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0. EDITORIAL #26

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I

VALUES

ENERGY CULTURES & BEHAVIOURAL CHANGE

Environment/Data/People

[Eco] Participation through Data Visualization as Design Strategic Approach for Engaging, Sensitizing, and Educating the Community to Energy Transition

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Abstract
In the face of a polycrisis marked by environmental, social, and economic upheavals, the transition to sustainable energy has become a global imperative. This transition is not only a matter of policy and infrastructure but also hinges on the individual citizen, who initiates and completes the process. Therefore, it is crucial for citizens to possess adequate energy literacy in line with the 2030 SDGs. Information Design plays a significant role in this scenario by creating communicative artifacts that narrate complex topics in an easily understandable manner to a broad audience. Moving from the cold, intangible dimension of data to a warm, tangible, human dimension can be achieved using visual metaphors, the creation of new levels of meaning, and the co-creation and participation in the visualization project. The physical and digital involvement with data can design a unique communicative bridge between people, the environment, and stakeholders. In this context, the participatory visualization and physicalization of data for eco-educational purposes termed [Eco] Participatory through Data Visualization - could be a promising area of investigation in communication design research and practice.

1. Introduction

In the current scenario, promoting the change towards sustainable energy sources requires an approach that actively involves both the individual and the community, including all economic and productive actors, to steer personal choices towards social responsibility (Leonardi, et al., 2023, translated by the Author). While, on the one hand, the role of social and political agencies is evident, on the other hand, it's crucial that the individual citizen who is the beginner and the finisher of the energy transition process and who, therefore, needs proper sustainability and energy literacy (IRENA, 2022) according to the SDGs 2030 (United Nations, 2015). Visual Communication Design, both in Information Design (Kirk, 2019) and Environmental Graphic Design (Calori & Vanden-Eynden, 2015), is able to make a relevant contribution in the energy transition scenario, by designing communicative artefacts capable of narrating complex topics in a quick and easily understandable way to a wide audience (Tufte, 1982).

2. The Importance of Being Energy Literate: the Role of Participation as Driver of Emotional Involvement

Energy literacy is a fundamental aspect in encouraging energy-saving behaviors and fostering sustainability. Energy transition is surely not only about technological change, but it must also reflect socio-cultural and environmental transformations on the local level (Chodkowska-Miszczuk, et al., 2021). In this sense, on the one hand, energy literacy encompasses cognitive, affective, and behavioral domains, influencing individuals' understanding of energy consumption, production impacts, conservation needs, and renewable energy

development (Aguirre-Bielschowsky et al., 2015), and, on the other hand, it focuses on the ability to assess energy-related problems, and the adoption of appropriate behavioral strategies (Usman et al., 2021). Energy literacy at all educational levels is crucial for promoting energy-saving practices (Cotton et al., 2016). This is particularly relevant in the "greening" agenda in higher education, where developing students' energy literacy is a key aspect (Cotton et al., 2015).

In the energy transition context, energy literacy is crucial for increasing public awareness and participation in energy-related issues (Hendinata et al., 2022). It is also linked to wider sustainability issues, making it a good proxy for measuring sustainability in educational institutions (Cotton et al., 2017). That's because energy awareness comes down to understanding the basic concepts, rules, theories, energy transfers, transformation processes, and the role that energy plays in everyday life (Chodkowska-Miszczuk et al., 2021). Moreover, energy literacy is considered a minimum required capacity for developing a sustainable society that actively engages in discussions on energy and environmental issues (Akitsu & Ishihara, 2018). The involvement of the education sector in promoting energy literacy is seen as a strategy to build awareness in students from an early age (Rohmatulloh et al., 2021; Putri et al., 2022). Furthermore, an energy-literate individual not only possesses basic energy-related knowledge but also comprehends both the environmental impacts of human energy activities on the ecosystem (Khuc et al., 2023) and the necessity of developing the skills to address energy-related challenges (Puspitasari, 2020; Usman et al., 2021).

To achieve these abilities, participation is an essential key strategy for fostering informed decision-making, promoting sustainable energy practices, and empowering individuals to contribute to energy transition efforts. Research has emphasized the importance of participation in enhancing energy literacy levels and encouraging engagement in energy-related issues (Ryghaug et al., 2018). Actively engaging in energy-related activities and discussions allows individuals to deepen their understanding of energy concepts, contribute to energy citizenship, and support the transition towards renewable energy sources (Ryghaug et al., 2018). Community awareness and participation are vital for driving changes that reduce climate change impacts and greenhouse gas emissions (Mohamad & Osman, 2022). For instance, engaging communities in energy-related discussions and initiatives can lead to collective action toward mitigating environmental challenges and promoting sustainable energy practices (Mohamad & Osman, 2022). Furthermore, involvement in energy literacy initiatives can increase awareness of energy consumption patterns, which is crucial for effective engagement in transitioning energy systems (Zanocco et al., 2022).

Adding to these, participation in the sense of being emotionally involved into the energy issue topic defines a crucial role to foster energy literacy through the design and fruition of data art experience. Information design strategies – such as

Data Visualization[1], Data Art[2] and Data Physicalization[3] – are essential for enhancing energy literacy by effectively conveying complex information in a more understandable and engaging manner, improving decision-making, changing attitudes, and reducing risky behaviors (García-Retamero & Cokely, 2013).Indeed, data art plays a significant role in communicating environmental data by evoking emotional responses and fostering connections with nature, creating empathy for ecological issues, influence pro-environmental attitudes, and encourage pro-environmental behavior (Curtis et al., 2012; Curtis, 2009; Brock et al., 2022). Through data visualization artifacts, individuals can develop a sense of empathy toward environmental concerns and engage in meaningful dialogues about sustainability (Sommer & Klöckner, 2021). Moreover, the emotional engagement facilitated by data art can lead to increased environmental awareness and sensitivity to ecological issues (Wang et al., 2022). Combining science and art opens new avenues for research and discussion on environmental matters, providing emotional and human contexts that enhance the understanding of complex environmental topics (Valentini & Nesci, 2021). To achieve these

1 Data visualization involves creating visual representations of data using common graphics like charts, plots, and infographics. These visual displays help convey complex data relationships and insights in an easily understandable manner.

2 Data Art, or Information Art, is a visual medium that draws inspiration from and integrates data, computer science, information technology, artificial intelligence, and related data-driven disciplines. It leverages data as source material to craft visually captivating and meaningful representations, conveying emotions to the audience by revealing insights, patterns, or hidden stories in an accessible and creative manner.

3 Data physicalization explores the use of physical artifacts to represent data. It intersects with various research domains, including information visualization, scientific visualization, visual analytics, tangible user interfaces, shape-changing interfaces, personal fabrication, graphic design, architecture, and art.

goals, emotional involvement with the data is mandatory because the participation with the content domain is a crucial determinant of the effects of interactivity (Wojdynski, 2015). In this sense, people participate in the visualization because in a dynamic data visualization – dashboard or interface – the result of the visualization is linked with the interaction and determines a custom result.

3. Participation through Data Visualization to Foster Energy Transition: Designing *Affective* Visualization

Through his action, the designer facilitates the co-creation of individual awareness and collective consciousness through the involvement of all actors (Rizzo, 2009) and by addressing personal choices toward social responsibility (Leonardi et al., 2023). The resistance of communities to understanding data – both due to a low level of graphicacy (Cairo, 2017) and relativism towards environmental issues – necessitates data humanization strategies (Bertling, 2023) to instill collective empathy towards the energy transition; a holistic approach that keeps in mind environment, data and people. Let's move from the cold and intangible dimension of data to a warm and tangible – human – dimension that is the result of both the use of visual metaphors and the creation of new levels of meaning (Lupi in Lange, 2019) and the co-creation and participation in the visualization project and ultimately the physical materialization of the information itself. It is possible to design a particular communicative bridge between people, the environment and stakeholders. To enhance energy literacy and support energy transition, participatory design strategies are essential for engaging stakeholders in the design and development of ener-

gy-related initiatives. Participatory design involves incorporating end-users, such as community members, in decision-making processes to ensure that resulting solutions align with their needs and preferences Tuhkala (2021). This approach can lead to enhanced quality and usability of energy-related designs, increased acceptance of innovations, improved comprehension of energy concepts, and more effective implementation of energy transition initiatives (Könings et al., 2007). In energy literacy, participatory design can entail collaborative efforts among educators, policymakers, and community members to co-create educational materials, workshops, and programs that deepen understanding of energy production, consumption, and conservation practices (Könings et al., 2010). By involving stakeholders in the energy literacy initiatives' analysis, design, and implementation stages, participatory design can guarantee that resulting interventions are pertinent, engaging, and successful in promoting energy literacy (Könings et al., 2010). In these terms, it is possible to assume that the participatory visualization of data (Moretti & Mattozzi, 2020) applied for eco-educational aims (Bertling, 2023) – a so-called [Eco] Participation through Data Visualization – could be an approach capable of considering thinking, attitudes, emotions, motivations (IxDF, 2016). Indeed, environmental data storytelling can trigger an emotional reaction, harnessing the power of motivation, imagination and personal values, the driving forces behind the most effective and lasting forms of social change (Lack, 2020, Translated by the Author). In this sense, data visualization should be humane, ethical, and do good to society (Lan, Wu & Cao, 2024): in a few words, it should be an effective visualization design.

3.1. Data Visualization and Community Interaction: Environmental Data as Participatory Interface

Integrating participation for building and staging data is key to engaging communities and improving understanding of environmental challenges. Individuals can participate in a tangible and engaging experience beyond traditional data dissemination methods. Participatory methods have been identified as a way to empower the public and prevent the reinforcement of existing power dynamics (Lorenz & Kolb, 2009). This approach democratizes access to information and promotes active involvement in energy-related decision-making processes. Through data visualizations, viewers and participants are immersed in a collective experience that raises awareness and encourages discussions about the energy transition.

Figure 1. Insidius Riding. Sample of the data visualization interface. © Hyphen Labs. Fair Use.

Figure 2. Insidius Riding. Sample of the data visualization interface. © Hyphen Labs. Fair Use.

Heartbeat of the Earth (2009 – ongoing) is a continuous initiative by Google Arts & Culture Lab that brings together artists and scientists in a unique participation, to use technology creatively to interpret, communicate, and expand upon environmental data. A first reference to the Google project is the mobile-first data story titled Insidio*us Riding* (2022) (Fig. 1). This project is the brainchild of the globally recognized artist collective Hyphen Labs, in collaboration with the Union of Concerned Scientists and Allison Akootchook Warden, a renowned poet and Indigenous spokesperson. The interactive narrative invites users to embark on a tactile journey, exploring the multifaceted challenges that our planet currently faces (Fig. 2). These issues are represented through the depiction of a melting glacier, a poignant reminder of the urgent need for environmental action.

One of the key concepts explored in this artwork is the ecological cascade effect. This phenomenon refers to a chain of secondary extinctions set into motion by the primary extinction of a pivotal species within an ecosystem. The loss of such a species can disrupt the balance of the ecosystem, leading to unforeseen consequences and potentially triggering a domino effect of extinctions. *Insidius Riding* delves into the intricate interconnections within our environment, highlighting the potential cascade effects of accelerated global warming, the thawing of the cryosphere, and rising sea levels. The artwork vividly depicts how these interconnected issues could precipitate an ecological collapse. For instance, the thawing of the cryosphere could lead to the emergence of prehistoric viruses locked away in ice for millennia. Similarly, the accelerated warming of our planet and rising sea levels could have cascading effects on our agriculture, leading to the disappearance of essential pollinators like bees and the consequent vanishing of crops. Through its immersive narrative and interactive design, *Insidius Riding* is a powerful environmental education tool. It encourages users to engage with the pressing issues of our time and fosters a deeper understanding of the delicate balance that sustains life on our planet. The story underscores the urgency of collective action and the need for each of us to play our part in preserving our shared home for future generations.

There is also a need to incorporate emotional and storytelling data elements into these visualizations, which can effectively convey complex information and elicit meaningful responses. As highlighted by Kennedy & Hill (2017), emotional engagement with data is essential for making sense of information,

emphasizing the importance of incorporating emotional components into data visualization strategies. In this sense, the second case study of the Google Project titled *Plastic Air* (2021) by Giorgia Lupi has surfaced, offering a profound exploration of microplastics' impact on our environment and health (Fig.3). As it turns out, discarded plastic remains. Instead, it degrades into increasingly smaller fragments known as microplastics. These minuscule particles eventually enter our air, becoming an invisible yet pervasive presence in our atmosphere. Through the work, viewers are provided with a unique lens, enabling them to "see" and explore the omnipresent plastic particles that fill the air around us. It incorporates published research from many esteemed institutions, including the University Fernando Pessoa, the University of Plymouth, the University of Georgia, the University of Victoria, the University of Strathclyde, Utah State University, and Université Paris-Est.

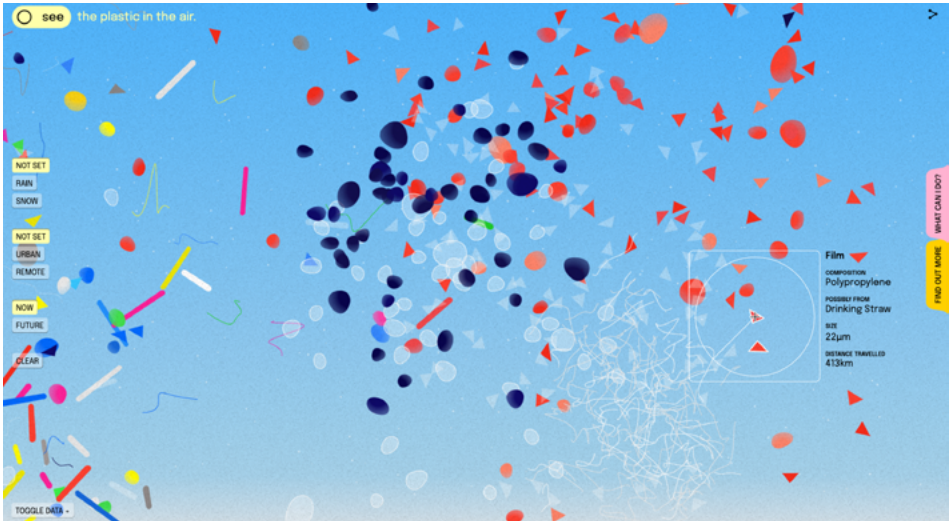

Figure 3. Plastic Air. Sample of the data visualization interface. © Giorgia Lupi. Fair Use.

Figure 4. Plastic Air. Sample of the data visualization interface. © Giorgia Lupi. Fair Use.

Plastic Air is a stark reminder of the far-reaching consequences of our reliance on plastic. It highlights the insidious journey of plastic from our hands to our atmosphere and, ultimately, back to us as we inhale these microplastics (Fig. 4).

The project underscores the urgent need for more sustainable practices and invites viewers to reflect on their consumption habits. Citizen participation, as emphasized by Chitsa et al. (2022), is critical to driving bottom-up transition and policy development, particularly within urban communities. Involving citizens in creating and staging data visualizations can help communities develop a sense of ownership and empowerment, leading to more effective climate change mitigation and adaptation efforts. Indeed, *Plastic Air* is a call to action, a plea for awareness, and a testament to the power of art in conveying complex environmental issues. It challenges us to reconsider our relationship with plastic and to strive for a future where clean air is not a luxury but a right.

3.2. Data Visualization and Community Involvement: Environmental Data as a Participatory Artifact

Adopting data visualization strategies can make otherwise complex and remote information accessible to the public. This process increases energy literacy and promotes concrete action on crucial environmental issues. In an era of widespread climate change denial and pervasive inertia on the part of citizens and governments, the ability to communicate clearly and engagingly through data physicalization becomes even more relevant to translate data into artifacts that are simultaneously tangible, visible, and perceptible with senses other than vision. As a reference, World Primary Energy (2020) is a data physicalization exhibit that blends technology, data, and design. It offers a comprehensive, interactive, and visually appealing perspective on the future of energy consumption. It serves as a reminder of the importance of renewable energy and its role in our future. This exhibit is a collection of 25 meticulously 3D printed pillars, each symbolizing the anticipated future energy consumption (Fig. 5). The data exhibit designers embarked on a journey to scrutinize the global progression of energy consumption. They looked ahead from 2020 to 2100 across five prospective scenarios. But the exhibit doesn't stop there. It goes further by incorporating factors such as population growth and temperature rise. These factors are seamlessly integrated into the exhibit via rear projection through a laser cut. The exhibit is interactive and controlled via an app. The data fueling this exhibit is sourced from a reputable institute dedicated to climate impact research, the Potsdam Institute. The data presents many perspectives and interdependencies, offering a comprehensive view of our energy future.

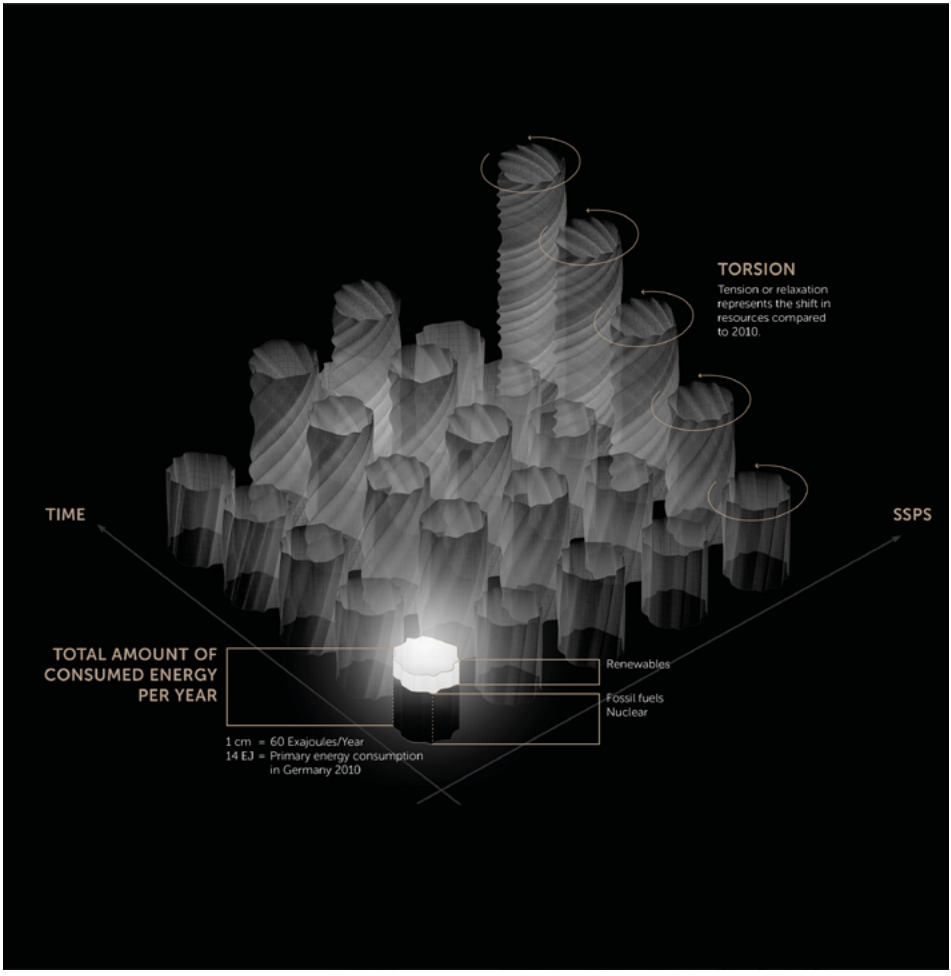

Figure 5. World Primary Energy. Sample of the data physicalization © Katja Budinger, Stéphane Flesch, Roman Grasy, Kathi Veitengruber. Fair Use.

The physical representation of the data aids in the analysis and comparison of database excerpts. Each pillar's height corresponds to the annual global consumption of primary energy. Furthermore, each pillar is bifurcated into two sections (Fig. 6). Renewable energies are depicted in white, while a combination of fossil fuels and nuclear resources is depicted in black.

This color-coded system provides a clear visual representation of the energy sources. The rotation of the form is another intriguing aspect of the exhibit. It illustrates the distortion of energy developments in future scenarios, providing a dynamic view of potential outcomes. The pillars are strategically arranged on a two-dimensional grid. The y-axis represents the timeline from 2020 to 2100, providing a chronological view of energy consumption. The x-axis, on the other hand, represents the Shared Socio-economic Pathways, offering a socio-economic perspective on energy usage.

Figure 6. World Primary Energy. Sample of the data physicalization © Katja Budinger, Stéphane Flesch, Roman Grasy, Kathi Veitengruber. Fair Use.

3.3. Data Visualization and Community Engagement: Environmental Data as Participatory Space

As Rosing and Eliasson (2018) emphasize, one of the most pressing challenges of our time is the sense of alienation and distance that many people feel to major global issues, thus losing a sense of belonging to the worldwide community. Indeed, data are a means to understand a complex world but not the end: we must always maintain sight of what lies behind the numbers, and to design practical tools and stories, we must learn to look through them (Lupi, 2022). In this sense, we could look at Artboat as a case study.

ArtBoat: Magazine Beach (2015-2020) is a unique data-art installation that breathes life into public green-blue spaces. It uses light as a medium and transforms the river into a canvas (Fig. 7). This i-project is powered by SeeBoat, a remote-controlled boat fitted with sensors and LEDs.

Figure 7. ArtBoat: Magazine Beach. Sample of the data physicalization © Laura Perovich, MIT. Fair Use.

Figure 8. ArtBoat: Magazine Beach. Sample of the data physicalization © Laura Perovich, MIT, Ph Neil Gaikwad. Fair Use.Use.

These components measure and visually represent water quality data in real-time. The project is the brainchild of Laura Perovich from the MIT Media Lab. It responds to the "Sky Art Conferences" by MIT's Center for Advanced Visual Studies, which used the sky as an installation site. Now, the water has become the primary site for artistic display. The project aims to make environmental data more interactive and understandable for communities and researchers. During ArtBoat installations, communities gather at riverside public parks. They collaboratively create light paintings on the water using a color-mixing board (Fig. 8). This board helps formulate light palettes, which are then used to control the color of a remotely operated ArtBoat. Essentially, this system serves as a paintbrush, and the river becomes its canvas.

Community photographers capture these moments of shared creation, community development, and public space ownership. They use long-exposure images to offer a fresh perspective of urban space. SeeBoat takes ArtBoat a step further by merging it with water quality sensors. This allows communities to color the river based on water quality data, enhancing their understanding of the environmental and climate challenges we face as a community. The project emphasizes the importance of community understanding of environmental pollution. This is particularly relevant given that many facilities in the US significantly violate their Clean Water Act permits. The initiative explores new ways to engage communities in environmental data and foster meaningful civic conversations. In doing so, it hopes to inspire a new wave of environmental awareness and action. In this context, data physicalization in public space emerges as a crucial tool for creating awareness and understanding of energy use, which is often "hidden" or "not directly apparent" to most people (Broms et al., 2010). By democratizing energy data through physical visualizations such as physicalizations of energy, communities can interact with and understand energy-related information in a more accessible and engaging way (Morais et al., 2021). Overall, incorporating participatory data visualization into public spaces increases public awareness and discourse and enables individuals to contribute to the energy transition movement actively.

4. Conclusion

From the thawing of the cryosphere to the emergence of prehistoric viruses, from the impact of microplastics to energy consumption and water quality, the projects presented

challenge us to reconsider our relationship with consumption, highlighting scenarios and perspectives of [Eco] Participation through Data Visualization as a tool for raising awareness and educating on environmental issues. Information design-led approaches, using a visual code that mediates between abstract concepts – data – and concrete objects – visualization – may indeed be able to bridge the gap between traditional and scientific knowledge, arousing interest and motivating concrete actions. However, what emerges is the need for a holistic approach capable of implementing strategies for humanizing data that consider their visualization and physicalization, the storytelling linked to them, improving the process of use and focusing on the active participation of citizens. Despite significant progress – from practice to research – there are some limitations, including making data accessible and understandable to a broader audience, the need for more sophisticated interactive tools, and integrating different data sources meaningfully. In addition, there is a disparity in access to the technologies needed for data visualization, which could increase the gap between different socio-economic communities. To address these limitations, future development areas should focus on creating more inclusive and accessible platforms, developing technologies that facilitate data interactivity and integration, and implementing participatory methodologies that actively involve local communities. In addition, it is essential to foster interdisciplinary collaborations that combine technical, scientific, and humanistic skills to develop more engaging and persuasive narratives. Thanks to the integration of participatory approaches and interaction with data through interfaces, objects, and spaces, users are encouraged

to engage with the urgent issues of our time, fostering greater sustainability literacy. A so-called [Eco] Participatory Data Visualization can increase motivation, awareness, and active involvement in addressing complex issues such as energy transition (Rappold et al., 2019; Provenzi & Barello, 2020). Investing in these strategies helps us understand environmental challenges better and brings us closer to achieving a more equitable, prosperous society in harmony with the planet. It is, therefore, necessary for professionals and policymakers to adopt a proactive approach in encouraging the use of data visualization for environmental education by investing in technology and data literacy programs, promoting collaboration between public and private entities to create interactive and accessible platforms, and supporting community initiatives that use data visualization to raise awareness and engage citizens. It is possible only through a collective effort to effectively address environmental challenges and promote the transition towards a sustainable future.

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