Bridging the Knowledge Ocean: A Design Study of Knowledge Translation for the OceanCanada Initiative

Marina Botnaru
marina.botnaru@ubc.ca

Delun Chun
delunchen@alumni.ubc.ca

Francis Nguyen
frnguyen@cs.ubc.ca

Rodrigo dos Santos
rodrigo.dossantos@ubc.ca

ABSTRACT

In recent years, the research on ocean science has increased noticeably. Given the impact of this research, communities near the ocean may want to enrich their environmental knowledge to ensure our oceans' future health. However, there is limited accessibility to this research; scientific information that might be publically accessible is often difficult to find and understand without proper background knowledge. To bridge this gap between the non-experts and academic information, we propose a public information access portal that leverages a set of information visualization (infovis) and knowledge translation (KT) techniques. We implement our design as a medium-fidelity (med-fi) prototype with the goal of facilitating citizen engagement with the OceanCanada Partnership. We present the results of a usability test with 4 participants of varying expertise in ocean research to investigate the effectiveness of visualization and KT in our prototype. We find that representing scientific literature through visualization and simplified textual summaries might improve the accessibility of ocean-related research toward non-academic audiences, though we lack the statistical power to come to any decisive conclusions.

Author Keywords

Knowledge translation, ocean science, OceanCanada Partnership, visualization, design research methodology

INTRODUCTION / PROBLEM SPACE

With the ongoing climate change, research is conducted to understand and address threats facing the ocean and communities that live in coastal cities and depend upon the oceans. Given the importance and relevance of this research, communities directly impacted may want to enrich their understanding of the marine environment to promote a shared vision of health and well-being of their local ecosystem. However, scientific articles are often difficult to find and understand by non-scientific audiences [2]. Therefore, how to efficiently disseminate the research contents to "general public" users, and facilitate their understanding of the scientific knowledge becomes an inevitable focal question.

A field well suited to tackling this problem is **knowledge translation (KT)**, where emphasis is placed on putting academic information into the hands of people and organizations who can put it into practice. Research in KT focuses on frameworks and strategies that researchers and organizations can employ to promote KT [4, 6, 15] rather than putting KT into practice; KT is highly contextual to the knowledge domain [16]. We abstract best practices from KT and apply them to textual and visual summaries of ocean science research with the intention of increasing non-expect engagement with these resources.

Based on existing practices, we propose an interface focused on KT of OceanCanada's academic papers[1]. The OceanCanada Partnership is an initiative whose goal is to understand and address threats facing Canada's Arctic, Atlantic and Pacific coastal-ocean regions and seek opportunities to develop a shared vision for the future of our oceans. We partner with OceanCanada to develop a design prototype that encompasses the general public's lack of accessibility to research and information surrounding ocean health, resources and sustainability. Our primary intention is to shorten the potential gaps between non-experts and academics by integrating knowledge translation and information visualization techniques of academic papers. We aggregate publication information provided by OceanCanada, and tease out the relationship between papers in order to develop an interface (See Figure 2) that links textual content and components of interactive information visualization (e.g., interactive charts, maps and digital images). We hypothesize that generated visualizations in addition to layman summary text encourage engagement from non-experts.

We follow the steps of a *design study* process where we work closely with stakeholders to get feedback in order to design the prototype [17]. We conduct design research activities to investigate the user's level of involvement and interest in the areas of ecology, economics and society. We report our exploratory findings and utilize our analysis to narrow down the scope of our project to a public information access portal, a human-based system of collecting relevant information from academic articles and translating them into plain language. Our resulting prototype of this interface presents the user with publication information and visually represents ocean science research

[1] https://oceancanada.org/all-publications/

as a set of topics. We receive feedback on our prototype through usability studies with 4 stakeholders. The evaluation process helped our team to further locate the design issues, and understand the expectations of both common users and experts in ocean-related studies.

Our contributions are therefore (1) A design study driven by visualization for knowledge translation where we evaluate our design decisions through user interviews and usability tests, and (2) implementation and discussion of knowledge translation in practice to ocean science research.

BACKGROUND AND RELATED WORK

We explore work in knowledge translation to better understand the state of knowledge translation and how it applies to domain-specific uses.

Knowledge Translation

These papers shed light on how these problems were approached by academics. Ben Levin [4] outlines some issues in knowledge translation, noting the difficulty in communicating scientific ideas through education, media and government. While more of a survey of the current state of effective knowledge translation, Levin acknowledges that solutions to knowledge translation are highly contextual. To begin tackling this problem, Graham et al. [5] provide formal definitions for knowledge translation and provide a framework in how to think about these problems: knowledge-to-action (KTA). This framework expresses the importance of identifying relevant stakeholders and building relationships before a common understanding of KTA can be established. Kothari and Wathen [6] take KTA a step further into integration knowledge translation (IKT) where they note that while knowledge translation is again a community issue, it is the researchers responsibility to be transparent and forthcoming about their research to stakeholders.

These papers discuss how academics frame knowledge translation and translation, however provide few concrete recommendations to approaching the problem in domain spaces. They all acknowledge that knowledge translation is highly contextual, involving relationships between relevant stakeholders and those who are disseminating information. This makes it all the more important for us to identify our target users and understand their needs in order to come closer to a design solution.

Systems of Knowledge Translation

As interest in the research to practice gap has increased, there are a number of online theoretically-informed frameworks available to researchers that can be used to help guide their research dissemination planning and activity. One of the leading science discovery platforms, "Researcher", is developed for academics to keep up to date with all new publications [3]. However, this application only provides first-hand academic resources to scientists and researchers. In our design study, we consider non-academic users as our primary readers (See Appendix 1.1 for how academic and non-academic personas inform both user groups considered in thin design research).

RESEARCH METHODOLOGY

The first step in the design study process is to empathize with our users. We conducted a set of research activities to better understand our stakeholders: non-experts and academic researchers. The research activities include a survey, an exploratory sketch activity (with non-scholars and scholars of research fields not directly related to OceanCanada areas of activity), as well as a workshop with some of OceanCanada scholars. With the information gathered from these research activities and subsequent data analysis, we generated a set of *areas of action*, actions and observations researchers or the public took when involved in KT. We take these areas of action in addition to further analysis as a basis for which we create *design requirements* that a design solution should follow. We describe the research activities, process and subsequent findings.

Survey

Given the wide net of users that our design solution might cater to, the "general public," we decided to scope down our target users to college students and the public interested in ocean science and distributed a survey to them. Our intent was to understand how and why these groups interact with ocean research and to see what information might be most important from a reader perspective. We hoped that analysis might identify what information is most desireable and how we could make that information accessible.

We asked a range of questions on the survey including, "If there is a tool that makes ocean knowledge more accessible, what topics would you be more interested in?" or "How do you normally acquire scientific or academic information in your field of study?" (See Appendix 4.1 for all survey questions). These questions were exploratory in nature.

We accrued a total of 10 responses from users of varying academic backgrounds. While the survey is underpowered to draw any statistically sound conclusions, we did note a theme in the types of information that participants gravitated towards: information about their local environment and information that might impact them on a more local, daily basis.

Exploratory Sketch Activity

Investigating people's way of making sense of textual information can create opportunities for the design of a system in which complex data can be written or visually represented to different audiences. With only a title, abstract, bibliographic information on hand, we asked a few participants (non-associated to OceanCanada) to briefly sketch what the article "Climate change impact on Canada's Pacific marine ecosystem: the state of knowledge" [7] was

about. In this article, the authors provide an overview of the recent literature on the Pacific oceans' conditions and species responses to climate change, and acknowledge that more studies on the impact of climate change in the socio-economic sectors (e.g., fisheries, local communities) are needed.

This exploratory sketch activity is helpful for identifying informational patterns and themes that emerge in ways similar to a mind mapping or collage activities, in which people could represent their thoughts and ideas in a visual, non-linear fashion [8]. For the purpose of this activity, participants' visual representation of the academic paper's title and abstract can inform us of the key words and sentences that triggered their attention, and what visual element they use to represent these words and sentences as well as the overall narrative.

In total, 6 responses were collected in this pilot research. In these, we observe that the visual elements sketched that were associated to some of the key words mentioned in the abstract (e.g., Fish; Fisherman; Fishing boat; People), but also to subjective concepts such as marine life, and climate change (e.g., Fish; Jelly-fish; Water; Sea; Sun; Cloud; Storm). In addition, the geographical locations mentioned in both title and abstract were also represented by drawings of the Canadian map and flag.

These synthesized representations can be seen as a way in which individuals approached complex information through a more personal and intimate perspective. With this in mind, what could OceanCanada scholars do to facilitate the interface between their research and the people who might not belong to their primary audience but could still benefit from their papers? Also, considering that some copyrights restrictions may add another layer of difficulty while accessing these publications, what could scholars do to maximize the impact and outreach of their papers?

Workshop with OceanCanada Researchers

We conducted an one-hour collaborative study with four OceanCanada scholars with different degrees and levels of participation within this research community. The intent was to have a sense of the motivations behind the researchers' aspirations, challenges, and perceived benefits of having their research published in non-academic formats. Three questions motivated this workshop: 1) What impact do you want your research to have in the world? 2) Whom do you address your research/articles outside of academia? 3) What aspects of your research do you communicate outside of academia?

During the workshop, the participants brainstormed and classified their motivations into three areas of interest to OceanCanada (Social, Economical and Ecological). This activity was followed by semi-structured interviews and group discussion over the aforementioned and additional supporting questions (E.g., "What aspects of your research are key to communicate?" and "How do you summarize your research without trivializing its message?").

The data gathered in this session was aggregated through affinity diagrams (See Appendix 4.2). Among intentions to "influence change in marine policies," "foster attention to social justice and ocean governance," and "create awareness about marine life," the participants expressed that creating strategies for simplifying research language is crucial to facilitate knowledge translation and translation. The activity of making the information easier to understand is expressed in the areas of action and subsequent design requirements we drew upon from the survey and workshop analysis.

Research Findings: Areas of Action and Design Requirements

Through our analysis we identified five distinct areas of actions that illustrate participants expressed mechanisms and motivation for simplifying their research, as well as seven design requirements. These areas of actions represent the fields in which tools, activities and methods are needed in order to address knowledge translation in OceanCanada research publications:

Communicating the research (outside of academia)

This area describes all comments made with relation to the communication process of results. A large component of our discussion during the design activity was centred around communication teams, as well as understanding how academic researchers interact with them to publicize their work.

Information simplification

Some authors tend to write their paper with a lay-language in mind from the beginning. However, communication teams can be involved in the process of simplifying the language used in academic research papers, as well as in the dissemination of the research information to the public. Communication team members re-work the language used in these papers to target non-academic audiences by means of press releases, and social media. This work may happen prior or in tandem with the academic paper publication.

Public outreach

Researchers and communication teams also make use of different strategies to tackle knowledge translation with public outreach. Infographics, video abstracts and presentations are examples of more simplified, accessible formats academic papers can have, possibly reaching and communicating to non-specialized audiences.

Information verification

As a consequence of textual simplification, some researchers find that their papers are often misrepresented in press releases, social media posts, or by means of via visual representation such as in infographics and video abstracts. Others mentioned that any simplified level is valid as long as the message of the conclusion gets out. For that end, some researchers described that they usually send out draft

copies of their papers and infographics to relatives and friends to see how much they understand. In both examples, strategies for validating the information across different media are needed.

Multi-participation
Researchers expressed that integrating multiple perspectives to the communication materials developed for the purpose of knowledge dissemination is also relevant. Plural perspectives can be assessed via comments and threads of discussion generated in blogs and social media publications.

Associated with these five areas of action, there is a set of seven design requirements that we identified in the research analysis (See Figure 1):

1. Present information in different media and levels of complexity;
2. Identify alternative channels to disseminate research information to different audiences;
3. Validate the semantics across different media and levels of information;
4. Evaluate the impact of the information of the research to different audiences;
5. Identify partners to collaborate in simplifying the information of the research;
6. Validate if the information of the research is relevant to the audience
7. Coordinate timely dissemination of information across different channels.

The prioritized list of design requirements is based on the analysis of the three main activities we conducted, as well as on the assessment of the personas and scenarios identified for this research (See appendix 1.1-2.3 for the personas and scenarios).

DESIGN PROPOSITION

We describe and propose a conceptual design of our prototype and describe features that our system will support. We motivate these features by linking them to our areas of action and design requirements. We reference first iterations of the prototype in the appendix, and show final mockups in the paper. We made the decision to move forward with the information portal prototype emphasizing the visualization aspect of simplifying research article information.

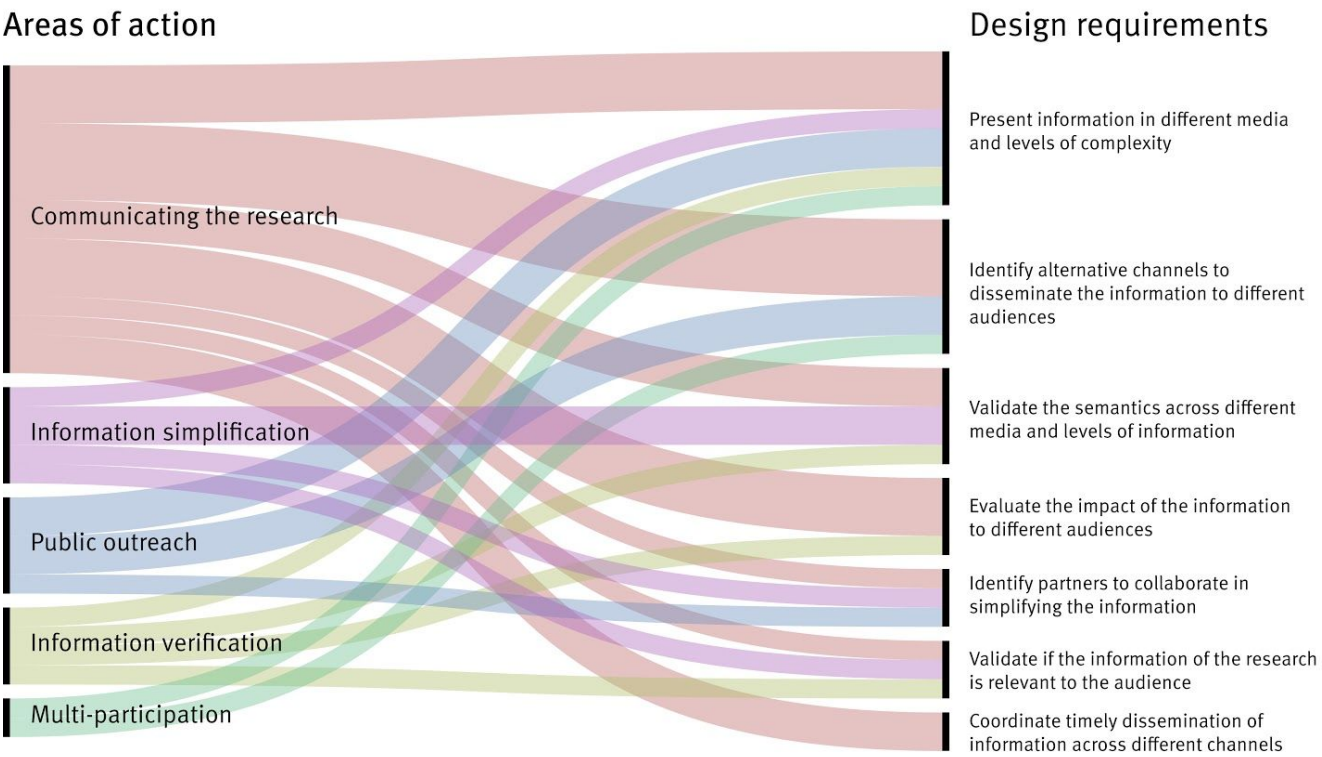

Figure 1. Strategies for simplifying research language: Areas of action and design requirements.

aspect of simplifying research article information. Our digital prototype[2] is available through the design platform Figma [9].

There are two main elements to the prototype: the information portal and the article page. The information portal organizes all the research papers available and allows users to filter according to a variety of topics that we generated based on the results of our requirements gathering. The article page attempts to contextualize the article in the greater research portal but also summarizes the article through a visualization. We designed two main visualizations that we want to test with users: a sunburst chart and a word cloud. Both of these visualizations are to be automatically generated (as a part of future work). The words and hierarchy in the article-level view are meant to be algorithmically generated using topic modeling, a natural-language processing summarization technique.

Conceptual Design

The overall direction of this conceptual model is to focus on what had emerged as the key refinement of the design. We propose an user interface that is primarily meant to connect non-academic readers with OceanCanada's papers, supporting them to access the overall information about the research in a single location. The interface consists of textual and visual representations of the research description, topics, and regions of the study.

The prototype is organized around the metaphor of a "digital collection". This interface would help them find the suitable "articles" from an extensive online "inventory", and review it from both academic and non-academic perspectives. Users without professional background may also have a desire to browse academic literature according to their interest, while OceanCanada's researchers and other scholars may benefit from navigating this institution's articles by different research fields. Similar to a digital collection, our prototype will allow users to browse a set of research articles, but also drill down into the article layer, where a user can view more details about a specific article.

Publication list and filters (Appendix 3.8)

OceanCanada's publications and areas of research are aggregated in the middle layer of the UI (See Figure 2). The list of publications can be filtered by research topics, region and via the word cloud visualization, representing the subjects of the collection. Word clouds have been shown to increase engagement of a set of documents [14]. The word cloud also provides visitors with an overall idea of the areas and relevance of the research papers available, as well as potentially simplifying and expanding the outreach of the research. This arose from researchers describing the need to display the collection of articles in a different media form and layer of complexity.

[2]Link to prototype available at: https://bit.ly/2wqnj0a

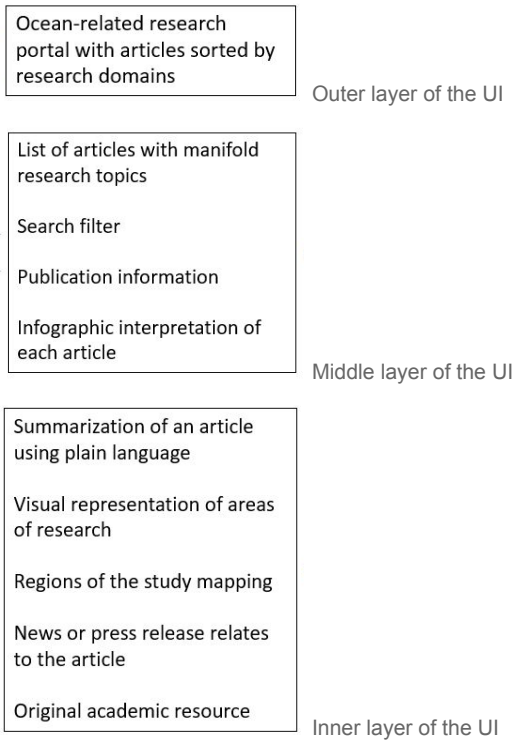

Figure 2. Some elements of the proposed design in relation to the inner, middle and outer layers of the user interface.

Article page (Appendix 3.1)

A view where users can find simplified information about the related OceanCanada's academic paper was a big design requirement of the system. In this page, users have access to a brief description of the paper, its authors, publication date, and images or videos that are used in or produced to support the reader with a better understanding of the context of the publication. Users can also find a link to the original paper (which is usually connected to the publisher's website.) If copyright restrictions are not applied to a specific article, the user could also download the PDF of the original publication. In addition to these, the visualization of the paper's research topics, the regions of study and the press releases that are published in the news (discussed below) also aggregate meaning and context to the article in different levels of information. The basic requirements of this page arose out of the fact that some researchers need the same information that exists on OceanCanada's site today. We decided to build on the information already present, like authors, abstract etc., but also add components to this page that help summarize the article visually, or link multiple types of media to the given research article. We describe 3 such features below:

Research topics (Appendix 3.4-3.7)

Each OceanCanada article will bring an information visualization of the research topics it addresses. In this concept design, we are proposing a sunburst chart that is generated based on relevant keywords that can be extracted

from the article. This visualization provides readers with a glimpse of the importance each topic plays in the article.

Regions of the study (Appendix 3.2)
This is another example of visual representations being used to support the data provided in OceanCanada's papers. When applicable, researchers can "draw" the region where the research was conducted and/or where it addresses. For that, researchers can make use of interactive map APIs (such as in OpenStreetMap and GoogleMaps), where they can manually georeference their research. Alternatively, such data can potentially be extracted from papers.

In the news (Appendix 3.3)
A list of press releases and social media publications that are related to a given research can also be displayed in OceanCanada's article page. This initiative can provide visitors with additional context about a research paper, in narratives with "different levels of complexity." It can also keep researchers informed of how their work is being discussed in different media, as well as how the research information is timely disseminated across various communication channels.

PRELIMINARY EVALUATION

We are interested in whether the visualizations we proposed (the word cloud and the sunburst chart) were effective towards the goal of summary and how they were interpreted. The other functionality of the prototype was simplified to the level of creating the linkage between the components of the portal. (Another aspect that drew the attention of the users was the news coverage of their work).

Usability Testing

We conducted usability tests utilizing [10] a think-aloud protocol followed by a semi-structured interview. We instructed participants to discuss their impressions and thought about our prototype asking them to share "[Their] understanding of what is happening in these screens or how easy it is to understand the tasks." An example of our tasks include, "Please explore the interface, then filter the set of articles to the topic of fisheries". We kept the tasks open-ended so that users would comment on the general flow of the interface. To dig deeper into impressions from participants, we followed the usability test with a semi-structured interview. Questions include, ""How do you feel the overall interaction in this interface? and "Do you feel this interface/prototype could increase the accessibility of academic info from a researcher point of view? Why?".

We began usability testing, testing the prototype with our peers / colleagues and with Ocean Canada researchers. We ended up having 5 participants for usability testing, aiming for the optimal number of participants in accordance with Nielsen Norman Group [11]. Due to technical issues, one of the recordings was lost in transcription. All the participants were tested through Zoom [12] with the recording of their screens after accepting the consent forms. Given the different levels of involvement of people in the topic of the oceans, the results are diverse, but have some similarities.

Findings

Given time and space constraints, we were unable to complete a full thematic analysis. We did transcribe[3] all the observations however and discussed as a group until we converged on what common issues were present and what adjustments should be made.

The most common theme was a request for legends and an explanation of the icons. It has to be mentioned that the presence of the icons without additional explanations might suggest that the users are willing to explore new, non-textual forms of expression of content. Also, the opinion that the authors of the article have to have their own page with all the publications was a common opinion but it was beyond our scope and we assumed that the authors would have such a page as a common practice for the information portals.

In the publication page, a list of articles is presented with the titles, authors and the most representative figures. Originally, the word cloud consisted of a wide range of keywords created to sort out the publications accordingly. As the participants showed a lack of understanding of the word cloud, we decided to design an additional filter interface in order to make the navigation process more effective. Besides word cloud, the selection of "Research topics" and "Regions of the study" are integrated in this new filter interface explicitly. Participants can view a list of hierarchical categories by manipulating these filter options, and search the articles in three different dimensions. According to the setting of the filter, the number of results included in each search is shown aside to "Select all" bottom.

After analyzing the similarities and the differences, we agreed to implement the following changes:

For the map the changes that were made implied the zoom out of the map to give a proper scale to the whole map to make it more recognizable for people who are not from the region. Due to the existence of the working group of Ocean Canada and precisely the Pacific, Atlantic and Arctic regional working groups, the map will have the delimitation of these 3 zones by colors and by the nametags. Since the zones will be in colors already, we will keep the grey color to underline the region of research. We will add name tags to the map.

For the "In the news" page, the default representation will be the list and the chronological one will be added a new icon, representing the time and helping the user to understand that the representation is based on the time when

[3] Raw data available at: http://tiny.cc/80drmz

the press release was published. The switch from one representation to another will be done by the toggle.

The list of the news will have the counting for the times users have opened the press release.

After entering the article page, users can view the publication information in terms of topics, regions of the study and relevant news. To increase the accessibility of each publication, users can download the full contents in PDF by clicking the "Download original article" bottom. However, the user might also enter the journal web page when the paper is only available for its members. The wording "original article" seems to be unrepresentative in this case. Whereas, the option of downloading the full content is selectable only if it is an open access journal paper, and has no copyrights restrictions. Therefore, another link for accessing a paper through the publisher's website is also inserted in the interface. It provides users with more options to acquire the relevant information, even if the paper is restrictive.

On the "article level page" the image from the list of the articles will be added in a better quality then the thumbnails. The image for the article will be adjusted in accordance with the content of the article and might be generated specially for the portal, in addition to the existing images of the article, if any. The Authors will have the universities affiliations listed under their names. Iconography related to the topics of research (possibility to bring these visual representations to the list of articles and article pages).

The Sunburst chart in "Article topics" section provides an immersive visualisation of the categorised topics. The hierarchy through a series of concentric rings disperses outward according to the broadness of the topic.

The main concern users had with the sunburst chart that needed additional explanation on the meaning of the sections and the colors. Also, given the presence of the word cloud on the main page for the exploration purposes, we decided to keep the chart only for the article level and adjusted it accordingly. Instead of using the color gradient to encode the relevant topics, we decide to only display all topics that are covered in a selected article to simplify the presentation of information. To help the user better the visualization, a prompt is created to show users how to read the information in the Sunburst chart.

SECOND PROTOTYPE ITERATION

We iterated on key aspects of the prototype[4] in order to incorporate user's aggregated comments and recommendations. These key aspects relate to how the "list of publications" are filtered and presented, as well as those found in the article page itself, including the "research topic," and the "regions of the research study" visualizations. We kept in mind the areas of action and design requirements elicited during initial design research, so that the new iteration was still relevant and in context to the purpose of this research project. That said, additional elements were also incorporated to provide further context to the article page, such as the idea of including images, tables and charts. The wireframes below are the result of this second design iteration. For each image, we describe what has changed in comparison to the previous version.

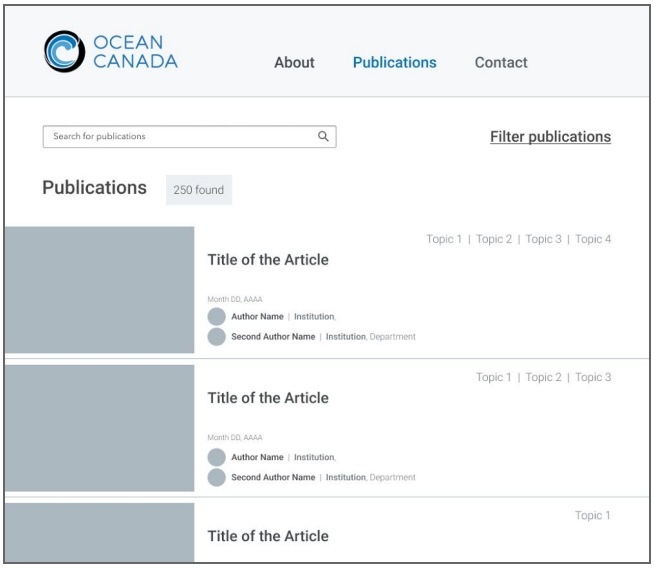

Figure 3: The "Middle Layer" of the interface, displaying all publications in a list to better align with existing platforms.

Publication list and filters

The publication page is presented as a list (See **Figure 3**), which indicates the author, publication date, and topics covered in each article. In the design of this page, we aim to create a concise overview of the publication for readers to quickly taste the themes. A most representative figure aside the title is selected to present the central idea for the article. All the participants in the user testing could promptly select the corresponding article as mentioned in the task. This result evidences the effectiveness of the visualization implementation in the publication page.

The search filter (See **Figure 4**) sorts out the articles based on their research topics, regions, and keywords. Each category consists of a number of literatures that are relevant to the selected parameters. As the participants operate the filter menu, the total number of results varies accordingly which provides them a sense of the amount of relevant information can be found through the database. The word cloud also visually indicates the quantity of the results with corresponding letter sizes. The design of the word cloud is altered to semantically organize groups and visually subdivide topics by location and color [14]. Based on the feedback from user testing, it proves that the filter design provides an intuitive interaction interface for participants to search the target articles in a time-efficient manner.

[4]Link to second iteration prototype: https://bit.ly/3aUTZ11

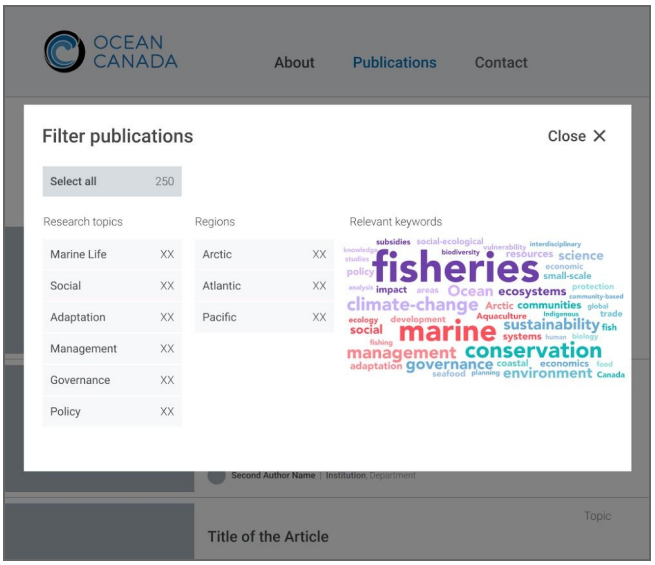

Figure 4: Filter feature with the word cloud embedded to facilitate engagement.

Article page

The design of the article page that we propose incorporates new layers of meaning onto the researcher's publications (See **Appendix 3.9**). The article page brings a description overview of what this publication is about, its authors and their respective affiliations, as well as the possibility to associate images that can both contextualize and reinforce the message of the research. It also features a series information visualization widgets: *Research topics* (Figure 6), *Regions of the study* (Figure 7), and press releases about the selected paper that were published *In the news* (Figure 8). This page supports the original OceanCanada's paper by disseminating its information in a different level of complexity, and potentially reaches different audiences. The *Research topics* and *Regions of the study* infovis, as well as the *In the news* features are further detailed below.

Research topics

The sunburst chart is designed to visualize the research topics covered in each article. The hierarchical data structures consist of an inner circle surrounded by rings of deeper hierarchy levels. The topics are narrowed down as the concentric rings disperses outward. The angle of each segment is proportional to the amount of articles stored in the database that are relevant to the corresponding topics. As some of the participants pointed out the difficulty of understanding the chart, we then added a legend to indicate different topics, and a short instruction to guide participants. By employing visualization techniques, users can quickly browse the scope of an article through a sunburst chart, which would be less mental burden than traditional representation.

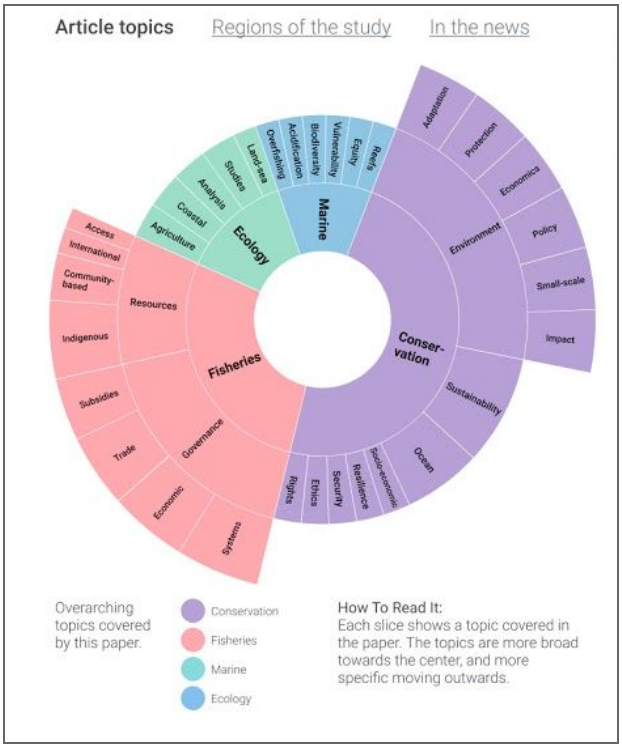

Figure 6: Sunburst chart with legend and instruction prompt in article page.

Regions of the study

Figure 7: Interactive map indicates the regions of the research in the article page.

The visualization of where the research was conducted or where it is about can support the readers to access information without the need to access the paper. Legends are also incorporated to this geo-visualization, and should also represent the regions listed as part of the filter feature.

In the news

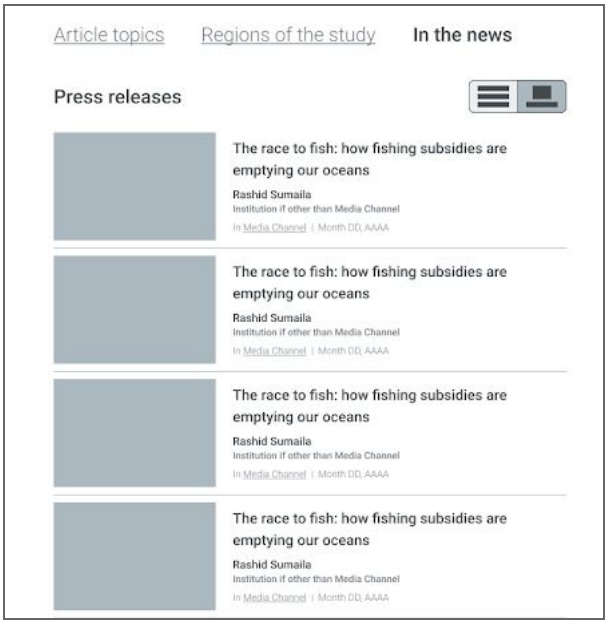

Figure 8: "In the news" list of press releases.

"In the news" tab aggregates all the public press releases related to the selected OceanCanada article in both list and timeline display formats. This feature can support readers to further explore information related to the academic research they are navigating. Understanding that news articles are often written in different levels of complexity, this initiative can also disseminate the research to a broader audience. Researchers will also benefit from having access to a public collection of press releases associated with their papers, visualise how these press releases were timely disseminated in relation to the paper publication, and how they reference the scholars' work.

Figure 9: "In the news" timeline of press releases.

DISCUSSION

The mixed methods approach (survey, assessing individuals interpretations of paper's title and abstract through sketch, and workshop with OceanCanada's scholars) have contributed to identifying the areas of action that OceanCanada can focus on to address knowledge translations of their research papers. The analysis of the data gathered during this research also helped us define the design requirements. With these requirements in mind, we realized that simple implementations can be done in order to work on complex themes such as academic knowledge translation and dissemination. Some of the directions taken in the design concept illustrate this level of simplicity. Sometimes, just by associating images to text we can add meaning and contribute to the semantics of a written piece [13] in different levels of granularity. The images, charts, tables that can be associated with the academic paper in the "Article page" have the potential to both simplify and reinforce the message of the paper.

Similarly, information visualizations can also provide additional context to the academic papers. In this sense, by using the word clouds and sunburst charts to visually represent the relevant keywords of the academic paper collection and areas of research of a specific paper, we are also providing readers with other ways to make sense of the academic information. This is consistent with the knowledge translation approach of translating knowledge at different levels of expertise — a text summary might be more catered towards academics as it might still have some jargon from the source document, while visualization can be interpreted more simply.

From the usability testing, participants who were researchers noted the limitations of the generation of the visualizations: the effectiveness of the visualization is highly dependent on how well the topics are generated. The visualizations are as useful as the topics they visualize are useful. We proposed to use a topic modelling, a natural language processing algorithm, to generate this hierarchy of topics, and a natural limitation is in how well this model can represent these series of topics. Future work should delve into what an effective topic model for this domain looks like.

FUTURE WORK

While we created two visualizations for topics in our prototype, different papers require different visualizations. Additional visualization widgets can be created to cover various chart options (e.g., interactive bar, scatter plot, gantt charts) and to encode other information present in documents. Research in infovis and NLP have shown promising results that could be extended for this project.

The Article topics and areas of research can also benefit from iconography. This is especially helpful for the "Middle layer" page in which a list of articles with several areas of research are displayed. These icons could provide visitors with initial visual cues that relate to the paper's research topics.

Social media can also benefit the *Article page*. Similarly to the press releases displayed *In the news*, we could also embed twitter and instagram posts that relate with the given article or OceanCanada work in general. With this feature, researcher can make use of #hashtags to aggregate additional content to their publication page. The hashtag #OceanCanada, #CanadianMarineLife, and #OceansAndFisheries are few examples that could be used.

CONCLUSION

Knowledge translation is a difficult, domain-specific task where designers have to balance many stakeholders and requirements. In partnership with OceanCanada, we propose an interface targeted for non-experts that leverages KT methods. We apply KT methods to a new domain, ocean research, by adding context through additional information such as press releases or through visual summarization in the form of a sunburst chart and a word cloud. We follow a design study approach to building our interface through constant user feedback, and evaluate our prototype through usability testing. Based on our preliminary usability testing, we find signs of user engagement with our visualizations, indicating this might be a promising method of KT for other domains.

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APPENDICES

A1: Personas

A1.1 Primary: Geoffrey Kennedy

Geoffrey Kennedy

19 years old

Undergrad student

From San Francisco, CA

Lives in Vancouver

"I try to read more academic articles, and acquire information for my research. Searching and organizing this type of information take up too much time for me."

Geoffrey is a university student studying Environmental Sciences at UBC, and interests in oceanography and hydrology research. He is very diligent and talented student, who spends 70% of his leisure time on searching and reading the information related to environmental sustainability through all kinds of online sources.

As a first-year undergraduate student, Geoffrey participates in physical oceanography research project at UBC Ocean Dynamics Laboratory. This research experience gives him opportunities to exchange knowledge with other lab members, and access to advanced technology in the field of ocean science.

He enjoys the process of research and learning, but also acknowledges the gap between his knowledge base and the academic research. He often has a hard time interpreting articles with complex data and terminologies. However, he finds that sorting out key points from those articles sometimes helps him understanding the overall idea.

While studying, he feels that searching literatures and reading papers could be the most time consuming process, and he is concerned that this process might affect his efficiency and reputation on the research.

Behaviours
- Looks for literature online.
- Uses social media to share information.
- Inclined to learn about the oceans and its effects for the planet.

Aptitudes
- Needs intuitive interfaces that are easy to search and extract information.
- Concerns about the health of communities that depend upon oceans.
- Willing to know more about fish and marine mammals.

Constraints
- Lacks of professional knowledge of ocean science.
- Lacks of experience on academic research.
- Shortage of time.

Frustrations
- Has a hard time understanding jargons and terminologies.
- Has difficulties elaborating the main ideas of articles without background knowledge.
- Has Trouble understanding papers in which the ideas seem unstructured.

Goals
- Needs a way to conduct information acquisition efficiently and precisely.
- Wants to normalize the academic language to a level that publics can understand.
- Needs a way to balance the information integrity and multiplicity.

Information sharing habit
Online communication

Level of knowledge in ocean science

Low — High

Concerns about the oceans' health

Interest for ocean-related articles

Tech friendliness

A1.2: Secondary: Maria Chin

Maria Chin

39 years old

Associate professor and Researcher at the UBC Ocean Dynamics Laboratory

Faculty staff for 3 years

From Vancouver, BC

"I'm constantly publishing, but I know that not one third of my readers are students on their first years."

Maria Chin works as a professor at UBC. She established Ocean Dynamics Laboratory in 2018 at UBC Department of Earth, Ocean and Atmospheric Sciences. Maria is interested in understanding how the oceans work. Her research interest includes coastal systems, physical oceanography, and geophysical fluid dynamics.

Over the past 3 years, Maria conducted lots of complex fieldwork and publications with her research team. She possesses large amounts of experimental data and resources in ocean research field.

She often exchange the technical information of experimental findings and academic knowledge with her research students who have professional backgrounds in ocean science.

In terms of knowledge sharing, Maria participanates in different academic exchange events between universities. Her profound knowledge and insights in academia can always bring some advanced research concepts, and inspire other academics.

Behaviours
- Conducts academic research and oceanographic fieldwork with graduate students.
- Participates in professional ocean research conferences.
- Shares technical resources and knowledge with other reseachers.

Aptitudes
- Prefers to use first-hand data, and review scientific papers.
- Think that numerical data and academic readings are more persuasive.
- Tries out advanced technology to conduct research.

Constraints
- Wants to spend more time working on her research.
- Doesn't address questions through online communication tools or social media.

Frustrations
- Belives open online publications aren't the best means for making her researh public, nor for getting reliable scientific information.
- Has difficulties meeting both the cognitive needs of novice practitioners and the experiential needs of expert practitioners at the same time.

Goals
- Wants to conduct more collaborative research projects with research partners and non-academic institutions.
- Wants to present her research findings in a professional manner.

Information sharing habit
Academic publications, e-mails/lists

Level of knowledge in ocean science

Low — High

Ocean health concerns

Interest for ocean-related articles

Tech friendlinesst

A2: Scenarios

A2.1 || Scenario 1: Frequent

Maria has to teach several undergraduate classes in different semesters, including introductory oceanography and marine pollution so she tries to stir up students' interest in these subjects by involving her research stories in the lectures. Most of her academic papers and literature are posted on Google Scholar and UBC Library. She introduces lots of critical research findings in ocean and environmental sciences to undergraduate students in her classes. She demonstrates the cutting-edge research technologies used in her lab, and shows the experimental data with numerical analysis in a very professional and convictive manner. After the lecture, a group of undergraduate students showed their great interest in her research, but they also felt it was hard to fully understand Maria's papers and experimental results based on their knowledge background. She also tried to simplify the technical contents, and explain the academic information to her students in a well-understood way. She felt that the undergraduate students were more likely to talk in plain language, which also increased the communication efficiency since the questions about academic jargons became less. Although, Maria thinks it's difficult to cover every piece of information in a paper and maintain the correctness of the contents when using a simplified verbal expression.

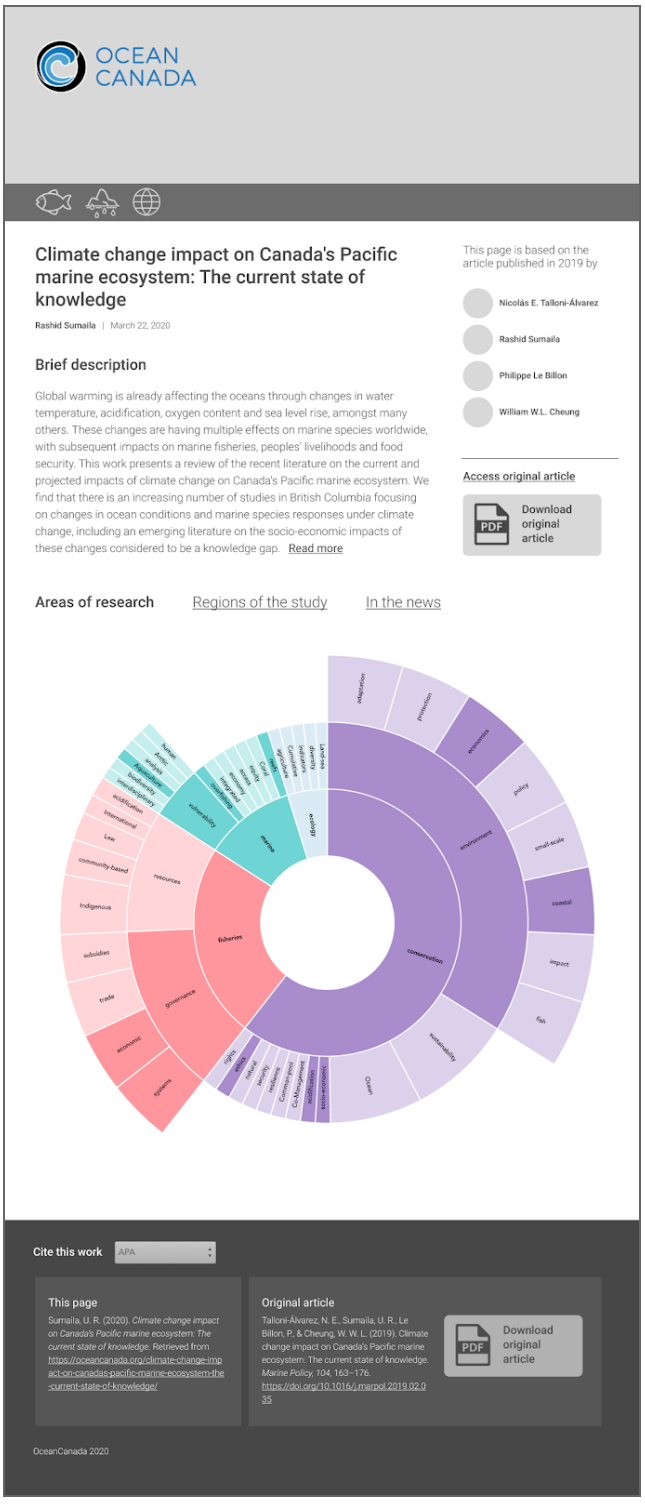
A2.2 || Scenario 2: Infrequent and Important

Maria conducts studies in ecosystem modelling approaches and tools in order to understand how human activities impact the ecology of our marine ecosystems. She leads her team to publish around 3-4 papers a year. One of her papers "A Critical Appraisal Of Catches And Ecosystem Impacts" is accepted by Science journal. She contacts the communication team in Earth and Ocean Sciences faculty, and plans to initiate a press release regarding her new paper. A staff from the communication team organizes an interview session with Maria, and records the general research information behind, and starts the rest of the press release process including reviewing the paper, simplifying the content, creating the video, and disseminating the newsletter. After a month, Maria is informed that the press release is still being processed. She really wants her research findings to be disseminated in an efficient and professional manner, but she thinks going through the press release process can be time consuming and complicated. She also wants to participate in workshops that are hosted by UBC Media relation office, and learn how to effectively conduct self-promotion, disseminate the research, and make it impactful. However, it is difficult for her and her research team to invest more time on the public outreach and press release process.

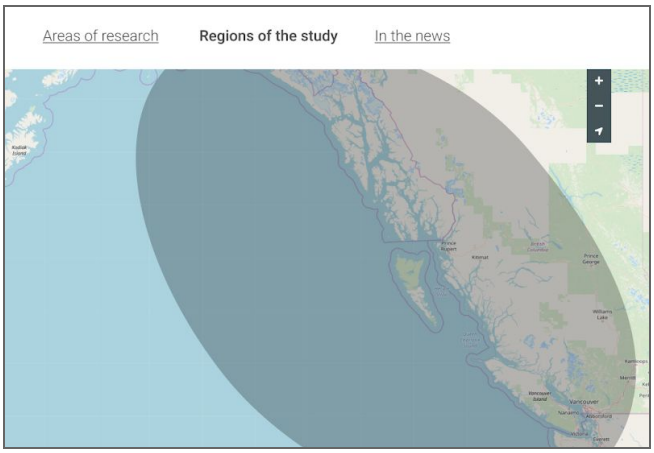
A2.3 || Scenario 3: Infrequent

Maria is a director in UBC Ocean Dynamics Lab, she leads her research team to conduct marine ecosystems studies. She is also directing a number of industrial projects in the field of ocean science. In order to keep track of the industry dynamics, Maria often uses Google Scholar and UBC Library to acquire the relevant information from the publications. By reviewing the experimental results and analysis from other researchers, she refines her research directions, and validates her research findings. However, without a search function that sorts the topics and categorizes the results types, she has a hard time finding the data that is relevant to her research. She thinks the coverage of Google Scholar is wide-ranging but not comprehensive enough for open access journals. When she tries to share those online resources with her research team, some of the students complain about the difficulty of accessing the papers that are only available for certain academic institutions or affiliations. She feels the process of information acquisition is time consuming. It takes a long time for her to filter out the papers, and determine which of the results are suitable for her purposes.

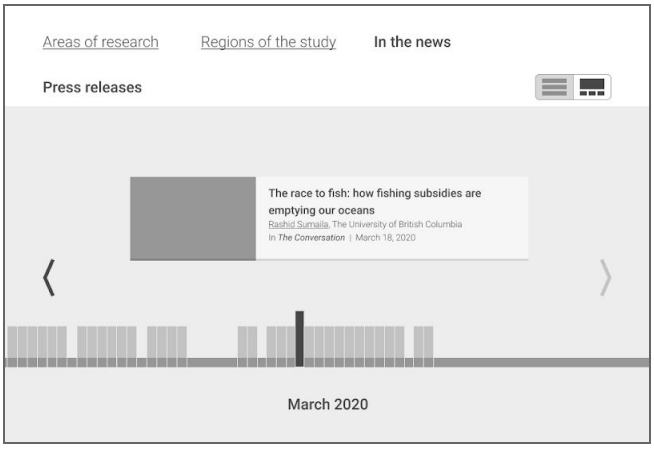
A3: Wireframes & Preliminary Prototype Design



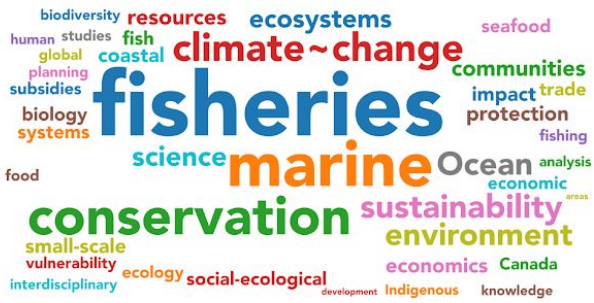
A3.1. OceanCanada's article page featuring a brief description of an academic article on climate change and a sunburst visualization of its related areas of research.



A3.2. A map displaying the geographic region addressed in the chosen paper's research. This map would be navigable and as specific to the region as possible. For papers that have no geographic component, this tab would not be available for selection.

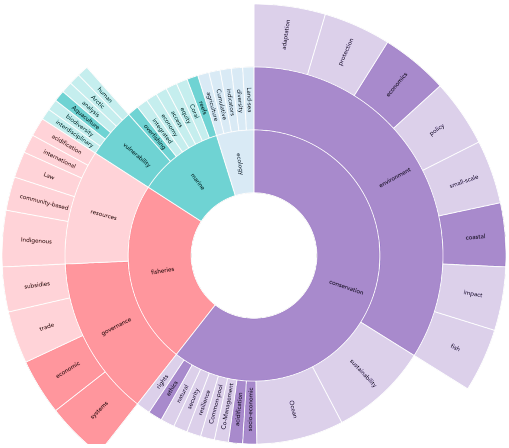


A3.3. Timeline of press releases and social media posts related to an academic article.

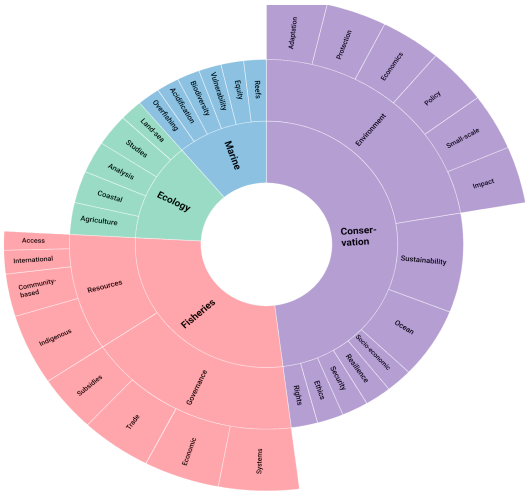


A3.4. Word Cloud v1.0. Words extracted from metadata and keywords provided by Ocean Canada.

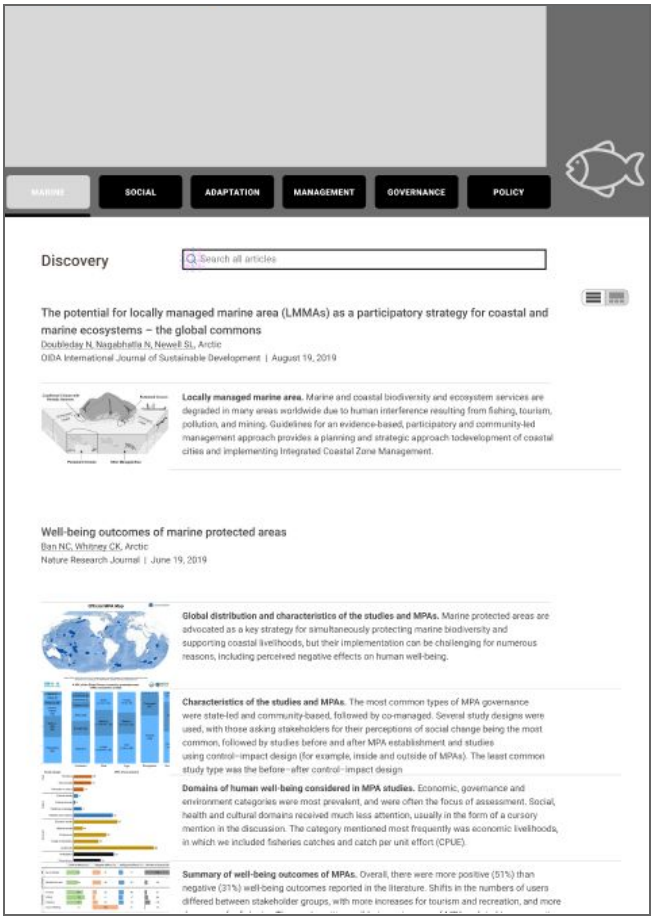
A3.5. Word Cloud v2.0. We redesign the word cloud and add semantic information through position and color. While manually grouped here, an ideal solution would group according to thematic similarity using word similarity measures.



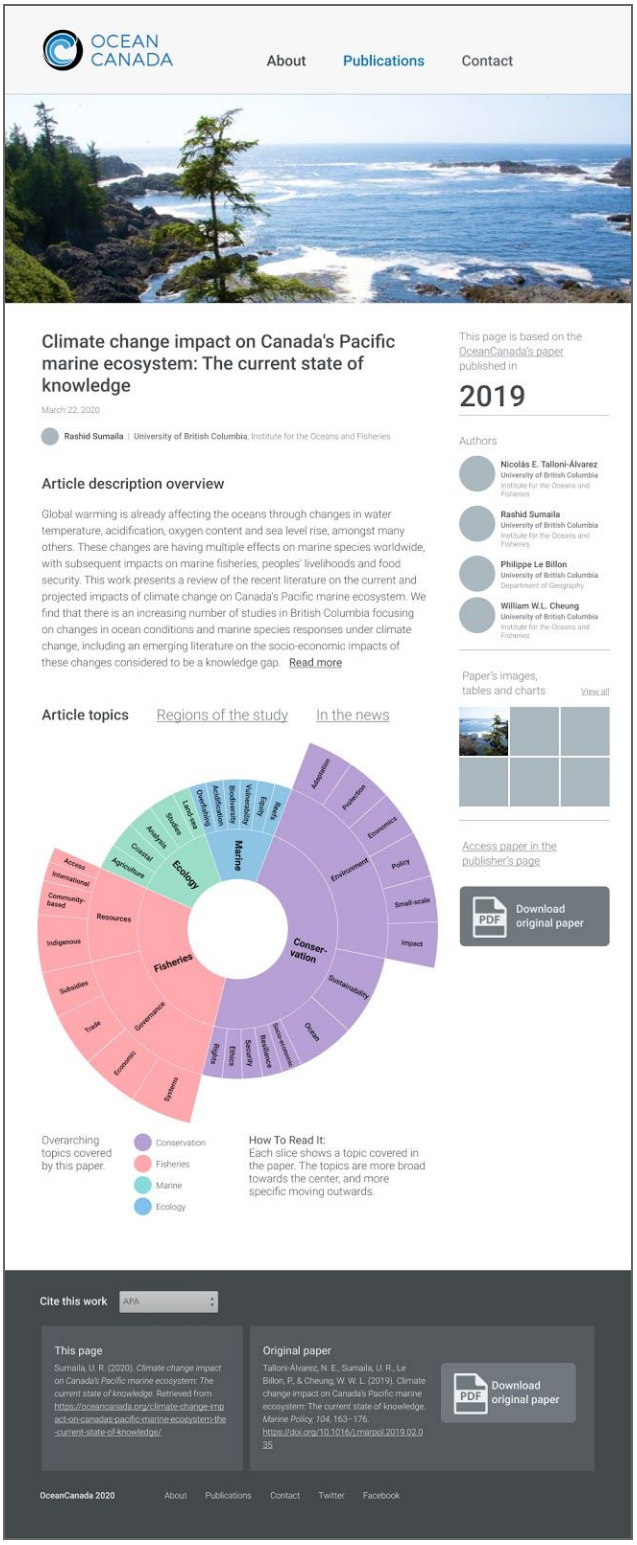
A3.6.Sunburst Visualization v1.0. Originally designed to be on the article page of the prototype, this chart was meant to show the whole taxonomy of possible topics. The shaded areas correspond to which subtopics the current article describes and can also be used as navigation.



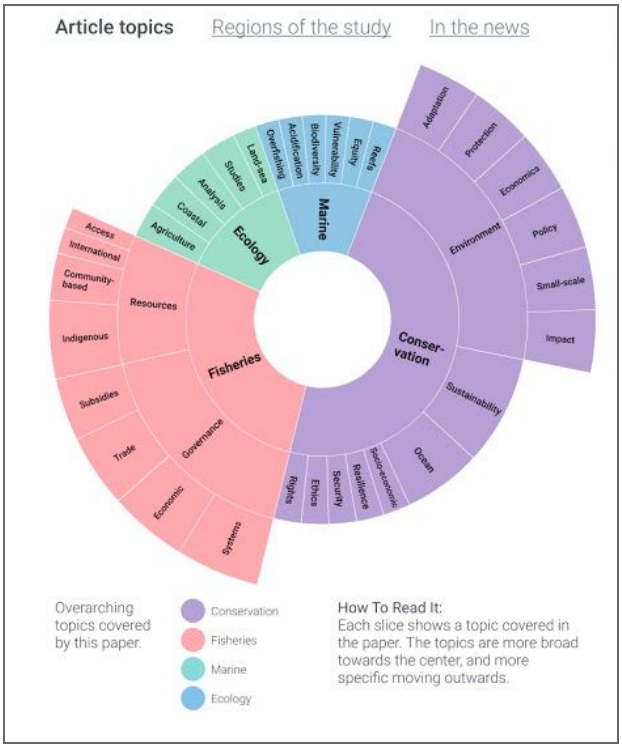
A3.7.Sunburst Visualization v2.0. The chart displays only topics about the current research paper. Topics are hierarchically generated through topic modeling.



A3.8 "Middle Layer" Collection of all research articles.

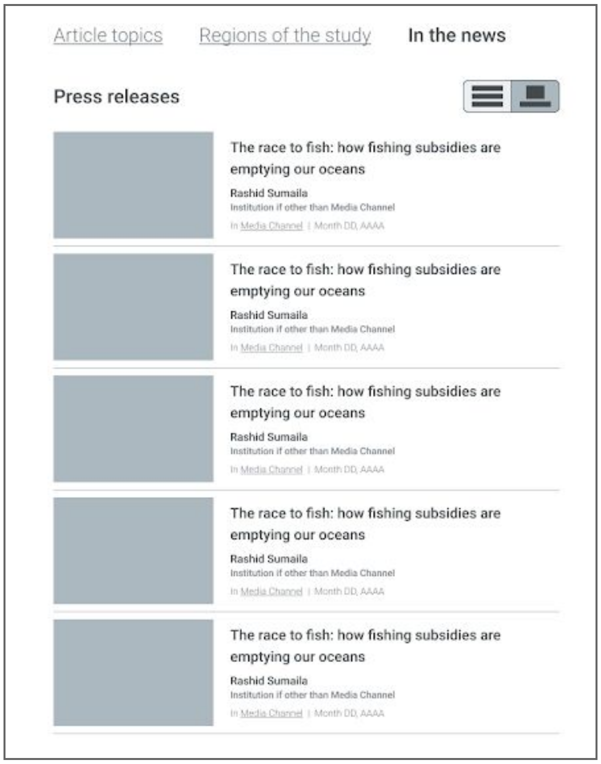


A3.9: Article page. It is composed of a collection of infovis, descriptions of the academic research displayed, as well as images (photos and charts) and news articles.



A3.10: Sunburst chart with legend and instruction prompt in article page.

A3.11: Interactive map indicates the regions of the research in the article page.



A3.12: In the news. List of press releases.

A3.13: In the news. Timeline of press releases.

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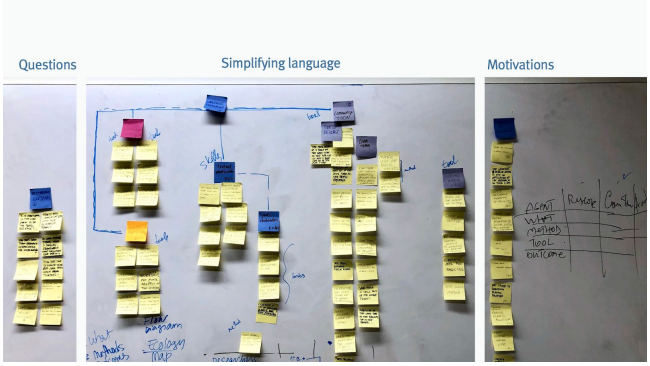
A4: Design Method Protocols

A4.1: Survey Questions

1. Please choose one of the category below that includes your age.
2. What is the highest level of education that you have achieved or are currently pursuing?
3. What is your field of studies?
4. Please rate the following questions on a scale from 1 to 5 (1 being the lowest, 5 the highest).
    a. How knowledgeable are you about the importance of the ocean for the planet?
    b. How interested are you in learning more about the ocean and its effects for the planet? (1 - not very interested, 5 - very interested)
5. How often do you read and listen to the news or information that is relevant to oceans?
6. Please chose the level of concern for each of the questions below
    a. How concerned are you with the health of the oceans?
    b. How concerned are you with the health of communities that depend upon oceans?
    c. How concerned are you with the quality of aquatic products?
7. What are your concerns about the oceans (if any)?
8. How do you see climate change impacting the health of the oceans?
9. If there is a tool that makes ocean knowledge more accessible, what topics would you be more interested in? Please rank them in order of priority 1 - being the most interested in and 6 - the least interested in.
10. Please list up to 7 terms that you most associate with the importance of the ocean on the planet
11. How do you normally acquire scientific or academic information in your field of study? Check all that apply.
12. What are your preferred methods of information sharing?
13. Feel free to share with us anything that you find relevant for this survey but was not asked above.

A4.2: Affinity diagram



Affinity diagram created as part of the analysis of the workshop with OceanCanada's scholars. Raw data of observations for affinity diagram available through the URL: https://bit.ly/3e2qL29

A4.3: Usability Test Script

User testing questions

Don't forget to screen / audio recordThe aim of this platform is to make academic research available to various audiences (ex: researchers, highschool students, reporters). Please speak up your impressions and thought about:

–Your understanding of what is happening in this screens or how easy it is to understand the tasks.

Please, try to filter the list of articles on the topic of 'fisheries'

Please go back to the home page

Please go to the article with the title "Climate change".

Now we are on the article page, where you can explore a little bit, for example if you wanna have a view over the Region this article is describing or if you wanna see what new coverage this article got.

As a next task, we want you to download the PDF of the article. Also, we want you to access the citation of the original article.

Follow-up questions:

1. How do you feel the overall interaction in this interface?
2. How clear was the word cloud exploration?
3. How self explanatory was the Chart visualization?
4. What other functionality would you add? Or which one you want to omit?
    a. What elements or functions should be improved for the current experience?

5. Do you feel this interface/prototype could increase the accessibility of academic info from a researcher point of view? Why?