Measures of Information Visualizations in Design Studio Education:
Designing Climate Change Visualizations

Duygu Beykal Iz [ID]
Ph.D. Candidate, Design Technology and Society Doctorate Program, Ozyegin University, Istanbul, Turkey,
(Corresponding author)
G. Zeynep Karapars [ID]
Department of Industrial Design, Ozyegin University, Istanbul, Turkey,

Abstract: The climate crisis and sustainability are priority issues that are increasingly integrated into all fields of study in universities. For the field of communication design, there is a challenge to deliver effective designs on the climate crisis due to the complexity of the issue and the large volume of scientific data involved. To overcome this challenge, information visualizations are designed to help communicate complex data. Information visualizations, being data-driven, necessitate specific design principles in addition to fundamental graphic design skills. This study investigates the communication of the climate crisis through information visualizations, with the aim of determining the prominent measures and relevant design language that can be incorporated into design studio education. We conducted three focus groups with academics teaching communication design studios and professionals who have work experience in information visualization design and experts who are doing projects on sustainability and the climate crisis. The findings highlight the importance of actionability, enlightening, evoking curiosity, evoking emotions, localization, personification and positivity in designing effective climate change visualizations. This study contributes to the fields of information visualization and communication design by offering measures to enhance climate change visualizations and providing insights for teaching these principles in communication and graphic design studios.

Keywords: Climate change communication, Information visualization, Design principles, Communication design, Design studio.

1. Introduction

Climate change is a global issue that has significant local effects requiring public understanding and action (Climate Action, n.d.). The public's awareness of the urgency and consequences of climate change has grown as the effects are felt more directly (Peoples' Climate Vote, 2021) However, it is still challenging to communicate the scientific evidence on climate change to lay audiences. The challenge is due to "the issue's complexity and abundance of data" (Ballantyne et al., 2016, p.73) as well as people's unfamiliarity with scientific contexts (Grainger et al, 2016). To address these challenges, universities are increasingly integrating climate crisis education across disciplines (Molthan-Hill et al., 2024), and in communication and design fields, there is a need to develop skills for translating complex climate data. In this regard, information visualizations have become a significant tool, helping to convey this data in a

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clear and accessible way, making it easier for the public to engage with and understand climate-related issues.

We organized three focus group studies with sustainability specialists, communication experts, and graphic design instructors in order to elicit measures and design language for effective climate change communication to lay audiences through information visualization. Our findings contribute to the fields of information visualization and communication design by offering principles to enhance the effectiveness of climate change visualizations and providing insights that can be integrated into design education.

2. Background
Effective communication of climate change has been a topic of interest since the second half of the 1980s with the initial communication revolving around scientific findings, conferences and decision-makers' meetings at the administrative level (Moser, 2010, p.32). However, as the global effects were experienced more and more and the scientific community witnessed how consistent the predictions in the IPCC scenarios were (Kurnaz, 2022), the need to communicate climate change to lay audiences has become a crucial issue.

Communicating scientific findings to lay audiences with the aim of setting them on action is increasingly being studied in the climate literature (Wu et al., 2023; Kumpu, 2022; Li et al., 2022; Agin and Karlson, 2021). Kurnaz (2022) suggested that "an intermediation or a translation between the language of the scientists and the language of general users" can help close the gap (p.224). There is a lack of mediators who would translate the knowledge and the need of information between the two groups (Kurnaz, 2022; Moser and Pike, 2015). Information visualizations can be mediating tools in filling the gap between lay audiences and scientists. In fact, DeCock-Caspell and Vasseur (2021) found that visualizations were an effective tool in engagement and knowledge mobilization of lay audiences. Information visualizations have also aided the communities

in understanding of the complex issue of climate change and therefore paved the way for discussions, collaborations and an active role in decision making for lay audiences (DeCock-Caspell and Vasseur, 2021).

Information visualizations are tools of communication and there are different approaches to explaining communications's role (Ballantyne, 2016; Kumpu, 2022; Moser and Pike, 2015; Moser, 2010). According to some researchers, climate change is not just an issue to be addressed and communicated but it is an "ideological, cultural and symbolic issue" defined during the communication process (Kumpu, 2022, p.307). This approach puts forward that audiences have an active role in the communication process (Okoliko and De Wit, 2021). This perspective emphasizes that effectively communicating climate change requires more than just information—it involves engaging with audiences on many levels.

We argue that design plays a critical role in creation of effective information visualizations for lay audiences on the complex subject of climate change. As a matter of fact, "arts and social sciences can introduce a wonder to the ordinary truths within communication and engage audiences through incorporating senses and contemplation" (Carey, 2009, p.19). However, to design information visualizations that communicate effectively, we must begin by understanding the core qualities, or measures, that define their effectiveness.

2.1 Measures in information visualizations
The term measure refers to characteristics of an information visualization that define or explain what is a "good" information visualization. In the literature, terms such as cognitive concept (Borkin et al., 2016); quality (Quispel et al., 2016); factor (Kim et al., 2017; Quispel and Maes, 2014); criteria (Quispel et al., 2016) are used as well in place of the term measure. In this study we used the term measure similar to the term dimension or aspect; a particular part or feature of something.

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The measures for "good" information visualization are memorability (Bateman et al., 2010; Borgo et al., 2012; Li and Moacdieh, 2014; Haroz et al., 2015; Borkin et al., 2016; Obie et al., 2019; Pena et al., 2020; Sezen et al., 2020), comprehension (Bateman et al., 2010, Obie et al., 2019; Chun, 2020), engagement (Boy et al., 2015; Haroz et al., 2015; Romat et al., 2020), clarity (Kostelnick, 2008), "accuracy, utility, efficiency" (Zhu, 2007), speed (Haroz et al., 2015), "attractiveness, soundness, utility" (Moere and Purchase, 2011), and enjoyment (Sezen et al., 2020; Romat et al., 2020). There is no consensus on the required measures of a "good" information visualization and the significance of measures vary according to different contexts (Torban, 2021; Popovich, 2021).

The studies by DeCock-Caspell and Vasseur (2021), Wang et al. (2018), Coelho and Mueller (2020), and Peña et al. (2020) highlight the importance of tailoring visualizations to specific contexts and audiences to achieve intended effectiveness. Therefore, it is necessary to further study measures of information visualization within a selected context. This study explores information visualization measures specific to the context of climate change communication.

2.2 Design Studio Education for Information Visualization

In design studios within communication and graphic design disciplines, students start off by learning the foundational elements and principles. According to Richard Poulin (2018), at the basic level, elements are the "whats" of the visual language; principles are the "hows" of this language. When elements and principles are carefully evaluated and used together, they enable the graphic designer to produce design solutions in an accessible, universal language. Without the proper application of basic elements and principles of design, visual communication would be ineffective and unable to "talk" to the target audience (Poulin, 2018: 10-12).

As a matter of fact, information visualizations make use of graphic design languages that have their foundations in perception principles (Poulin, 2018, p.9). Utilizing these principles, visualizations can improve understanding and engagement. Achieving a "good" information visualization requires an understanding of the design language, which in graphic design terms, includes elements/components that make up the visualization and rules/principles on how they all work together.

According to Ware (2010), skilled graphic designers use graphic design elements such as color, form, and space to aid the users in their visual quest for perceiving and making sense of an information visualization. In other cases, design teams follow a rigorous path to decide on a visual language; they employ user research, create explicit design systems, analyze competitors, find solutions to overcome cultural barriers, decide on a language and work a few cycles of design-test-redesign (Congote, 2022; Kuznetsov, 2020).

The design language depends on what is being designed or what is intended for the user to accomplish. For communicating a brand's identity consistency, clarity and cohesion come to the fore (Congote, 2022). In other cases, when the aim is to guide the user towards making comparisons, juxtaposition and symmetry are used (Aseniero et al., 2020; Legg et al., 2021). Design language can also aid communicating a message or a concept. Promann (2018) examined the displays of the devices that showed electricity consumption data and claimed that if data is presented by using proximity, a gestalt principle, people would see their own electricity consumption as a part of the society of which they were a part. However, data-driven information visualizations require specialized design principles, measures, alongside a graphic design language. In design studios focused on information visualization, students need to go beyond mastering foundational design elements and principles; they should also learn to apply specialized techniques tailored to data-driven contexts. While core design skills are essential, creating effective information visualizations demands an additional layer of expertise in principles specific to conveying complex data.

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These include the aforementioned measures such as clarity, engagement, memorability…etc. Therefore, understanding and teaching these context-specific measures is essential for creating effective information visualizations tailored to diverse audiences.

3. Methodology

We conducted three focus group studies with subject-experts and academics to explore critical measures for climate change information visualizations and the essential qualities of a design language in line with the measures. The research question is:

RQ: What are the measures of an effective information visualization on climate change that should be incorporated into design studio education?

Eight experts participated in the first focus group study and their expertise is as follows: One of the participants was a data literacy expert who is one of the founders of Data Literacy Society (Istanbul) and holds a doctorate in media communication studies. A second participant was a communication expert who is an assistant professor in the Department of Media and Visual Communication, who had designed a course on climate change communication through animation. Two specialists from the Sustainability Center of the university who have been tasked with increasing awareness on climate change and other sustainability issues for students and university community attended the focus group study. There were also four graphic design instructors; one full time instructor, two part time instructors, and one associate professor in graphic design with experience in designing information visualizations. In the second focus group study, the participants were two graphic designers with 18 to 20 years of experience. The third focus group study included two graphic designers (with 20 years and 8 years of expertise) from an award-winning graphic design agency. The first focus group study was conducted face-to-face whereas the second and third focus group studies were conducted online over Zoom with the aid of Miro application.

The expert focus group studies were carried out in three consecutive sessions:

In Session 1, all the participants were asked to individually think about a question on how to communicate climate change to the public. After a few minutes, they were asked to join in a free discussion on the topic. The discussion continued for approximately 45 minutes. The authors of this paper took notes during discussions to share it in the following session.

In Session 2, measures of information visualization derived from the literature were presented to participants with short definitions of each measure. In addition, moderators shared their notes from session 1. The participants discussed the measures and contributed with additional measures they found significant for the topic of climate change and lay audience.

In Session 3, participants were presented with a sample of 104 information visualizations which were hung on a wall or presented over Miro application. They examined each visualization according to discussed measures and selected appropriate visualizations that exemplified each measure.

The information visualization samples evaluated in Session 3 were collected from social media (Instagram and X) and websites. The resource of visualizations are as follows: National news outlets (BBC Turkish, TRT Haber [Turkish Radio and Television], Anadolu Agency), digital news agencies (gzt, İklim Haber), non-governmental bodies (TEMA Vakfı [Turkish Foundation for Combating Soil Erosion], Greenpeace Turkey, Yuvam Dunya, Istanbul Climate Save, Change.org/iklim, 350 Turkiye, Ben de Buradayım [I am here too]), data visualization and social research companies (Konda Research, Doğru Veri [Right Data], Veri Kaynağı [Data Source], social media of commercial companies (Dohi Agriculture, Gıda Danışmanım [My Food Consultant] and one governmental organization (Meteoroloji Genel Müdürlüğü [General Directorate of Meteorology]).

The visualizations were collected from Instagram and X [Twitter] using the inbuilt search tool within the applications. The keywords used in the search included "climate", "climate change", "climate crisis" and "environmental issues" [in Turkish; iklim, iklim

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değişimi, iklim krizi, çevresel sorunlar]. To investigate the most current visualizations, the visualizations published between 2019-2023 were acquired. After excluding duplicates, 104 visualizations were left to be evaluated for this study.

The analysis was completed in three stages: In the first stage, two authors privately coded each focus group study. In the second stage, two authors privately categorized the codes from each focus group study. Then they discussed each other's categorization and reached an agreement on the categories. In the third stage, the authors worked together to theorize the themes by weaving back and forth between the raw data, the codes, and the categories (Coffrey & Atkinson, 1996). Each focus group is considered as a single data unit as the concepts for measures are generated together while participants have discussed and built on each other's ideas (Morgan, 1997).

4. Results

In this section we present the measures elicited in the focus groups; focus group study 1 (FG1), focus group study 2 (FG2) and focus group study 3 (FG3). Figure 1 (Fig. 1) shows the code categories used in the analysis process and Figure 2 (Fig. 2) shows measures in literature and measures derived in analysis.
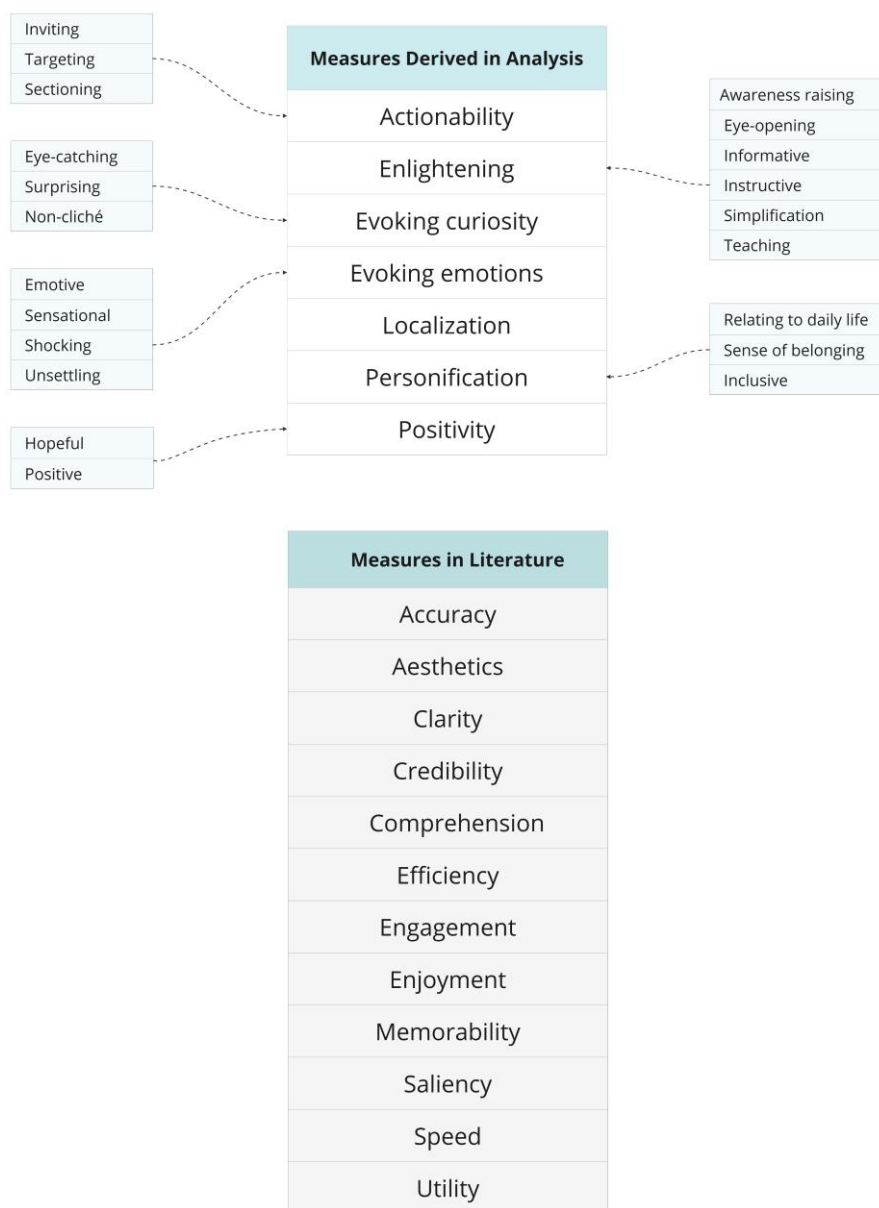
4.1 Actionability

Actionability refers to the ability of the visualization to promote taking action and making decisions (Sorapure, 2023, p. 258). In climate communication literature, taking action is considered as a part of engagement with climate change on personal and public levels. On the personal level, engagement is more about dealing with mental obstacles in favor of behavioral change such as adopting an environmentally conscious way of life and taking part in decision-making processes; on the public level, the focus is on societal

Code categories	FG1	FG2	FG3
Actionability	●	●	●
Awareness-raising		●	
Emotive		●	●
Evoking curiosity	●	●	●
Eye-catching	●		
Eye-opening	●		
Gamification			●
Hopeful	●		
Illustrative	●		
Inclusiveness /inviting			●
Informative		●	
Instructive	●		
Localization	●	●	●

Code categories	FG1	FG2	FG3
Non-cliché	●		
Personification	●	●	●
Positive	●		●
Relatability to daily life			●
Sectioning		●	●
Sensational	●		
Sense of belonging		●	
Shocking		●	
Simplicification		●	●
Surprising (hook)		●	
Targeting		●	
Teaching	●	●	
Unsettling		●	

Figure 1: Code categories used in the analysis process.

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Measures Derived in Analysis

| Inviting |
| Targeting |
| Sectioning |

| Eye-catching |
| Surprising |
| Non-cliché |

| Emotive |
| Sensational |
| Shocking |
| Unsettling |

| Hopeful |
| Positive |

Actionability
Enlightening
Evoking curiosity
Evoking emotions
Localization
Personification
Positivity

| Awareness raising |
| Eye-opening |
| Informative |
| Instructive |
| Simplification |
| Teaching |

| Relating to daily life |
| Sense of belonging |
| Inclusive |

Measures in Literature

Accuracy
Aesthetics
Clarity
Credibility
Comprehension
Efficiency
Engagement
Enjoyment
Memorability
Saliency
Speed
Utility

Figure 2: Measures in literature and measures derived in analysis.

transformation and the primary force behind this transformation is the political system (Kumpu, 2022, p. 307). In the focus group studies, the majority of the discussions on action taking were focused on the personal level.

In the literature, O'Neill and Smith (2014) underlined the power of visuals in illustrating the past effects of climate change and inspiring imaginations on the future of climate change. Wang et al. (2018) studied the effects of visuals and imagery on the engagement of general audiences in the context of climate change communication and concluded that images have a key role in public engagement. The researchers also underlined that there is no single solution for creating these visuals, as

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different goals and different audiences necessitate distinct strategies.

In line with the findings in the literature, participants suggested using realistic imagery to show possible risks and negative outcomes of climate change (FG1). They suggested that AI technology can be used to create images of the future scenarios. Visualizing possible future scenarios such as the rise of sea levels and its effect on the local geography may create a sense of urgency and also underline the seriousness of the climate crisis. Adding to that, realistic imagery is claimed to aid lay people to envisage the outcomes of climate change. This finding is similar to Ballantyne et al. 's (2016) study which shows that visual representations aid in clarifying climate change data, help lay people have a concrete understanding of the issue and provide a perspective to grasp uncertainties inherent to climate change (p.83). The overall idea is to include powerful images that will engage the audiences and also enhance their understanding of the impact of the crisis. The participants stated that the images can amplify the effects of the message. Through the use of powerful, captivating imagery, emotions can be evoked, an urge to take action may rise.

In addition, experts also mentioned information visualizations to be sectioning; dividing big chunks of information into digestible small parts (FG2 and FG3). The sectioning was explained by one of the participants through to-do-lists. To-do-lists from our daily life organize our chores and work so that it is less overwhelming for us to go through them (FG2). As we check the items we complete on our to-do-lists, the pile of things to do become manageable and taking action becomes easier, a sense of relief is felt. Similarly, another participant had pointed out that when they receive a design brief, they divide the brief into smaller parts. They organize the parts according to their importance and less important elements are omitted (FG3). Again, the idea is not to overwhelm, make understanding and taking action easier for the audience.

Two final components included under the measure actionability were inviting (FG3) and targeting (FG2). One of the participants stated that for an information visualization to be inviting, it should ask a question; questions help the audience reflect on the issue and participate in it by thinking about the answer to that question (FG3). This reflection can foster a sense of involvement, potentially motivating audiences to take personal action on climate change. On the other hand, a targeting aspect may also prompt action. Information visualizations with clear targeted messages may be pointing towards issues that the audience can take action on. For instance, an information visualization focused on the environmental impact of meat and dairy production can guide viewers toward this particular issue, making it easier for them to consider actionable steps (FG2).

4.2 Enlightening

The measure of enlightening comprises two components: educating and informing. Although the two concepts are used interchangeably in daily life, in the focus groups, it was discussed separately, as they required slightly different design considerations. We explain the two components below.

Educative quality of an information visualization is due to the context. Climate change is a complex topic; its reasons are complex and its effects are wide and complicated. First and second focus groups agreed that there is ignorance in the lay audience and having to consider this as a design input in climate crisis visualizations. "Foolproof visualizations" (FG2) and "designer's awareness of the level of ignorance" (FG1) was deemed necessary for an effective information visualization on the climate crisis. That is, without assuming prior knowledge and by breaking down all complex concepts (FG3) is an approach that should be taken to make sure that the information is accessible to everyone.

Simplifying, clarifying and clearly explaining terms and avoiding intense terminology were key concepts discussed in FG1 and FG3. The issue of simplification was also discussed in

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terms of the language used within data visualizations. Keeping communication within the frame of daily language without overloading with domain terminology is suggested for promoting a better understanding. This is in line with research results of Wu et al. (2023) that suggest transforming professional and complex language into the everyday language so that lay audience can comprehend the issue and an emotional resonance can be generated.

It is suggested that designers should try to layer (FG1, FG2) the information. It is dividing the information into a few successive layers, beginning from the simplest facts and direct relationships to more complex dynamics. An example given is as follows (FG1): Instead of merely presenting a data chart about the decreasing rain levels per meter square, an information visualization can illustrate the relationship between decreasing rain per meter square with decreasing crop yields and then connect those to decreasing crop yields and food scarcity.

Participants in FG2 mentioned climate crisis concepts need to be explained in the information visualizations. Another suggestion is to make abstract concepts more tangible by use of correct metaphors (FG1, FG3). "...explain the results of [climate crisis] by illustrating tangible results such as draughts, floods, heat waves" FG3. Finally, the volumes, and sizes present in climate data are hard to grasp for human scale. A designer can visualize quantitative data in a relatable way. The concept of 100,000 hectares of forest can be difficult to grasp, but illustrating it by equating this area to the number of football fields can help lay audiences better understand the scale (FG1).

The component of informing is more about creating awareness about the events and processes that are related to the climate crisis. Designers are encouraged to create "eye-opening connections" (FG2) in information visualizations by use of appropriate metaphors and examples. In FG2, the discussion was on revealing the potential of individual actions by "flowing the information visualization to a person's daily life". A way of flowing into daily life can be to breach the taken for granted habits such as eating hamburgers (FG1).

4.3 Evoking Curiosity

Climate change has been in the media for decades now. There is an abundance of information visualizations in the media. Focus group study 1 participants pointed out that visualizations such as fish in a dried, cracked lake bottom or a bird walking on a cut-down forest floor have been used so many times that they became "cliché". Today such information visualization designs can make people get bored and non-responsive. They argued that there is a growing climate change blindness in people, borrowing the concept from ad-blindness on the web. Their suggestion was to find original ways to visualize information, by use of metaphors, images and illustrative styles.

An example suggestion was to create an illustrative information visualization about the consumption of one thousand liters of water to produce one liter of cow's milk. One of the participants suggested that using a hand-drawn illustration of a cow taking a bath in a tub would be both attention grabbing and also underline the big amount of water required (FG1). The hand drawn lines and hand-written-style font would make the whole design more personal and intimate, promoting a personal reflection on the issue. A similar remark was put forward by another participant about creating a visual hook to grab the attention of the audience (FG2). Since people's attention spans are decreasing, a shocking hook in the design would be pulling in the audience to the information visualization.

4.4 Evoking Emotions

In all the focus groups, the emotional effect of the visualization design on the audience was discussed as a critical point. This is because "works which trigger emotions get more reactions" and "people form connections with the subject" (FG2) and could "activate people" (FG3). Among the 104 visualization samples designed just to convey information were found to be less effective in terms of conveying the message (FG3). The samples that targeted emotions (and thus effective ones) were described as "sensational" (FG1), "disgusting"

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(FG3), "depressive" (FG3), "frightening" (FG2), "optimistic" (FG1). Participants explained that the above emotions in the information visualization samples were evoked by use of color palette, type of images and the word selections in the texts.

On the other hand, there was no consensus on the type of emotions that should be targeted by designers. FG2 participants argued that targeting 'blind' emotions are very important and invoking fear is a common strategy in climate crisis communication. On the other hand, FG1 participants reached an agreement on avoiding fear as it creates eco-anxiety which in turn causes people to stop trying. FG3 participants did not suggest use of any pecific emotions but they emphasized that in order to create a connection with the audience, to convey messages effectively and finally to trigger people, the designs should definitely incorporate emotional dimension.

4.5 Localization
Localization was considered as a powerful tool to consider in design decisions in two focus groups. In focus group 2, participants argued that the communication strategy in previous years proved to be ineffective as no local consequences were presented. They said that "...the images of polar bears swimming in melted arctic ice caused the climate crisis to be perceived as a far and away situation…we need to use images and metaphors that exist here". In focus group 1, it is suggested comparing the home country with other countries or the world as a method of localization. Geographical comparisons may help lay audiences to understand the situation in their local city or country in relation to the global situation. This train of thought is supported by a study in the literature as well. DeCock-Caspell and Vasseur (2021) found that local people were more engaged and were able to comprehend how the climate crisis is affecting the environment when they saw aerial photographs of their local coastline. It can be said that people in various countries have similar traits for understanding the climate crisis.

Another way of localization is to consider local culture in the design of information visualization. In focus group studies 1 and 2, participants suggested that targeting traditions and customs can have a strong effect. However, the suggested approach in the two focus group studies were opposite of each other: The first one suggested focusing on negative effects of the local customs on climate (FG1), whereas others cautioned about 'attacking' them (FG2).

4.6 Personification
We are contributing to climate change with our modern, conspicuously consuming lifestyle. The experts in focus group study 1 emphasized the importance of individual actions, even if they are miniscule compared to the scale of the issue. In focus group studies 1 and 2, it is argued that explaining the negative effects of an individual's everyday habit can help people relate to the climate crisis more easily. Through relatable examples, lay audiences may realize the role of the individual and seek for solutions. A simple flat illustration of a hamburger's layers and the amount of water spent to produce that layer is an everyday example (FG2). The simple design of the illustration targets the non-scientist audience. The content of the illustration matches the consumption habits of fast-food consumers in Turkey; as stated by Deniz and Abbasaliyeva (2022) 59% of the fast-food consumers in Turkey prefer eating hamburgers.

Relating to daily life was also mentioned by participants in the third focus group. By providing examples from daily life, an information visualization may enable the audience to connect with the issue on a more personal level (FG3). Real stories from everyday life, even very simple acts of recycling may help audiences to see that every personal action counts and the individual can make a positive impact with even small contributions (FG3).

In addition to creating connections through examples from daily life, creating a sense of belonging (FG2) also establishes a connection between the individual and the climate crisis. Situating the audience as part of their neighborhood, then expanding to the city, the

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country, and ultimately Earth, could foster a personal connection to the environment and therefore inspire a sense of responsibility and motivation to engage in sustainable actions.

4.7 Positivity

In FG1 and FG3, participants suggested keeping a positive and hopeful design language in communicating climate change to lay audiences. They discussed that when faced with the harsh realities of climate change, being positive can be a very effective strategy to stay clear of any potential negative emotional effects, such as eco-anxiety (FG1). The negative emotions of stress, helplessness, anger or fear brought on by awareness of environmental problems are referred to as eco-anxiety. Instead of overwhelming lay audiences with the impacts of the climate crisis, focusing on possible solutions and actions, promoting hope may support sustainable behavior. The participants pointed out one of the good examples by commenting "this one focused on accomplishments rather than warning about the consequences, this is a positive information visualization" (FG3).

Positivity does not mean putting aside the urgency or the seriousness of the issue. In fact designers need to attain the delicate balance between anxiety and urgency (FG2). It is about framing the communication in a constructive and actionable way to make sure lay audiences have motivation and empowerment to act upon the information they acquire through the data visualizations.

5. Discussion and limitations

This research focuses on information visualization measures specific to the climate crisis context, therefore mentions of the existing information visualization measures were not coded during the analysis. Note that existing measures were not rejected by participants when we presented them in the focus group sessions. Therefore, we take accuracy, aesthetics, clarity, credibility, comprehension, efficiency, enjoyment, engagement, memorability, saliency, speed and utility as valid measures for climate crisis context. On the other hand, we suggest additional but specific measures to teach for the information visualization design for climate crisis context. We suggest enlightening, evoking curiosity, evoking emotions and personification measures. In addition, we elaborate on how to employ actionability (Kumpu, 2022; Wang et.al., 2018), positivity (Parry et.al., 2022) and localization (DeCock-Caspell and Vasseur, 2021) for information visualization designs. Actionability, positivity and localization concepts are mostly found in climate crisis communication studies. The three concepts were strongly emphasized as measures in all three focus group studies.

We observe a tendency in the information visualization studies for isolating graphical design elements (e.g., icons, colors) in order to study their effects on measures like memorability (i.e. Haroz et. al., 2015). However, design is more than the sum of its parts. An information visualization overloaded with icons, for example, might confuse rather than clarify. Similarly, the harmony between various elements can significantly influence the overall effectiveness of the visualization. Therefore, this study adopts a holistic approach, considering design strategies and language in their entirety rather than isolating individual elements.

In the literature, there is a growing number of studies in interactive information visualizations (Walker et al., 2020; Herring et al., 2017; Neset et al., 2016) to increase the understanding of climate change and community engagement. Herring et al. (2017) found that interactivity led to considerable shifts in beliefs and attitudes of the lay audience (p.102). On the other hand, Newell et al. (2016); compared static and interactive visualizations on climate change regarding the measures of audience interest [engagement] and understanding [comprehension]. They concluded that interactive visualizations were more engaging but static ones were more useful for obtaining detailed information on the issue. Climate change related information visualizations for lay audiences are mostly shared and accessed on web and social media platforms. Although the platforms per se are interactive, the information

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visualizations shared within them are actually static. The lay audience in question experiences information visualizations as static visual artifacts. As a result, interactive visuals were out of the scope of this study.

Information visualization literature often approaches visualizations from a practical and perception/cognition standpoint, emphasizing measures like clarity and speed, largely rooted in the discipline of psychology. However, throughout the focus groups, the experts prioritized measures such as personification, localization and actionability which consider audiences not as an isolated group in a vacuum but as culturally situated individuals with different views, beliefs and backgrounds. In the focus groups, the perspective was from the audience's active process of meaning-making rather than mere perception of information visualizations. In the real world, when an information visualization is presented, audiences play an active, rather than passive, role in constructing the meaning (Okoliko and De Wit, 2021) of that design. As a result, our findings align with the communication design approach rather than a cognitive psychology approach.

The findings of this study are based on expert opinions gathered through three focus group studies. Future research should increase the number of studies, as well as that they should include participants from NGOs who actively strive to communicate the climate crisis to the public. Further studies are needed to examine the effect of information visualization design decisions through empirical user research. Gaining insights into how various audiences view and engage with visualizations can help improve communication about climate change.

6. Conclusion

This research provides an exploration of the measures for designing information visualizations in the climate crisis context that can be utilized in teaching design students. We conducted three focus group studies with communication design academics, design professionals and sustainability experts. We identified actionability, enlightening, evoking

curiosity, evoking emotions, localization, personification and positivity as specific measures in information visualizations about the climate crisis. We suggest design education for information visualization should incorporate the aforementioned measures in projects regarding the climate crisis.

Through captivating imagery, targeted designs and inviting content, actionability focuses on encouraging the audience to take personal and public level actions on the information provided. Educative content designed for audiences with all levels of knowledge on the climate crisis, simplified and clear explanations and awareness raising informative approaches make up the enlightening measure for effective information visualization designs. By avoiding cliché imagery and including eye-catching illustrative styles may evoke curiosity and surprising hooks can enhance audience attention. Whether it is frightening or hopeful, an information visualization should evoke emotions to convey the importance of its message. Localization helps make the information relevant to the audience's local context, supporting personal connection and relevance. Positivity helps maintain engagement and motivation, lowering the risk of eco-anxiety while finding a balance between paralyzing negative feelings and urgency. Personalization makes the issue relatable by connecting it to the audience's everyday life while creating a sense of belonging for individuals within a public-embracing approach. By focusing on these specific measures, the research provides a comprehensive set of measures that can be incorporated into design studio education on information visualizations; for impactfully bridging the gap between scientific data and public understanding.

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References

Agin, S., & Karlsson, M. (2021). Mapping the Field of Climate Change Communication 1993–2018: Geographically Biased, Theoretically Narrow, and Methodologically Limited. *Environmental Communication*, 15(4), 431–446.
https://doi.org/10.1080/17524032.2021.1902363

Aseniero, B. A., Perin, C., Willett, W., Tang, A., & Carpendale, S. (2020). Activity River: Visualizing Planned and Logged Personal Activities for Reflection. *Proceedings of the International Conference on Advanced Visual Interfaces*, 1–9.
https://doi.org/10.1145/3399715.3399921

Ballantyne, A. G., Wibeck, V., & Neset, T.-S. (2016). Images of Climate Change – a Pilot Study of Young People's Perceptions of ICT-Based Climate Visualization. *Climatic Change*, 134(1–2), 73–85.
https://doi.org/10.1007/s10584-015-1533-9

Bateman, S., Mandryk, R. L., Gutwin, C., Genest, A., McDine, D., & Brooks, C. (2010). Useful Junk?: The Effects of Visual Embellishment on Comprehension and Memorability of Charts. *Proceedings of the 28th International Conference on Human Factors in Computing Systems - CHI '10*, 2573.
https://doi.org/10.1145/1753326.1753716

Borgo, R., Abdul-Rahman, A., Mohamed, F., Grant, P. W., Reppa, I., Floridi, L., & Min Chen. (2012). An Empirical Study on Using Visual Embellishments in Visualization. *IEEE Transactions on Visualization and Computer Graphics*, 18(12), 2759–2768.
https://doi.org/10.1109/TVCG.2012.197

Borkin, M. A., Bylinskii, Z., Kim, N. W., Bainbridge, C. M., Yeh, C. S., Borkin, D., Pfister, H., & Oliva, A. (2016). Beyond Memorability: Visualization Recognition and Recall. *IEEE Transactions on Visualization and Computer Graphics*, 22(1), 519–528.
https://doi.org/10.1109/TVCG.2015.2467732

Boy, J., Detienne, F., & Fekete, J.-D. (2015). Storytelling in Information Visualizations: Does it Engage Users to Explore Data? *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 1449–1458.
https://doi.org/10.1145/2702123.2702452

Carey, J. W. (2009). *Communication as Culture: Essays on Media and Society* (Rev. ed). Routledge.

Chun, R. S. (2020). Giving Guidance to Graphs: Evaluating Annotations of Data Visualizations for the News. *Visual Communication Quarterly*, 27(2), 84–97.
https://doi.org/10.1080/15551393.2020.1749842

Climate Action. (n.d.). United Nations Sustainable Development. Retrieved May 9, 2024, from
https://www.un.org/sustainabledevelopment/climate-action/

Coelho, D., & Mueller, K. (2020). Infomages: Embedding Data into Thematic Images. *Computer Graphics Forum*, 39(3), 593–606.
https://doi.org/10.1111/cgf.14004

Coffrey, A. & Atkinson, P. (1996). *Making Sense of Qualitative Data*. California: Sage.

Congote, C. (2022, November 1). Creating a Visual Design Language—Flatirons Development. Retrieved May 9, 2024 from https://flatirons.com/blog/design-languages/

DeCock-Caspell, M., & Vasseur, L. (2021). Visualizations as a Tool to Increase Community Engagement in Climate Change Adaptation Decision-making. *FACETS*, 6(1), 240–251.
https://doi.org/10.1139/facets-2020-0032

Deniz, M. & Abbasaliyeva, V. (2022). Effects of Global Fast-Food Restaurants on Local

Journal of Design Studio, v:6 n:2
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Fast-Food Markets: Case of Turkey. *İnsan ve Toplum Bilimleri Araştırmaları Dergisi* , 11 (2), 1066-1088. https://doi.org/10.15869/itobiad.1059484

Grainger, S., Mao, F., & Buytaert, W. (2016). Environmental Data Visualisation for Non-scientific Contexts: Literature Review and Design Framework. *Environmental Modelling & Software*, 85, 299–318. https://doi.org/10.1016/j.envsoft.2016.09.004

Haroz, S., Kosara, R., & Franconeri, S. L. (2015). ISOTYPE Visualization: Working Memory, Performance, and Engagement with Pictographs. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems - CHI '15*, 1191–1200. https://doi.org/10.1145/2702123.2702275

Herring, J., VanDyke, M. S., Cummins, R. G., & Melton, F. (2017). Communicating Local Climate Risks Online Through an Interactive Data Visualization. *Environmental Communication*, 11(1), 90–105. https://doi.org/10.1080/17524032.2016.1176946

Kennedy, H., Weber, W. and Engebretsen, M. (2020) Data Visualization and Transparency in the News. In: Engebretsen, M. and Kennedy, H., (eds.) *Data Visualization in Society*. Amsterdam University Press , pp. 169-185. ISBN 9789463722902

Kim, N. W., Schweickart, E., Liu, Z., Dontcheva, M., Li, W., Popovic, J., & Pfister, H. (2017). Data-Driven Guides: Supporting Expressive Design for Information Graphics. *IEEE Transactions on Visualization and Computer Graphics*, 23(1), 491–500. https://doi.org/10.1109/TVCG.2016.2598620

Kostelnick, C. (2008). The Visual Rhetoric of Data Displays: The Conundrum of Clarity*. *IEEE Transactions on Professional Communication*, 51(1), 116–130. https://doi.org/10.1109/TPC.2007.914869

Kumpu, V. (2022). What is Public Engagement and How Does it Help to Address Climate Change? A Review of Climate Communication Research. *Environmental Communication*, 16(3), 304–316. https://doi.org/10.1080/17524032.2022.2055601

Kurnaz, L. (2022). *Son Buzul Erimeden: İklim Değişikliği Hakkında Merak Ettiğiniz Her Şey* [Before the Last Glacier Melts: Everything You Wanted to Know About Climate Change] (3rd ed.). Doğan Kitap.

Kuznetsov, G. (2020, March 30). Visual Design Language: The Building Blocks Of Design. Smashing Magazine. Retrieved April 20th, 2024 from https://www.smashingmagazine.com/2020/03/visual-design-language-building-blocks/

Legg, P. A., Chung, D. H. S., Parry, M. L., Jones, M. W., Long, R., Griffiths, I. W., & Chen, M. (2012). MatchPad: Interactive Glyph-Based Visualization for Real-Time Sports Performance Analysis. *Computer Graphics Forum*, 31(3pt4), 1255–1264. https://doi.org/10.1111/j.1467-8659.2012.03118.x

Li, C. J., Schulz, J. H., & Thuston, S. (2022). After the Forum I Realized there is more I can Do: Communicating Climate Change to Youth Using Dublic deliberation. *Applied Environmental Education & Communication*, 21(3), 254–272. https://doi.org/10.1080/1533015X.2022.2062068

Li, H., & Moacdieh, N. (2014). Is "chart junk" useful? An Extended Examination of Visual Embellishment. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 58(1), 1516–1520. https://doi.org/10.1177/1541931214581316

Molthan-Hill, P., Ledley, T. S., Blaj-Ward, L., & Mbah, M. F. (2024). Climate Change Education at Universities: Relevance and Strategies for Every Discipline. In M. Lackner, B. Sajjadi, & W. Y. Chen (Eds.), *Handbook of Climate Change Mitigation and Adaptation* (pp. 153-2). Springer. https://doi.org/10.1007/978-1-4614-6431-0_153-2

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Beykal Iz, D., Karapars, G. Z., (2024). Measures of Information Visualizations in Design Studio Education:
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Moere, A. V., & Purchase, H. (2011). On The Role of Design in Information Visualization. *Information Visualization*, 10(4), 356–371. https://doi.org/10.1177/1473871611415996

Morgan D.L. (1997). *Focus Groups as Qualitative Research*. London: Sage.

Moser, S. C. (2010). Communicating Climate Change: History, Challenges, Process and Future Directions. *WIREs Climate Change*, 1(1), 31–53. https://doi.org/10.1002/wcc.11

Moser, S. C., & Pike, C. (2015). Community Engagement on Adaptation: Meeting a Growing Capacity Need. *Urban Climate*, 14, 111–115. https://doi.org/10.1016/j.uclim.2015.06.006

Neset, T.-S., Glaas, E., Ballantyne, A. G., Linnér, B.-O., Opach, T., Navarra, C., Johansson, J., Bohman, A., Rød, J. K., & Goodsite, M. (2016). Climate Change Effects at Your Doorstep: Geographic Visualization to Support Nordic Homeowners in Adapting to Climate Change. *Applied Geography*, 74, 65–72. https://doi.org/10.1016/j.apgeog.2016.07.003

Newell, R., Dale, A., & Winters, C. (2016). A Picture İs Worth A Thousand Data Points: Exploring Visualizations as Tools for Connecting the Public to Climate Change Research. *Cogent Social Sciences*, 2(1), 1201885. https://doi.org/10.1080/23311886.2016.1201885

Obie, H. O., Chua, C., Avazpour, I., Abdelrazek, M., Grundy, J., & Bednarz, T. (2019). A Study of the Effects of Narration on Comprehension and Memorability of Visualisations. *Journal of Computer Languages*, 52, 113–124. https://doi.org/10.1016/j.cola.2019.04.006

Okoliko, D. A., & De Wit, M. P. (2021). From "Communicating" to "Engagement": Afro-Relationality as a Conceptual Framework for Climate Change Communication in Africa. *Journal of Media Ethics*, 36(1), 36–50. https://doi.org/10.1080/23736992.2020.1856666

O'Neill, S. J., & Smith, N. (2014). Climate Change and Visual Imagery. *WIREs Climate Change*, 5(1), 73–87. https://doi.org/10.1002/wcc.249

Parry, S., McCarthy, S. R., & Clark, J. (2022). "Young People's Engagement with Climate Change Issues Through Digital Media – A Content Analysis". *Child and Adolescent Mental Health* 27, No. 1, pp. 30–38. https://doi.org/10.1111/camh.12532

Peña, A., Ragan, E., & Harrison, L. (2020). Memorability of Enhanced Informational Graphics. *Interdisciplinary Journal of Signage and Wayfinding*, 4(1). https://doi.org/10.15763/issn.2470-9670.2020.v4.i1.a54

Peoples' Climate Vote. (2021). United Nations Development Programme (UNDP). https://www.undp.org/publications/peoples-climate-vote

Popovich, N. (2021, April). Covering Climate Change in the Newsroom. S-H-O-W Conference /Impact. https://graphichuntersshow.nl/

Poulin, R. (2018). *The Language of Graphic Design: An İllustrated Handbook for Understanding Fundamental Design Principles* (Revised edition). Rockport Publishers, an imprint of The Quarto Group.

Promann, M. (2018). Examining the Role Visual Graph Structures Play in Collective Awareness and Cooperative Decisions. *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–6. https://doi.org/10.1145/3170427.3180303

Quispel, A., & Maes, A. (2014). Would You Prefer Pie or Cupcakes? Preferences for Data Visualization Designs of Professionals and Laypeople in Graphic Design. *Journal of Visual Languages & Computing*, 25(2), 107–116. https://doi.org/10.1016/j.jvlc.2013.11.007

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Quispel, A., Maes, A., & Schilperoord, J. (2016). Graph and Chart Aesthetics for Experts and Laymen in Design: The Role of Familiarity and Perceived Ease of Use. *Information Visualization*, 15(3), 238–252. https://doi.org/10.1177/1473871615606478

Romat, H., Henry Riche, N., Hurter, C., Drucker, S., Amini, F., & Hinckley, K. (2020). Dear Pictograph: Investigating the Role of Personalization and Immersion for Consuming and Enjoying Visualizations. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–13. https://doi.org/10.1145/3313831.3376348

Sezen, E., Tsekleves, E., & Mauthe, A. (2020). Bar Charts versus Plain Numbers: Visualizations for Enhancing the Soccer-watching Experience on TV via a Second Screen. *The International Journal of Visual Design*, 14(2), 35–60. https://doi.org/10.18848/23251581/CGP/v14i02/35-60

Sorapure, M. (2023). User Perceptions of Actionability in Data Dashboards. *Journal of Business and Technical Communication*, 37(3), 253–280. https://doi.org/10.1177/10506519231161611

Torban, A. (2021, April). Before Impact: A Mental Model to Help You Plan for Engagement. S-H-O-W Conference / Impact. https://graphichuntersshow.nl/

Walker, J. D., Letcher, B. H., Rodgers, K. D., Muhlfeld, C. C., & D'Angelo, V. S. (2020). An Interactive Data Visualization Framework for Exploring Geospatial Environmental Datasets and Model Predictions. *Water*, 12(10), 2928. https://doi.org/10.3390/w12102928

Wang, S., Corner, A., Chapman, D., & Markowitz, E. (2018). Public Engagement with Climate Imagery in a Changing Digital Landscape. *WIREs Climate Change*, 9(2). https://doi.org/10.1002/wcc.509

Ware, C. (2010). *Visual Thinking: for Design*. Morgan Kaufmann.

Wu, M., Long, R., Chen, H., & Wang, J. (2023). Is Social Media More Conducive to Climate Change Communication Behavior? The Mediating Role of Risk Perception and Environmental Values. *Environment, Development and Sustainability*. https://doi.org/10.1007/s10668-023-03870-1

Zhu, Y. (2007). Measuring Effective Data Visualization. In G. Bebis, R. Boyle, B. Parvin, D. Koracin, N. Paragios, S.-M. Tanveer, T. Ju, Z. Liu, S. Coquillart, C. Cruz-Neira, T. Müller, & T. Malzbender (Eds.), *Advances in Visual Computing* (Vol. 4842, pp. 652–661). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-76856-2_64

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Appendix

Photographs from the conducted focus group 1.

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Focus Group 2

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Focus Group 3

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Sample codes from analysis process on Miro.

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