Research Article

Visual Science Communication: The next generation scientific poster

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To communicate by visual means lies in the nature of humankind. Today, in the natural sciences, visualizations transfer data into useful and communicable information. But which types of visualizations are best suited to represent scientific findings in a clear and comprehensible way? This is where visual science communication research starts. To communicate the latest scientific findings to the public, we have developed a new format that combines the traditional scientific poster with a new and innovative approach: the next-generation interactive scientific poster. New technical possibilities offered by interactive media help to transform scientific findings in an intuitive way that allows, due to interaction, to adjust the level of detail and information that is presented to various audiences (see Figure 1). We explain how we have conceptualized, developed and designed the interactive scientific poster »Explore the Ocean« with an interdisciplinary team of scientists and information designers to create a platform to bring ocean observations and findings to a broad public to improve ocean literacy in society. Additionally, the interactive poster also provides an opportunity for scientists to communicate their often complex results to stakeholders. One of the biggest challenges for visual science communication is to develop effective visualizations that are attractive and emotional, yet scientifically accurate and substantial. For the production of these new visualizations, an interdisciplinary team is key to providing state-of-the-art design and programming skills but also to ensuring scientific accuracy. In this perspective article, we describe the advantages of interactive media in the visual communication of marine sciences. Furthermore, the suitability of interactive media to raise ocean literacy and societal connections to the ocean is discussed.

We conclude that the collaboration between scientists and design experts has significant advantages and enables the transformation of scientific findings through advanced visualization techniques into a consistent language and effective communication media for specific audiences.

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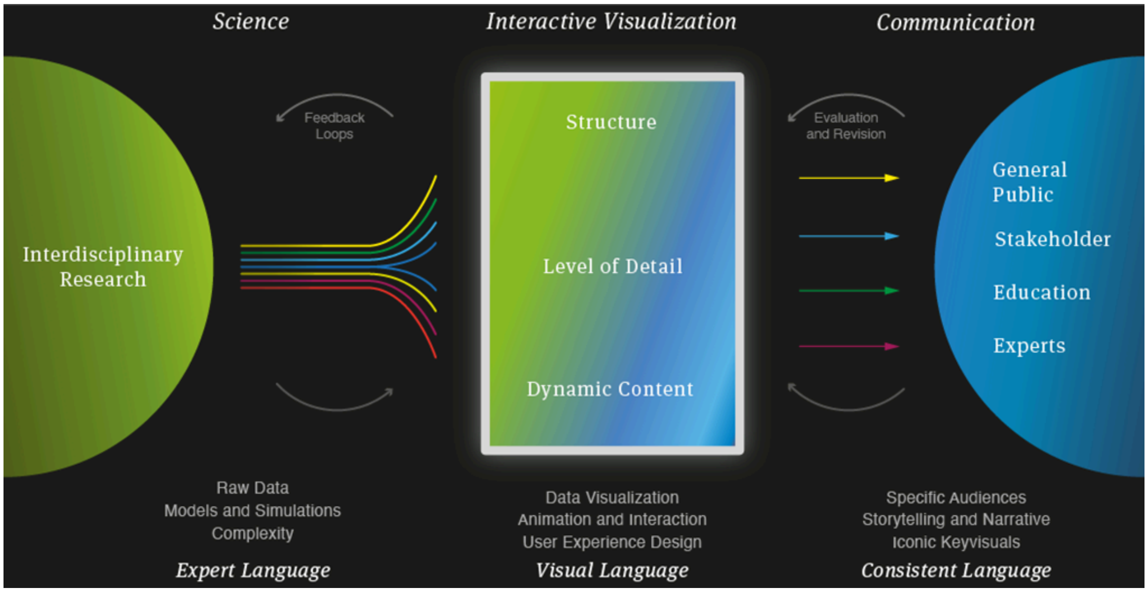

Figure 1. *Knowledge Transfer Process in Visual Science Communication: Research data and findings are translated into a visual consistent language to communicate with specific audiences. To develop the interactive visualization an iterative process with scientists and designers is needed. Testing, evaluation and revision loops with the audience improve the product. A specific audience can be reached on a visual and emotional level and can be introduced to a detailed scientific topic through narration and iconic keyvisuals.*

1. Introduction

Long before written language, people used visuals to communicate. Prehistoric cave paintings did not only serve as a message for future generations, they still touch us today and help us to understand past cultures. The links between knowledge and visuality have historic and cultural roots (Drucker 2014). Also, today we often express ourselves faster and more comprehensively through the use of visual means. In science, data analysis is followed by a visualization to understand and gain insights into the data. The challenge in the visualization of scientific knowledge is to select the appropriate mean of visualization to filter and depict relevant research results. Obtained visualizations are used for the communication of knowledge in publications, lectures or on scientific posters. Here, we want to emphasize the traditional scientific posters, since they contain the visual quintessence for communication between scientists: Usually printed on DIN A0 paper, they depict state-of-the-art research, experimental setups and results in a coherent way and thus serve as a template to present

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concepts or newly gained findings. Usually, scientists are expected to have the ability to design scientific posters in an appealing and logical way, visual literacy is assumed. However, the development of this ability is seldom taught. Thus, scientists very often fail to choose the appropriate visualization method (O'Donoghue et al., 2010).

In recent years, technical progress, for example in the biological and medical sciences, has led to an enormous increase in the amount of data that needs to be analyzed. At the same time, good visualization of these "big data" or "omics" is becoming more and more urgent, since the understanding of this huge, often very complex amount of data can be simplified through visualization (Gehlenborg et al., 2010). Numerous tools and software have been developed to support scientists in data visualization (overview in Pavlopoulos et al. 2015). For many scientists, the advantages of eloquent science communication are also becoming increasingly clear, as it fosters the acceptance and perception of their research in the general public and thus helps scientists to achieve higher public visibility, which can entail the chances of receiving research grants. The increased interest in science communication is also reflected in the distribution of funds to foundations and funding agencies. In recent years, the share of funding for science communication has grown and has even established itself as an independent field of research: The science of science communication. What is still missing, however, is the integration of visual knowledge developed in a long tradition of art and design research and it is now time to bring this knowledge together and establish a new visual science communication.

The demand for communicating scientific findings to the public has increased (Brownell et al., 2013; Bubela et al., 2009; Secko et al., 2013; Strasser et al., 2019), not least because of the massively increased possibilities offered by digital and connected media (Pavlov et al., 2018). Social media also gave rise to a discussion about the truth of scientific findings and general skepticism about scientific facts (McClain, 2017). This in turn created a new need for self-representation and how complex research contexts can be communicated to the general public and stakeholders in an understandable and comprehensible way (see Figure 1 for an overview of the knowledge transfer process in visual science communication). Consequently, we are observing an increase in research and publications in this field: In 2020 articles with the term "science communication" in their title have been published 4 times more since the beginning of this millennium (Google scholar search on 25th of April 2020) and publications in the three most relevant journals for science communication have quintupled between 1980 and 2016 (Guenther & Joubert, 2017).

The traditional means of science communication are usually either found in written form as texts and articles, as visualizations such as infographics and animations, or as video and sound documents. Thanks to new technical possibilities, these means have been supplemented in recent years by new media and formats such as interactive websites, virtual or augmented reality apps. Interactive media have the benefit of being able to map information at various levels of intensity or complexity and thus easily respond to different levels of individual knowledge (Figure 1). In addition, interactivity enables the combination of different media to communicate science in an effective and interesting way. Recently it has been shown that interactive media are more capable to explain complex biological concepts than traditional media (Horn et al., 2016).

These positive effects of interactive science communication enable the development of a consistent visual language to address various audiences (Figure 1): The general public can be reached on a simplified, visual and emotional information level and can be introduced to a detailed scientific topic through in-depth links and texts. Especially interactive animations are very well suited to explain more complex correlations. This strategy of reduced cognitive load also supports the use of interactive media with scientific content for hybrid learning in schools. Narrative image sequences and animations support the process of cognition and learning, and multimodal learning comes closest to direct experience (Dale, 1969; Sorden, 2013). Since young adult audiences are already confident in the use of interactive media, it is important to be able to communicate scientific topics on these contemporary platforms on a professional level in order to be perceived as authentic and reliable.

To evaluate interactive media, an important factor is the usability of the respective media as well as the user experience (UX). However, in contrast to the mere functional quality of usability, the UX evaluates more emotional aspects, such as motivation, curiosity, enjoyment and identification (Hassenzahl, 2008; Kulzer & Burmester, 2018; Paul & Heinecke, 2014). Therefore, great importance is given to these aspects in the development of interactive media, as this defines the quality of the design.

Since 2007, we developed and researched visualization and communication formats in various scientific fields. Our design research is mostly project-oriented and we test, evaluate, and reflect on their impact on the general public (Frahm, 2019; Hauser et al., 2017). One of the biggest challenges for visual science communication is the combination of traditional and contemporary media and the production of new media. This is because the teams producing these media must be interdisciplinary to meet the design and programming challenges but also to ensure scientific accuracy. The

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collaboration between artists, designers and scientists has advantages for all parties and enables the best possible output and should be pursued more intensively in the future (Duscher et al., 2017).

In this perspective article, we focus on visual science communication in its fundamentals and especially on the advantages of interactive media to improve and increase the use of information derived from ocean observations and marine science institutes for the communication of scientific knowledge and to raise ocean literacy. We describe an innovative format to communicate scientific information by combining interactive with traditional communication means: the next-generation interactive scientific poster. It combines the traditional science poster with new technical possibilities by using a large interactive multi-touch display as hardware and interactive media programming as software. It presents scientific knowledge in an intuitive way that allows, due to interactivity, to adjust the level of information that is presented as a unique experience to the user. The interactive poster primarily addresses a technophile and media-orientated audience that prefers to be inspired by expressive images and animations. However, the perhaps less technically versed audience also appreciates the format of the interactive poster: Modern and contemporary technology contributes to a perception of actuality and progressiveness of research. In order to inform stakeholders, the simplified and clear presentation of the research topic gives an overview and starting point upon which the currentness of the respective research can be further discussed (Kulzer & Burmester, 2018). Experts appreciate the non-linearity of the interactive poster, which allows them to present their research in an individual way (Hauser et al., 2017).

2. Implementation

2.1. Fundamentals in visual science communication

Cartographer and information designer Edward Tufte once stated that excellent design is clear thinking “made visible” (Tufte, 2001). To define excellent design through thinking and perception, it is helpful to analyze how understanding basically works. Design can be structured and tested following the stages of understanding (Kirk, 2016): First, there is perceiving: What does a visualization show? Then interpreting: What does it mean? And at least - comprehending: What does the visualization mean to me? And are there any actions to take?

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When designing, a consistent visual language is key: Analog to semantics and syntax in the written language, a consistent visual language enables a stringent narrative structure. The insights gained from classic communication design and user experience design play a central role: Systematic use of visual images has created standards and consensus across a wide variety of disciplines that depend on visual observation and analysis (Drucker, 2014; Kemp, 2000). The following aspects are crucial fundamentals of a clear visual language and they are essential for interactive information design and for the positive effects of learning with multimedia presentations in visual science communication:

- **The relationship between text and image** was redefined at the beginning of the 20th century by typographers like Jan Tschichold. The New Typography (1928) and Asymmetric Typography (1935) articulated a graphic method, not just a statement of aesthetic belief (Drucker, 2014). Since then, graphic and editorial designs have developed methods to structure information by organizing texts hierarchically and making them more accessible. This was also the starting point for navigation systems' structural orders in contemporary interactive media.
- **The visual representation forms and formats of complex data** (Kirk, 2016) are crucial for the understanding of trends and correlations of data. And especially in a time of distrust in scientific data, a serious but comprehensible presentation is necessary.
- **The analysis and preparation of data to convey information.** The beauty of data is often hard to find, especially for non-scientists. Therefore, the cooperation of scientists and designers in the interpretation of the data is crucial. For a visual to qualify as beautiful, it must be aesthetically pleasing, but it must also be novel, informative, and efficient (Steele & Iliinsky, 2010).
- **The cognitive process of perception** is well investigated with the cognitive load theory according to Sweller (1988) and confirmed in several studies (Clark et al. 2006). According to this theory, information is best retained and received if there is no overload of the visual channel and the working memory can be supported by using different sensory channels (Weber et al., 2013).
- **Visual storytelling** is a powerful way to establish step-by-step presentations, especially in the communication of scientific topics. This form of sustainable learning is particularly successful. Instead of showing the overall picture, the process of creation is built up step by step and thus becomes comprehensible (Nussbaumer Knaflic, 2015; Weidenmann et al., 1998). The concept of storytelling with data differs from the "traditional" telling of a story using characters, events, and scenes, but is basically about the emotional and suggestive mechanics of storytelling. Traditional stories typically present a set of events in a linear progression. Data stories similarly can be

organized in a linear sequence, they can also be interactive and draw non-linear but holistic connections. (Segel & Heer, 2011).

- **Animation and time-based media and their dramaturgical and narrative potential**. Remembering narrative forms is deeply rooted in human psychology. Multimedia support the way that the human brain learns: Animation and videos in combination with a narrative verbal or textual explanation have a deeper impact and learning effect than an exclusively verbal or textual presentation (R. Clark & Mayer, 2008; Mayer, 2009; Sorden, 2013).
- **The interaction between humans and machines** has been the subject of many usability studies since the 1980s (e.g. Hassenzahl, Diefenbach & Göritz, 2010; Partala & Kallinen, 2012; Tuch et al., 2016). In the conventional sense, this interaction analysis refers to actions to control and navigate the specific content rather than to a holistic experience of use. Interaction enables immersion and makes connections or processes become visible that otherwise might be too complex to understand. Therefore, interactivity leads to an integrative knowledge generation and enables different points of view.
- **Organization and structuring of content with nonlinear media.** (Weidenmann, Paecher, and K. 1998) researched the methodology of "zooming presentation". The connection between overview and detail increases the quality of knowledge acquisition and brings the user into an active relationship. This supports an activating, cognitive process (Hassenzahl 2008).
- **Unique Experience Design is the key to knowledge transfer**

  New possibilities in the design of interactive media make use of positive experiences in the operation of touchable surfaces. Touch and swipe gestures make the operation of interactive applications intuitive and are familiar to users from handling everyday media such as smartphones and tablet PCs. Numerous studies of user experience (e.g. Hassenzahl 2008) show that touch media can be used to improve the mediation and comprehensibility of the operating structure. Thus, users can pursue their own interests and selections within an interactive application. Especially with interactive infographics, a high degree of interaction is desired, so that users have a positive experience and are motivated and enthusiastic about infographics (Weber et al., 2013). In science communication, these aspects of experience design have been mostly neglected so far. This is primarily due to a lack of visual design strategies. Consistent design, classical derivations from information design and user experience design must be given higher priority in scientific communication. Visual science communication does not only make visuals just look nicer. Visual language is essential to make useful comparisons, it gives structure to data and a new perspective to look at. At the same time, visual design needs to be trustworthy. It may not idealize data and it has to be transparent with all information about its sources (Duscher et al., 2017).

- **Information aesthetics**

  Several international awards such as the "German Design Award in Gold 2019" or the "Information is Beautiful Award 2019", which is highly renowned among design experts, attest interactive scientific posters a high level of design quality and aesthetics. But what makes an information visualization really "beautiful"? A successful information visualization must be novel, informative, efficient and aesthetic (Steele & Iliinsky, 2010). However, these are not the goals of a beautiful visualization, but rather its intrinsic attributes (Gough, 2017). Aesthetics play a major role in the design of interactive scientific posters but is not an end in itself. It increases the attractiveness and motivation to engage with a topic (Overbeeke et al., 2003) and, in contrast to classical scientific visualizations, enables non-experts to access a subject. A well-designed visualization stimulates the intellect (Hagy, 2010) and emphasizes the value and importance of scientific investigation. Excellent science is highlighted by excellent design, representing the precision and depth of research (Duscher et al., 2017). Art and design have thousands of years of knowledge about the aesthetic impact of visualizations. Combined with new technological forms of representation, this can lead to a new approach in visual science communication.

2.2. *Towards a new approach for interactive media in science communication: The next generation interactive scientific poster*

The novelty of the interactive scientific poster lies in the combination of different media in one interactive application. Thus, the combination of data visualizations, detailed 3D animated models and coherent formulated texts creates a new communication format that enables scientists to present their research in a comprehensible and multi-faceted way. The interactive poster is highly informative because it allows various insights also for non-experts: Starting from a general overview and introduction, the user can choose the degree of in-depth knowledge and determine the level of detail. Fundamental to the interactive poster are its interactive usability and the consistent presentation of the scientific content. By structuring the content, different aspects of scientific research are gathered in a single poster, which can be accessed according to the user's interests and pre-knowledge and thus leads to a positive user experience. For the development of an interactive scientific poster, we always work in an interdisciplinary core team consisting of information designers, 3D artists, programmers and scientists. The strength of the interdisciplinarity of our team lies in the combination of high design competence, i.e. showing the complex science content in a visual consistent language, with the scientific accuracy of the visualized contents.

In the following section, we will describe the implementation of the fundamentals and findings of visual science communication into the new format interactive scientific poster. So far, we have developed eight interactive scientific posters in close cooperation with scientists from different fields (see supplement table 1). Two of them were evaluated regarding user experience and presentation Frahm 2019; Hauser et al. 2017).

Use case interactive scientific poster: »Explore the Ocean«

Due to the poster's interactivity, a user can immerse in marine research (see supplementary video). Through intuitive touch and swipe gestures, ocean research knowledge can be explored at a portrait-mounted 55" interactive multi-touch display (Figure 2). Intuitive zooms, for example, enable easy recognition of geographical data patterns and data sets can be compared with each other.

Project start: Communication goals, target groups, "user stories"

In the beginning, we clarify in collaboration with the involved scientists where the poster is situated and which functions, features and communication goals the interactive scientific poster should have: i.e. who exactly is the target group, what are the contents should be communicated, does the poster work with a presenter or is it self-explanatory. To define these functions, brainstorming, card-sorting, and so-called "user stories are formulated in a creative process. Taking this information into account and following the fundamentals of visual science communication explained in the section above (and in Figure 1), the concept including all contents, structures and design decisions can be developed.

Concept and structure of "Explore the Ocean"

This interactive poster is installed on board of a cruise ship and at the main entrance of the GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany. It can be accessed by presenters, but should primarily be self-explanatory. Its target group are interested laypersons - i.e. interested users with a certain level of general education but no expertise in marine research. In the case of the cruise ship, the target group can be described more precisely as elderly, established and scientifically interested travelers, who like to deepen their personal experiences with accurate scientific knowledge. The main communication goal of the interactive scientific poster is to increase the ocean literacy of the target group. Interaction with the poster “Explore the Ocean” allows an immersion below the sea surface, the water column and the sea floor, but also up into the atmosphere and shows organisms and processes that are normally invisible. Fifteen marine research topics including geodynamics, biosphere and climate were prepared to comprehensively communicate information and findings (see supplementary for the list of the topics). A further part shows gliders, buoys and other ocean observation instruments.

Structure and navigation: An animated, rotating globe with the heading "Explore the Ocean" is presented on the start screen. Two arrow buttons allow moving through the four main parts: geodynamics, climate, biosphere, and observing systems (Figure 2, above section). The "Explore" button takes the user to the contents of the four main parts, each of which contains four to five subchapters. E.g. in the biosphere part, topics such as fishing, exotic animal species, invasive species, plastic waste and acidification can be explored. The user interface (UI) structures the sequence of the subchapters to support the user to grasp the enormous set of millions of data points and information. The globe acts as a visual metaphor, on which global datasets are visualized. Zooming is allowed by a spread or pinch movement following the zooming presentation principles described by Weidenmann, Paecher, and K. 1998. In the upper left area, two small buttons are permanently displayed which allow the user to get to the starting point, or to an alternative menu overview, in which all topics are shown in list form.

Within one subchapter, there is a conceptual difference between the function “display of global datasets” on the globe and the close-up “talking head”, where a scientist is portraited and the respective subchapter is explained in greater detail (Figure 2, below section). Here, a narrative implementation using data, 3D animations and comprehensibly formulated texts enables detailed information. This interactive poster explains all contents in addition to text with journalistically prepared audio commentaries, simulating the scientist that explains her or his research topic. Due to this consistency in structure and visual language, the user recognizes and understands the navigation and can quickly grasp the information.

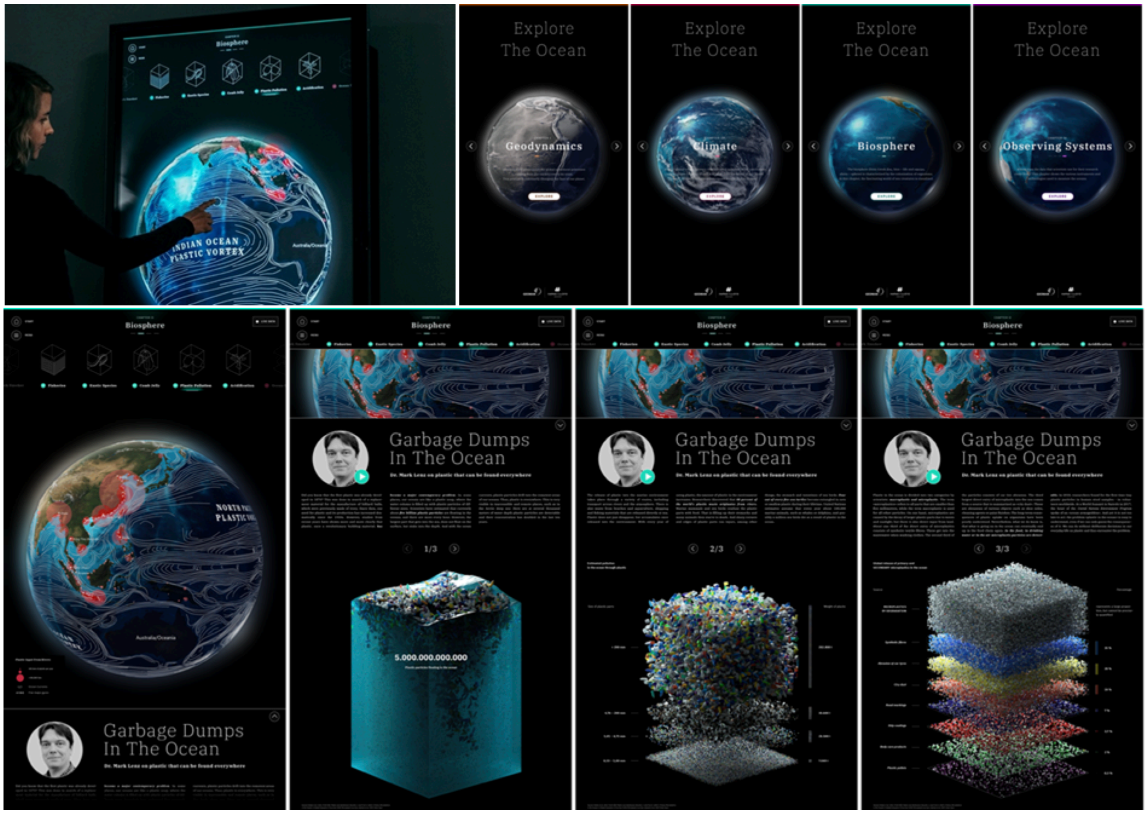

Figure 2. *Above: Interactive Scientific Poster "Explore the Ocean", Interaction sample (left). Start screens (right). Below: Two modes: global overview of data (most left) and "talking head scientist" (following three panels). The content microplastic in the ocean is presented in a sequenced narration that breaks complex scientific data down into smaller sequences, to enhance understanding of the topic.*

Narration in "Explore the Ocean"

For more than twenty years narration and storytelling has been used to enhance students' engagement and learning motivation in digital formats (Huang & Grant, 2020). Narration can be defined through the selection, organization, connection and evaluation of information that is meaningful for the audience. Storytelling as a method to structure data and convey contents can be seen as a subtype of narration, as it uses the same clear framework to effectivity enhance communication (Nussbaumer Knaflic, 2015). A clear selection and structure of the content supports a better understanding, which in turn facilitates access to further information (Götz & Rigamonti, 2015; Sukalla, 2018). To convey ocean literacy, we narrated each of the 15 sub-chapters by organizing them in a logical structure where each piece of information is building on the previous one. For example, the subchapter "plate tectonics" is followed by "natural hazards" where information on plate movement

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is crucial to understand the development of earthquakes and tsunamis. To structure the content of each sub-chapter we divided the information of one subchapter into three to four sequences: The sub-chapter on plastic in the Oceans (Figure 2, below) starts with the information and data on how much plastic is currently floating in the ocean (Figure 2, second figure from the left). With this information in mind, the audience finds in the next two sequences (Figure 2, third and fourth figure from the left) additional and more detailed information on the difference and occurrence of macro- and microplastic. The use of narration in the sense of information organized in sequences and pointing out the connections facilitates the understanding process.

Additionally, evoking emotions in visual science communication supports the encoding of information and efficiently helps the retrieval of information (Tyng et al., 2017). We evoke emotions in the interactive poster by producing iconic pictures, e.g. plastic in the ocean (see Figure 2), we aimed at triggering emotions through design. This was also confirmed by a recent user experience evaluation (Frahm, 2019) of “Explore the Ocean”, which found that visualizations and animations were perceived as aesthetic and enabled a pleasurable reception; the implementation of narration in the structure contributed to a good understanding and awareness of scientific content and the intuitive navigation contributed to a positive user experience.

3. Discussion, perspective and conclusion

The utilization of multimedia in science communication supports the way that the human brain learns: People learn more deeply from the combination of words and pictures than from words alone (Mayer, 2009; Sorden, 2013). However, the user group that feels most confident with multimedia has its limitations as it seems attractive to young people between 20 and 45 years that are familiar with the usage of digital media and appreciate animations and 3D graphics (Frahm 2019). However, we argue that the interactivity and interconnectivity of the contents can be as attractive and informative for other target groups that may not be as familiar with it. In this case, a person that presents the interactive poster can overcome the hesitation of using and handling the interactive poster.

Reaching the public with scientific findings has become an important field for scientists and communicators in the last years. A number of rules and standards have emerged to reach the general public adequately (Bucchi & Trench, 2016; Cheplygina et al., 2020; Marai et al., 2019). These are particularly relevant for scientists who have not had any courses in communication theory in their scientific careers. Thus, those scientists who engage in science outreach by themselves stand out, as they are not only perceived by the public, politicians and funding agencies, but also by their peers. In most cases, however, going public is very time-consuming and the actual research can suffer as a result. Of course, it can be argued that for modern scientists, communicating their results is as important as the research itself (Stylinski et al., 2018). However, we argue that adequate science communication should take place in an interdisciplinary team of scientists, communicators, designers and programmers. The reasons for this are manifold: this collaboration produces media (such as illustrations, infographics, animations or interactive exhibits) that are not only appealing and easy to understand, but also contain the correct scientific message. In a team of many, the scientist doesn't spend as much time in science outreach, as he/she would do, on their own, but still can control what scientific message is communicated. The development of the interactive scientific poster had exactly this approach - it supports scientists starting with the choice of the right presentation of their data and visualization of their work, to bring science and its relevance closer to as many people as possible, but also to acknowledge the cutting-edge research with an excellence in design. Interactivity as a new method for transferring knowledge to the public not only allows a wide range of information to be experienced together, but also adapts intuitively to the recipients: depending on the level of pre-knowledge and interest, interactivity can be used to explore different layers of complexity. Therefore, we consider interactivity, especially for the communication of scientific content, to be a very useful tool to increase scientific literacy in the public.

Currently, there is a wide range of data visualization tools available, especially for large, complex data sets such as genome data for example. However, the challenge for the scientist using these tools is twofold: Firstly, many of these tools are very time-consuming to use and handle and the achieved data visualizations often only represent a partial aspect of the collected data. If a scientist uses various tools or software for data visualization, he/she produces visualizations that have no visual consistency. In order to use these visualizations later on for any form of communication, the scientist has to bring them manually into a consistent visual language, which is time-consuming and requires further software as well as their control. A visually consistent design language of images, be it on a poster, in a lecture or in publications, is one of the most important design rules necessary for successful, efficient communication (see fundamentals). The second difficulty is that the scientist analyses and visualizes individual aspects of the dataset but may not be able to see the connections between the different aspects clearly because he/she is overwhelmed by the sheer amount and complexity of the data and accordingly produced visualizations (Clark et al. 2006).

Until now, we have focused on the transfer of knowledge from science to the public, i.e. science outreach. However, our work shows synergetic effects: the visualizations that we have produced for science communication to the general public were re-used to communicate the latest findings in presentations by scientists to their peers. This shows how important it is to produce excellent and accurate scientific visualizations as they have the power to represent cutting-edge scientific knowledge and also for experts (Duscher et al., 2017; Weber et al., 2013). Therefore, additionally of targeting the general public we also want to support the scientific community with excellent visualizations and interactive formats in the future. With the development of truly integrated, intuitive and usable tools that help scientists to understand their data, but also support communication and knowledge transfer between scientists we want to support science-to-science communication. We claim that efficient interaction and communication between scientists is the fundament of knowledge generation and transfer in interdisciplinary research teams. In future studies, we want to investigate in more detail which features, and interfaces scientists need to discuss their latest research results using interactive visualization. We also want to investigate how the possibilities of interactive science visualization can be used in education. In both user groups, we consider a great potential for the further development of interactive posters.

Conclusion

Collaboration between scientists and designers fosters new insights

Nowadays, new scientific visualization and communication strategies are in demand more than ever. Our experience in the development of interactive scientific posters shows that the cooperation between scientists and designers leads to unprecedented visualizations and new perspectives. In the discussion and conceptual development of scientific content, a new level of reflection and learning emerges, which also leads to a change of perspective and a new presentation of facts among scientists and researchers. Design and visualization support science by transforming expert knowledge and language into a communicable, visual representation and language. Interactive media offer many new possibilities for visualization at different levels of knowledge. In our opinion, this can best be achieved when scientists and visual designers work closely together.

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