Designing a Multilingual, Multimodal and Collaborative Platform of Resources for Higher Education

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Abstract. While digital technologies have revolutionized how we collect, store and retrieve information, there is a lack of strategies that support academic collaboration at the institutional level. Today it is vital to know how to communicate accurately and efficiently, respecting the specificities of each communicative context. We present an interface prototype aimed to overcome the communication barriers imposed by specialized languages, which are becoming more relevant as a result of the increasing specialization of knowledge. This article presents the first iteration of the conceptualization process of the interface layout, its interaction logic and visualization structures. It is essential to consider the hierarchical structures/algorithms to represent and support the collaborative creation of academic knowledge resources.

Radial tree layouts are an optimal solution for displaying large hierarchies, however the implemented radial layouts in ECharts are not being used as analysis tools, instead, they are used as a means of creating, mapping, navigating and exploring different facets and knowledge resources of academic projects, and specialized language glossaries. To sum up, this article provides a framework and fundamental guidelines for an interface layout that explores and promotes academic collaboration at the institutional level in order to overcome the lack of knowledge about the resources produced by different actors in the academic context.

Keywords: Specialized Languages · Visualization · Interface Design

1 Introduction

While digital technologies have revolutionized the way we collect, store, and retrieve information, there is a lack of strategies that effectively support academic collaboration, as well as strategies that promote awareness of the type of knowledge/educational resources produced at academic/institutional level [1]. Today it is vital to know how to communicate accurately and efficiently, respecting the specificities of each communicative context. This challenge imposes a shift from the academic *modus-operandi*,

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where resources are scattered, to a solution that promotes synergies and interconnections between the different scientific areas, academic actors and the knowledge/educational resources designed and produced.

Quite paradoxically, it's considered that the systems available to share academic knowledge/educational resources have probably never been so easily accessible, however, overwhelming systems/interfaces are everywhere. Some examples are the data collections inaccessibility, mainly due to the implemented technologies; a lack of truly open data policies in some fields (e.g., science field); and interfaces or websites unfriendly designed that difficult the access to information and knowledge (e.g., open data repositories, government websites, science digital libraries) [2–4]. Thus, it is important to responsibly design effective and efficient strategies that simplify the digital systems we use, including designing new interfaces to visualize, collaboratively create, and share academic resources. In the academic context, there is a need to design collaborative knowledge and educational resource sharing platforms, which underlines the importance of designing solutions that simplify the actual digital systems we use.

The present article deliberately focuses on two specific objectives of the lang2science project (originally named PortLinguE) to deliver an interface and a set of tools based on advanced exploratory information visualization structures. These tools will support the collaborative design and sharing of the different facets and knowledge resources of academic projects; and an on-line glossary tool whose role would be to foster the collaborative construction of a common language among academic actors aimed to overcome the communication barriers imposed by specialized languages. The interface concept is based on the relations between academic actors, topic areas, the resources produced, such as projects and their different facets, among other important resources, such as the possibility of designing and creating specialized language glossaries. This body of knowledge provides evidence about the existence of important resources that can be used and adapted to support the interaction and also build bridges between traditionally distant disciplinary areas by blending different angles on science, and the different actors of the academic context.

To sum up, it is urgent to develop new methods and strategies to improve and promote collaborative environments based on the sharing of knowledge resources produced in the academic context. This implies, first of all, building a common culture that overcomes the communication barriers imposed by specialized languages, which become increasingly relevant as a result of the growing specialization of knowledge. Second, to provide insights into the different resources produced by research and development projects in the academic context.

The remaining article is divided in the following sections: section two presents the general outline of the lang2science project, explaining the motivation behind its elaboration and the objectives that guide it; section three provides a brief definition of radial tree layouts, some advantages and disadvantages are noted, and some important projects and techniques are referenced; section four provides the interface model, interactivity conceptualization, and the implementation of radial trees in ECharts; the last section presents a brief discussion and future directions.

2 The Lang2science Project Contextualization

We live in a digital information society where many areas of knowledge coexist, but it is not a given that we know how to understand and communicate according to the terminological idiosyncrasies of these areas. The tendency toward specialization has been accompanied by the proliferation of documents written on a wide range of subject fields, which are often available in open access (webpages, repositories, databases). It is in this context that the lang2science project emerges, which aims to create a platform for specialized languages with the purpose of providing creative multimodal resources for science communication, exploring critical and visual literacy needs in higher education digital learning environments. The concept of specialized language escapes a unique definition, but it can be said to point to a language with specific features developed in response to the communicative needs of speakers, in a given area of expertise. This is in line with the definition proposed by ISO standard 1087:2019[1], according to which a special language is a "natural language used in communication between experts in a domain and characterized by the use of specific linguistic means of expression"[2].

In this project, as important as the technological side is the pedagogical side, through its multimodal dimension. In lang2science, multimodality works as a mechanism to foster the taste for science in the most diverse audiences, through the creation of creative contents of science communication. By producing multimodal content based on scientific texts, academic actors become science communicators, thereby acquiring several competences included in the digital education action plan (2021–2027).

The use of computational and information visualization approaches facilitates the study of larger document collections, or other cultural artefacts [5]. Therefore, the main goal is to acquire a better understanding of academic knowledge resources through an Information Visualization (InfoVis), User Interface Design (UI) and User Experience (UX) approach [4, 6]. Information visualization is a process that transforms data into information in order to provide actionable insights so that users can interpret and easily comprehend [7–11]. UI and UX design[3] anticipate users' requirements to guarantee that the interface has components that are easy to access, understand, and use in order to simplify possible actions [12, 13]. Owing to the didactic nature of the lang2science project which repurposes the wealth of knowledge resources in open access, we plan to encourage academic actors to create their own resources, using two features of our platform (see Fig. 1).

The first feature is to collaboratively design a specialized language glossary based on an aesthetic/visual approach. According to our perspective, glossary visualization is an area that needs to be explored, so communicating glossaries through visualization structures in an interactive and understandable way is a challenge due to the unstructured nature of the data. New approaches to text visualization can provide important clues, new techniques and algorithms. Therefore, it is significant to reference important reviews on

[1] https://www.iso.org/obp/ui/#iso:std:iso:1087:en.

[2] ISO 1087:2019. Terminology work and terminology science – Vocabulary. Standard, International Organization for Standardization, Geneva, CH, 2019.

[3] https://www.usability.gov/what-and-why/user-interface-design.html.

the state of the art of text visualization, such as [14], which references important surveys that focus on text visualization, and also proposes an interactive visual survey of text visualization techniques[4]; [11, 15], cover some fundamentals regarding text visualization and presents some important works; [16] provides an overview on visualizations that support close and distant reading of textual data and highlights beneficial visualization approaches for research in the digital humanities; [17] provides a systematical review of existing text visualization techniques; [18] presents a different approach to text visualization based on text elements (e.g., microtext lines, skim formatting, typographic sets), however, no focused study is provided on optimized visualization methods, techniques, structures and algorithms, for implementation. A more detailed review regarding this topic is out of the scope of the current paper.

Glossaries are known to most people due to their presence on the final pages of books, in a space made to exhibit terms related to the text, allowing the readers to do fast consultancy across a list of terms and definitions. More broadly it can be defined as a collection of terms with their respective glosses, "a brief explanation (…) of a difficult or obscure word or expression"[5]. Making sense of all this content seems like a challenge for information and language specialists, so it is essential to develop resources and strategies to overcome this challenge. One strategy is to use the glossary to help users access the semantic meaning of a text [19], and to create a collection of terms or jargon related to a specific document or field of study [20]. Currently, there is no widely used method for creating and structuring glossaries; they are generally organized and presented alphabetically [21]. The most basic way to organize the contents of a glossary is alphabetically. The starting point in building a glossary is to extract a terminology and its definition. From this point on, it is possible to create more sophisticated structures such as thesaurus, taxonomies, ontologies and logical constraints [22]. Therefore, in the context of glossaries, hierarchy happens when a Knowledge Organization System (KOS) (e.g., taxonomy) is adopted [23]. A more detailed discussion regarding this topic is beyond the scope of this paper. Moreover, it is an important tool to graphically represent the dynamic language that is constantly changing, with new terms constantly being bred. But exploring and visualizing glossaries is a topic that has not been addressed by many researchers. The most common projects rely on the visualization of hierarchical structure that results from the glossaries analysis as taxonomies or ontologies. Exploring it across the hierarchical structure between the terms makes it possible for projects like ecolexicon [24] or FuncTree2 [25] to investigate the root-parent-child relation at different levels. Visualizations built specially to encompass glossary terms are uncommon, and examples of this segment of visualization are rare, probably due to the data characteristics.

The second feature is to design and visualize project knowledge resources produced in academic context, considering the same hierarchical radial layout. These project resources provide evidence about the existence of important knowledge that can be used and adapted to support the interaction between different fields and the different actors in the academic institution. Radial tree layouts are an optimal solution for displaying large

[4] https://textvis.lnu.se.

[5] https://www.merriam-webster.com/dictionary/gloss.

hierarchies [11, 26, 27], because uses space more efficiently than horizontal or vertical trees The next section presents a brief definition of radial tree layouts, some advantages and disadvantages are noted, and some important projects and techniques are referenced.

3 Radial Tree Layout: Objectives and Characteristics

Given traditional humanities research methods, as for instance close reading, the use of advanced information structures allows to perform micro and macro-level analysis on large collections (close and distant reading) [5, 16, 28]. Hierarchical structures or trees are a set of techniques to visualize a specific type of relation. Trees can be used to describe computer files systems, phylogenetic trees [29], organizational structures, ancestry lineage, and also language can be described as a tree (e.g., Sentence Parsing Tree[6]) [15, 27, 30].

This section provides a brief definition and describes the fundamental properties of tree layouts, but also points out some advantages and disadvantages. In the case of the presented context, two radial layouts are used to explore and map different facets of academic projects, and a glossary of specialized language. The radial hierarchical structures are primarily intended for scholars to quickly gain insight into the different facets of projects, and another point is the presentation of glossaries based on a micro and macro-analysis approach. Some key references regarding important surveys, and about the latest developments on hierarchical structures are also presented. The main focus is on 2D hierarchical structures, more specific 2D radial layouts.

There are two main categories to visualize hierarchical topologies [27], namely a specific type of node-link diagrams, normally presented with a vertical, horizontal or radial layout (e.g., dendrograms, decision trees, flow charts, radial trees, ring trees), and containment or partitioning layouts such as treemaps that use nested rectangles, or sunburst structures that use rings that are sliced for each category node [15, 26, 27, 31]. The main focus of this section is on radial tree layouts, which is a technique for drawing hierarchies, and uses space more efficiently than horizontal or vertical trees. Radial trees are represented by two types of visual marks, namely nodes and lines/links that represent the relations between nodes [27, 30, 32]. In radial tree layouts the depth of the tree is encoded as the distance away from the center of the circle, where the links are drawn as "smoothly curving splines" rather than straight lines [26]. It also uses polar coordinates instead of cartesian coordinates [27]. The approach of Lombardi [33], namely drawing edges with arcs instead of straight lines, allowed for optimal angular resolution where the polynomial area can be guaranteed [27]. Regarding this point, radial tree layouts tend to scale better according to a defined set of criteria.

One advantage of radial trees compared to containment layouts (e.g., treemaps) is the possibility to visualize the hierarchical structure of the tree and to design a tree in a more compact form compared to vertical or horizontal trees. However, it is important to highlight some issues regarding tree visualizations. One problem that is common to all visualizations is scalability. The higher the number of nodes and the harder it is to

6 https://www.nltk.org/book/ch08.html.

accommodate all nodes into one single visualization. Another issue regarding vertical or horizontal tree layouts, is that with a high number of nodes they become very extensive layouts, and therefore are not suited for efficient navigation. Another problem is the nodes' labeling, which is an important communication tool in order to understand the nodes' meaning, namely the labeling clutter when a larger number of nodes' is used, which also affects the scalability of the algorithm. Interaction techniques are used to mitigate this issue and will be explained more later in the next section (e.g., the use of interactive tooltips).

There are important visualization techniques that have been developed for displaying large hierarchies, [30] provides a tree visualization catalog with a set of references regarding different tree layouts and techniques; [27] presents an extensive survey of 2D tree visualization approaches, highlighting some techniques and developments up to 2015; [29] proposes a set of design dimensions based on the items in treevis.net[7] to understand tree visualizations from an evolutionary perspective; [34] uses a radial tree as an interactive navigation structure applied to mobile devices; more recently [32] presents GoTree (Grammar of Tree visualizations), namely a grammar for tree visualization for non-expert users to design tree visualizations more easily. It also presents Tree Illustrator based on GoTree, a declarative grammar for specifying tree visualizations that cover a broad set of possible layouts by specifying visual elements, coordinate system, and layout [35]; [5] presents empirical and promising results regarding the use of radial tree layout which has allowed to promote a dynamic research process with proven value for both scholars and readers, and [1] proposes a web-based interface where users can visualize learning objects on a hierarchical knowledge graph. A broader review of the state of the art is beyond the scope of the current article.

To sum up, hierarchies or trees are one specific category of networks. It starts with one single node, namely the root node, and following the root node there can be two or more children. Each node can have between zero and multiple children, and each child can have only one parent. The purpose of using a radial structure is to provide the user with an overview of the different facets of research projects (see Fig. 6), and the relationships of the semantic data in the case of glossaries. The radial structures were implemented in Apache ECharts[8], which is an open-source JavaScript visualization library, namely a declarative framework for rapid construction of web-based visualizations [36].

The next section presents the graphical user interface, the radial structures and some interaction details.

4 Graphical User Interface and Interactivity Design

This section presents the first iteration of the interface layout, and a brief explanation of the interaction process.

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[7] https://treevis.net.

[8] https://echarts.apache.org/en/index.html.

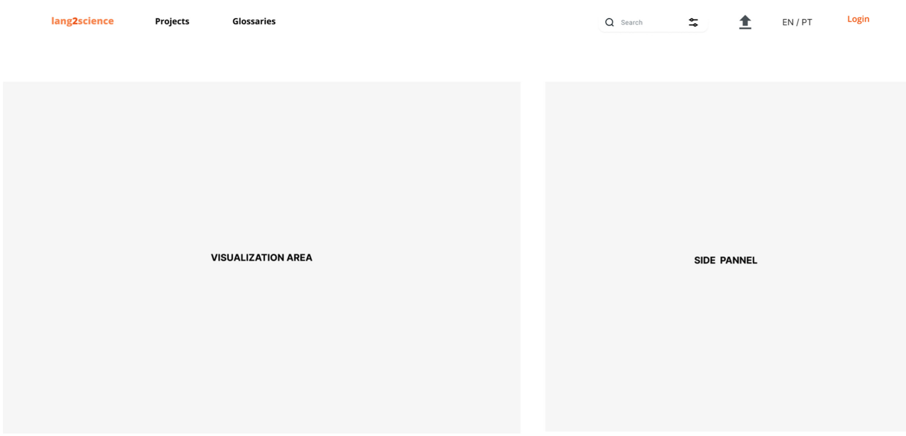

Fig. 1. Mock-Up Interface Design

The interface is constituted by two main pages: the interactive glossary page (see Fig. 3 and 5) and the project page (see Fig. 6), that will be future integrated in the lang2science platform, and can be accessed in the navigation bar (see Fig. 1). The main goal is that users can build and share knowledge resources. The graphical layout is subdivided in three main sections (see Fig. 1): the navigation bar (main buttons and the search field box), the visualization area, and the metadata main panel. The two main pages share the same structure, namely the visualizations areas, and a side panel where the content will be displayed as the user interacts with the visualization. However, the major difference between these two pages lies in the requirements of each page, as the glossaries page uses a search box in the lateral panel to support the user's context while navigating the terminology. The projects page uses a side panel for displaying text, videos, images or podcasts (see Fig. 6). It is important to mention that the content components were built in HTML, CSS and JavaScript.

The two radial trees structures aim is on displaying hierarchical semantic data (see Fig. 3 and Fig. 6). Both visualizations have in common the chart choice, the radial tree, as a consequence of the data nature shared between them, which was determinant in this choice. Navigating and exploring the semantic data may be achieved through the use of interactive controls and techniques. Navigation controls depend on the used visualization and include interactions such as scaling the view through the use of the zoom technique, as well as providing context between the region of interest and the entire visualization. In both visualizations users can use the mouse wheel to change the scale of detail through the zoom technique. This allows an overview of specific points of interest. In addition, hovering the mouse over a node labels the content of the node, and highlights the node's label and its descendants (see Fig. 4). A mouseover event triggers a tooltip to display detailed information/metadata related to nodes (e.g., Augmented Reality) as shown in Fig. 4. Another visual feature is the transparency of the tooltip that is used to prevent users from losing sight of the context. An important interaction technique implemented was to visually "gray out" the context to reduce visual clutter when clicking in a node. Opacity with a value of 0.9 (Alpha Channel) was used to make the context transparent, as shown in Fig. 4. This technique makes it possible to focus on a node and its respective links without letting users lose sight of the context, and thus provide a continuous and predictable experience. Exploration interactions include functionality for data inspection, namely a data filter, and a search box for performing dynamic queries (see Fig. 3).

There are two different ways to update the data on the platform, the first possibility is to directly add the content on the interface through forms, this will be the only option to add content on the knowledge resources page. The second option is related to the glossary web page, where the glossary can also be updated by uploading an Excel file (upload button), where the user needs to add all the terms and their definition (see Fig. 2). It is optional to add complementary content such as equivalents (in the case of a multilingual glossary), videos, podcasts, or images related to each term or node (see Fig. 2). The purpose of developing these two options is to facilitate cooperative work since glossaries are often built-in partnership between researchers. The tool can be seen as an agent of integration in which users have full control of their work and the content embodied by making it available to the community. This interaction process will be addressed and implemented in future work.

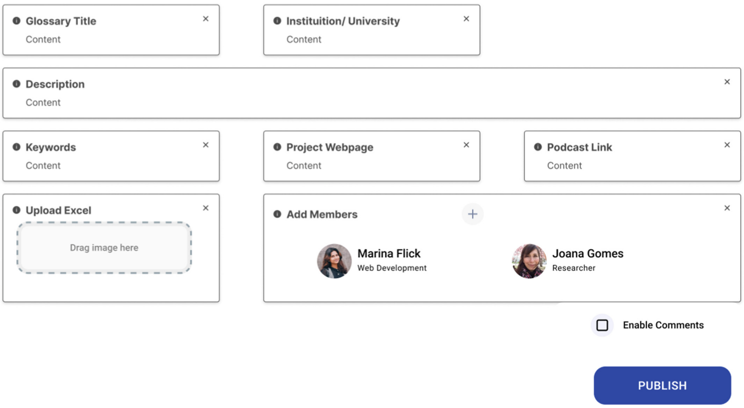

Fig. 2. Glossary Form Mockup Component

Interactivity plays an important role in exploratory information visualization approaches, so the following sections describe and present the interactivity logic of the interactive glossary and the interaction process of the knowledge resources visualization.

Hence, we propose to build an interactive interface intended to provide users with contextualized uses of languages for specific purposes in different domains of expertise and in different languages, and also to map knowledge resources related to academic projects.

4.1 Interactive Glossary

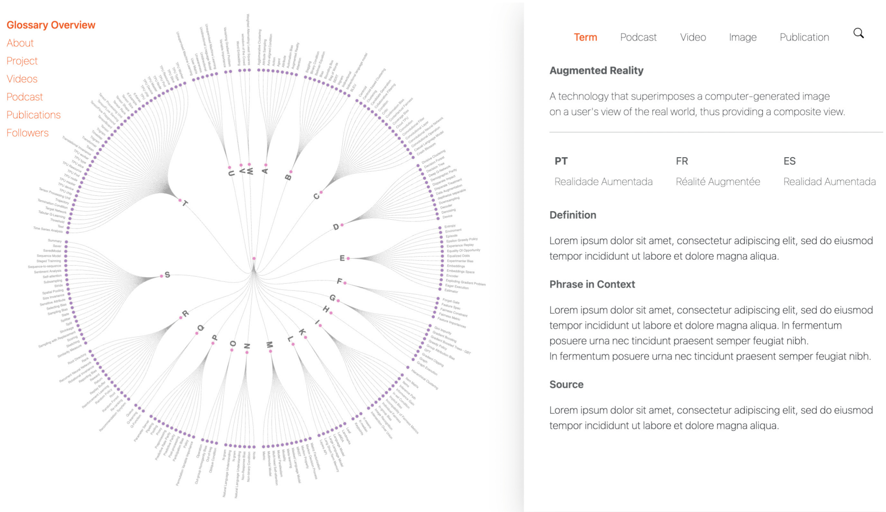

Fig. 3. Alphabetical glossary Expanded View

The glossary prototype uses Google Machine Learning Glossary which has approximately 460 terms [37]. Glossaries are versatile text structures, and allow two types of visualization approaches. In the first approach, users can visualize the glossary based on the alphabet letters (see Fig. 3); and in the second approach, the visualization is based on machine learning topics (e.g., Clustering, Decision Forest) (see Fig. 5). While the change may seem small, there is a significant impact on the visualization. Hierarchical glossaries may contain more or fewer categories while the maximum number of categories (parent nodes) in an alphabetical glossary is always twenty-six.

When users access the glossary, two main components appear. The first content component, the information and metadata panel, is triggered by clicking on a node that provides information and metadata regarding the search term, namely its definition, its use in context, its related terms and associated resources (images, videos, among others). The second component is a search box on the right side of the lateral panel and gives users access to the glossary's terms.

These elements follow the mantra "Overview first, zoom and filter, then details-on-demand" [38]. Hence, as mentioned above, the page provides an overview of the data through the radial tree with the option to zoom. In addition, there is the option to filter the content by clicking on a node or by using the search box in the lateral panel.

Establishing a valid visualization model for both glossaries (organized either by alphabetical letters either by topics) was a challenge as the characteristics of the graph can change according to the updated data, since the depth of levels adds complexity to the visualization, especially regarding hierarchical glossaries that can contain numerous

Fig. 4. Alphabetical Glossary Tooltip

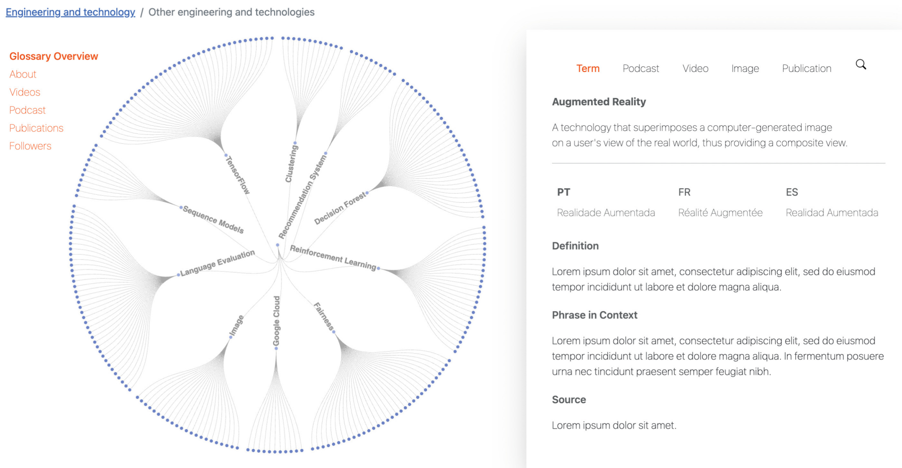

Fig. 5. Glossary organized by Machine Learning topics

depths, directly impacting the visualization context. To optimize the term search mode, the user can use a search box on the lateral panel (see Fig. 3 or 5). Each of these glossaries can also be linked to a multimodal mapping approach on a given subject that can also be created on the platform and that will be explained in the next section (see Fig. 6).

4.2 Projects Visualization and Interaction

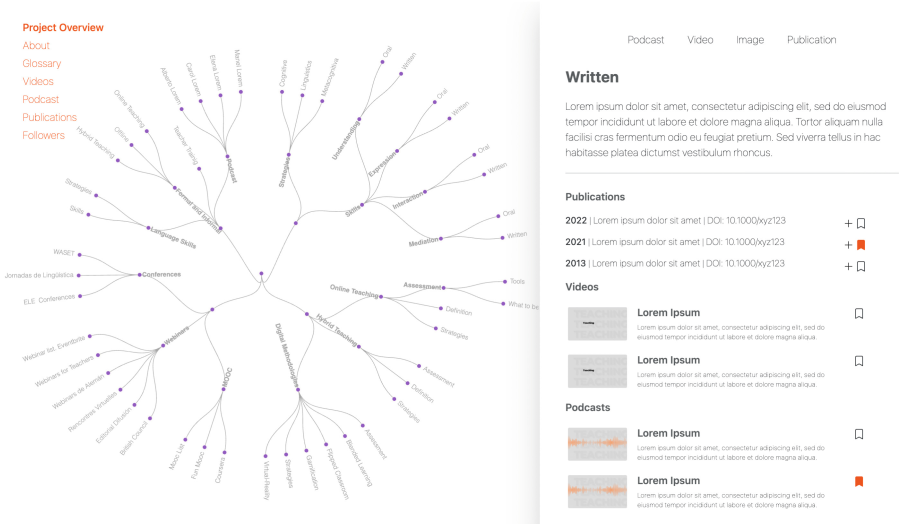

Fig. 6. Project Visualization

The goal of this page is to create a knowledge resources map in which users will be able to organize content related to academic research, acting as a tool to facilitate the dissemination of project-related work (see Fig. 6). The goal is to help make the connections between research and research-related resources by giving users access to curated material presented in an innovative way.

The mapping page features one visualization area, namely the radial tree visualization that consists of an overview of the project knowledge resources; and one information panel, on the right side of the screen, that displays the content related to the user's interaction with the structure, exhibiting the corresponding multimodal content, and an index navigation panel that labels the parents and children's nodes. Figure 6 presents an example of the multimodal mapping created within the scope of the DIAL4U project financed by European funds, whose objective is to help language teachers to take advantage of new online teaching practices, by extracting, classifying and visualizing information from articles and scientific studies dedicated to language teaching using digital tools. The main goal is to be able to aggregate many other multimodal mapping projects in order to cover different domains of expertise.

An important point is the node labeling strategy used to mitigate the labeling clutter issue. The leaf nodes have a fixed label, and the metadata regarding the nodes inside the structure (i.e., child and parents) is accessed through a mouseover that shows and magnifies the label. This strategy is adopted in both radial structures. The resources integrated into the project will be displayed by default in alphabetical order in this first phase. In the future, the project creator should be able to customize the content disposition.

It is important to mention that both glossaries and research projects are organized according to the Revised Field of Science and Technology (FOS)[9] classification of the Frascati Manual. The classification can be seen at the top of the page as a tool to give the user a holistic view of the glossary created by each knowledge area (see Fig. 5).

Therefore, science digital libraries interfaces are not an effective solution when dealing with complex topics, as for instance the Covid-19 articles flood [39].

5 Final Considerations and Future Work

The relation between digital technologies and scientific culture challenges us to design novel interfaces where the access to knowledge resources may contribute to the development of innovative approaches. Lang2science is an example of a project that focuses on the process of creation and dissemination of academic resources based on open access data. To address this question, we use information visualization to explore the content of academic knowledge resources and to identify patterns of content creation. This article describes an interface model which was designed to validate and guide the visualization and interaction process in content creation. The creation of these resources can help to design a two-way interaction between academia and scientific open data. These resources could be re-used and enhanced by others to create scientific plus value. Therefore, the visualization structures implemented are intended to facilitate the exploration and navigation of knowledge resources organized in hierarchies that are designed by academic actors. By organizing knowledge resources into a semantically meaningful hierarchy, we hope to reveal patterns and relationships among topic areas, semantic data and knowledge resources (e.g., videos, podcasts, glossaries, images, among other resources). Two radial tree layouts were implemented in Apache Echarts in order to validate and test the interaction, exploration and navigation process.

The future work will consist in a deep literature review on text visualization, and what type of structures can efficiently support glossaries visualization. Glossaries visualization is still a very underdeveloped area. It is also important to conduct a user study/evaluation based on performance and satisfaction metrics to understand how users will interact with radial tree layouts as exploratory and navigational structures and how the propose tool/interface is effective for academic collaboration at the institutional level. The study will be conducted with academic actors playing 3 types of roles: students, researchers and professors, for a total of 15 testers and according to a set of task scenarios, using the Think Aloud protocol.

Another point is to develop and implement form components so that users can design and build glossaries and project-related resources based on a user experience logic.

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9 https://www.oecd.org/science/inno/38235147.pdf.

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