Measuring User Engagement from Interactive Media

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Abstract

In this study, we delve into the concept of user engagement to see how user engagement is affected by the use of interactive media. Necessary literature will define user engagement to give us a clear idea of what we are exploring. Introducing interactive media to users, we want to implement metrics to capture the interactions a user makes with the media, as this will help us to give an insight into user engagement. The metrics are then visualized through an analytical dashboard which we will use the information for analysis. Being able to gather data from interactive media, we want to see how interactive media affects user engagement by comparing it to static media. We will adopt research methods to understand how interactive media and static media affect the user engagement of the users. With these methods, we will be able to see how effective interactive media is on user engagement by analyzing quantitative and qualitative data.

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Chapter 1

Introduction

Interactive media is more commonly used than ever and we see it almost everywhere. According to Content Marketing Institute's research from 2017, 46% of marketers are using interactive content and 79% of the marketers say the plan to use or increase their use of interactive content [1]. CMI conducted the same research in 2016 and the results have since seen an increase in the use of interactive content. In marketing, interactive media is used to attract more attention and sell more products or services, and for others, for instance news and media outlets use interactive media as a part of their storytelling, allowing the readers to get immersed in the stories. For example, at the time of writing this thesis, the world is rampaged by the virus COVID-19, and it can be exhausting to consume all information regarding the pandemic. With interactive media, storytellers can create interactive charts and maps to show different countries and their current status on COVID-19 from number of cases to number of vaccinations. One of the most sought out information web pages under the pandemic is VG's information page regarding the corona (Source: https://www.vg.no/spesial/corona/). It has been on the front page of this Norwegian newspaper since the pandemic started and is still active today because people want to stay updated on the situation. It contains simple graphs and charts, but brings out the message quicker and more comprehensively than a long form article would [2].

Why is interactive media more commonly used? There are many reasons for the increase in interactive media; hence it is still being researched upon. Most prior research has identified a positive effect from the usage of interactivity to create an enjoyable experience that users get from websites. For example, a study from Bar-Ilan University, they found out when subjects, without time pressure, preferred interactive sites over static sites because the interactive site provides the necessary tools for enjoyment [3]. Perhaps this phenomenon is correlated to a study published by Carnegie Mellon Uni-

versity where they have found interactive activities are six times more likely to help students learn than watching videos or reading books [4].

Interactivity has been proven to be an effective tool for keeping readers engaged, but how effective is interactive media compared to static media. Is interactive media becoming the preferred way to engage with users? Interactive media is a powerful tool to help readers have a pleasant and informative experience, but it can also be intimidating and confusing, if not correctly crafted or used. One thing is that interactive media makes technology more intuitive to use. Many interfaces often encourage users to experiment with their products rather than reading detailed instructions for their proper use. Designers often create their interactive media products with intuitive use in mind [5]. With interactivity, the web experience becomes more personal. It creates a feeling of a playful and engaging relationship and you have multiple ways to gather information, which differs a lot from static websites where the content is pretty much always the same for every visitor. A downside with interactive media is that since interactive media requires user inputs and inputs can sometimes lead to errors. When creating interactive media, we need to think of all edge cases that can potentially break our interactive media. Therefore, it is more time-consuming to create since it requires more training and knowledge. Interactive websites also take more time to load because of all the data it requires to be shown on the site. The interactive content must be optimized and ensured it works on the users' browsers. Even if the interactive media is elegantly crafted, heavy load time can make the user frustrated and dissatisfied with the website [6].

Interactivity has been shown to create unique experiences for the user, but it can also cause frustration if not used correctly. Because of this, it is not guaranteed that interactivity is the better media content for showing information and creating an experience. Interactivity has its advantages for creating unique experiences, but it has its disadvantages that cause pain points. The intention of this study is to take a look into interactive media and its impact on user engagement and how it compares to static media. To get this insight, we will first implement metrics and create an analytical dashboard allowing us to see how users have engaged with the interactive content. Secondly, we will use user research methodologies to compare interactive media against static media.

1.1 Research question and Problem Statement

We mentioned the intention of this study was to see how interactivity affects user engagement and how it fares up against static content. To achieve this, we must identify the metrics to allow us to measure user engagement on interactive media and use these

metrics to compare user engagement between interactive media and static media. This study identifies the following questions:

1. How can we measure user engagement from interactive media?
2. How does interactive media affect reader's engagement compared to static media?

To answer the first question, we will use relevant literature and appropriate methods to develop and test the metrics in a real world environment. These metrics will allow us to get an insight into user engagement which we can then use to compare user engagement from interactive media and static media.

To answer the second question, we will adopt two user research methods. The first method we will use is A/B-test for quantitative data. A/B-test is used to measure user engagement on a larger user group. The test will have two pages. The content is mainly the same for both pages, but page A has interactive media and page B has static media. The purpose of this test is to see how website visitors engage with the content and how the two media compare to each other in terms of our implemented metrics. The second method we will use is semi-structured interviews with observation for qualitative data. We will recruit participants to ask them questions regarding their thoughts and experiences about interactive content and static content. We will also use the same pages from the A/B-test for our observation. We will look for any comments the participants make when experiencing the two styles of presentation.

For this study, we will look at data visualizations as our type of media and do measurement on the interactivity between the users and the visualizations. Data visualizations are graphical visual representations of information and data. The visualizations are provided by everviz.

Since we are creating metrics to measure user engagement on interactive visualizations and comparing interactive visualizations against static visualizations, we can write our hypothesis as the following:

> If a website contains interactive visualizations, then the user's engagement will increase since the visualizations are more engaging as they allow user interactions.

After conducting the study and analyzing the results, we will see if the hypothesis holds.

Chapter 2

Background

2.1 Understanding the concept of User Engagement

The word *engagement* itself is very broad and there exist multiple research articles defining the word and the meaning behind the word. Brenda Laurel defines user engagement in her book *Computer as Theathre* as" the state of mind that we must attain in order to enjoy a representation of an action" so that we may experience computer worlds "directly, without mediation or distraction" [7]. Within the same concept, the definition of user engagement from Simon Attfield's paper *Towards a science of user engagement* refers it to the quality of the user experience that emphasizes the positive aspects of user experience as necessary for engagement [8].

Other definitions of user engagement focus less on the individual user's perspective and more on the designer's and industries' perspectives; the artifact as the focal point. The website CodeFuel explains user engagement as a measurement to see how engaging and valuable your products or products are [9]. Another website focusing on UX and UI design named Parlor uses the term *product engagement* as a synonym for user engagement. This term encompasses any interaction the users have within a product or an app [10].

The first definitions of user engagement focus on the qualities and experiences a user achieves when engaged with the artifact, while the second definition focuses on the artifact being the source for causing engagement and how artifact adopts changes to best deliver experiences. With the two definitions in mind, Heather O'Brien in her book, has come up with the following definition as bridge from various disciplines and perspectives [8]:

"User engagement is the emotional, cognitive, and behavioral experience of a user with a technological resource that exists, at any point in time and over time".

This definition is quite broad, which is intentional since the goal is to encapsulate the essence of the two definitions. It highlights the important factors such as emotional, cognitive, and behavioral experiences that are important for user engagement. And under this definition, user engagement represents the purposeful choices a user makes with the focus on the quality of the experience while having the artifact maximizing this experience.

We will adopt the definition from O'Brien to measure engagement, which gives us insight into how interactive media affects these factors. We delve into the qualities of the user experience and the content in focus by collecting data on how the content affects the user's engagement.

2.2 Measuring User Engagement

User engagement measures how often and for how long a user interacts with a website or an application. Understanding the concept of user engagement leads to a successful application, one that is not only are just consumed, but is also engaged with. This also increase the desire to use the application longer and repeatedly. Having an insight into user engagement allows you to create a better overall user experience for your users [8].

Engagement is not black and white; in fact there are many gradations of user engagement where each gradation is different from one another. For example, we can look into individual sessions (engaging interaction) and across multiple sessions (long-term engagement). This depends on the goal one wants to achieve by measuring engagement [8].

The definition of user engagement we use consists of emotional, cognitive, and behavioral dimensions. This gives us many approaches for its measurement such as questionnaires, surveys, and physiological approaches which include observational methods. The method we will adopt is a web analytics approach were we implement and use metrics to track user interactions in the form of quantitative data, and also interviews with observation to give us details on how the different qualities have been affected.

2.3 User Data Collection

Measuring user engagement will involve tracking the user and their actions, which is a process of monitoring, collecting, and analyzing a user; in other words, data tracking or web tracking. Niklas Schmücker defines web tracking in his paper as "technologies used to collect, store and connect user web browsing behavior records" [11]. Common usage of the collected data is to offer personalized experiences to the user. By collecting user data either directly or analyzing previous interactions, the data can be utilized to develop unique experiences to match the user's interests and needs [12]. User data collection is not only used for personalizing the user experience, but can be helpful in other situations. For instance, if a user forgets their user credentials to a website, the website could ask the user for information like email or phone number, a common method for account recovery.

There are many methods for data collection such as surveys, interviews, observation, and online tracking. We focus on online tracking and interviews as the methods in order to analyze user engagement.

2.3.1 Online Tracking

Within online tracking, there exists different data one can collect. For each data, there exist different approaches one can use, but the purpose stays the same; to better understand the users. Norton, one of the biggest software companies for providing device security, identity protection, and online privacy, defines online tracking as:

> Online tracking is an analysis of online user's behaviors, generally for the purpose of delivering personalized browsing experience [13].

There are good and bad in online tracking. One of the good we already mentioned is that it allows the website to create personalized experience towards the user. For example, YouTube and Netflix use a recommender algorithm to make recommendation on what you might want to watch based on user data such as videos previously watched, what category you like, what other people with similar preference watches [14][15]. This is useful for businesses looking to better understand user behaviors allowing them to create and deliver personalized browsing experiences that are most relevant to the users.

The bad thing is that the user often does not know the degree to which they are being tracked. Users often cannot control how much data can be collected and how the data is being managed. This concerns our data privacy and security and transparency

surrounding where the data is stored and who has access to it. The worst case scenario with online tracking is the user data being shared with third parties and stored in databases susceptible to *cyber threats*. A cyber threat is a potential negative action or event caused by a vulnerability that leads in an unwanted impact on a computer system or application [16]. This potential danger is one of the many reasons we have internet regulation.

Tracking user data can have legal and ethical privacy implications, and we have to make sure we comply with local and industry data privacy standards [17]. Each country follows its law for the collection and management of user data. Since we are implementing for everviz, which are based in Norway, we follow our local laws as well as Europe's privacy regulation, the General Data Protection Regulation (GDPR), as a result of being a member of the European Economic Area (EEA).

2.3.2 General Data Protection Regulation

The General Data Protection Regulation is a regulation in EU law on data protection and privacy in the European Union (EU) and the European Economic Area (EEA). The GDPR is a law for protecting a persons privacy and human rights. It also addresses how personal data is transferred outside the EU and EEA areas [18]. GDPR states the rules on how companies, governments, and other entities can process personal data of citizens who are EU citizens or residents.

The GDPR applies to companies which processes personal data established in the EU, or companies established outside the EU and is offering services or is monitoring the behavior of individuals in the EU [19]. Within the same source, if processing personal data is not a core part of the business and your activity doesn't create risk for individuals, then some of the obligations may not apply.

There are some relevant terms that must first be explained. If we work with any of these legal terms, then we must see if we comply with the GDPR.

Personal data is any information related to an individual that can be directly or indirectly identified. Names and email addresses are personal data commonly used. Location information, ethnicity, gender, biometric data, religious beliefs, web cookies, and political opinions can also be personal data.

Data processing covers any action performed on data, whether automated, or manual. Actions can be for example, collecting, recording, organizing, storing, using, and so on.

Data subject is the person whose data is processed, which are your customers or site visitors.

Data controller is the person who decides why and how personal data will be processed.

With the GDPR in mind, one question arises when doing this project: **Do we comply with the regulations?** As mentioned, since Norway is a part of the EEA and everviz is operating in Norway, GDPR can apply.

2.3.3 Personal data vs. Non-personal data

We must first identify which type of data we are working with to see if the GDPR applies. In an article by Michèle Finch and Frank Pallas, they talk about the concept of non-personal data from a law and computer science perspective, and the delineation between personal data and non-personal data. In this article, they have created a figure to identify if you are working with personal data or non-personal data [20].

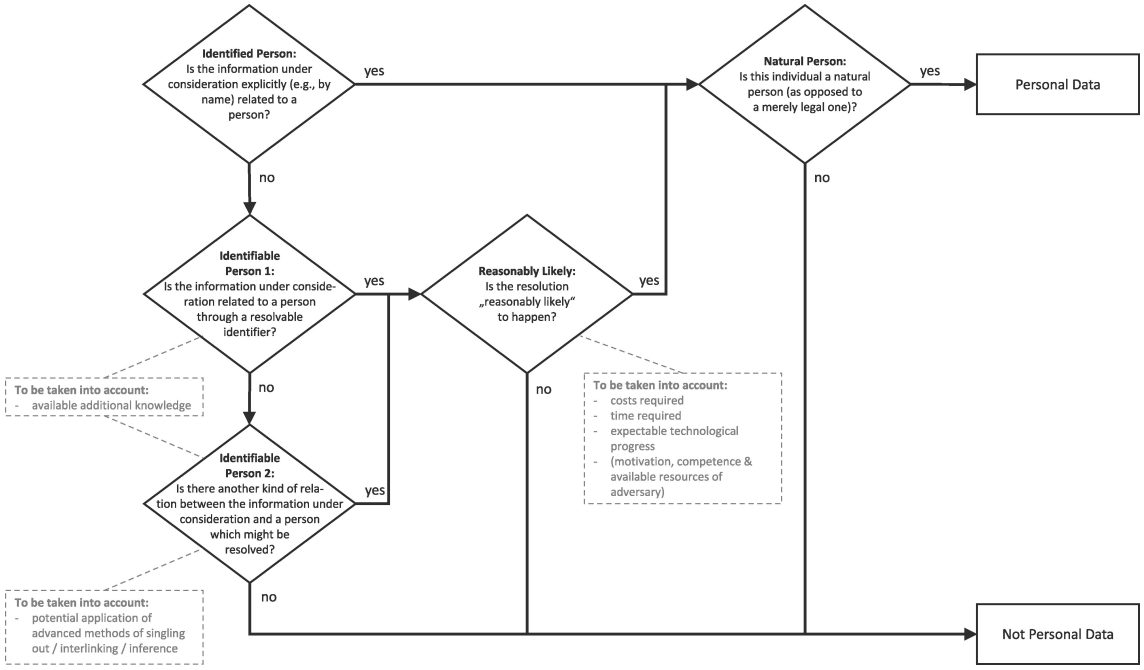


Figure 2.1: Which type of data are we operating with

According to this figure, we operate with *non-personal data* since the information we are storing from our metric are not relatable to identifiable data. The stored data is aggregated and in quantity, meaning it is not possible to fetch out data to single out a person.

While personal data is defined in the GDPR, non-personal data is defined in the Free Flow of Non-Personal Data Regulation. This is a new regulation that became applica-

ble from 28 May 2019. In short, this regulation aims to help, in particular small and medium-sized enterprises, to expand business across borders by making it easier to process data, in particular non-personal data. Together with the GDPR, the two regulations aim to provide a stable legal and business environment for data processing [21].

This new regulation defines non-personal data into two categories:

1. Data that originally did not relate to an identified or identifiable natural person, or

2. Data that were initially personal data, but were later made anonymous

We operate with the first category where the data originally did not relate to an identified or identifiable person. It is important to state that the data being collected by site visitors has no trace of being identifiable. One thing to consider with the new regulation is that data still needs to be available to regulatory authorities. We cannot deny regulatory authorities access to the data.

The metrics we have implemented are operating with non-personal data for data collection. We mentioned in the introduction that we are conducting A/B testing, which is another type of method that requires data collection. The tool we are using for A/B testing is called Google Optimize but what this tool does is it creates two web pages and randomly navigating the visitor to either of the two pages. If we want to count unique visitors, we would require some additional data about the visitor. Our test does not require any additional data. We simply count the number of visitors; hence we can get returning users. The setup of the test is explained in chapter 6.

To conclude, tracking, monitoring, and collecting user data is not a core part of their business. Everviz main business is to offer cloud-based tools for data visualizations. This project does not collect any personal data that neither can be traced back to nor identify the data subject. This project does not require any cookies or IP-addresses to measure engagement. The data processing in this project is collecting metrics and making comparisons with the collected data. The data is being stored within the database of everviz and is solely used for statistics. We do not operate with personal data, but non-personal data. The GDPR only applies to personal data, meaning that non-personal data falls outside its scope of application [20].

Chapter 3

Metrics

We mentioned earlier that we will use online tracking to collect non-personal data. We identify metrics depending on the company's interest, the website, and the media. Because our interest lies in interactivity on visualizations, we implement metrics to track interactivity done on visualizations created by everviz.

These metrics were inspired by preparation done in the semester before this thesis started. The preparation included eye-tracking devices to see how participants read and experienced interactive content in articles. The articles contained visualizations provided by everviz. Observation were made to see how participants interacted with the visualizations. These interactions are used as metrics to measure the effect the visualizations have on user engagement.

3.1 Clicks

When we define click, we use the mouse as the device for our definition. A mouse can differ from one another, but they mainly have a left- and a right-click. Left-click is the primary button for a click, while right-click is the button to perform alternative actions. A click is an action which is performed on a desktop or a website by a user. There are different types of mouse clicks. A single click is commonly the primary action of the mouse. Single clicking, by default, selects (or highlights) an object. Double-click is an action that requires to pressing the default mouse button twice quickly, which opens or executes the selected object [22]. This action only makes sense if the element is clickable, meaning if the user clicks on an element, it will respond with feedback. User gets an indication if an element is clickable, either the mouse transforms to a hand cursor or the element transforms; for example background or color change.

3.1.1 Method for measuring clicks

Clicking on one single element is counted as one action. The metric will not count if the user clicks on empty spaces in the visualization, but only on elements of the visualization. The clicks are saved as data of type number and are accumulated before being sent to the server after a fixed interval.

3.2 Hovers

A hover, which is also called a mouseover, mouse hover or hover box, is an action where the user moves the cursor over a target area. The target area is often an element that transforms when performing this action [23]. It is first required that the user hover the cursor over the element before clicking on a clickable element; hence hover is always performed before clicking.

3.2.1 Method for measuring hovers

Performing a hover on an element counts as one action. Only elements giving feedback are counted as a hoverable element; e.g., the original element transforms. Similar to clicks, these actions are stored in data of type number and are accumulated and sent to the server after a fixed interval.

3.3 Visibility

Visibility refers to the content's state of being visible. By visible, we mean the content has been rendered and is displayed on the user's screen such that the user can make sense of the content.

The definition of visibility can differ depending on the websites and methods of measurement. One can define visibility as, for example, if the content has appeared on the user screen but the user has yet taken noticed of it, e.g., 1% of the content is visible at the bottom or the top of the screen. Some define visibility of the content if it is 100% visible to the user.

From the preparation with the use of eye-tracking glasses, we noticed the participants shifted their focus on the visual content only when the content was more than 50% visible. If the participant was reading a paragraph while the visual content appeared, the participant would still have their focus on the text. By the time the participant was done reading the text, around 60% to 70% of the visual content was already shown. At

this stage, when the user shifts their focus to the visual content, they would scroll down to get the full view of the visual content, i.e., 100%.

3.3.1 Method for measuring visibility

This project define visibility of the content when the content is 70% visible, which triggers the timer to start when 70% of the content is visible. This is also when users begin to scroll down to get the full view of the visualization.

We measure visibility of content in time, similar to a stopwatch. If the content becomes visible, we start the timer for that visualization and stop the timer when it is not visible anymore. The timer resumes if the content is visible again after being out of sight. At the end of the fixed interval, we add this time to the total viewing time. The total time shows how long the content has been visible on the users screens.

3.4 How are these metrics used to measure user engagement?

There exist many ways to measure engagement from users such as pageviews, time on page, bounce rate, page per session, page/scroll depth, and more. Depending on your goal, you use metrics that best match your goal. Our goal is to see how engaging the visualizations are. The metrics, clicks, hovers, and visibility, are one way to see how engaging the visualizations are. These metrics are presented by a dashboard we implemented for this thesis.

This project introduces one way of measuring engagement with the focus on interactivity on the media provided by everviz. Later, we will see how engaging the interactive visualizations are by comparing it to static visualizations using these metrics.

Chapter 4

Methods

To get an insight into the user's engagement, we will adopt different development tools to develop our insight tool and use research methods to explore user experience obtained from interactive media.

4.1 Preparation

In our preparation, we conducted an observation with eye-tracking glasses to see how participants interacted with the interactive visualizations from everviz. The participants were given articles with interactive graphs to interact with. We asked the participants questions related to the articles. Questions were formed around the content of the article. During these observations, we looked for interactions made on the visualizations that could indicate influence on engagement. We are using these metrics as our baseline for measuring engagement, and these metrics are used for statistically analyzing engagement.

4.2 Waterfall Model

For development of the the metrics and the dashboard, we followed the waterfall development methodology. It was not strictly followed in terms of the schedule given circumstances such as limitations of technologies and tools, but followed the phases of the model [24].

The requirement phase includes gathering project requirements, which includes finding out how to implement the metrics and functionalities of the dashboard. This phase also includes technologies used for both the design phase and implementation phase.

Design phase consist of design principles to design the dashboard. Here we create a higher-level or logical design to describe the purpose and the scope of the dashboard. When this is complete, the dashboard is then realized in the implementation phase using the proposed software technologies.

The implementation phase begins with using the technologies to implement both the metrics and the dashboard based on the requirements and specifications.

After the implementation phase, we put the metrics and the dashboard for testing to ensure they have no flaws and errors and complete all the requirements.

Deployment & maintenance is the last phase of waterfall development phase. We follow the deployment phase where we deploy the metrics and the dashboard to be available. The maintenance phase is up to everviz to follow if needed.

Following this type of development allows us to follow a natural flow of this thesis where we build the metrics and the dashboard from the design to implementation and have it ready to use for testing towards the end of the thesis without needing to reiterate the design. For implementation, we could always add more to the code if needed during the testing. The purpose of this thesis is not to have a complete dashboard, but a working prototype we could use for analytic purposes.

4.3 Interview

Interviews have the ability to "go deep" in the answers which fit nicely into our research. The advantage of using this method is that it allows us to ask a range of questions about a problem and gives the interviewees the freedom to provide detailed answers where the answers can be used to gather data that otherwise would be hard to capture from other methods. With interviews, the questions can encourage reflection and consideration so that the interviewees respond with a great length, generating ideas and sharing insights that would have been lost to surveys [25]. Arguably the greatest strength of using an interview is that you are able to observe your interviewees' attitude and behavior. You are able to notice their range of motions and emotions that could be crucial to your research.

4.3.1 Interview strategies

There exist different strategies to conduct an interview. *Fully structured* interviews follow a script with predefined questions. Using this strategy means you need to follow the order of the questions, which includes no open questions from both the interviewer

and the interviewee. A fully structured interview is easier to analyze as the questions are the same for all interviewees. The answers can be categorized and grouped, which makes the data easy to compare. *Unstructured* interviews is quite the opposite of fully structured interviews where you have initial questions; from then you would listen to your interviewee and ask questions around the topic of your interviewee choosing. The benefit of following this structure is it allows the interviewee to focus on the topics and concerns they find important. *Semi-structured* interview is a mix of fully structured and unstructured interviews. You have a script you follow but are allowed to ask questions outside the script. You can let the conversation flow very natural to dig through the interviewee's comments and answers. If the interviewee mentions something interesting, you could ask the interviewee to clarify [25].

We will adopt semi-structured interview as it allows us to go outside our script and delve deeper into questions and answers. We want the possibility of discussing topics mentioned by the interviewees and asking questions about experience they attain during the session.

4.3.2 Thematic Analysis

When analyzing the result from each participant, we use *thematic analysis*. Thematic analysis is a method used for analyzing qualitative data you gather from interviews or transcripts [26]. The reason for using thematic analysis for the interviews is for us to make it easier to group similar thoughts and opinions. Those similar views can be grouped and categorized, which allows us to find common factors affecting user engagement.

The process of performing a thematic analysis starts with familiarization, going through the data we have collected. This involves transcribing the audio and reviewing notes. We are also doing video interviews with the participants. Any reactions and comments that occur during the sessions are noted. The procedure of the interview is explained in chapter 6.

Next step is to code the data, highlighting sections with color coding. Data from similar topics get the same color. For example, if multiple participants express the same opinion, we color these opinions the same color, making it easier for grouping them together to create themes.

After color coding, we determine the theme for the codes. It is broader than the code, and you usually combine several codes into one single theme. Then we review the themes to see if we have an accurate representation of the data. We split the themes up,

discard them, or create new ones if we encounter problems. The themes help us to get an overall view of the participants shared thoughts and opinions on our topic, which will help us to answer our research question. The last step ends with writing the result with our themes. We will see if the results support our hypothesis or not.

4.4 A/B testing

A/B testing, also known as *split-testing* is a user experience research method for comparing two alternative designs for websites. There also exist *A/B/n testing* where you compare *n* multiple designs, but the essence is you have a version A, the *control*, and version B, the variation, and compare the two versions of a single *variable*. The variable represent the single isolated design change in the webpages, for example color of a button [25]. In an A/B testing, the server randomly select between website "A" and website "B" to the next visitor.

A/B testing is designed to find the optimal solution among the variations to an already known UX problem. The method is effective together with quantitative data gathering where the results can be statistically analyzed. With this approach, A/B testing can be used to collect user data and to design for user experience that meet user expectations.

This method is commonly used because the data derived from A/B testing provides data of user behavior, which fits our thesis. What we are doing with A/B testing is not to improve any online experience, but we remove the interactive part of the visualizations to see what difference it makes in terms of user engagement. The goal of A/B testing is to provide insight into user behaviors and to determine which of the two version is more effective for user engagement.

4.5 Dashboard design

Defining metrics to measure engagement is one thing. We need to present the metrics in a way that makes sense. Naturally, dashboard came up as the idea of showing the data, but there are some expectations we need to fulfill when using dashboard design.

A dashboard is a screen in your application that displays information. It is used everywhere from photo-sharing apps to business intelligence suites. A dashboard cannot contain whatever we want it to display. It must make sense in the context it is meant to be used in. Effective design is crucial for dashboards. They are meant to be easy to use and must save the user time, and they should display the important information in an

efficient manner. Depending on intended use, dashboard designs can vary widely.

For our thesis, there exist three main types of dashboard designs that can be applicable with the data we are collecting and presenting:

1. Operational dashboards are types of dashboard that help the user to see what is happening right now
2. Strategic dashboards, a type of dashboard that allows users to track their focal strategic goals through Key Performance Indicators (KPIs)
3. Analytical dashboards are dashboards that gives the user an insight of performance trends

There are some advantages with each of the dashboard design types that you can benefit from, but it depends on your goal with using dashboard as a presenter. Our goal with using a dashboard design is to present the users a status on how their visualizations are doing in terms of providing user engagement. With our goal, the analytical dashboard would be optimal to showcase the metrics. The user will see the past trends and current trends of their visualizations.

Chapter 5

Dashboard

5.1 Design process

With an analytical dashboard as our design type, we created multiple designs in a design tool called Figma. We used Figma to create and explore different designs for the dashboard.

When creating this dashboard, we also kept in mind the overall look of everviz. We had to be consistent with the styles, colors, and layout, as this dashboard is going to be an integrated part of their business.

5.2 Navigation

A dashboard is meant to show the metrics for each visualization. Hence, the user must be able to get access to the visualization of interest. We came up with two ways for the user to get access to the dashboard. The first one being dashboard as a *modal window*. A modal window is a graphical control element overlayed over the main window. A modal window disables the main window but keeps it visible in the background, while the modal window is a child window in front of the main. An example of using a modal window is when you click on an image on the main window and the image appears, being highlighted by enlarging the image and making the main window darker. The second approach is having the dashboard on a completely new window, the same way you would open a link in a new tab in your browser. The key point is to avoid interrupting the workflow of the user. A workflow consists of multiple activities to go from A to B where each step of an activity must provide context and information to the next activity. In terms of implementation, presenting the dashboard on a new page

is easier, but this requires the dashboard to contain additional information as one can easily lose their workflow when progressing to a new page.

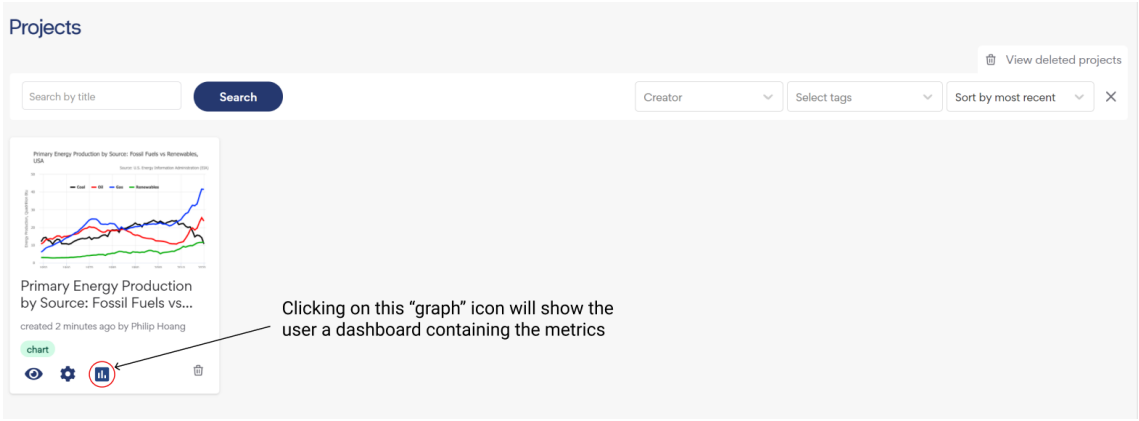


Figure 5.1: Each visualization now comes with a new icon to access the analytical dashboard

To access the dashboard of a visualization, we propose a button. From the main dashboard overview containing your creations, each visualization will have this button. The button is an icon of a chart, and clicking this button will simply open and direct you to a new page containing the analytical dashboard for that visualization.

5.3 Dashboard layout

A dashboard is build up on *containers*. Each container contains one main information. We mentioned maintaining the workflow when doing a new activity. Since the dashboard is accessible through a new page, we must maintain the workflow; e.g., any important context or information must be brought to the next activity. The first container contains information about the visualization. On the left-hand side of this container, we display the visualization's name, date of creation, and name of the creator. On the right-hand side, you have a live view of the visualization, which means the visualization is the same as the one that gets published.

Under the first container, we present the metrics on each row. Each row consists of a total sum of the metric and a chart to show the trend. We use column bar charts to represent past trends for the metrics. Since most languages read from left to right, we have put the container with the total sum of a metric as it is the most important information. Then we have the chart or the trend next to each metric on each row as you will get a natural flow when reading the metrics. While the first container of each row shows you the total sum of the metric, the bar chart shows you for each day since it was published. Hovering over a bar shows you how many interactions were made for that specific day.

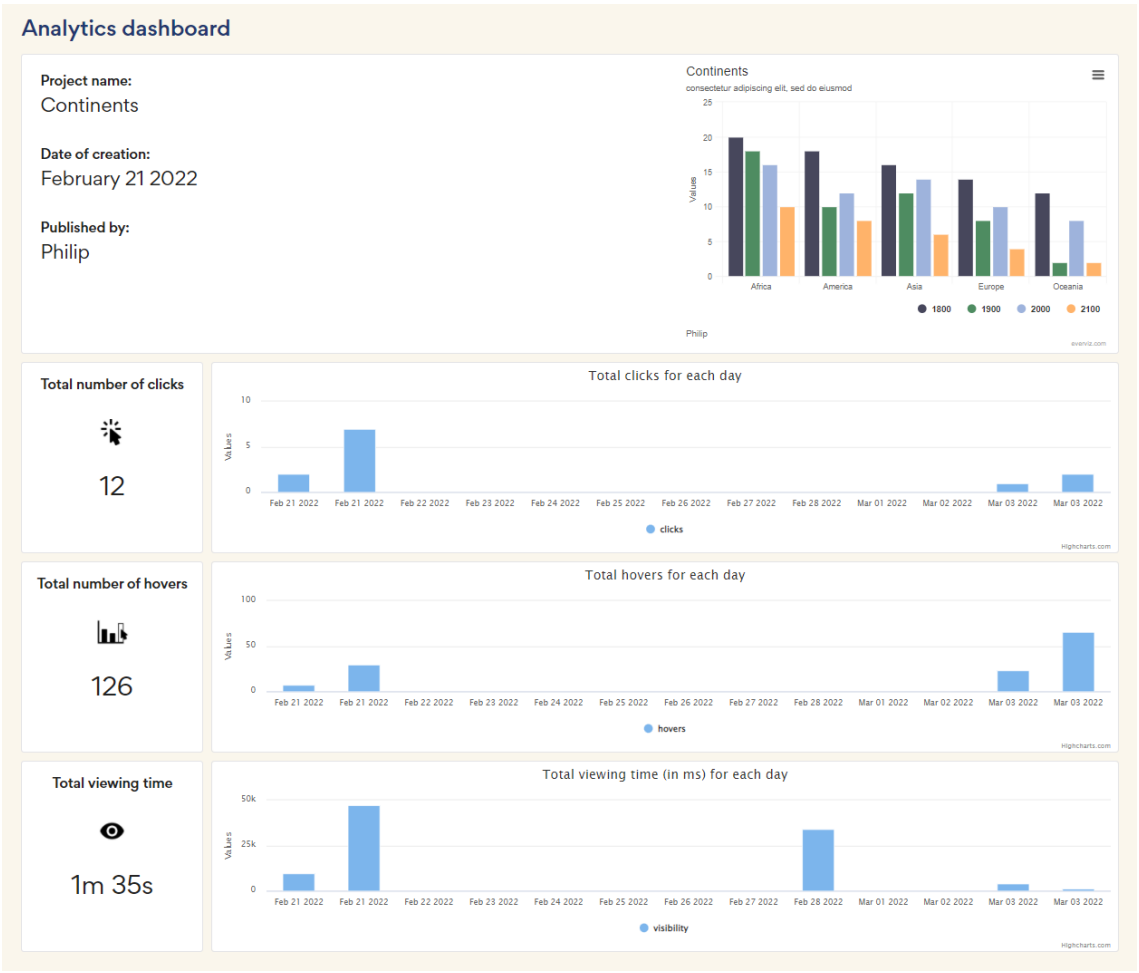


Figure 5.2: The analytical dashboard

5.3.1 Design choices

Many of the design choices are restricted to what an analytical dashboard should contain. For an analytical dashboard, it is required to have a chart to show historical data. We use charts from highchart's library, the same software library everviz is using to create visualizations. It was natural to use this library, since the style of the graph is one of the characteristics of everviz, and most importantly, the charts are ready-to-use which reduces the development time. We also mentioned we need to follow everviz's brand when developing this dashboard, which means fonts and colors have to match the brand.

The containers containing the sum of each metric also have icons corresponding to the metric. The icons make it easier for the user to see what kind of metric they are looking at. Icon helps to strengthen the context surrounding the subject, making the context easily recognizable. The icon for click metric is an icon of a pointer performing a click action. The action is indicated with lines coming out of the tip of the pointer. Icon for

hover is a chart icon with a pointer. The pointer is placed on one bar where this bar is in another color than the other bars that do not have a pointer. This indicates this bar is being hovered over, an action that one can do with everviz's visualizations. Although it is an icon of a bar chart, the hover icon represents all visualizations with hover interaction enabled. The last icon is an icon of an eye, representing the total viewing time of a visualization. This is the only metric we count in time. The data it shows on the chart is in milliseconds, and we convert milliseconds to hours, minutes, and seconds when displaying the time for total viewing time, making it easier to read.

5.4 Technical development

The development is divided into two parts, the front-end, and the back-end.

The back-end development consists of implementing the metrics from the bottom up. There exists technology for using existing metrics such as Google Analytics and Google Tags, but because of limitations of the technologies we had to implement it ourselves. After implementing the metrics to be able to collect data, we send the collected data to our database. The database receives the data after a fixed interval (currently five seconds but are prone to change in the future). This means all interactions done within this interval will be accumulated before being sent to the database.

For development, we used MySQL database and MySQL workbench to store the data. We later switched to Amazon Web Services (AWS) when deploying to production.

The front end development consists of implementing the dashboard according to our design and fetching the data from the database through an API. The front end is using ReactJS, and we use Tailwind CSS to style our dashboard, both being used for the whole website of everviz.

5.4.1 Development tools

Visual Studio Code is a source-code editor supporting different programming languages, from imperative languages such as JavaScript and C++ to declarative languages such as JSON and CSS. We used this editor to write our code both for the back- and front-end.

During testing, we used MySQL and MySQL Workbench to locally store our data. MySQL is an open-source relational database management system based on structured query language (SQL). MySQL Workbench is a visual database design tool which

provides user interface to create and manage databases as well as for writing SQL queries.

GitHub is an open source Version Control System for tracking and managing changes to any set of files. It is commonly used to coordinate changes and updates to a repository between multiple developers. The project of everviz uses git for development, meaning we had to use git to gain access to their repository.

React is a JavaScript library for building user interfaces. This library allows developers to create large web applications that can change data without reloading the page. The language React uses is Javascript XML (JSX) which is JavaScript that allows the usage of HTML tag syntax to render components.

Chapter 6

Procedure

With the metrics developed and the dashboard implemented, we can carry out our necessary experiments to measure engagement.

6.1 Setting up the A/B testing

As mentioned in chapter 4, we will be conducting an A/B test. The content of the pages are similar beside one variable, which the variable will be crucial for our comparison. The variable is minor enough to not disrupt the experience of the content, but major enough to allow us to see the differences in efficiency on engagement in the pages. The page we will use for our A/B testing is a blog post from everviz. This blog post is about how you can create research data graphs and charts for the web using the tools from everviz. The blog post introduces eight different formats for displaying data, each format having different data.

The way our experiment will run is we create our new page and make the necessary changes. Since we are comparing interactive against static content and our main page has interactive visualizations, we create a new page with static graphs and charts (see figure 7.1b to 7.8b).

Variation A will have interactive graphs. Users will be able to interact with the graphs, such as clicking and hovering, anything that responds with feedback. To get more information about the graph, the user will have to either click or hover over the elements of the graph. Each interaction will be tracked, collected, and shown in the dashboard for the corresponding graph. The interactive blog post can be found here: https://www.everviz.com/how-to-make-research-data-graphs-and-charts-for-the-web/

Variation B will have static graphs. Users will not be able to interact with the graphs.

Since interactive graphs require you to interact with them to get additional information, the static version will display the necessary data of the graph to not disrupt the experience. For example, on the columns on the bar chart, we will display the numbers on the bar itself (see figure 7.2b). Not all visualizations will be able to display data because of its format. The static version of the blog post can be accessed here: https://www.everviz.com/how-to-make-research-data-graphs-and-charts-for-the-web-static/

We will use Google Optimize to host the two pages. With Optimize, it allows us to test variants of web pages and see how they perform against the variable we have specified. A/B testing will have a duration of three weeks.

6.1.1 What type of data are we interested in

We use A/B testing to find the variation that caused most engagement between the two pages. We look into how interactive content and static content affect the engagement of visitors, and to achieve this we will use our implemented metrics on the graphs. We then use the implemented dashboard to gain insight into both interactive and static visualizations. The interactive version will function as normal where we track the implemented metrics. The static version of the blog post does not allow interactivity; hence it will not be able to collect clicks and hovers. We will use viewing time as the main metric for comparison. For the interactive version we will use hovers and clicks to look for patterns to see if they influence the viewing time.

6.2 Setting up the interviews

In addition to A/B testing, we will also conduct six interviews to collect qualitative data from users. The process of conducting interviews is broadly inspired by A/B testing. We will use the same blog post in this interview, but the participants will be exposed to both variations, unlike traditional A/B where users get exposed to only one of them. The way this interview process will work is we have two semi-structured interview guides, one for where the participant is exposed to page A and then page B, and vice versa for the other guide. Between the two guides, many of the questions will be very similar, but the main part of the interview is where the questions are different. The reason for this setup is to see what kind of expectations the participants have towards the visualizations. Do they expect the visualizations to be interactive, what happens if we remove some of the data that only interactivity can give, and do they prefer interactive content over static content? Those are some of the questions we will look into to see how both interactive content and static content affects their experience.

The participants were recruited by reaching out through private messaging. Since our target group is anyone who uses a computer to read articles, everyone is applicable for this interview. We reached out to everyone and recruited anyone who voiced interest, resulting in our group of participants with the age between 23 and 26. Some of them are students taking bachelor's or master's degrees, while others work in their profession.

The interviews were conducted through online video calls. Since the goal of the observation is to see how the participants react to the blog post and its content, we want the participant to feel most comfortable when reading. With online video calls, one tend to forget there is another person on the other side observing. Therefore, we felt having the participants sitting at home was the best environment for them to make the reading experience the most natural.

Since our interviews are through video online calls, we get the opportunity to video record the sessions. Before recording, we must get confirmation from the participants to record. A consent form is sent to the participants during the interview prior to the observation. The consent form is from Norwegian Centre for Research Data (NSD), responsible for managing data for research purposes. If the participants allow us to record the session, they sign the consent form (see appendix A). The video recording is for us to not miss important responses and reactions. The audio will be transcribed, anonymized, and deleted when finished.

The interview follow many steps written by Catherine Courage and Kathy Baxer in their book *Understanding Your Users: A Practicalt Guide to User Requirements Methods, Tools, and Techniques*, where they go in depths into different research methodologies. We follow the five phases of an interview described by the authors which are introduction, warm-up, body of the sessions, cooling-off, and wrap-up.

Our interviews will follow a semi-structured interview guide where we have a set of questions for the participants. Our interviews are structured as the following:

We begin with an **ice-breaker**, which acts as a pre-phase (see appendix B). This is not a part of the interview itself, but is used to make the participants settle down into the environment of the interview. The questions in this pre-phase are aimed at getting to know our participants, including asking simple questions directed to our topic to prepare their mindset.

We move forward with an **introduction**. Introduction begins by introducing myself, stating the topic and the purpose of the interview and why the participants were asked to participate in this project. We also ask the participants' permission to video record the

session. If allowed, participants will sign our consent form. The video recording will be deleted right after transcribed to ensure anonymity. The participants were allowed to leave at any moment during the interview.

Right after introduction, we start our **warm-up** phase. We start our video recording and begin questioning our participants. The questions are intended to be easy, non-threatening questions to ease the participant into the interview. For example, we ask how often the participants read articles on the internet, how important media is to them when reading articles, and their experience with visualizations and interactive content. These questions are to get an insight into their reading habits and what we can expect from the participants' reading behavior, but also to prepare them for the main session.

After warm-up, we begin with **body of the session**, the main part of the interview. Our body of session is divided into two observations:

> **Observation 1**: The participant will begin to read either first blog post A or B. During this observation, we will look for any interactions, reactions, and expectations from the participant. After done reading, we will ask the participant questions on how they felt about the blog post and the visualizations.
>
> **Observation 2**: Similar to previous observation, but the participant will look at the other version depending on which the participant saw first. In this observation, we will focus on visualizations since they are the only things that are different. Questions are formed around the experience they obtained from the visualizations.

After each observation, we ask the participants to tell us how they experienced the visualizations, what they liked and disliked about them, their favorites and their least favorites. Some questions are different from each other for the two guides. The questions are aimed towards how the participants experience the changes in the visualization from one version to the other. For example, we ask group A what they think about the removal of interactive elements and if it ruined their reading experience (see appendix B, A to B Version), while we ask group B if the addition of interactive elements made the visualizations more enjoyable (see appendix B, B to A Version). The reason for some of the questions being different is we want to see what expectations they have set for themselves, if their expectations are met, and to what extent did it affect their engagement.

After having read and interacted with the blog post and the content, we move on the **cooling-off** phase. The participants have been asked intense and detailed questions re-

garding the topic. At this point, we ask more general questions to summarize the topic. The questions are formed around interactivity versus static. We ask the participants what type of content they preferred and why. We then ask what they think about interactive and static content in general. These questions are to give us an overall idea of what type of content was most preferred and the reason for it.

We **wrap-up** the interview with some closing questions. We turn off our video recording and ask the participants if they have any questions.

6.2.1 Random number assign simulator

In traditional A/B testing, it is random for which website variation the visitor will get. We want to have a similar approach when we determine which version the participant will see first. We do it by randomly assigning them to either group A (variant A, then variant B) or group B (variant B, then variant A). We want both version to be equally viewed first. With six participants, we want three participants viewing version A first and the other three viewing version B first. We randomly assigned participants to each group by using a small program we created in Python. This program uses **true random number** module from the Python library. True random numbers are generated by measuring truly physical random parameters such as mouse position, operative system, etc. so we can truly generate random numbers. We simulate the program several times to see if we get consistent result. Consistent is if we have three numbers in each list and the numbers are different each time we run the program. After concluding the program is reliable enough to pick random participants, we run the program one final time to conclude our list of participants. This result is the final result which we will use when recruiting and interviewing our participants.

6.2.2 What type of data are we interested in

During our interview questioning, we will look for participants' opinions on interactive content and static content. During the observation, we will observe interactions and reactions, and ask them about their experience they have obtained from the visualizations in both versions. Our hypothesis states that if we have interactive content, then their reading engagement will increase as the interactive content provides an extra element that static content cannot provide. This means the overall opinions of participants will prefer interactive visualizations over static visualizations. We will see if our hypothesis holds after analyzing the interview results.

What is great about interviews is we can pick up any comments the participants might

have during the session. The comments can be satisfactions or frustrations that we cannot get with A/B testing. We can also observe the participants' body language and reactions while they are doing our test. Anything that can contribute to our hypothesis will be evaluated.

Chapter 7

Results

7.1 Results from interview

Conducting the interviews with observations gave us very interesting data. We conducted six interviews, all being digital through online video calls, and there have been a diversity of opinions, both expected and unexpected. Interviewing these participants has been eye-opening and has given us a new perspective on interactive content and static content.

7.1.1 Prior knowledge and experience of media

We begin the interviews by asking the participants about their prior knowledge and experience with interactive content from any type of articles. We also asked the participants how often they read articles and how often they encountered visualizations. All participants mentioned they read news articles daily where half of them read each morning. Some read research articles more often than once each week during their period of writing their thesis.

Two of the participants did not find having media in the articles as important. By media, we mean illustrations, images, videos, etc. While it is not as important, they mention it is nice if the articles contain them, but does not contribute to their reading experience. The other participants expressed that media is important for their reading experience, making them more engaged with the content of the article. One participant would only read articles if there exists some media.

Since we are presenting visualizations in our blog post for observation, we ask the participants about their thoughts and experiences of visualizations. All participants

expressed visualizations contribute to their reading experience, but some participants voiced it depends on the context and theme. If the article is presenting data, then visualization is a must. One participant sought out visualizations if there were any, but it depends on the context of the article. This shows us our participants felt that visualizations can be important to the reading experience if used in the appropriate settings. Only one participant voiced that it either contributes to the experience or does nothing in contrast to the other participants.

We asked the participants about their thoughts on interactive content in articles, where our questions were about if interactive content would contribute to their engagement and if the participants would spend more time on the articles. All of the participants expressed that interactivity is not a requirement, and almost all the participants would likely spend more time on the article if there is any interactive content. Only one participant expressed having interactive content does not make any difference; the same participant that found visualizations either contributing to the experience or not at all.

7.1.2 The blog post

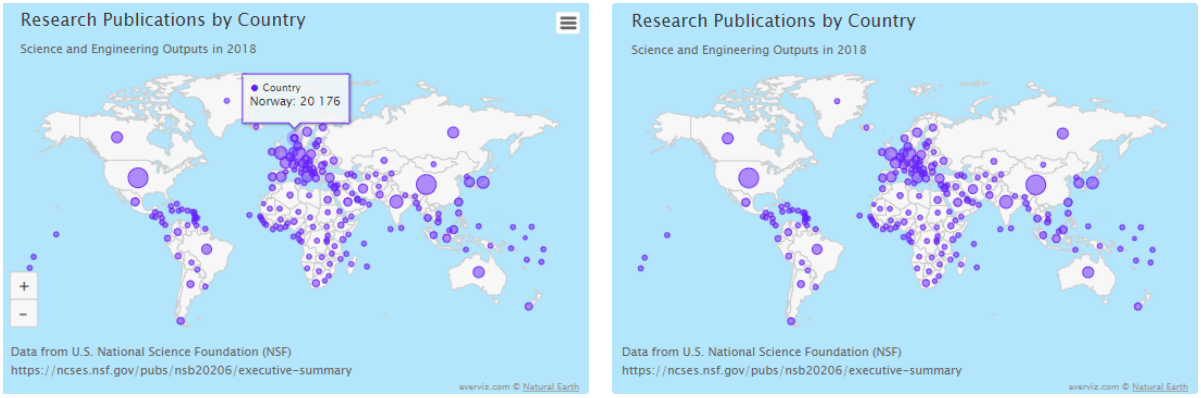
After asking questions about their prior knowledge and experience on visualizations and interactive content, we let the participants read the blog post. The blog post consists of eight different visualizations. We divided the participants into two groups, group A and group B. Group A read the blog post with interactive visualizations first, then static visualizations afterward, and vice versa for group B. Regardless of the version they read first, the content is mainly the same. Some participants found the blog post a bit lengthy, while others found it just fine. All of them expressed it helped to have the visualizations between the paragraphs.

After reading the blog post, we then asked what they thought about the visualizations they were presented. We ask the participants to comment on each of them since the visualizations are quite different from one another.

For the purpose of showing interactivity in the visualizations in figures, we have hovered over an element which shows a tooltip for that element indicating a hover action. Tooltip is additional information that appears when clicking or hovering over an element, usually of a small box.

7.1.3 Visualization 1

The first interactive visualization is of a world map consisting of one circle on each country. The circle represents how many research articles each country has published.



(a) Interactive (b) Static

Figure 7.1: Visualization 1: Research Publications by Country

Higher number results in bigger circle. On the interactive version, we can see it has two buttons on the bottom left side. Clicking on these buttons will either zoom in or zoom out on the map corresponding to the button. We can also see a tooltip that appears when hovering over a circle.

The static version is a map with circles on each country. Zooming, clicking, and hovering are all disabled.

Group A

Group A were introduced to the interactive version first, and they all voiced satisfaction with this visualization. One participant in this group said something very interesting: "You can explore the world yourself, allowing you to have much autonomy over what you want to do". This indicates that the participant felt very engaged as the interactivity allowed them to control their own narrative.

When group A were introduced to the static version afterward, they tried to get more additional information by hovering and clicking around. They all voiced that the map was "useless" and "unnecessary" because they could not read from it anymore. One participant expressed it would have been better if each country was colored the same way as the second map (see visualization 7).

Group B

Group B saw the static version first, and they all expressed frustrations. None of them enjoyed this static version because they got no information from the circles, and they expressed that the map felt very messy because of all the circles overlapping each other. One participant tried to zoom in on the map with the built-in browser functionality. When we asked the participant why the participant zoomed in, they responded because it was impossible to see the national borders and the circles were too small to see

what they really represented. All participants tried to interact with the map, but this participant was the only one in this group that tried to zoom in. This was because this participant said they had expectations of it being interactive prior to the discussion we had in the warm-up phase.

When group B was exposed to the interactive version afterward, they all felt the map improved by a lot. They immediately hovered over the circles and zoomed on the map and expressed satisfaction.

The takeaway from the comments regarding this map is interactivity is essential because having a world map and a cluster of circles makes the static version impossible to understand. Each circle contains additional information that you could not get without interactivity.

7.1.4 Visualization 2

(a) Interactive (b) Static

Figure 7.2: Visualization 2: Typical Publishing Timeframes for Selected Scientific Journals

The second interactive visualization is a column chart which introduces different scientific journals and the timeframe for publication. Each publication has a column and each column is divided into two. The green column represents how many days it takes for the journal to get accepted, and the blue column represents how many days it takes for the journal to get published. Hovering over each column reveals the specific number of columns for both green and blue columns. You can also click on the names of

the columns to hide or show the columns.

The static version displays the numbers in each green and blue columns.

Group A

The participants in group A found the interactive visualization simple and easy to read. They felt they got the information they needed from it by hovering over each of the columns. One participant expressed that this visualization was their favorite, but also said it might be because this is the type of visualization they have been used to since high school.

What was interesting is that the participants in group A, they all found the static version better than the interactive. They felt the static version was more readable because they did not need to hover over the columns to read the data. One participant felt now that it was unnecessary for the visualization to hide the numbers to begin with; that they could now passively read the data instead of needing to hover over each column. In the interactive version, when hovering over the columns, they had to remember the number to make a precise comparison since the numbers disappear when not hovering. One participant expressed that this static visualization was the one they enjoyed most compared to the other static visualizations.

Group B

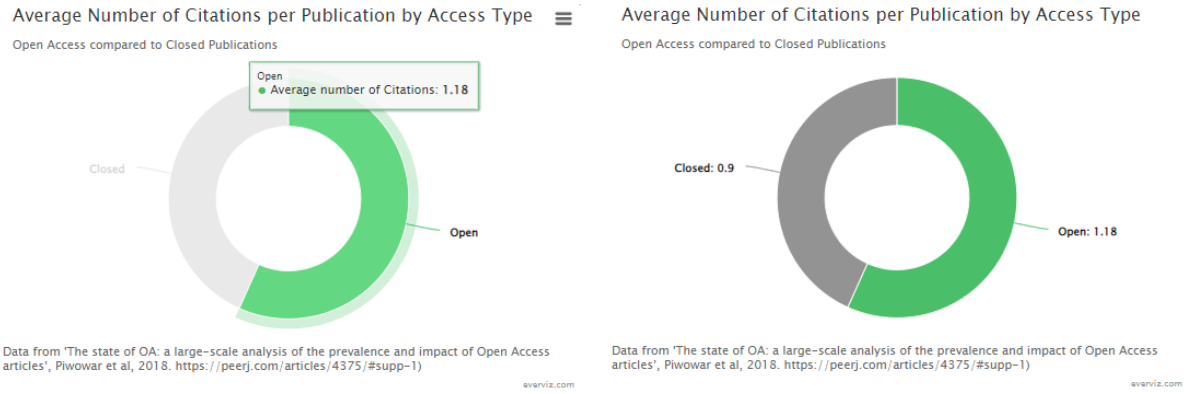
Two of the participants in group B were displeased with this interactive visualization. One participant found it confusing having one blue column over the green column. They did not understand if it was a part of the whole column or not, so they recommended having the blue column down beside the green column to make it less confusing. But the participant liked how the numbers were displayed on the graphs compared to the first visualization. The other participant felt the graph conveyed too much information. The visualization listed too many journals, so if there were fewer journals they would think it would be easier to concentrate on the visualization. The last participant found satisfaction in the visualization and felt they got enough information out of it.

Moving to the interactive version, the one participant that had issues with concentrating on the visualization felt now it was better when the data were hidden, that you had to hover to get the data. The other two participants did not find any improvements in the interactive version.

Participants from group A found the static version better, while one participant from group B found the interactive version better. The two participants from group B felt interactivity did not improve their experience. Unlike the first visualization with the

world map, this static visualization gave either a better or neutral experience. The reason for a better experience is because the visualization displays the numbers on the static visualization without the need for hovering. We conclude with most of the participants preferred not to actively engage with the visualization but rather have the data presented.

7.1.5 Visualization 3



(a) Interactive (b) Static

Figure 7.3: Visualization 3: Average Number of Citations per Publication by Access Type

The third visualization is a doughnut chart consisting of two data points, one for the average number of citations per publication for the closed access type and one for the open access type. Hovering over each part reveals the exact number. Clicking on a specific part will move the clicked part from the center, splitting up the doughnut.

The static version displays the numbers for the two access types.

Group A

All participants in group A found this interactive visualization simple but boring. One participant expressed they did not find the interactivity necessary and that the visualization could just be of an image. Since it is so simple to begin with, the data could just be displayed on the visualization.

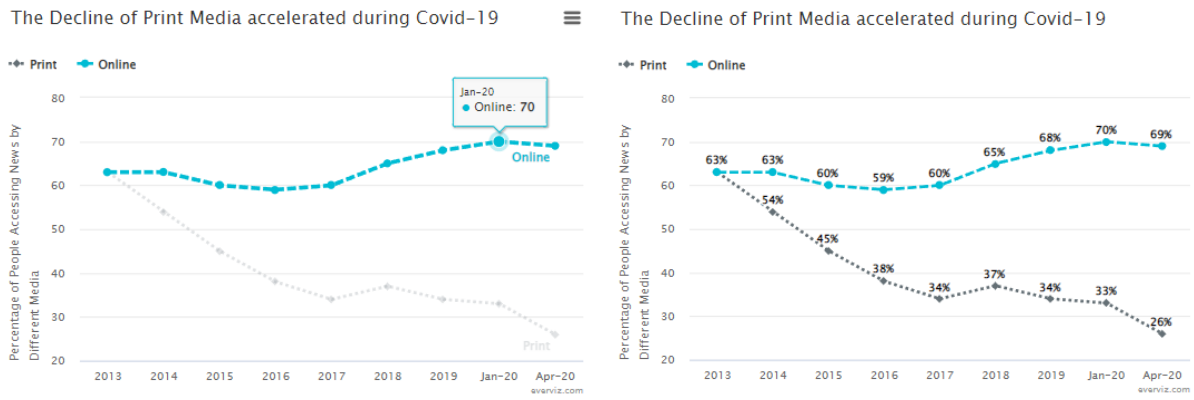
Going to the static version of this visualization, all the participants enjoyed this version better. They expressed the unnecessary need for interactivity and found the static version better because the data was again displayed on the visualization without the need for hovering, the same as visualization 2. The participant that expressed the visualization could be of an image to begin with immediately found the static version much better than the interactive version.

Group B

Group B participants found the static visualization very simple and clear; with one participant expressing it was too basic. The participants did not find the interactivity either helpful or necessary on the interactive version.

The main takeaway is that interactivity does not affect much on the experience one gets from the visualization if it is simple to begin with. The visualization had only two data points, and some participants expressed that the data could just be presented on the graph itself.

7.1.6 Visualization 4



(a) Interactive (b) Static

Figure 7.4: Visualization 4: The Decline of Print Media accelerated during Covid-19

The fourth visualization is a line graph showing the rise of online media and the fall of print during Covid-19. Hovering on each point of the graph shows the exact number, at the same time, highlighting the line which one hovers over while playing down the other line. Clicking on the name of the lines hides or shows the lines.

The static version shows the exact number at each point.

Group A

Group A all found the interactive visualization quite normal and simple, and they understood the message behind the visualization. Having interactivity did not affect their experience.

Two of the participants found the static version much better; the same reason mentioned earlier for the previous visualizations were the data was displayed on the graph.

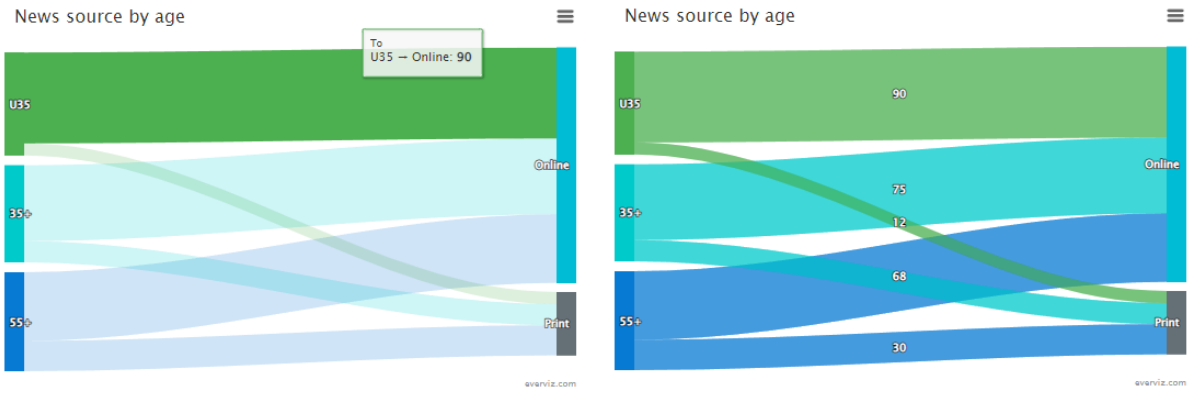
Group B

Group B participants enjoyed the static version because it was simple, clear and easy to understand. One participant liked this one the best because of the number presentation

on the line graphs. And when they were introduced to the interactive visualization, they had the same comment as on previous interactive visualizations, where the animation and interactivity felt unnecessary and made no big difference to their experience.

We get the same result as the previous visualizations where if the visualization is simple, then interactivity is not necessary if there is space for the visualization to have the number displayed. Most participants found more satisfaction in the static visualization over the interactive version.

7.1.7 Visualization 5



(a) Interactive (b) Static

Figure 7.5: Visualization 5: News source by age

The fifth chart is a Sankey diagram, a type of flow diagram showing the flow rate. This diagram shows which type of news source each age group uses and how many of each age group uses one of the two news sources. Hovering a flow highlights the age group and how many that uses that new source.

The static version has the number displayed in the middle of each flow.

Group A

The participants from group A had different opinions from each other on this interactive visualization. One participant found this visualization quite the same experience as the previous interactive visualizations, expressed while not too exciting but quite simple. One participant enjoyed this visualization together with the previous visualization because they gave more context to the topic; while the last participant did not understand it too well, voicing an explanation of the numbers would be nice.

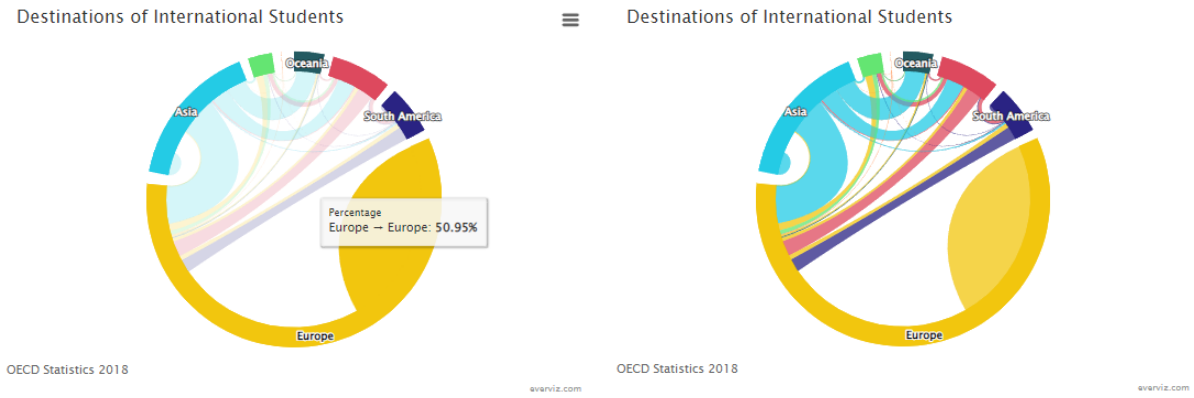
Introducing the static version to them, they all felt it was better because they got the data without interacting, the same reason as the previous visualizations having numbers presented.

Group B

Group B had also very mixed opinions on the static version. One participant found this visualization most enjoyable because of its visual presentation, while another found it most confusing because they did not understand what the numbers were presenting. The other participant did not completely understand it to begin with, but understood it after extensive reading.

When looking at the interactive version, they all felt the interactivity felt quite utilized in this visualization because of the animation and the highlighting when hovering over the elements. While they felt the interactivity being more utilized here compared to previous visualizations, they enjoyed how the static version presented the numbers.

7.1.8 Visualization 6



(a) Interactive (b) Static

Figure 7.6: Visualization 6: Destinations of International Students

The sixth interactive chart is a dependency wheel, used for data that flows in two directions. This chart shows where students from each continent tended to study. The chart is split into continents and shows the flow for which continent the students tend to study to. Hovering over a flow shows the name of the continent and the percentage.

The static version shows nothing but the names of some of the continents.

Group A

For the interactive version, one participant expressed the visualization took time to understand, but found it very fun after understanding it. Another participant found this visualization "genius", how they were able to create it. They expressed that it was visually the best and how they were able to show where students go to and go from. The last participant in this group strongly disliked this visualization, but this was because they did not understand it. "Think it was the messiest and the most confusing

one" expressed this participant. The participant was also annoyed that not all names were written on the visualization, which dragged the experience down. The participant expressed an explanation of the different elements would give a better experience.

When they were introduced to the static version, they immediately disliked it. They all expressed that it did not make sense anymore and that it became difficult to understand. One participant felt it was quite necessary to have interactivity, because without interactivity you lose information. The same participant said "they could add name of the continents and percentage of each student in each of the continents, but then it would be too much on the figure", expressing that a visualization like this would be very messy if it had numbers on the visualization itself in comparison to the previous visualizations.

Group B

Group B saw the static version first, and they all expressed the same, that it was interesting to look at but had a hard time understanding what it was showing. Two of the participants found this visualization the worst of them all, while the other participant found it the most interesting of them all. The two participants that did not like it said it was interesting because they did not have prior knowledge of this type of visualization. But they also felt it was tricky and difficult to understand because there was no explanation of the lines and colors. One of them found this visualization the worst of them all.

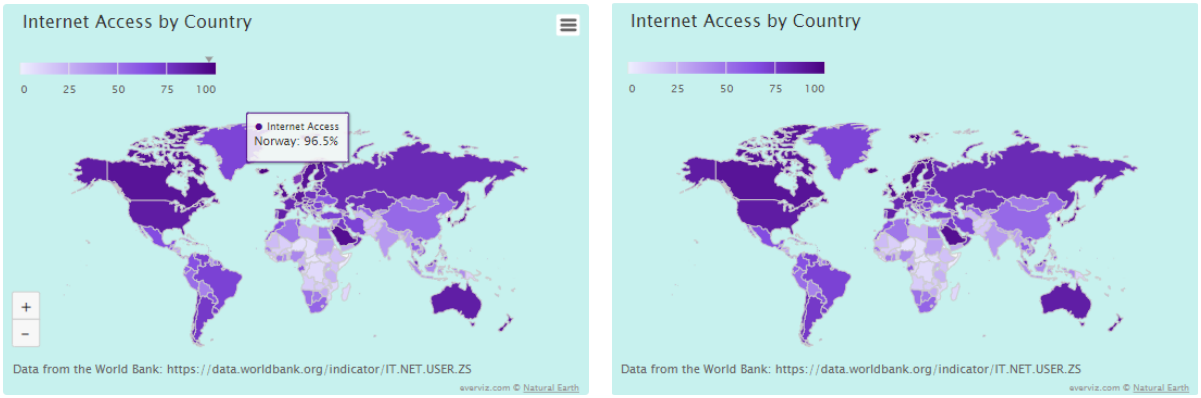
The participants that did enjoy it said it was "eye-catching" and found it visually the best. This participant did not like it for the information, but it was the nicest to look at, making it the most interesting one out of all the visualizations. This participant did also express that they understood the meaning behind the visualization even without numbers, but had to spend a good time studying it.

Going from static to interactive, the one participant that found the static version the worst visualization felt now it was the best one. This was because they felt it was necessary to have the interactivity in the visualization, that you could see exactly where the lines are connected to and at the same time get exact data when hovering. It provided additional information that was missing in the static version. The other participant that voiced the same opinion as the other participant felt interactivity solved the concerns they had for the static version, which made the visualization more understandable. But they still felt this interactive visualization was the worst one out there. A quote from this participant, "It is still messy because you have some many lines that go in so many directions, like a failed sewing project".

The participant that did enjoy the static version felt it was still nice to look at, but now had some concerns with the interactive version. They wished it was possible to zoom in on the visualization because some of the lines were so thin, "you have to be very careful with the mouse to be precise".

This visualization made quite the impact on all the participants. All participants spent most time on this visualization, both on the static version and the interactive version. Some participants quite enjoyed it because of its unique and visual presentation, while others disliked it because of lack of explanation.

7.1.9 Visualization 7



(a) Interactive (b) Static

Figure 7.7: Visualization 7: Internet Access by Country

The interactive version is a world map showing the percentage of each country having access to the internet. The map also has a legend explaining the colors of the map. The stronger the color (purple) is, the higher the percentage. Hovering over a country shows the exact percentage. While hovering over a country, a small arrow will appear over the legends showing where the color of the country appears on the legend. The map also allows zooming.

The static version has nothing but the legend explaining the colors.

Group A

For the interactive version, participants in group A felt it was easy to understand and the feedback from the interactivity made sense. They felt they got a similar experience here as the first map where you could zoom in and out and hover on each country to get more information.

Two of the participants felt the static version still works and made sense because it has a legend explaining the color of each country. One participant felt the experience of

the map went down when the interactivity was removed from the map. "It was clear in the first variation, but not it is not equally fun since you don't get the percentage", and having that information available was important for the participant.

Group B
Group B participants all immediately compared this static map to visualization 1. They felt this map was more clear and understandable than the first one. The reason was because there was a legend explaining the color and there is nothing covering the borders between the countries, making the visualization more readable.

Going over to the interactive version, two of the participants felt the experience got better since you got more information out of the map. The other participant expressed interactivity was good but not completely necessary on it because you clearly see the message whether it is interactive or not.

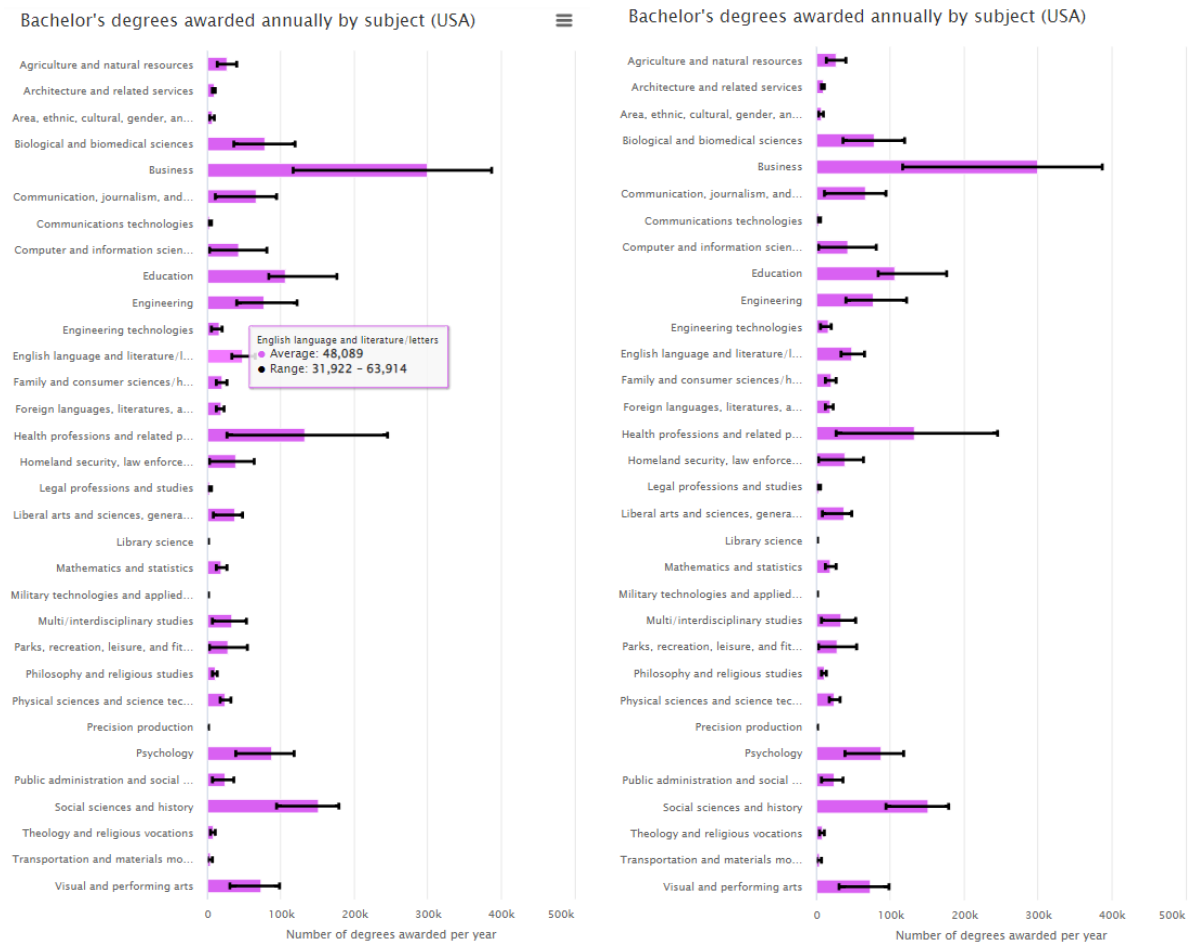
All the participants felt this map was clear and understandable and having interactivity on the map did either nothing for the experience or gave a better experience since they got more information out of it. Either way, the static version still works very well, because the visualization has a legend explaining the colors.

7.1.10 Visualization 8

The last visualization is a bar chart with range bars. The purple bars show the average number of degrees awarded annually. The range bar provides more information about the level of data behind the averages, giving an indication of the variance in numbers between the years. Hovering over a degree reveals the number of the average bar and the range bar.

The static version shows only the average bar and the range bar.

Group A
The first participant of this group said something interesting; "I think this visualization works, but can also guess that people won't understand it". This statement turns out to be true for some of the participants. One participant expressed it was not visually pleasing to look at, mainly because of the color and that the visualization was quite big. Also, this visualization being big seems to affect the last participant. This participant voiced that it was difficult to completely understand the visualization since they could not fit the whole visualization on their screen. Screen resolution, font size, browser and such, all affect the size of content and media, and unfortunately this visualization became too big for some of the participants which negatively affected the



(a) Interactive (b) Static

Figure 7.8: Visualization 8: Bachelor's degrees awarded annually by subject

experience.

Going from interactive to static, we got relatively the same answers from the same participants. First participant had knowledge of this type of graph and felt the static version was somewhat the same; "You lose the precision compared to the previous, but you can still see where the black lines go up to". The participant that earlier said it was not visually pleasing to look at now thinks this is the worst visualization of them all.

Group B

The first participant of this group B was the only participant that did not have any experience with this type of graph; thus they did not know what the black lines were presenting. But they could refer to the numbers on the x-axis which helped with the understanding; still, they did not find the visualization that enjoyable. The other two participants had previous knowledge of this type of visualization and felt they got enough information out of it despite not getting accurate numbers. One of the two participants

mentioned "I think if a person has seen it for the first time, they would have found the black line confusing", which was true for the first participant of this group.

The two participants that had prior knowledge of this type of visualization felt the interactive version was better because they got more detail out of it. For the last participant, interactivity was also better were they expressed they got more of it, but they found the graph that pleasant to look at.

What we found interesting was the participants that had prior knowledge and experience of this type of visualization found both interactive and static clear and understandable, and the interactive made the experience a bit better. For others that did not have the same knowledge, they felt it was either not great to look at or confusing. Also, the visualization being big did not help with the experience, but they all preferred the interactive over the static one.

7.1.11 Interactivity versus static

In group A, two of the participants preferred the interactive version over the static version; the reason being interactivity provided additional information that static could not, especially on the visualizations that were more complex in format. But one of the two participants that preferred interactive felt there was a very thin line between interactive and static. They found many of the static visualizations, especially from visualization 2 to visualization 5, more enjoyable because these visualizations had numbers displayed on them. The participant could then passively read the data without the need to actively hover over the different elements. The third participant in this group also voiced the same reason to choose the static version over the interactive version; the only participant in this research to overall prefer the static visualizations. This participant stated most static visualizations worked better than interactive visualizations, and only visualization 1 and visualization 6 did not do well as static visualizations.

From the B group, all the participants enjoyed the interactive visualizations more than the static ones. The first participant stated the visualizations with interactivity made more sense and felt the visualization became more special and enjoyable when they could mouse over the elements to get more information. The second participant stated the interactivity was not distracting or flashy, and none of the visualizations gave a negative effect. Either the visualization gave a neutral experience or a positive experience. While the last participant preferred the interactive version over the static version, they felt some frustration that came with interactivity. Mainly because of the data that appeared which made the participant having a hard time understanding, which affected

the experience negatively. But overall, the interactivity made it more enjoyable.

7.1.12 Conclusion of the interviews

5 of 6 participants preferred interactive content over static content, but it was quite close. We saw a pattern in the comments from the participants were many of them enjoyed the static visualizations over the interactive visualizations if the numbers were already presented. They all expressed that if the visualization, its format, is simple to begin with, then interactivity is unnecessary because it does not provide additional information. Having the numbers on the visualizations itself without the need for hovering made them more clear and easier to grasp for many of the participants. For example, from the second visualization to the fifth visualization, most of the participants felt the static version was better.

One reason for the interactive version shining over the static version was because of the engagement it provided, which was very noticeable on visualization 1. All participants expressed excitement over the functionalities of the map, such as zooming and hovering. Many of the participants even zoomed all the way in on the map to see each country more closely, in which one of the participants expressed autonomy. Even though visualization 6 had very mixed opinions, this visualization caused the most engagement. When we observed the participants, we saw they spent the longest time on it. One reason was because the participants had never seen a visualization like this, which sparked interest in some, but for others it caused confusion. Either way, all participants studied it and tried to make an understanding out of it, and interactivity contributed to them staying longer on it.

Another reason that contributed to interactivity being preferred is because either the interactivity contributed to a positive experience or neutral experience. None of the participants felt interactivity created a negative experience. We had one participant that had a negative experience with interactivity. This was because they had a hard time understanding the data after hovering over the elements, but the interactivity itself did not drag down the experience.

7.2 Result from A/B test

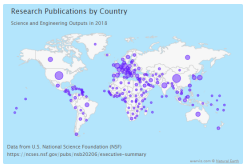
We ran our test for three weeks starting from March 29, 2022, to April 18, 2022. Our traffic consist of 6298 unique users. The design of the test was to ensure visitation was randomized but still resulted in an equal number of visitation for both versions.

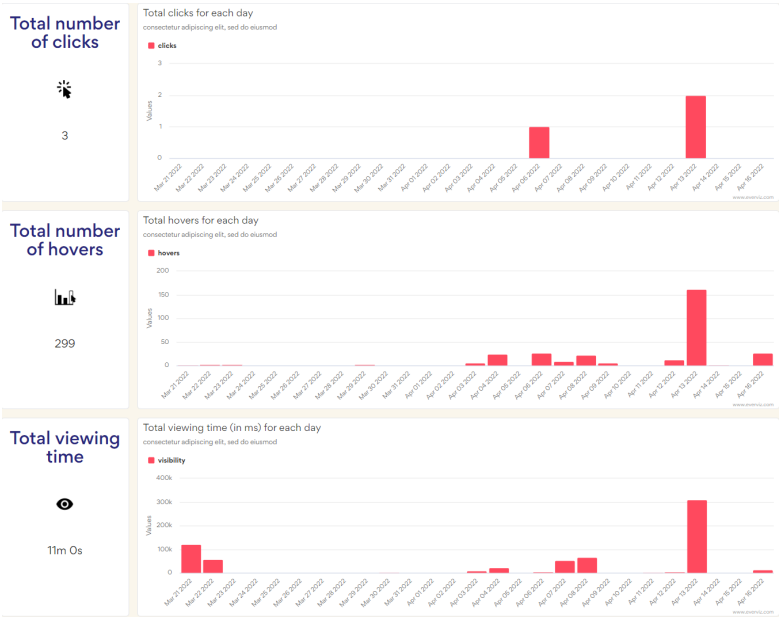
We let the test run its course for its defined period, and at the end of the period, we screenshot the dashboard from each (visualizations) and analyze the metrics they have been collecting. As discussed in chapter 4, our metrics are clicks, hovers, and visibility, which the interactive visualizations are able to collect. Not all of these metrics are available for the static version since you cannot click or hover on the elements. But the visualizations are still able to see how much time users have spent on them. We will mainly use this metric to compare the two versions against each other, at the same time, see if hover and clicks contribute to viewing time for the interactive side.

Some visualizations have data for days before March 29. This is because we did some tests to see if the visualizations were able to collect some data, but we started the A/B test from March 29, which is when we collect data from real users. We will disregard the data before this date from our analysis.

When collecting data, we must assume outside factors can affect data gathering. Outside factors can be such as the users leaving their computers while having visualizations visible screen while, placement of the visualizations, screen size, devices, browsers, etc.

7.2.1 Metrics for visualization 1





(a) Interactive

(b) Static

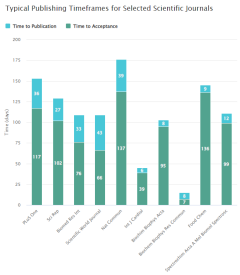
Figure 7.9: Dashboard for Research Publications by Country

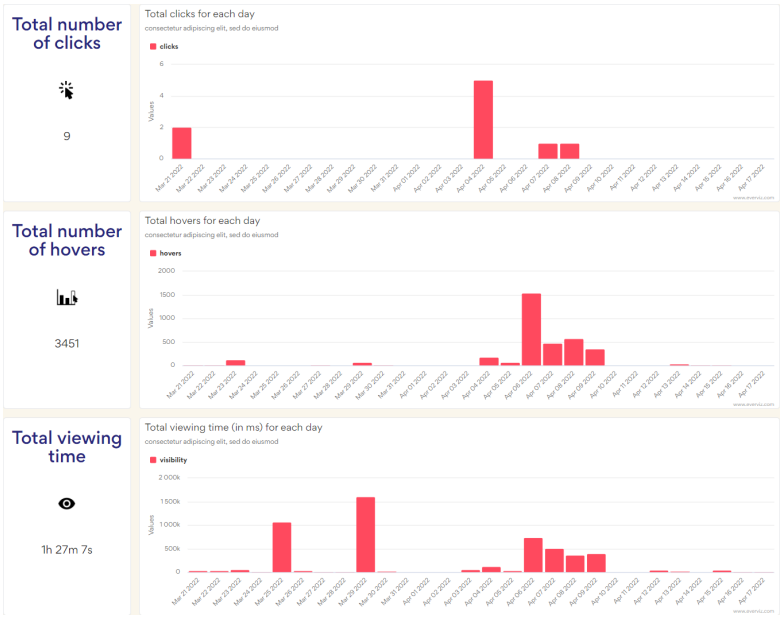
Because of our test data, we disregard 3 minutes from total viewing time and 4 hoverings from total number of hovers for the interactive visualization. The real total viewing time is 8 minutes and the total number of hovers is 295.

The difference between the total viewing time of the two versions is less than 2 minutes. We can see from the dashboard that hovering might have impacted the viewing time since the visualization provides more interaction.

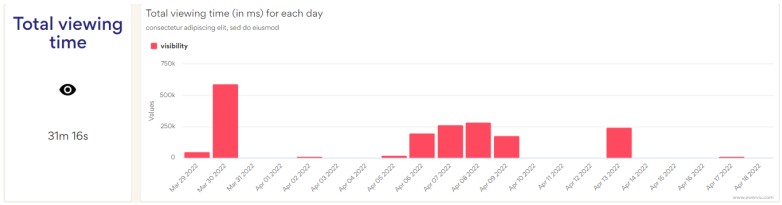
Assuming the one-day spike on the static version is not because of outside factors, we can see that the interactive visualization has higher engagement than the static version. The reason for the 2-minute difference is because they have high interactivity, especially on April 13.

7.2.2 Metrics for visualization 2





(a) Interactive

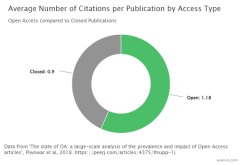


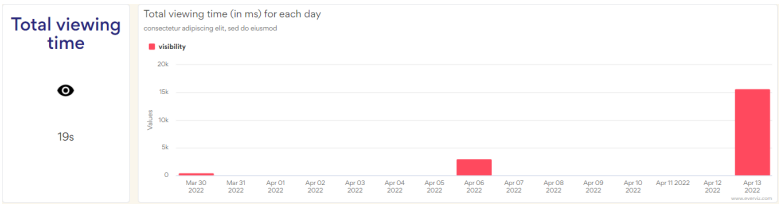
(b) Static

Figure 7.10: Dashboard for Typical Publishing Timeframes for Selected Scientific Journals

This visualization had quite the spike for both static and interactive, as they had the highest viewing time of all the visualizations by a margin. Disregarding about 17 minutes of test data from the interactive visualization, the total viewing time comes down to 1 hour and 10 minutes. The total viewing time for the static version is about 31 minutes, giving us a difference of 39 minutes between the two versions. We also see the visualization has also collected quite some hovering with a total of 3335 after subtracting test data.

7.2.3 Metrics for visualization 3





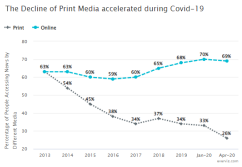
(a) Static

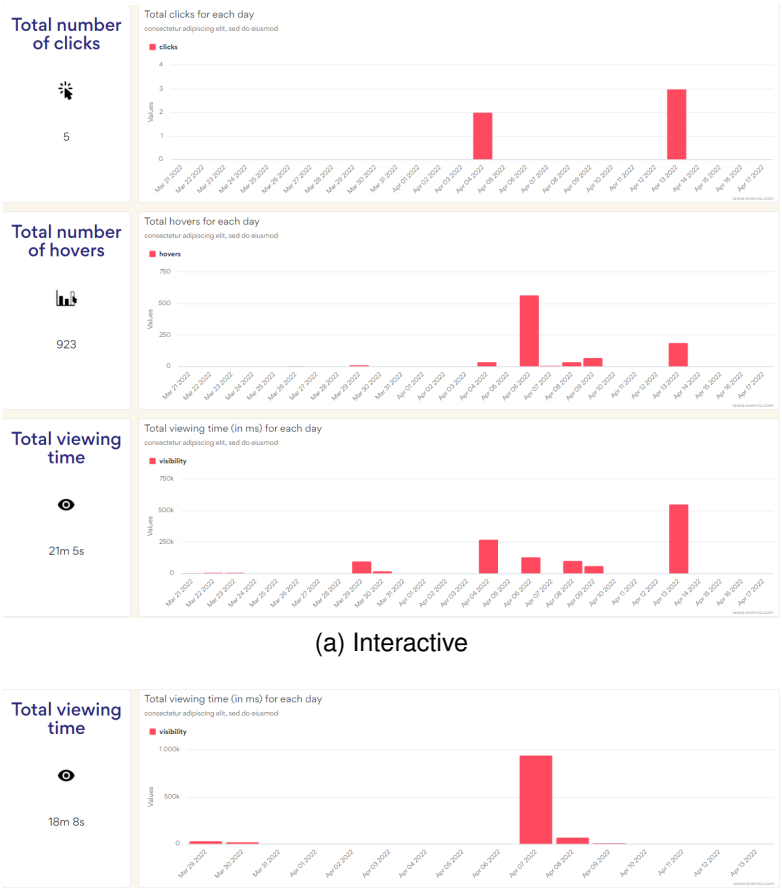
Figure 7.11: Dashboard for Average Number of Citations per Publication by Access Type

(Missing screenshot of the dashboard for the interactive version)

From the interactive visualization, we have a total viewing time of 15 seconds with 28 hovers and 0 clicks, while the static visualization has a total viewing time of 19 seconds. From the dashboard of the interactive visualization, we can have collected hovers from different days, but this has not been reflected on the viewing time. Starting the timer is something that happens before the user is able to hover or click because the visualization must be visible. Because of technical issues, we have not been able to track the time for these days when there have been interactions. We can then assume that the viewing time of the interactive visualization is higher than 15 seconds.

7.2.4 Metrics for visualization 4





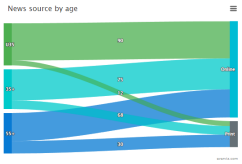
(a) Interactive

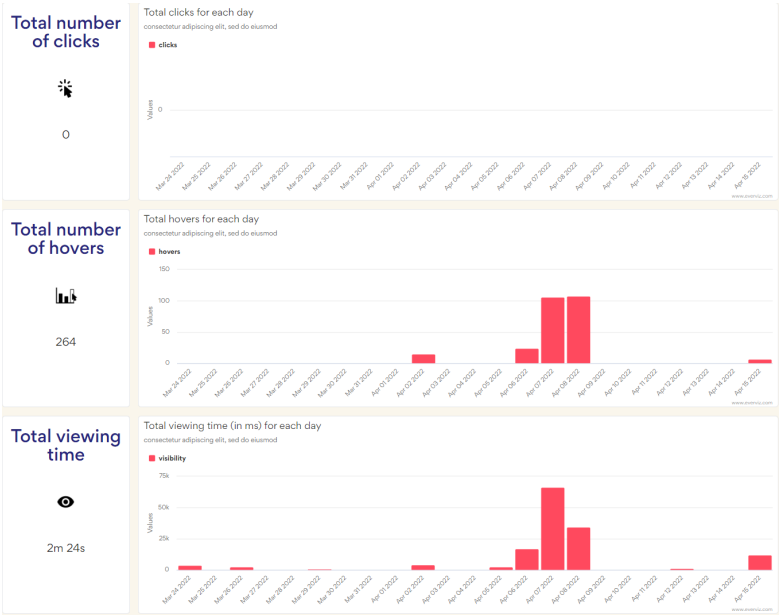
(b) Static

Figure 7.12: Dashboard for The Decline of Print Media accelerated during Covid-19

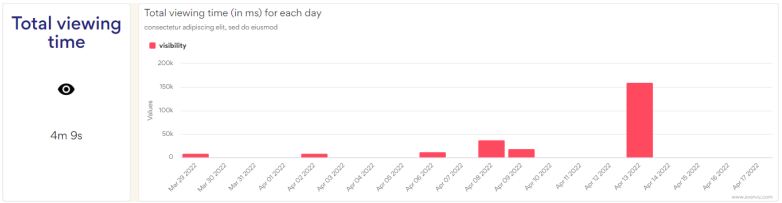
Our interactive visualization has been able to track a total viewing time of 21 minutes with 923 hovers and 5 clicks. Our static visualization has been able to track a viewing time of 18 minutes. The interactive visualization comes ahead in 4 minutes.

7.2.5 Metrics for visualization 5





(a) Interactive

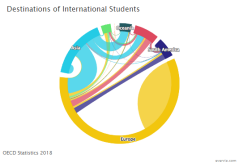


(b) Static

Figure 7.13: Dashboard for News source by age

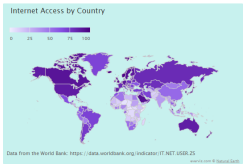
The interactive visualization has collected over 2 minutes of viewing time with 254 hovers and 0 clicks, while the static visualization has a viewing time of 4 minutes. The static version has a higher viewing time than the interactive version.

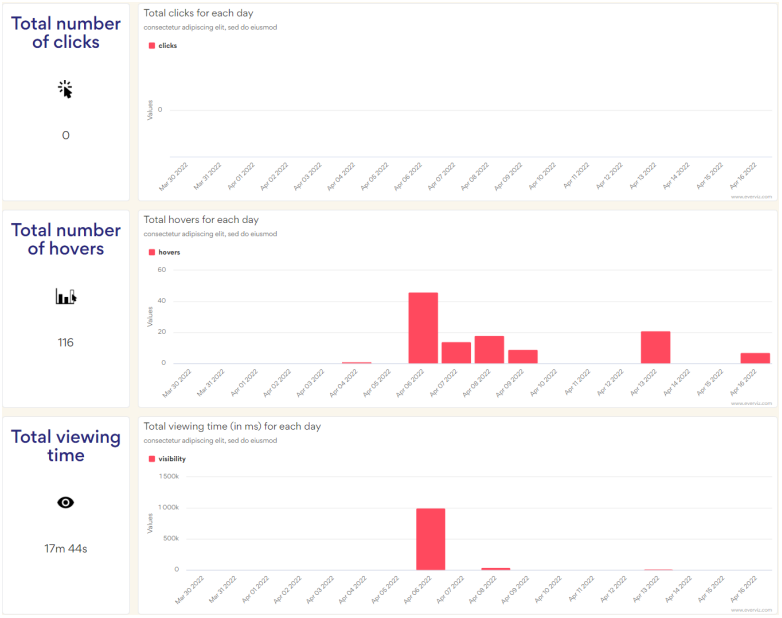
7.2.6 Metrics for visualization 6



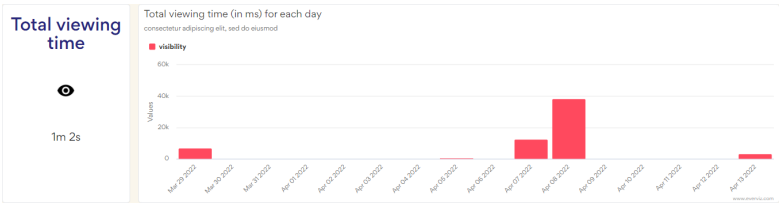
Unfortunately, the visualization has not been able to track the metrics properly. In our opinion, it would be very interesting to see the metrics this visualization has been collecting because from the interview, this visualization caused the most reactions from the participants. With its unique format and the comments from our participants, we can assume it would have interesting data.

7.2.7 Metrics for visualization 7





(a) Interactive



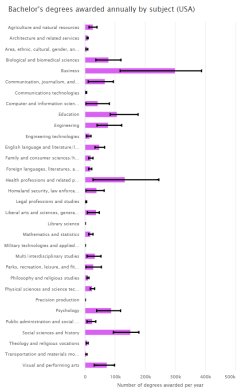
(b) Static

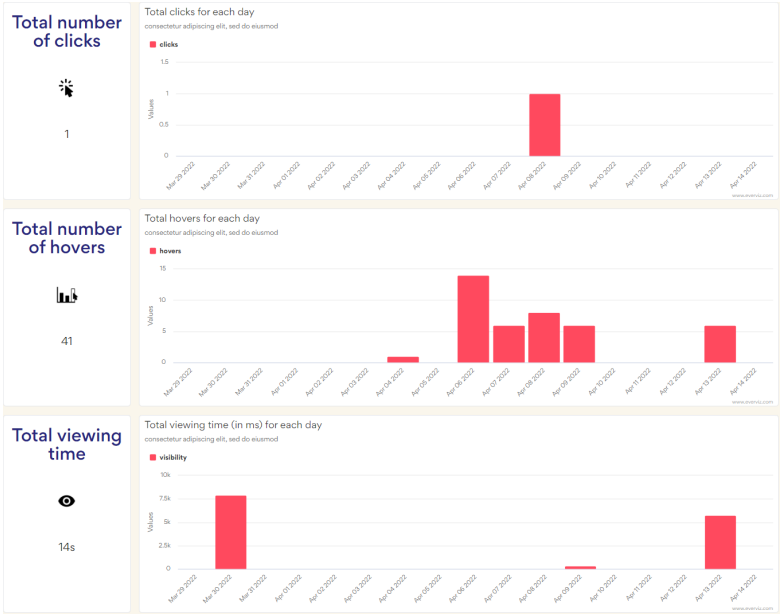
Figure 7.14: Dashboard for Internet Access by Country

The interactive visualization has a total viewing time of 17 minutes and 44 seconds with 176 hovers and 0 clicks. The static visualization has a total viewing time of 1 minute and 2 seconds. There is a considerably difference between the two versions with over 16 minutes.

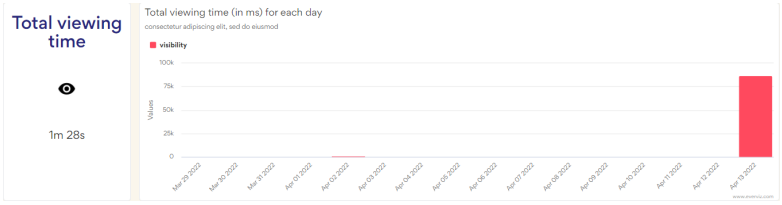
The same thing has happened here as it was for visualization 4, where some days it has not been able to track viewing time despite having collected hovers on these days. We can assume the total viewing time is higher for the interactive version.

7.2.8 Metrics for visualization 8





(a) Interactive



(b) Static

Figure 7.15: Dashboard for Bachelor's degrees awarded annually by subject (USA)

The interactive visualization has collected a viewing time of 14 seconds, 41 hovers and 1 click, while the static visualization has collected a viewing time of 1 minute and 28 seconds.

We meet the same issue as the previous interactive visualization where we have on some days been collecting clicks and hovers but no viewing time.

7.2.9 Conclusion of A/B testing

Our A/B test met some technical issues that we did not discover immediately. Under testing, we saw it collected the necessary metrics and therefore assumed it would run smoothly during its duration. Unfortunately because of technical issues, we lost data for some of the visualizations. We could have prevented this from happening if we checked on the visualizations occasionally. But because we assumed it would run as planned without any issues, it led us to be too confident in the technology.

Technical issues are one thing, but we can also assume other inconsistencies with the trackers are caused by outside factors. All possible interruptions in data gathering make it difficult to get complete head-to-head comparable data. We also see that visualizations having buttons, for example the zoom buttons for maps, do not get counted because we measure the plot itself. These buttons failed to get counted because they are not a part of the plot, and our implementations are for the plot itself. Another factor we have not considered is the device the user is using. The visibility tracking are working for both computers and smartphones, but we have implemented clicks and hover metrics to collect from the use of computer mouse. Tapping on a mobile screen is not the same as clicking, meaning if a user on a phone taps an element to reveal information, this would not get counted as a click. The use of different devices may give us high viewing times and low interaction data from hovering and clicking.

Visualization	Interactive	Static	Difference
1	8m	6m 12s	1m 48s
2	1h 10m 7s	31m 16s	38m 51s
3	15s	19s	4s
4	21m 5s	18m 8s	2m 57s
5	2m 24s	4m 9s	1m 45s
7	17m 44s	1m 2s	16m 42s
8	14s	1m 28s	1m 14s

Table 7.1: Viewing times and the difference between the interactive and static

Regardless of technical issues and outside factors, we have been able to gather data for many of the visualizations from nearly 6300 visitors. This many visitors, for a three-week duration do even out these factors to an extent. Overall, the interactive visualizations do have a higher viewing time over its counterpart except for visualization 5 where the viewing time was higher for the static variant. For visualization 3, the data shows us a difference of 4 seconds, and we have also lost some viewing time data for the interactive version. Therefore, we cannot conclude that the static version has higher viewing times. Visualization 8 has also days when it collects interactive data but no viewing time. It is hard to tell if it is greater than the viewing time of the static

visualization, but we assume it is higher than its current viewing time.

Visualization 2 has quite high viewing time for both versions compared to the others. The viewing time can have been influenced by outside factors, but the graph has captured the most attention. From the comments of our participants in the interviews, they seem to enjoy this graph quite well because of its familiar format. Perhaps this reflects on the behavior of our visitors and have contributed to the high viewing time.

Even though we have some inconsistencies in our data, we do see an interesting pattern in the static visualizations that might contribute to the viewing time. Starting from visualization 2, the viewing time is relative high, and as we go further down in the blog post, the viewing time for the visualizations decreases. Maybe this correlates to the behavior of our participants in group B, where they tried to interact with the few first visualizations and realized it was not interactive. We can also assume that the placement of the visualizations has an impact on viewing time. For the interactive version there is more of a "wave" pattern starting low and ending low. Along the way, the readers have stopped to engage with the visualizations that have captured their attention and disregarded those that had less impact on their engagement.

Since most of the interactive versions have a higher viewing time than the static versions, we can assume it is because of interactivity. It can either be because of the interactive element itself the readers are playing with, or the interactive visualizations hide most of the data and require the users to interact with it to reveal information. Either way, interacting with the visualizations does force users to stay on the visualization for a bit longer. Doing an action like hovering or clicking and then reading the revealed information does take more time than just passively reading the data, which contributes to viewing time as proven from our interviews.

Chapter 8

Discussion

The goal of this thesis was to explore the following research questions:

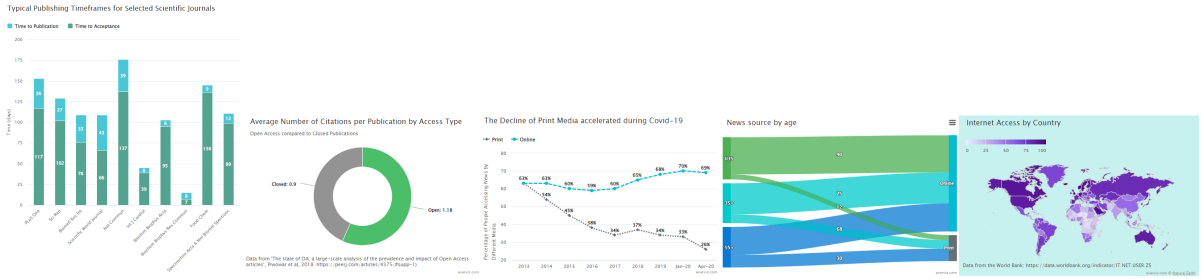
1. **How can we measure user engagement from interactive media?**
2. **How does interactive media affects reader's engagement compared to static media?**

Answering the first question, we narrowed the concept of user engagement to best fit our purpose. Doing this allows us to limit our methods for measuring user engagement. Depending on the media, there are different metrics to use. In this thesis, we have first defined what user engagement is, from what type of media we want to measure, and how we are going to measure it. Since our media are interactive visualizations created from the tools of everviz, we look at possible interactions the visualizations are able to present to the users. Possible interactions we have observed are clicking and hovering on different elements of the visualizations. We also introduce visibility of the visualization as a third metric where we measure the time users have spent on the visualizations. All of these metrics are tracked and stored in each visualization, which we display through a custom analytic dashboard to visualize and present the metrics.

Being able to measure user engagement from interactive media and present the data, we want to see how interactive media fare against static media, which introduces the second question. In our introduction we talked about how interactive media is becoming more commonly used as the preferred media for keeping users more engaged, but we want to explore this statement. And to answer this question, we create a hypothesis that helps us answer the question of which we reiterate; If a website contains interactive visualizations, then the user's engagement will increase since the media are more

engaging as they allow user interactions.

We have adopted two research methods to answer our hypothesis; semi-structured interviews for qualitative data and A/B testing for quantitative data. The qualitative data tells us how users experience both interactive and static visualizations and how this experience affects their different qualities under our definition of user engagement, which takes into account emotional, cognitive, and behavioral qualities. We collected quantitative data to see how interactivity affects user engagement compared to static media in terms of statistical analysis. Since static visualizations do not contain interactive elements, clicks and hoverings are not enabled. Therefore, the data we mainly look at is the viewing time of both media types. For the interactive visualizations, we see if clicks and hovers are factors that have led to higher viewing time.



(a) Visualization 2 (b) Visualization 3 (c) Visualization 4 (d) Visualization 5 (e) Visualization 7

Figure 8.1: Simple visualizations

(a) Visualization 1 (b) Visualization 6 (c) Visualization 8

Figure 8.2: Complex visualizations

What we have learned from interviews is that almost all participants preferred interactive visualizations over static ones. Although they preferred interactive visualizations, some static visualizations performed better than their counterparts in terms of readability. From the observations and the comments we collected, we can divide the visualizations into two categories, *simple visualizations* and *complex visualizations*. Combining both interactive and static, simple visualizations are visualizations the participants felt

they did not need explanation of the plot or the elements, while complex visualizations are visualizations that were either unknown for them or had elements that required further explanation. Simple visualizations are graphs and charts that are understandable for both versions. Complex visualizations can be understandable on one version, but are incomprehensible for the other version. For simple visualizations, we observed the interactivity was either unnecessary or gave a neutral experience based on the comments. Visualizations from 2 to 5 are categorized as simple visualizations. Except for one participant, these visualizations were all preferred as static according to our participants because they felt having data (numbers and text) displayed on the plot contributed to readability unlike interactive visualizations were the data was hidden under interactivity which required hover actions. We also categorize visualization 7 as a simple visualization for both interactive and static. The participants that voiced even if it is of a map, having the legend explaining the color of the countries helped them to understand the visualization. In contradiction to the other map, visualization 1, nothing explained the elements, and combined with overlapping elements made the map frustrating to read. This map required interactivity to make sense, which reflected on the actions of one of our participants as they zoomed in using the built-in browser functionality. Other visualizations requiring interactivity are visualizations 6 and 8. Visualization 8 was known for some of the participants making both the interactive and static versions understandable. For others, the interactivity was necessary for explaining elements, specifically the black range bar. Visualization 6 was, according to our participants, unreadable if it was not interactive.

Mentioning the participant using the browser-built zoom functionality, this reflects on how the setup of the interviews and the division of the two groups affected their experience. When we divided the participants into two groups, we wanted to see if they had any expectations and prior knowledge of the visualizations coming into this observation and if seeing either of the media types first would have an impact. This was indeed true as we see the *priming effect* in action. Priming is a technique in which the introduction of one stimulus influences how people respond to subsequent stimuli. This effect happens by activating an association or representation in memory just before another stimulus or task is introduced [27]. This priming effect was very noticeable for group B that were introduced to static visualizations first. On visualization 1, the participants all tried to interact with the visualization before realizing it was static. Going to visualization 2, they tried again to interact with it and concluded that the rest of the visualizations were static and made no interactions afterward. It is the expectation the participants set themselves, and when this expectation is not met, they answer with negative reactions. But this widely depends on the format of the visualizations.

As we mentioned, simple visualizations worked really well on static versions; therefore interactivity was not necessary. But complex visualizations had this expectation of being interactivity, which resulted in frustration when complex visualizations were static. When group B were introduced to the interactive version afterward, they were positively surprised. Surprised because the frustration they voiced earlier is now untangled. Again, this priming effect runs its course as we see the participants having the expectation of the visualizations not being interactive. We see the negative effect when the participants of group B see the static visualizations when expected to be interactive, and the positive effect when they see the visualizations are interactive afterward. For group A looking at the interactive version first, we did not observe a clear positive or negative effect of priming. But this was very noticeable when they were introduced to static visualizations. Removing the interactivity, some of the visualizations became unreadable as we mentioned earlier, creating a negative experience. But also the removal of interactivity and making the data visible to the participants made them enjoy some static visualizations more than the interactive visualizations. Some participants voiced they were surprised at how well the static visualizations worked. We see the priming effect influences the preference of participants when they first see one version and then the other because of expectations. Perhaps because the questions in the "warm-up" section of the interview are directed towards interactivity, they set the expectations for the participants. But dividing into two groups and alternating the versions gave us the insight of these expectations being kept or disregarded.

Interactive visualizations gave either a good experience or a neutral experience and almost no bad experience, and combined with frustrations over complex static visualizations weighing over the enjoyment of simple static visualizations resulting in interactivity being the preferred version among the participants. What we can draw from our interview results is interactivity does give a better experience overall but at the same time can be annoying if it feels unnecessary, all depending on the format of the media.

From our A/B testing we have collected quantitative data. Because of technical issues with collecting data from A/B test, we occurred on some inconsistencies. Other factors affecting the data can be leaving the computer while having the visualization visible on the screen, technical devices, implementation and others. Regardless, having close to 6300 visitors, we have been able to gather comparable data. We see a pattern in our data where interactive visualizations have a generally higher viewing time compared to static versions. As one of our participant mentioned, you have this autonomy to delve deeper into specifics data of your interest, and having this autonomy allows you to spend more time on a visualization because you have interactive elements that

gives you the control over your own narrative, which may contribute to high viewing time of the interactive visualizations. For the days when there are interactions from clicks and hovers, we see we have an increase in viewing time. Almost all days with relative high viewing time have high interaction compared to days with low interaction and low viewing time. When we compare the results of A/B testing with data from the interviews, we see the pattern from our quantitative data matches with the behavior of the participants from our interviews. From observations and comments, the participants spent more time on interactive visualizations; most noticeable were the visualizations 1 and 6. Unfortunately, we have lost quantitative data for visualization 6, but we can assume it had a relatively high viewing time based on our qualitative data. But the high viewing time on interactive visualizations does not necessarily equal to a positive experience. A/B test data tells us only one thing, that users have spent more time on interactive visualizations but does not reveal how the different qualities of user engagement has been affected. Drawing data from our observations, the users of A/B test might have spent more time on interactive visualizations, either because of interactive visualizations are enjoyable to interact with or frustration to read because the data is hidden and must make interactions which also requires more time of the users.

8.1 Limitations

Click is an interesting metric as it is the metric that has not been able to collect much data. Except for zoom buttons on the interactive world map, none of the participants clicked or tried to click on the visualizations, despite some of the visualizations having clickable elements. We assume it is because of the instant feedback users get when hovering over the elements, eliminating the need for clicking as they assume it is not necessary to click. The clickable elements (excluding buttons) where not exactly presented as buttons, making it non-intuitive it was clickable. Measuring clicks has also not been implemented on the actual buttons, and we have observed in the interviews that participants have clicked on buttons; for example zoom in and out buttons on a map. The click metric is on the plot itself, e.g., the lines, points, countries, etc, which all are shared with hover-action. Exploring this metric more closely and looking for cases where clicks would be necessary for interactive media would be interesting.

The process of developing the dashboard went longer than expected. The original plan was to use Google Tag Manager and Google Analytics. For Google Tag Manager, you inject measurement code into particular parts of your codebase. Google Analytics is a web analytics service that provides statistics and basic analytical tools for search engine optimization (SEO) and marketing purposes. Our desire was to use Google Tag

Manager to track metrics and then send the metric data to Google Analytics for analysis. The ideal plan was to have Google Analytics and its collection of metrics shareable with the customers of everviz. The main reason for us not using Google Analytics is because of its collection limits. This limit is to protect their system from receiving more data than it can handle since there are many users using Google Analytics. Some limits are such as 10 million hits per month, 200,000 hits per user per day, and 500 hits per session. Exceeding these limits requires you to upgrade your Google Analytics account, which was not an option for us.

An option we could do to strengthen our validation towards the hypothesis is to use the metric and the dashboard when conducting the interviews. Together with qualitative data from the comments of our participants, we could gather quantitative data from the observations. With this, we could precisely see what visualizations the participants were most engaged with. Having the participant comment on the experience could be supported with quantitative data. But unfortunately doing this would skew the data gathered from A/B test since the blog post the participants read is linked to the articles used in the test. While the participants were commenting on the visualization to tell us how they experienced it, they scrolled to the visualization. While showing us, they would have the visualization visible on the screen which would result in high viewing time while not being engaged with it. A separate data collection and dashboard for the participants would solve this problem, but this was overlooked until the end of the process of qualitative data gathering.

8.2 Future work

It would be interesting to look at another age group, perhaps looking at a group consisting of elderly people. One quote from the participant says the following: "Maybe if I was old, I would probably have been overstimulated and confused over the choices... that things are moving and I would get a surprise: "Did I press something wrong?"". Because the younger generation has this prior knowledge of interactivity, we are familiar with this type of media. We have grown up with technology; we use it every day, and there are new concepts that arise all the time resulting in us adapting to the technology and its concepts relatively quickly. But this might not be true for an older generation. The older generation did not grow with the same technology as younger people, resulting in a steeper learning curve. When they are met with concepts they are not used to or even never seen, negative experiences can occur from these concepts. I have my own family that always need to ask for my help with technology because they think it is overwhelming for them to learn them all. Our participants might have a bi-

ased view towards interactivity because it is something they are familiar with; at the same time the concept itself is encouraging engagement. That is why we think it would be interesting to observe another age group to get a new and unfamiliar view on the concept of interactivity.

The current solution of the dashboard shows you the first day it started collecting the metrics to the current day. If the period gets very long, then it would be hard to see the dates on the x-axis and the numbers on the y-axis. Allowing users to select a specific time period would eliminate this problem. Naturally, the containers showing the total numbers must follow the selected time period.

We have defined our way of measuring engagement, one of many ways to do it. Our metrics collect all elements within a visualization, meaning it does not separate elements from each other. We only separate metrics from each other; hovering is hovering and clicking is clicking. But clicking on an element in a graph, even though it does not respond in a feedback counts as a click since we can interact with it. This does not necessarily contradict with our implementation, but it would be interesting to separate elements from each other; i.e., categorize elements of similarity.

Combining these metrics with existing metrics such as page views, time spent on page, bounce rate, etc., would give us a very good insight into user engagement. It would strengthen our implemented metrics and give the creators of the visualizations a better knowledge of how users have interacted with the visualizations. This knowledge can also be used to improve existing and future content. But this would require additional data, which might stretch to gathering personal data and must have regulations in mind when introducing other metrics.

The dashboard has proven to be a tool to give us an insight into how the visualizations have impacted the readers by collecting data for the implemented metrics. Next step for the dashboard and the topic of user engagement is to delve deeper into how the dashboard can be used as a tool for the creators of the visualizations. Many questions arise from this topic: How does this user group use the dashboard? How can they make sense of the data we are presenting to them? Is the design of the dashboard effective and meaningful, and what can they benefit from using this dashboard and the data? These questions introduce us to a new research area by looking at the dashboard in the hands of the creators of the visualizations.

8.3 Conclusion

We have provided a tool to measure user engagement from interactive media by introducing different metrics and a way to display these metrics that gives us an insight into the performance of the media. With the dashboard, you can see how your visualizations have performed by showing you the trends of the different metrics. And with further development, the dashboard has great potential to give us more data about user engagement by combining and introducing other metrics. Not only is the dashboard a tool to give us an indication of how big of an impact the visualization has made on the readers, but the creators of the visualization can use the dashboard to improve future and existing visualizations by looking at the trends.

We are also concluding that interactive media does have a bigger impact on user engagement based on our quantitative data where users have spent more time on interactive visualizations compared to static visualizations. But our qualitative data has shown us user engagement is impacted both positively and negatively. Having interactive elements creates unique and pleasant experience, but when interactivity becomes the extra layer one must go through to obtain the information which could already be presented, we can then question if it is necessary to opt for interactive elements over static elements. Perhaps a combination of the two media types can create the utmost experience since you might be able to capture both sides of the target group. Nevertheless, this thesis has proven that interactivity does contribute to user engagement and evokes strong reactions, but at the same time it is not the sole solution for creating engaging content. In fact, simple content without the additional need for an interactive element can still and is contributing greatly to the reader's engagement.

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Appendix A

Information and consent letter

Vil du delta i forskningsprosjektet

Analyse av leseengasjement?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å undersøke hvordan innhold i nettsider påvirker leseengasjementet til brukere. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål
Forskningsprosjektet introdusere andre målenheter for å samle inn brukerinteraksjon samt ser på hvordan brukerne samhandler med interaktive og statisk innhold som blir presentert på nettsider og i artikler.

Forskningsprosjektet inngår i en masteroppgave innen Medie- og Interaksjonsdesign.

Hvem er ansvarlig for forskningsprosjektet?
Universitet i Bergen er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?
Utvalgskriteriene for å delta på forskningsprosjektet er om du eier en datamaskin, og om du bruker internett for lesing av artikler. Du har blitt spurt om å delta siden du er en kandidat oppfyller disse kriteriene og som kan gi nyttig informasjon til forskningsprosjektet.

Du vil ikke kunne bli gjenkjent av publikasjon. Ingen kontaktinformasjon vil bli lagret. Observasjon og analyse vil bli anonymisert i etterkant.

Hva innebærer det for deg å delta?
Dersom du deltar innebærer det at du vil inngå i en intervjuprosess. Videoopptak vil også bli tatt opp for meg å transkribere senere. Opptaket vil bli slettet etter å ha blitt transkribert.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.
De som vil ha tilgang til informasjonen prosjektet samler er meg, og Universitet i Bergen.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?

Opplysningene anonymiseres når prosjektet avsluttes/oppgaven er godkjent, noe som etter planen er juni 2022.

Når prosjektet avsluttes og opplysninger har blitt anonymisert, vil all personopplysning bli slettet.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke personopplysninger som er registrert om deg, og å få utlevert en kopi av opplysningene,
- å få rettet personopplysninger om deg,
- å få slettet personopplysninger om deg, og
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Universitet i Bergen har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- Universitetet i Bergen, Philip Hoang, epost: philip.t.hoang@outlook.com, telefon: 451 21 061
- Vårt personvernombud: Janecke Veim, epost: Janecke.veim@uib.no, telefon: 55 58 20 29 eller 930 30 721.

Hvis du har spørsmål knyttet til NSD sin vurdering av prosjektet, kan du ta kontakt med:

- NSD – Norsk senter for forskningsdata AS på epost (personverntjenester@nsd.no) eller på telefon: 55 58 21 17.

Med vennlig hilsen

Philip Hoang (Masterstudent)

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet [sett inn tittel], og har fått anledning til å stille spørsmål. Jeg samtykker til:

- ☐ å delta i intervju
- ☐ å delta i å bli videoinnspilt

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

----
(Signert av prosjektdeltaker, dato)

Appendix B

Interview guides

(A to B Version) Semi-interview guide

tirsdag 22. februar 2022 10:29

Page A: Interactive graphs
Page B: Static graphs

The participant for this interview will view page A first, then page B.

Ice breaker (pre-phase) to allow the participant to settle down in the situation

- What is your name?
- What is your occupation?
- What do you like about your occupation?
- Website(s) you usually like to visit?
    - What do you like these websites?
- Do you like to interact with content such as graphs, animations, quizzes, and such?
    - Any favourite interactive content?

Introduction

"My name is Philip, a student at University in Bergen, currently studying master's degree in Media- and Interactiondesign.

Thank you for participating in this interview!

The theme of this interview is user engagement, and the goal of this interview is to see how interactive and static content affects your reading engagement. You will read an article, containing different type of charts and make comparison.

If you do not mind, I wish to take an audio recording. This allows me to go through the recording in case I miss some important comment from you. Information you share will be confidential, meaning all information you provide will anonymized and the recording will be deleted after transcribed.

You have the option to leave the interview at any point. Please do stop me if you have any questions."

* Make the participant sign consent form from NSD

Warm-up

- How often do you read articles on the internet, either news articles, research articles, blogposts, etc.?

- When reading articles on the internet, how important it is for the article to contain images, videos, charts, etc.?

- How often do encounter infographics such as charts, maps, graphs, etc.?

- Do you find these content helpful to the article you are reading?

- If the article has interactive content, would you spend more time, less time, or no difference

Body of session

"We will now start with the observation in how you experience graphs and charts. Even though you are getting observed, I want you to be as comfortable as possible, just like how you would read an article at home.

I will ask you questions about your thoughts of both the articles and the graphs.

* Let participant engage with page A

https://www.everviz.com/how-to-make-research-data-graphs-and-charts-for-the-web/

* End of page A

Phase 1: Questions about page A (interactive):

- What do you think about the article?

- What do you think about the graphs that were presented?

- Did the graphs make it easier for you to read the article?

- Which graph did you like the most?
    - What part did you like about this graph?

- Which graph did you like the least?
    - What part of the graph made you frustrated?

- Did you feel that you got sufficient information from the graph?

- Was there something you felt was missing from these graphs?
    - If yes, any changes you would recommend?

"You will now again look at the same article, but this time the graphs are different. You don't need to read the article all over again. The graphs are now static, so I want you to explore graphs and tell me how you experience them."

https://www.everviz.com/how-to-make-research-data-graphs-and-charts-for-the-web-static/

Phase 2: Questions about bage B (static):

- What do you think about these graphs this time around?

- The interactive part of the graph was removed, but was the graphs still understandable?
    - Did they make sense?

- Which graph did you like the most?
    - What part of the graph did you like about it?

- Which graph did you like the least?
    - What part of the graph made you frustrated?

- Did the removal of the interactive part ruin your reading experience?
    - Did you find it less enjoyable to read?

Phase 3: Questions about interactive content vs. static content

- You now saw the same graphs in two versions, statich graphs and interactive graphs.

Which of the versions do you prefer? Why?

- Anything specific you like about static content?
- Anything specific you like dislike about static content?
- Anything specific you like about interactive charts?
- Interactive content can be fun to interact with, but have you ever experience frustrations/annoyance with interactive contents?

Wrap-up

- Any questions regarding the project, the process, or anything in general?

"Thank you for your time and the information you shared with me today!"

(B to A Version) Semi-interview guide

tirsdag 22. februar 2022 10:29

Page A: Interactive graphs
Page B: Static graphs

The participant for this interview will view page B first, then page A.

Ice breaker (pre-phase) to allow the participant to settle down in the situation

- What is your name?
- What is your occupation?
- What do you like about your occupation?
- How often do you browse the internet?
- Website(s) you usually like to visit?
    - What do you like these websites?
- Do you like to interact with content such as graphs, animations, quizzes, and such?
    - Any favourite interactive content?

Introduction

"My name is Philip, a student at University in Bergen, currently studying master's degree in Media- and Interactiondesign.

Thank you for participating in this interview!

The theme of this interview is user engagement, and the goal of this interview is to see how interactive and static content affects your reading engagement. You will read an article, containing different type of charts and make comparison.

If you do not mind, I wish to take an audio recording. This allows me to go

through the recording in case I miss some important comment from you. Information you share will be confidential, meaning all information you provide will anonymized and the recording will be deleted after transcribed.

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- How often do encounter infographics such as charts, maps, graphs, etc.?
- When reading articles on the internet, how important it is for the article to contain images, videos, charts, etc.?
- Do you find these content helpful to the article you are reading?
- If the article has interactive content, would you spend more time, less time, or no difference?

Body of session

"We will now start with the observation in how you experience graphs and charts. Even though you are getting observed, I want you to be as comfortable as possible, just like how you would read at home.

I will ask you questions about your thoughts of both the articles and the graphs.

* Let participant engage with page B

https://www.everviz.com/how-to-make-research-data-graphs-and-charts-for-the-web/

* End of page B

Phase 1: Questions about page B (static):

- What do you think about the article?

- What do you think about the graphs that were presented?

- Did the graphs make it easier for you to read the article?

- Which graph did you like the most?
    - What part of the graph did you like about it?

- Which graph did you like the least?
    - What part of the graph made you frustrated?

- Did you feel that you got sufficient information from the graph?

- Was there something you felt was missing from these graphs?
    - If yes, any changes you would recommend?

"You will now again look at the same article, but this time the graphs are different. You don't need to read the article all over again. This time the graphs are interactive, so I want you to explore graphs and tell me how you experience them."

Phase 2: Questions about page A (interactive):

- What do you think about these graphs this time around? What was different?

- Do you feel the interactive part made the graph more or less understandable or no difference?

- What do you think about actions and the feedbacks from the interactive part of the graphs?
    - Did they make sense?

- Which graph did you like the most?
    - What part did you like about this graph?

- Which graph did you like the least?
    - What part of the graph made you frustrated?

- Did the addition of interactive part increase your reading experience?

- Did you find it more enjoyable to read?

Phase 3: Questions about interactive content vs. static content

- You now saw the same graphs in two versions, statich graphs and interactive graphs.
  Which of the versions do you prefer? Why?

- Anything specific you like about static content?

- Anything specific you like dislike about static content?

- Anything specific you like about interactive charts?

- Interactive content can be fun to interact with, but have you ever experience frustrations/annoyance with interactive contents?

Wrap-up

- Any questions regarding the project, the process, or anything in general?

"Thank you for your time and the information you shared with me today!"