Enhancing Scientific Communication Through Information Visualization: A Proposal for a Multimodal Platform

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Abstract. This article delves into the realm of science communication and data visualization, presenting a platform designed to enhance the dissemination of scientific knowledge. Rooted in the context of the DIAL4U project, the study investigates the creation of online resources to bridge the gap between scientific experts and diverse audiences. The integration of multimodal data and advanced visualization techniques underscores the platform's point in fostering engaging interactions with the public. This endeavor facilitates the creation of resources that cater to varied scientific communication goals, ranging from sharing recent findings to influencing public opinions. Through science communication and visualization, this article contributes to the evolving landscape of effective scientific discourse and knowledge dissemination.

Keywords: Science Communication · Data Visualization · Multimodal Content · Digital Platforms · Academic Literacy

1 Introduction

This research focuses on the development of a scientific communication tool to address and facilitate the sharing of scientific information with different audiences. Effective communication of scientific knowledge to wider audiences remains a key challenge in our evolving digital information landscape. In which new formats and actors arise in the area, in part due to social media innovation leading to a diversification in the field. As members of the scientific community at the forefront of knowledge generation, it is our responsibility to engage in knowledge transfer, develop creative and practical approaches to education, and engage on the creation of resources to understand and improve education. This research investigates the creation of online resources as a potential solution to this challenge, offering a clear, interactive, and highly engaging medium for the public based on an information visualization user interface.

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1.1 Science Communication

On this section we'll analyze the multifaceted panorama of science communication. Effective scientific communication is a complex process that requires a differentiated understanding of the various target audiences [1]. Whether it's the general public, specific interest groups, the media, political decision-makers, or individuals with no scientific background, starting a dialog about science requires direct interaction between scientists and a heterogeneous public [2]. To achieve this, leveraging resources such as analogies and visual aids, while respecting the audience's existing knowledge, becomes pivotal for sustaining engagement and enhancing comprehension [3].

To effectively communicate science, it's crucial to prioritize the objectives of sharing recent findings and generating excitement for the field. It's also essential to promote public appreciation for science, deepen understanding of scientific concepts and viewpoints, and incorporate diverse perspectives when tackling complex societal issues [4]. The goal is harnessing a range of strategies and resources, to develop cutting-edge and dynamic approaches to science communication, and foster engagement and bridge gaps [5].

It is essential to highlight that the landscape of science communication is multifaceted, encompassing various models and approaches [5]. While some scholars advocate for a unidirectional flow of scientific information from experts to the public as an effective strategy, alternative models prioritize the inclusion of dialogue and deliberation among the public, experts, and decision-makers [1]. The progression of these models traces back to the Deficit Model in the 1960s, transitioning to the Public Understanding of Science (PUS) paradigm in the 1980s and 1990s [6]. Both models inherently acknowledge the necessity to address gaps in public knowledge. However, despite the waning popularity of the deficit model and its empirical limitations, a deficit-oriented approach continues to persist in science communication [1].

The enduring influence of deficit-focused approaches can be attributed to factors such as the presumption among academics that audiences are eager to learn [1]. Moreover, the simplicity of attributing gaps in understanding to the public rather than the science itself has contributed to the persistence of this approach. Notably, the PUS paradigm posits that enhancing the general public's scientific knowledge will correlate with increased support for science [6]. Nevertheless, this paradigm's longevity underscores the necessity for a more comprehensive and nuanced approach to science communication. Consequently, the emergence of models like Public Engagement with Science (PES) signals a shift toward bidirectional discourse between science and the public, fostering active participation and collaborative interactions [7]. This transformative shift aims to empower the public and promote equality in scientific discussions and decision-making [8].

2 Information Visualization

The fundamental role of Information Visualization (InfoVis) in the effective transmission of scientific knowledge as a communication tool with great potential in today's information-oriented society, since it can present information in an engaging, interactive, and accessible way [9, 17]. Information visualization, a fusion between science, art,

and design, amplifies the perception of visual patterns, trends, and anomalies, redefining how reality is apprehended [10].

Serving as a complementary tool to scientific communication, InfoVis assists in elucidating textual information through graphical representations. By effectively conveying complex data in a visual format, it ensures objective communication across diverse audiences and promotes the dissemination of scientific knowledge [10]. Visualizations are asserted to be the most effective means for constructing and conveying evidence-based public policy recommendations on climate change, vaccines, and policing [9].

The foundational principles of InfoVis draw from various intellectual knowledge domains, including, Design, Art, Cartography, Human Computer Interaction, among other knowledge areas [10]. This combination maximizes the generation of reliable, replicable, and representative results. By analyzing the historical, conventional, and practical facets within observational, descriptive, hermeneutic, normative, and critical approaches, visualization optimizes its potential to convey intricate scientific concepts effectively [10].

Within both academic and civil society spheres, InfoVis serves as a conduit for communication. It underscores three vital aspects of scientific communication: the scientific knowledge dissemination, the scientific experience dissemination, and the scientific community dissemination [11]. Notable examples include the University of Oxford's "COVID-19 Pandemic: Visualizing the Global Impact"[1] which disseminates scientific knowledge, and "Mapping Antibiotic Resistance"[2] which employs interactive maps to depict antibiotic resistance levels worldwide. Similarly, Stanford University's Palladio[3] project (2021) illustrates the integration of graphical interfaces with humanistic methodologies, enabling users to create historical visualizations pertinent to their research.

This paper introduces an exploratory InfoVis approach within the DIAL4U project, focusing on seamlessly integrating interactive layouts with knowledge discovery to enhance the scientific communication process. Our contributions aim to bridge the gap between scientific knowledge and the general public, making usage of InfoVis a valuable resource to engage the public. The impact of this research on the public's understanding will be quantified through upcoming user tests, allowing us to measure the effectiveness of these approaches.

2.1 Hierarchical Structures Visualization

Within the realm of information visualization, an array of techniques exists for depicting hierarchical structures. These techniques include nesting, stacking, indentation, and node-link diagrams. Among the various tree visualization approaches, such as treemaps, layered icicles, indented plots, and hierarchical node-link diagrams [18] (the latter of which will be employed in this work), each possesses distinct advantages and disadvantages tailored to specific dimensions of data exploration and other aspects [12].

[1] https://ourworldindata.org/coronavirus.
[2] https://resistancebank.org/.
[3] http://hdlab.stanford.edu/palladio/.

Node-link diagrams, treemaps, and sunburst layouts are all layout fitable to hierarchical data [12, 14]. Node-link diagrams perform well to show the overall structure and parent-child relationships in a hierarchy. Making it easy to see how nodes are connected with edges, which is good for complex and interconnected hierarchies. However, they can overlap and take up a lot of space as the hierarchy gets bigger [13]. Treemaps and sunburst layouts are more compact and space efficient [18]. They use nested shapes or circular segments to represent nodes. This makes it easier to summarize and compare hierarchical data. Sunburst layouts display efficiently the hierarchy in-depth and the area of each node on the representation [14]. However, they may not be as good at showing complex parent-child relationships and interconnectedness as node-link diagrams.

For instance, treemaps efficiently use available display space through a space-filling approach, allowing for effective data representation [12]. However, they fail in conveying intricate hierarchical structures, especially when dealing with sizable datasets characterized by complex branching and depths [18]. In contrast, node-link diagrams adeptly communicate hierarchical relationships, yet may exhibit inefficiencies in utilizing display space as hierarchies grow deeper, particularly in situations with exponential growth [12]. The aim of these visualization techniques is to offer users an intuitive and interactive means to investigate, comprehend, and interact with the content effectively.

In the context of graph theory, a tree is defined by nodes and links. Crucially, trees feature hierarchical relationships among nodes, categorizing them into distinct roles: "above" or "parent", "below" or "child", and "at the same level" or "sibling" [12]. Within this framework, a tree represents the collective assembly of nodes and links within a hierarchical dataset. Tasks centered around the complete tree visualization constitute tree-level tasks, focusing on the overarching presentation of the entire tree.

3 Methodology

3.1 The DIAL4U Project

In response to the evolving landscape of education, particularly language instruction, the DIAL4U[4] project emerges as an initiative co-funded by the European Union's Erasmus + program, targeting the advancement of digital language teaching, and learning methodologies to cater to dynamic educational demands.

This multifaceted endeavor aspires to enhance language education through a comprehensive approach. By equipping language educators with knowledge, crafting tools for language acquisition, disseminating learning across diverse contexts, and promoting the use of open educational resources, the project envisions a holistic access to language learning resources. These efforts collectively work towards enhancing the effectiveness and accessibility of language learning experiences while empowering learners to take an active role in shaping their educational journeys.

One of the facets of this project centers on the creation of an interactive guide for educators. This guide is designed to facilitate the development of language skills within virtual and multimodal contexts. Recognizing the vital role of mediation interaction in

[4] https://www.dial4u-uni.eu/.

foreign language acquisition, this guide aims to empower educators in access language instruction materials.

The content is organized in a logical sequence, starting with teaching modalities and progressing through methodologies, strategies, learning paths, and concluding with various resources, including a collaboratively created glossary. This structured approach allows for user-friendly navigation and enables individuals to explore the interface at their own pace, fostering an accommodating learning environment.

Aligned with the overarching goals of the DIAL4U project, this research introduces a model for science communication through an interactive exploratory visualization. The objective is to empower users with academic expertise to proficiently communicate research content and structural elements. By fostering effective communication through visual representation, this project not only complements the DIAL4U initiative but also contributes to the broader landscape of science communication.

3.2 Data Collection

In crafting a visualization tool for language educators, the project harnesses the capabilities of multimodal data. The construction of data structures is a collaborative effort involving DIAL4U partners, particularly language teachers who curate pertinent information and hierarchical arrangements reflective of the language landscape. This data, accessible online via a designated link, is organized in a JSON file format – ideal for accommodating large datasets with hierarchical structures. The JSON file encapsulates both the hierarchical order of data and the corresponding content for each data point within the multimodal data, including text, video, podcast, or images.

3.3 Interface Development

In this project, we propose a visualization and interface to communicate and share knowledge regarding specialized languages utilizing a node-link diagram. We also choose to use the radial node-link diagram as a visualization method. This method is versatile and helps users to easily explore and clearly represent large hierarchical structures, making it easier to compare different elements within the tree. This visualization technique is especially effective when used with the zoom and collapse functionalities, as they allow more targeted exploration of specific parts of the hierarchy [14]. This type of approach is also used in both 2D and 3D formats and can even incorporate hyperbolic surfaces [12] for enhanced complexity [16].

The used radial tree layout provides a clear and concise overview of the project components and their interdependencies in an effort to facilitate user interaction with InfoVis. The design of the DIAL4U webpage[5] involved a meticulous process aimed at seamlessly integrating advanced visualization techniques with user-friendly content dissemination. The webpage design was designed to accommodate the multifaceted needs of language educators and learners alike. Drawing on web development technologies such as HTML5, CSS, and JS, and the Echarts.js library further enriched the interface's

[5] https://www3.elach.uminho.pt/dial4u/index.html or https://dial4u.000webhostapp.com/home.html.

dynamic capabilities, enabling the creation of an interactive visualization that has the potential to engage users and facilitate comprehension. Notably, the page layout adopts a dual-column structure, where on the left, a radial tree visualization offers an intuitive representation of hierarchical relationships. Adjacent to this visualization, the right-hand column shows content intrinsically linked to each node in the tree, triggered by clicking on the node in the visualization. This arrangement leverages the synergy between data visualization and content dissemination, embodying the project's commitment to effective science communication (Fig. 1).

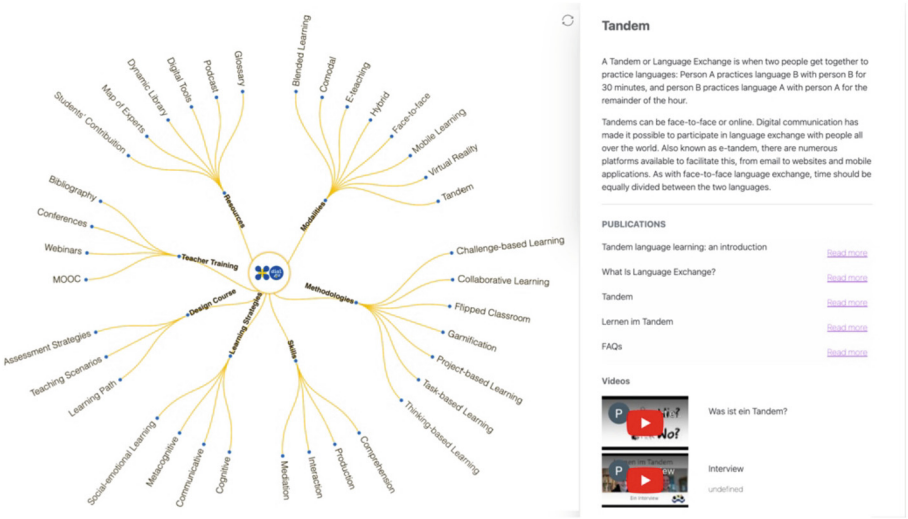

Fig. 1. Web page interface presenting a radial tree visualization and content related to nodes. Developed within the framework the DIAL4U project.

4 Amplification and Future Directions

This project evolved to a new perspective [15], the solution presented in this paper, in the context of the DIAL4U project, not only demonstrates its potential for wider replication, but is also promising for a broad impact. Taking into consideration the DIAL4U context, a dynamic platform has been conceptualized in order to empowering users to create hierarchical visualizations linked with multimodal content created and curated by the users. This innovative platform will serve as a catalyst for communication, facilitating the articulation of research structures and results with greater public involvement.

The transition between DIAL4U to Lang2Science [15], were catalyzed by the synergy between the goals and objectives of both projects. In the evolution of the DIAL4U into Lang2Science [15], a significant stride is taken toward a vibrant community of practice dedicated to scientific communication. Fostering collaboration, shared learning, and the collective enrichment of knowledge dissemination practices. This step signifies not only a cultural shift in the sense of a stronger and more interconnected scientific community but also a technical advancement. Due to the expansion of capabilities

and functionalities offered by the platform. This transition implies the development of a more sophisticated and robust interface, data management systems, and interactive visualization tools.

The Lang2Science [15] platform draws inspiration from the design principles of the DIAL4U project, aiming to empower individuals to generate their own interactive resources for knowledge dissemination. By leveraging the foundation established by DIAL4U, Lang2Science seeks to amplify resource offerings, including features like users profiles associations and links connected to the project's main page. Since the content associated with each project is of substantial value, users can readily access and exploit this collective repository of research materials. The new project uses the same DIAL4U node-link diagram layout, a radial tree, to compose the interface design. The choice was based on positive feedback from users. Users can exercise control over the visualization by toggling labels on or off for each node, thereby enhancing the user experience and facilitating navigation within the visualization structure.

Aiming to empower users to create their own interactive resources and facilitating the sharing of knowledge. The project Lang2Science, a funded initiative, endeavors to establish a repository of resources that collectively support scientific researchers and the community, fostering citizen science, and open science. As part of this global effort, a platform is being actively developed to provide interactive communication resources specifically designed for the effective dissemination of scientific knowledge.

5 Conclusion

Our research has highlighted the potential of online and interactive resources as a valuable tool to bridge the gap and enhance science communication. The replicability potential demonstrated by the DIAL4U project indicates that similar initiatives can take advantage of InfoVis alongside multimodal content to improve user engagement. Given the abundance of high-quality online resources available, these can be seamlessly linked to the platform, further facilitating communication and knowledge dissemination. Increasing communication effectiveness.

As future work, the Lang2Science platform will offer a repository of resources that meet the needs of scientific, academic, and technical literacy. With the integration of specialized language resources, Lang2Science has the potential to make an effective contribution to the way students and educators communicate science. The next crucial step involves subjecting the DIAL4U to obtain a broader perspective on the user experience of the DIAL4U project website requires user testing based on satisfaction and performance metrics. This iterative process will ensure that our design aligns perfectly with the user's expectations in order to improve their experience. By grounding our efforts in user feedback, we aspire to refine and amplify the impact of our platform on the landscape of science communication and education.

Furthermore, the project's future perspectives include the use of advanced AI, powered by a Language Large Model (LLM), to automate the creation of JSON structures for specific knowledge domains. This automation will facilitate the easy generation of visualizations, benefiting academic users who can take advantage of this technology to create educational resources more efficiently and effectively.

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