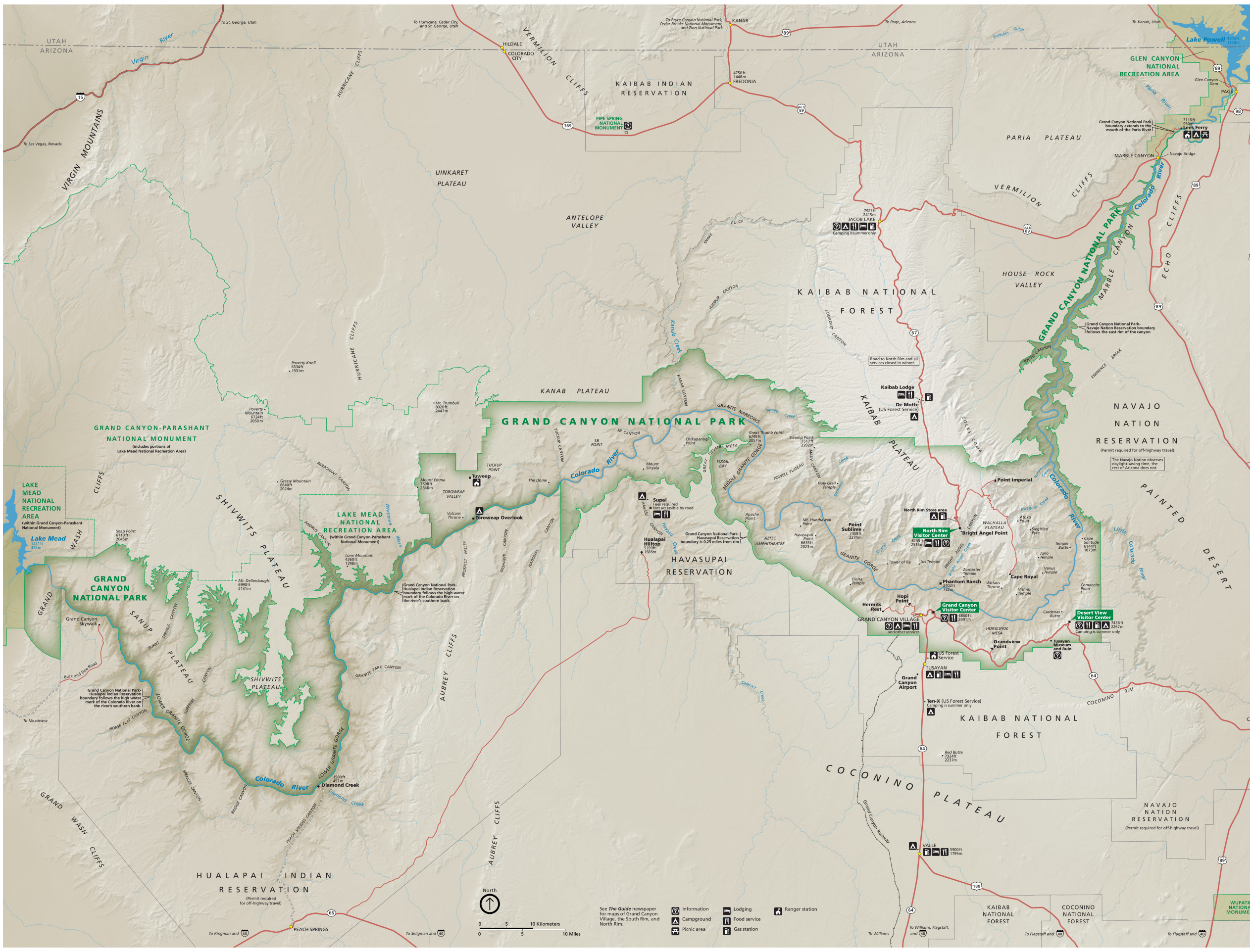
Wu, D., & Bi, R. (2016). Mobile and Desktop Search Behaviors: A Comparative Study. Data Analysis and Knowledge Discovery, 32(2), 1–8.

10. Appendix

10.1. NPS Park Maps

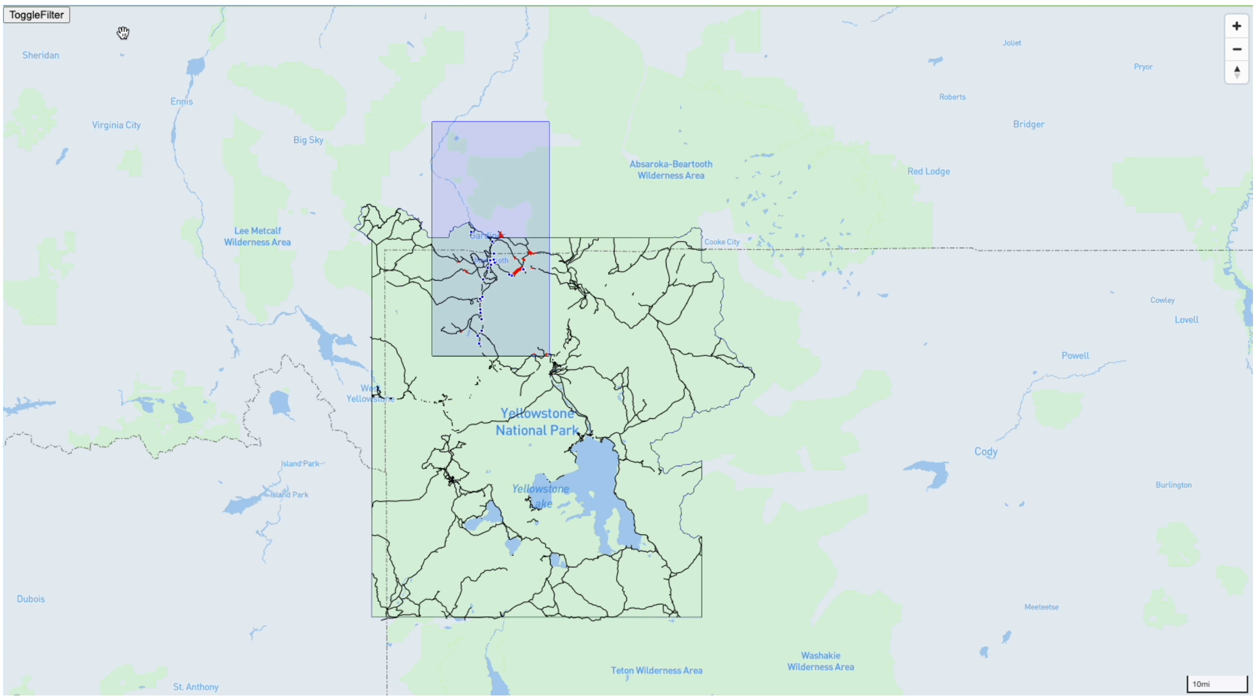


App. 1: Official map of Yellowstone NP (NPS, 2023)



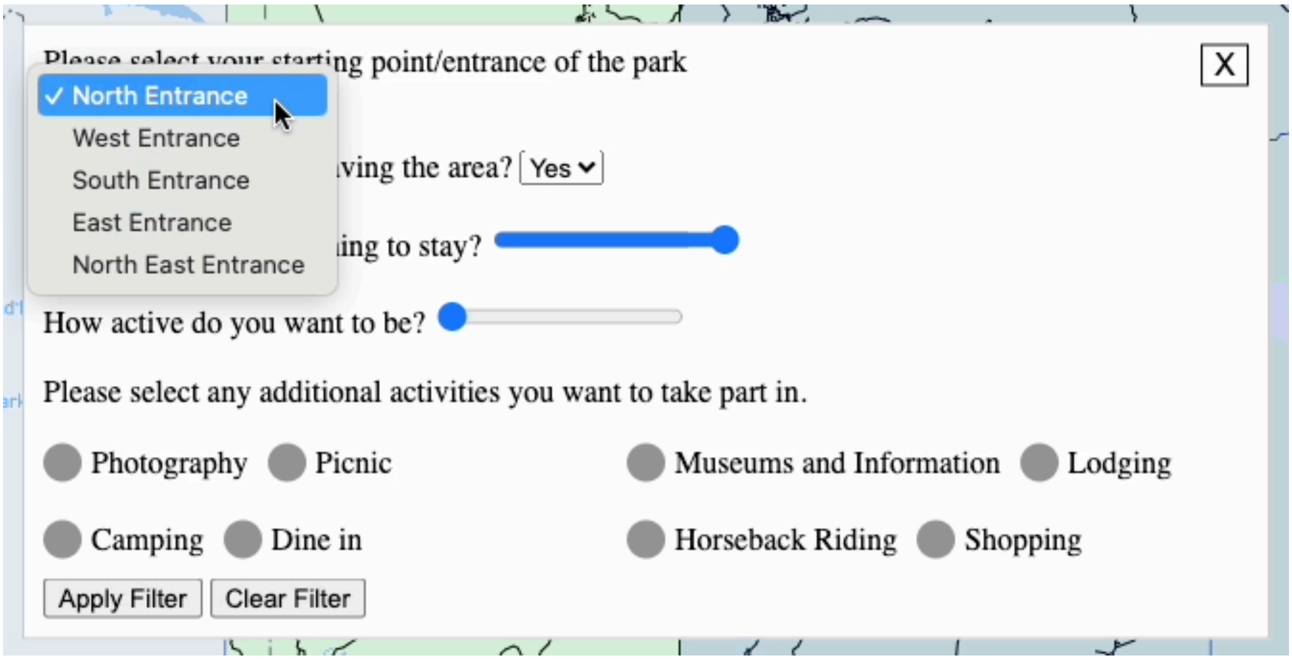
App. 2: Official map of Grand Canyon NP (NPS, 2015)

10.2. Progress Screenshots

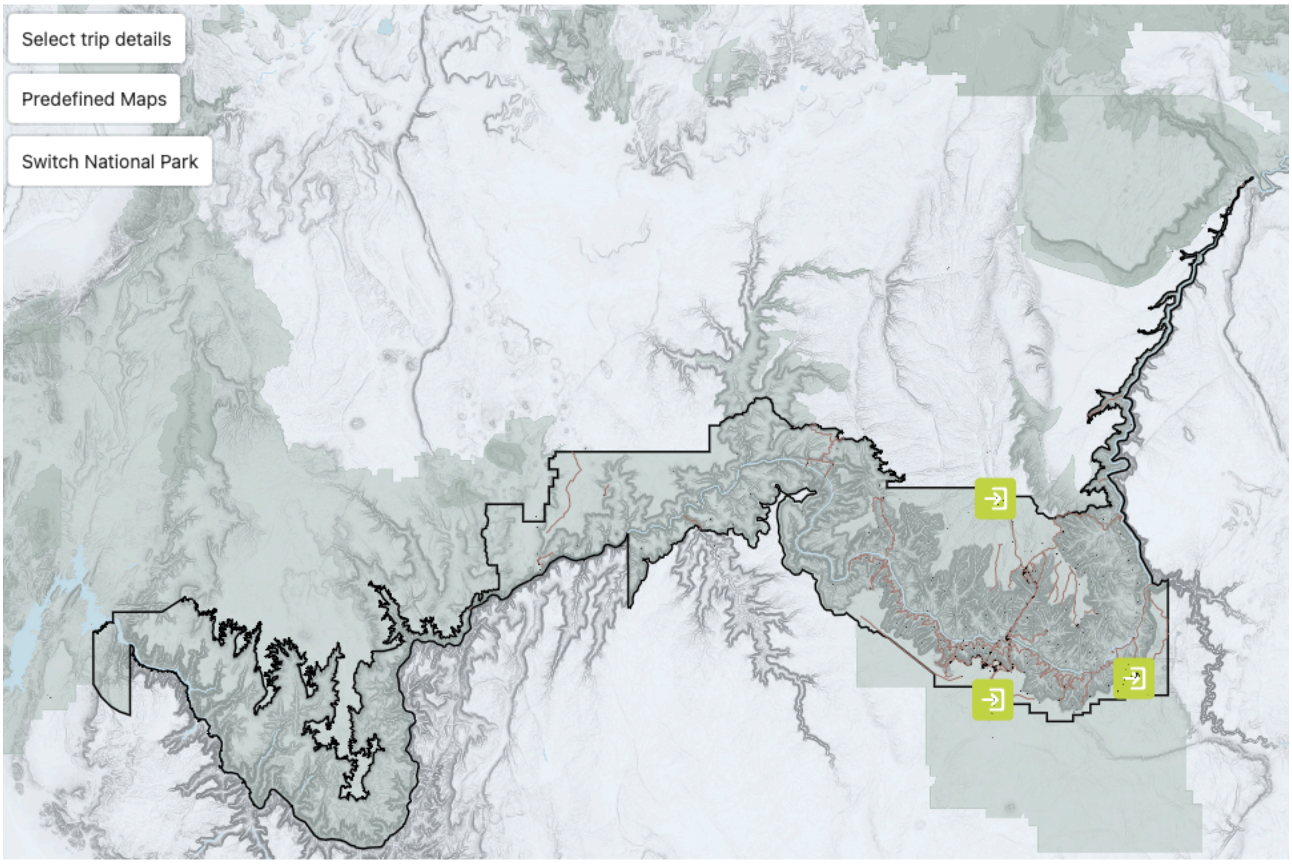


Page B

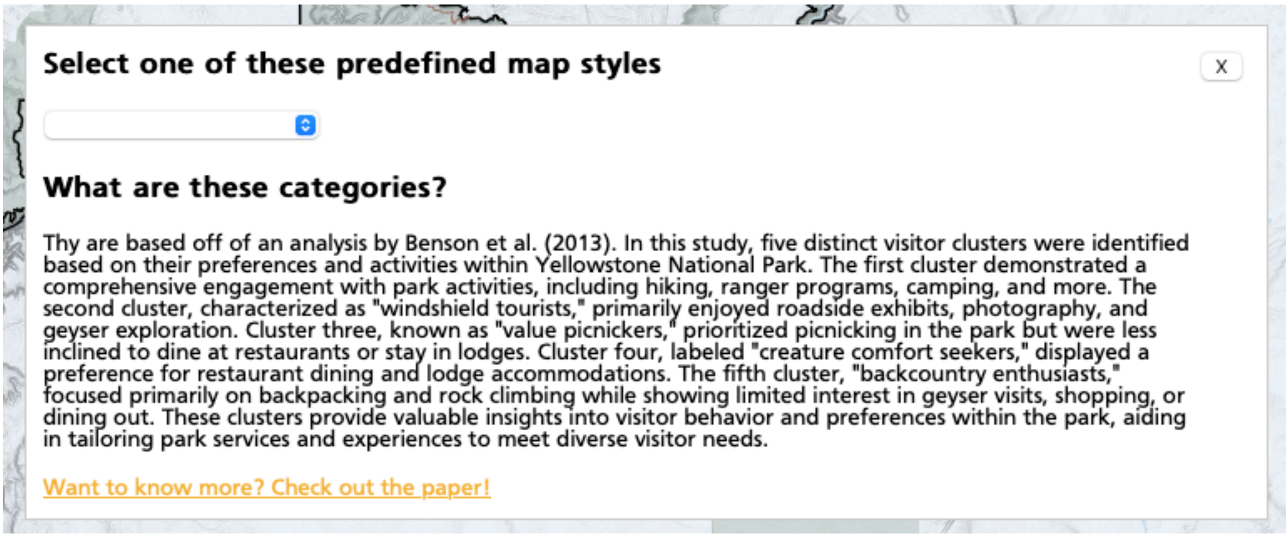
App. 3: Progress Screenshot of the map - first working filtering example



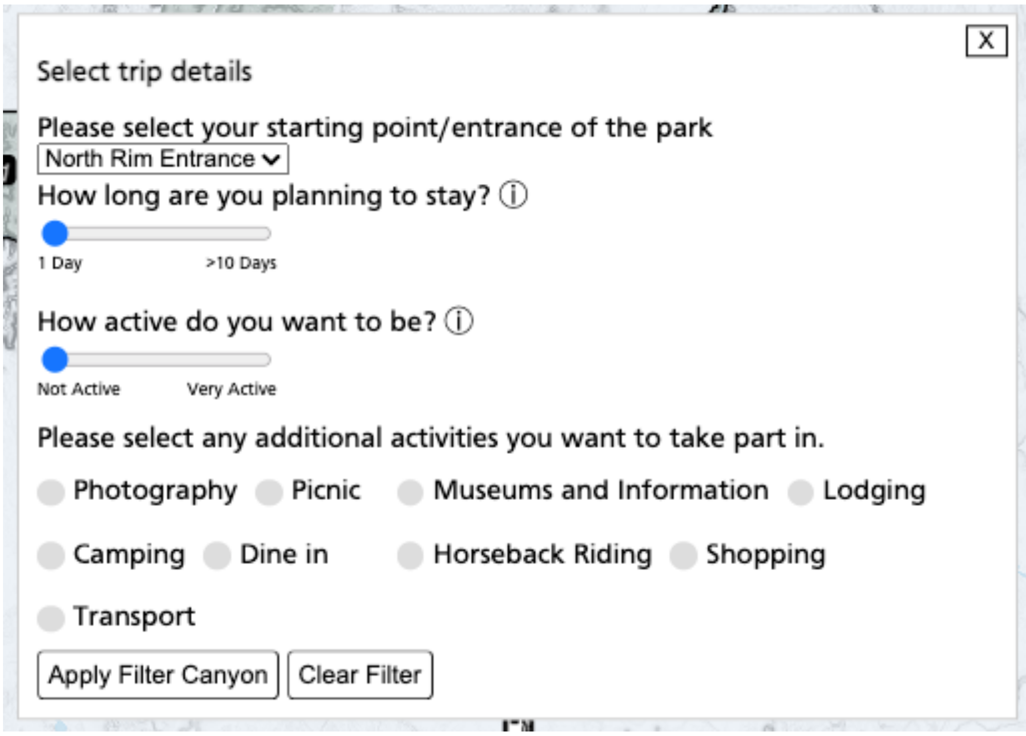
App. 4: Progress Screenshot of the map - first example of the filtering window



App. 5: Progress Screenshot of the map - Addition of Grand Canyon NP, a “Switch NP” button to navigate between the parks, and highlighted park entrances (as suggested through the user study)



App. 6: Progress Screenshot of the map - refined explanation of the predefined map categories



App. 7: Progress Screenshot of the map - refined filtering window for individual settings

Framework for the creation of user-centred, adaptable national park maps

Based on the Master Thesis “Blazing the Trail — Creating a customisable Web Map for Yellowstone and Grand Canyon National Parks”

Vanessa Henkes

7. September 2023

Introduction

In the rapidly evolving digital landscape, the development of adaptable map interfaces has become paramount for organisations and individuals alike. These interfaces serve as dynamic tools, facilitating efficient navigation, information dissemination, and user engagement across various domains, from national parks to urban planning. However, creating such interfaces is a multifaceted endeavour that demands a structured approach to ensure usability, accessibility, and continuous improvement. This conceptual framework is born from the recognition that the journey towards a successful adaptable map interface is characterised by distinct stages, each laden with unique challenges and opportunities. Through a blend of research, practical experience, and user-centric design principles, this framework aims to provide a comprehensive guide for developers, designers, and stakeholders.

In this document, we will delve into the five core stages of adaptable map interface development: Knowledge, Preparation, Application, Evaluation, and Review. At each stage, we will unravel key insights, methodologies, and best practices that empower the creation of interfaces that resonate with user needs and preferences. As we navigate through this framework, we'll explore the critical importance of understanding project objectives, embracing user-centric design, and integrating accessibility guidelines. Strategies for responsive web design, aesthetic mapping, and efficient data processing will be shared. Furthermore, the process of evaluation will be clarified, offering guidance on gathering and analysing user feedback to facilitate ongoing improvement.

While this framework serves as a compass for developing adaptable map interfaces, it's crucial to acknowledge that the journey is not without its challenges. Limited sample sizes, subjective interpretations, and technical complexities are among the obstacles we'll address. By confronting these challenges head-on, we pave the way for future innovations and improvements in the realm of map interface development. Ultimately, this framework is a testament to the ever-evolving nature of digital cartography and user experience design. It is our hope that by sharing these insights and lessons, we empower creators to craft map interfaces that are not only adaptable but also intuitive, inclusive, and responsive to the diverse needs of their users.

Background of the Framework

The development of an adaptable map interface is a multifaceted endeavour that necessitates a structured approach founded on user-centric design principles and empirical insights. To lay the groundwork for our conceptual framework, it is crucial to delve into the context and motivations that have propelled its creation.

Complexity of Map Interface Development: The inception of this framework was driven by the recognition of the intricate nature of map interface development, especially when adaptability and user-friendliness are paramount. Crafting an interface that seamlessly caters to diverse user needs and preferences requires a systematic approach that balances technical prowess with user experience optimisation.

User-Centred Design: The cornerstone of this framework lies in the fundamental tenets of user-centred design. Acknowledging that the success of any map interface hinges on its ability to resonate with users, we have sought to prioritise their voices and preferences throughout the development process. User feedback, preferences, and experiences provide valuable guidance.

Empirical Insights: The framework draws from empirical insights garnered through a comprehensive user study. By engaging with participants from various demographics and backgrounds, it was possible gather a wealth of data that informs the design decisions. This empirical foundation lends credibility to the framework and ensures that it is grounded in real-world user experiences.

Technological Landscape: The rapid evolution of technology and the increasing reliance on digital maps for navigation and exploration underscore the need for adaptable and user-friendly map interfaces. As mobile devices become the primary medium for accessing maps, the framework acknowledges the shifting technological landscape and aligns its principles with contemporary usage patterns.

National Parks and Tourist Destinations: The framework's application domain, which initially focused on Yellowstone National Park and subsequently expanded to include the Grand Canyon National Park, recognises the unique challenges posed by such tourist destinations. These parks, with their diverse ecosystems, attractions, and visitor profiles, demand interfaces that can cater to a broad spectrum of user interests and preferences. For a more intricate and detailed analysis of the literature regarding the parks, the motivations of visitors to the latter, and user centred design, see the master thesis upon which this framework is based: "Blazing the Trail — Creating a customisable Web Map for Yellowstone and Grand Canyon National Parks".

Continuous Improvement: Finally, the iterative nature of the framework itself reflects the commitment to continuous improvement. As users' needs evolve and technology advances, the framework remains flexible and adaptable, ready to incorporate new insights and innovations to enhance map interfaces.

By acknowledging these contextual factors and embracing the principles of user-centric design, empirical research, and adaptability, our framework seeks to provide a comprehensive guide for the development of adaptable map interfaces that not only meet but exceed user expectations. As we delve deeper into the framework's components, we aim to illuminate the intricate interplay between knowledge, preparation, application, evaluation, and review, ultimately fostering a user-centric approach to map interface development.

Knowledge

A fundamental pillar of a project is the acquisition of knowledge. To embark on the journey of designing a map interface, one must first understand the project's objectives and the philosophy underpinning it. For instance, if the design is meant to emulate paper maps created by an organisation like the National Park Service (NPS), an understanding of the NPS philosophy is essential. This includes grasping the design principles they adhere to, such as incorporating a relief map and landcover data. Additionally, when crafting an adaptable interface, it is imperative to comprehend the needs and preferences of potential users. In the context of a National Park, visitors may have distinct requirements compared to users of public parks or city squares. Once the project's aim and user preferences are reasonably clear, the next phase can begin.

Preparation

The preparation stage is a critical bridge between acquiring knowledge and actual implementation. During this phase, insights gathered are translated into actionable design strategies. This involves creating an initial draft and layout outline for the map, identifying key elements, and establishing a foundation for project management and time allocation. A well-structured layout, defined in this phase, streamlines interface development by reducing the need for later adjustments. Accessibility guidelines, especially for inclusivity, must be integrated at this stage. Data acquisition and processing also draw heavily from the knowledge stage. For example, insights from a study of hiking formulas inform the development of optimal functions — an essential component of this phase. An outline of filtering algorithms, central to the adaptable user interface, is also created during preparation.

Application

With the layout established in the preparation phase, the actual programming of the interface can begin. This stage involves translating design concepts into a functional map interface, with a focus on aspects like visual aesthetics, user interaction, and intuitive navigation. Research findings from the knowledge stage can now be applied. For example, if research was conducted on creating responsive web interfaces for multiple screen sizes, this knowledge becomes invaluable, particularly as more users access maps on mobile devices. Aesthetics, design principles, and philosophies — such as the NPS design philosophy — are applied rigorously. Depending on the underlying basemap, a suitable programming environment is chosen, ensuring the map performs seamlessly. Navigation between graphical user interface (GUI) elements is carefully considered, adhering to user expectations of button placement. Questions also arise about the initial user experience: should filtering windows be open by default, is the legend best kept closed initially, or does the site require an onboarding tutorial for new users? The approach in this stage is to create a functional interface, knowing that it will be revisited and refined based on new knowledge and user feedback in the iterative framework.

Evaluation

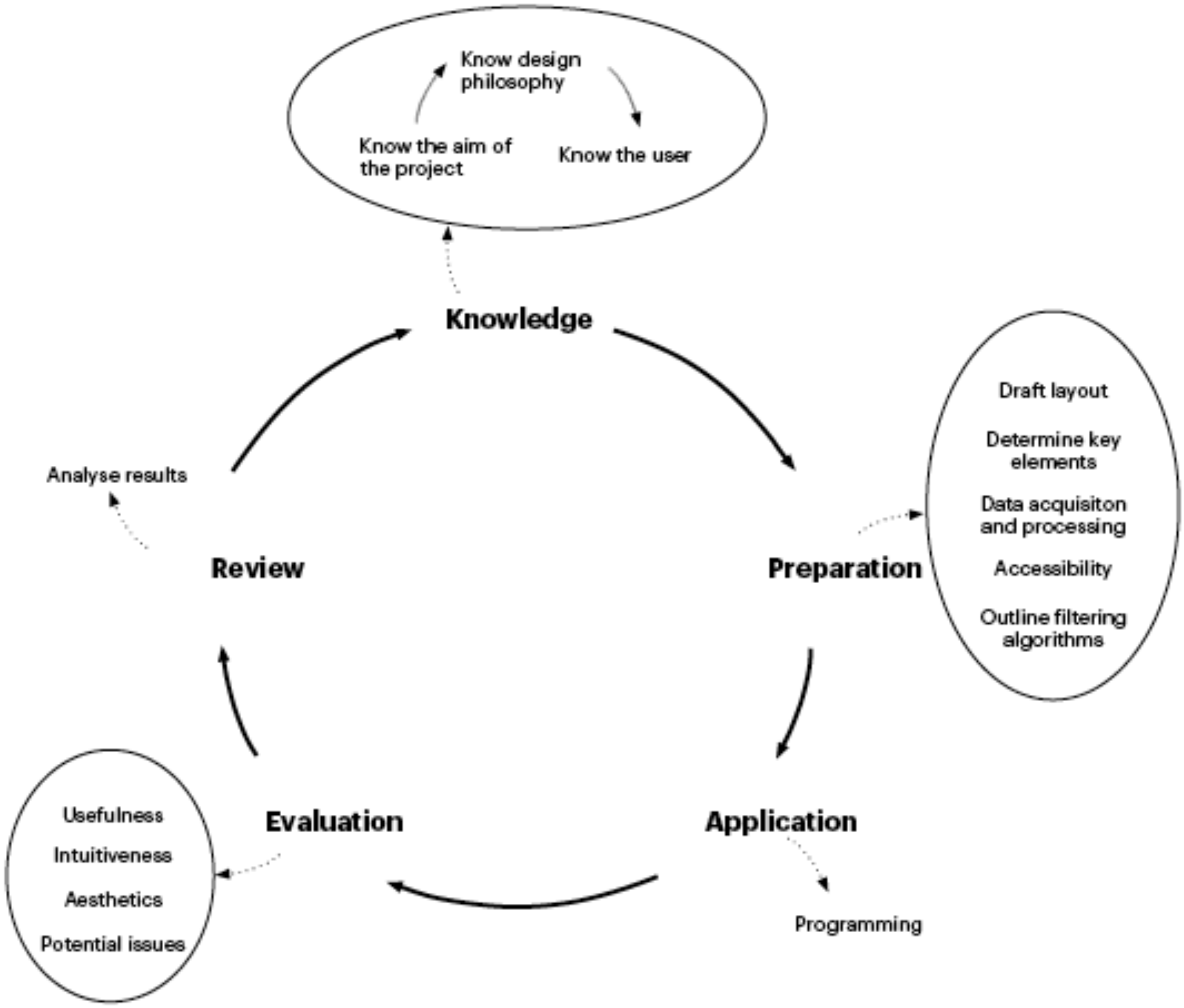
As the initial version of the project takes shape, it's crucial to subject it to thorough evaluation. The first step is to determine the type of evaluation needed. A mixed-methods approach, combining both quantitative and qualitative measures, proves effective in assessing the website interface. Quantitative measures often employ Likert scale-type questions, allowing users to rate their experience on a scale. Open short-answer questions complement these quantitative ratings, providing qualitative insights. Formulating questions that users can easily understand is paramount. User studies should be structured to avoid complexity and technical jargon. The user study should assess all aspects of the interface, considering intuitiveness, aesthetics, usefulness, and potential issues. Feedback from domain experts, if applicable, can also be valuable. It is essential to allocate ample time for the user study since recruiting participants can be time-consuming. While a limited sample size, like in the study this framework is based on, has its limitations, it can still provide valuable insights. Third-party software, like Microsoft Clarity, can further assess website performance by capturing user sessions and providing insights into dead-clicks, quick-backs, and potential JavaScript errors.

Review

After collecting sufficient data from the user study, it is time to review and analyse the results. Various data analysis methods can be applied, depending on the type of questions asked. For Likert scale questions, bar charts depicting answer frequencies and statistics like the mean, variance, and standard deviation can be informative. Qualitative questions, as seen in this study, can benefit from clustering analysis, helping identify user concerns and preferences. The significance of these issues informs the next steps when returning to the application phase. The review stage completes the iterative cycle, allowing for continuous improvements and refinements based on user feedback.

Contributions and Limitations

This conceptual framework offers a systematic, user-centric approach to the development of adaptable map interfaces. It harmonises design, user preferences, and iterative feedback, making significant contributions to this domain. However, there are limitations, including a limited sample size in the user study, potential subjectivity in qualitative analysis, and the need for technical expertise. Addressing these limitations involves expanding sample sizes for broader insights, using different approaches for more robust analyses, and creating user-friendly tools to simplify algorithmic integration. Despite these constraints, this framework serves as a valuable guide for map interface development, enriching the design process with insights and lessons, and providing a foundation for future innovations in this field.



App 8: Conceptual Framework for creating adaptable web map interfaces

Conclusion

In an era where digital maps have become indispensable companions for travellers and explorers, the development of a user-centric and adaptable map interface emerges as a critical endeavour. The framework presented herein represents a culmination of extensive research, empirical insights, and a commitment to enhancing the user experience in navigating the natural wonders of Yellowstone National Park and the Grand Canyon National Park.

Empowerment through Knowledge: At the heart of this framework lies the recognition that knowledge is the cornerstone of effective map interface development. Understanding the aims of a project, the philosophies of the relevant institutions, and the unique needs and preferences of users lays the foundation for success. By comprehensively exploring these aspects, developers are equipped with the insights needed to make informed decisions at every stage of interface creation.

Preparation for Excellence: Preparation serves as the bridge between knowledge and application, transforming insights into actionable strategies. It is here that the framework underscores the importance of careful planning, layout design, accessibility considerations, and the creation of filtering algorithms. By meticulously laying the groundwork, the stage is set for a seamless and user-friendly interface.

Application with Precision: The application phase transforms concepts into functional map interfaces, focusing on aesthetics, user interaction, and intuitive navigation. Drawing from the wealth of knowledge acquired in earlier stages, developers craft interfaces that resonate with users. The choice of mapping libraries and technologies, coupled with adherence to cartographic principles, ensures that the final product meets and exceeds user expectations.

Evaluation for Continuous Improvement: Continuous improvement is a cornerstone of the framework, and evaluation serves as the vehicle for enhancement. A mixed-methods approach, encompassing quantitative and qualitative measures, empowers developers to gather invaluable feedback from users. The iterative process of refining the interface based on user responses ensures that it remains relevant, intuitive, and adaptable to evolving needs.

Reviewing for Relevance: The review phase brings clarity to the successes and challenges encountered during interface development. Through data analysis and clustering, the framework identifies critical areas for improvement, providing a roadmap for future enhancements. By revisiting the knowledge phase armed with fresh insights, developers ensure that the interface remains a dynamic and responsive tool for users.

The framework's contributions extend beyond the confines of interface development. It paves the way for a systematic and user-centric approach that harmoniously integrates user preferences, design considerations, and iterative feedback. However, limitations such as sample size constraints and technical expertise requirements must be acknowledged. Future researchers are encouraged to expand sample sizes and consider mixed-method approaches to further enrich the understanding of adaptable map interfaces. In conclusion, the conceptual framework presented here offers a comprehensive guide for creating adaptable and intuitive map interfaces. Rooted in user-centred design principles, empirical research, and a commitment to continuous improvement, it empowers developers to craft interfaces that not only meet but anticipate user needs. By embracing the framework's principles, one can embark on a journey toward map interfaces that not only facilitate navigation but also inspire exploration and appreciation of our natural wonders. As the digital landscape continues to evolve, this framework stands as a testament to the power of user-centric design in shaping the way we interact with the world around us.