

Learning the Semantic Web with tools for information visualisation and data storytelling

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Abstract

Data literacy and visualisation literacy are pivotal for students to effectively explore and interpret digital data collections. In Digital Humanities, such skills facilitate engagement with data-driven information systems, making abstract information tangible and actionable. This study investigates the role of a web-based storytelling editor, i.e. MELODY, in enhancing students' ability to create narratives from digital collections through data visualisations. By analysing how students integrated visual elements into their stories and reflecting on project feedback, we uncover how WYSIWYG tools contribute to develop essential competencies in data and visualisation literacy. Findings highlight the importance of intuitive visual elements in fostering critical thinking and iterative learning, as well as the challenges faced with incomplete data sources. Further insights underscore the need for improved educational tools and practices that support exploratory learning in Digital Humanities.

Keywords

Data Visualisation Literacy, Semantic Web Education, Data Storytelling

1. Introduction

Data and visualisation literacy are critical competencies in today's information society. For instance, in the Digital Humanities students must increasingly engage with complex cultural heritage data collections [1], manipulate raw data into meaningful insights, and leverage both their analytical and creative capabilities. Mastering Semantic Web technologies is a desired expected skill, which is however often taught in separate learning paths than data analytics. Learning (and therefore teaching) such competencies poses a number of challenges, particularly for learners with limited technical backgrounds [2], and many have advocated for easy-to-use tools [3]. To the best of our knowledge, previous studies on data literacy [4, 5, 6] lack attempts to teach Semantic Web together with information visualisation basics. Nonetheless, information visualisation methods could effectively ease the steep learning curve required by Semantic Web technologies [7].

Prior studies have demonstrated that combining narrativity with information visualisation techniques fosters critical thinking and interpretative skills, which are fundamental for humanists to navigate and engage with complex datasets [8, 9]. Specifically, integrating storytelling into visual analytics encourages users to critically assess data representation choices, mitigating the risk of oversimplification. This is particularly relevant in the Humanities, where uncertainty, vagueness, and incompleteness are inherent characteristics of knowledge production. By embedding narrative elements into data exploration, students are prompted to reflect on the epistemological limitations of their sources, fostering a more nuanced and responsible engagement with data.

MELODY is a what-you-see-is-what-you-get (WYSISWYG) platform for data storytelling design and publication, which seamlessly integrates curated texts, SPARQL queries and data visualisations into an accessible, user-friendly interface, allowing users to craft narratives enriched by charts, maps, text searches, and tables [10]. MELODY has recently been used as a teaching tool in a Humanities master

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course program¹ that introduces Semantic Web technologies to undergraduates with no technical background, and requires them to investigate a music-related topic and produce data-driven narratives.

In this paper we examine student projects realised using MELODY to identify key aspects of how WYSIWYG improves data and visualisation literacy. In particular, we are interested in data exploration and communication aspects (i.e. how students engage with data collections), and the challenges and opportunities emerged. Findings reveal how intuitive visual storytelling tools, like MELODY, improve students' ability to explore and communicate complex datasets, fostering data and visualisation literacy while highlighting challenges related to incomplete data sources and technical usability.

The article is organised as follows. In section 2 we discuss previous works on data literacy and the Semantic Web, highlighting a clear gap in adopting information visualisation as a learning tool. In section 3 we present the corpus of data stories produced by students using MELODY, and in section 4 we present results of our analysis. In section 5 we provide students' feedback reported as part of the exam, and in section 6 we discuss results, drawing conclusions and future works.

2. Literature review

It is argued that information visualisation can enhance data literacy and critical thinking [11, 7]. Likewise, storytelling has demonstrated being a creative, project-driven approach to cultivate data literacy [3, 12]. By allowing students to integrate visualisations into data stories, storytelling bridges the gap between data analysis and ethical dissemination. Such an approach makes data meaningful to students, promoting critical engagement and communication skills [13]. Indeed, while experts prefer technically precise visualisations, less experienced users favor contextually rich and engaging formats, where contextual and narrative elements are present. A balance between the two approaches is essential in educational contexts, where students must learn not only to design accurate visualisations but also to understand their narrative potential. Moreover, data visualisations play a dual role: reducing cognitive load and enabling critical engagement with datasets [13]. To this extent, scholars have argued on the importance of integrating visualisation literacy courses into curricula, so as to make it a critical skill for learners [13, 14]. [6] offer a broad view of the data literacy learning landscape, identifying information visualisation in educational paths as a pivotal competency.

Exploratory platforms like the Comédie-Française Registers Project (CFRP) exemplify this potential, allowing users to interact with datasets through intuitive interfaces [15]. However, studies suggest that while such tools simplify initial engagement, they often lack the depth to support advanced exploration, underscoring the need for balanced designs that foster both comprehension and creativity [16].

Studies have shown that the combination of narrativity and information visualisation helps expand critical skills essential for working with complex data, encouraging users to question, contextualise, and interpret visual representations rather than passively consuming it [3, 8, 17, 18]. To the best of our knowledge, MELODY is the only open source platform that integrates both aspects—narrative and data visualisation—within a single environment, which would require the use of multiple tools [10].

MELODY is a web-based platform designed for data storytelling with Linked Open Data. It allows users to query any SPARQL endpoint, visualise results dynamically, and integrate structured data into curated narratives. The main requirement to create the data story is the URL of a SPARQL endpoint. In the data story canvas, users can select and arrange various UI components—such as charts, maps, tables, and text blocks—to construct their narrative. Content creation is simplified through WYSIWYG forms, allowing authors to input plain text or SPARQL queries, with immediate preview of results. The final output is a web document containing an ordered list of components, which can be modified and rearranged at any time. Additionally, users can export their data stories as static HTML, PDF, or JSON files, ensuring flexibility in presentation and sharing.

However, MELODY is specifically tailored for linked data. Created to address the research needs of humanists—linguists, historians, musicologists—and validated through their input [19], the platform

¹<https://www.unibo.it/it/studiare/dottorati-master-specializzazioni-e-altra-formazione/insegnamenti/insegnamento/2023/402023>

was designed to facilitate the exploration of cultural heritage datasets, which today are predominantly served as linked data [20]. Despite its intuitive interface, learning Semantic Web technologies remains challenging for humanists, as they must acquire SPARQL querying skills and an understanding of linked data structures, which are often beyond their traditional expertise [21, 16].

Teaching the Semantic Web often presents unique challenges due to its technical nature and steep learning curve, especially for students from non-technical backgrounds. Interdisciplinary approaches to data science education, as highlighted by [2], emphasize the importance of integrating qualitative and quantitative reasoning to make complex technical subjects more accessible to diverse learners. While not directly referencing Semantic Web technologies, their advocacy for inclusive and interdisciplinary pedagogies underscores the need for teaching methods that bridge these gaps and cater to students from a variety of academic and professional backgrounds. [7] provide evidence of the educational potential of Semantic Web technologies, focusing on Wikidata as a teaching platform. They highlight how visualisation makes linked data accessible by enabling learners to explore connections, identify gaps, and critically assess data quality. This approach fosters key skills such as data modelling, ontology design, and critical thinking, establishing visualisation as a vital tool in Semantic Web education. However, their study also identifies significant challenges, including high thresholds for newcomers, inconsistent data modelling practices, and usability issues, which underscore the need for more intuitive educational tools. Despite these benefits, the integration of visualisation into Semantic Web education remains underexplored.

3. Methodology

MELODY provides users with a flexible environment for creating web-based data stories that combine curated text elements (e.g., titles, paragraphs) with interactive data visualisations. The platform supports various visualisation types, including bar and line charts, scatterplots, doughnut charts, and maps with filters. Additionally, it allows the integration of numerical counters (i.e., numerical values displayed alongside descriptive text) and interactive text searches. These searches return results as tables, where clicking on specific values dynamically generates new tables, enabling an iterative *follow-your-nose* exploration. Users with a GitHub profile can publish their data stories for free in a dedicated online catalogue².

The study presented here was conducted within a master's course on Semantic Web technologies at the University of Bologna. Students were introduced to MELODY through a short tutorial session, during which they learned how to use its core functionalities, such as performing SPARQL queries, selecting visualisation types and parameters, and designing advanced interactive features like iterative text searches and filters. After this introductory session, students independently explored the platform to complete their projects. As part of their coursework, students were required to create one or more data-driven stories to explore topics in music history using the online MELODY platform³. Students had the possibility to build these projects on top of any Linked Open Dataset, though the majority (82% of the stories) chose Wikidata as their primary data source.

To analyse the outcomes, we examined 51 data stories, focusing on (1) the frequency and distribution of visual elements (e.g., charts, tables, maps) and (2) their role in structuring narratives. The results of this analysis are presented in section 4. Additionally, we collected qualitative feedback from students during their project presentations as part of the course examination. This feedback provided insights into their experiences in creating the data stories. These qualitative reflections were systematically categorised into a dataset for further analysis in section 5. Both the dataset of student-created data stories and the structured feedback data are publicly available in a Zenodo repository [22].

²<https://melody-data.github.io/stories/>

³<https://projects.dharc.unibo.it/melody/>

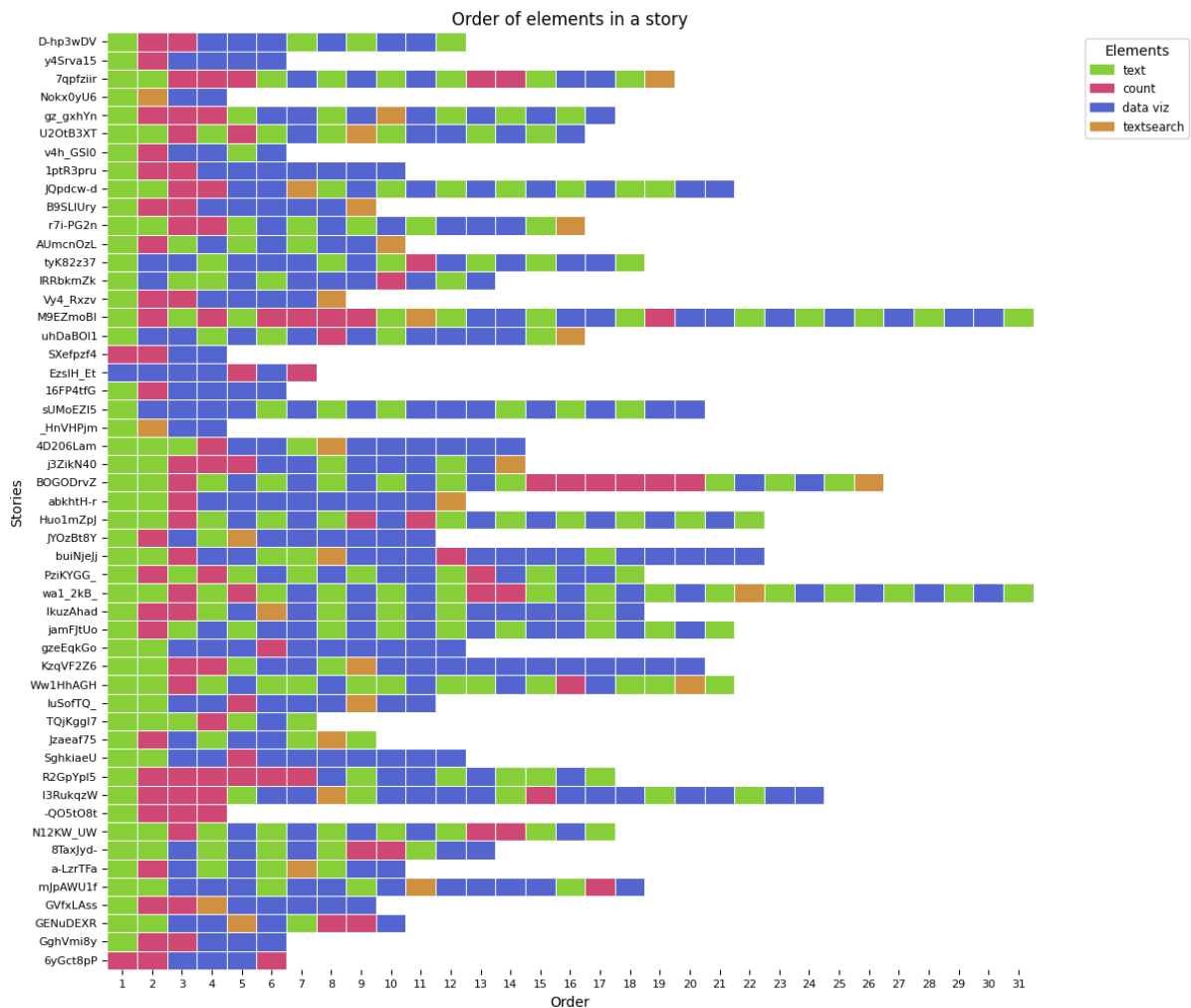


Figure 1: Distribution and order of appearance of MELODY visual and text components in data stories.

4. Results

Visualisations play a central role in structuring data stories, as shown in Figure 1, which illustrates the distribution and order of element types across narratives. Data visualisations (blue cells) were the most frequently used element, appearing in nearly all stories (stories without visualisations have been pruned from the corpus), followed closely by text blocks (green cells), which complemented the visuals with explanations. Counters (red cells), often placed at the beginning of stories, served to highlight key statistics and provide an introduction to the analysed dataset. Instead, text searches (orange cells) were rarely used, and did not constitute a decisive element in the story, rather they were used among other visualisations. **Tables** were the most popular visual form to present information clearly and concisely. Other visual forms, such as doughnut charts, maps, and bar charts, were also widely used, while **line charts and scatter plots** saw limited application (Fig. 2).

Students use mainly two approaches to integrate text and visual elements within their narratives. As emerged from Figure 1, text blocks are frequently used alongside visualisations to provide descriptions or context. Notably, the placement of text blocks as the final element in many stories suggests that students may use them to summarise results highlighted by previous visualisations. Figure 3 shows the negative correlation between the length of data stories and the length of last textual elements. Stories with longer sequences of elements are often concluded with relatively concise summaries, while shorter stories tend to allocate extensive descriptions at the end. This pattern reflects the existence of two main approaches in combining visuals and text, possibly influenced by the complexity of the story at hand.

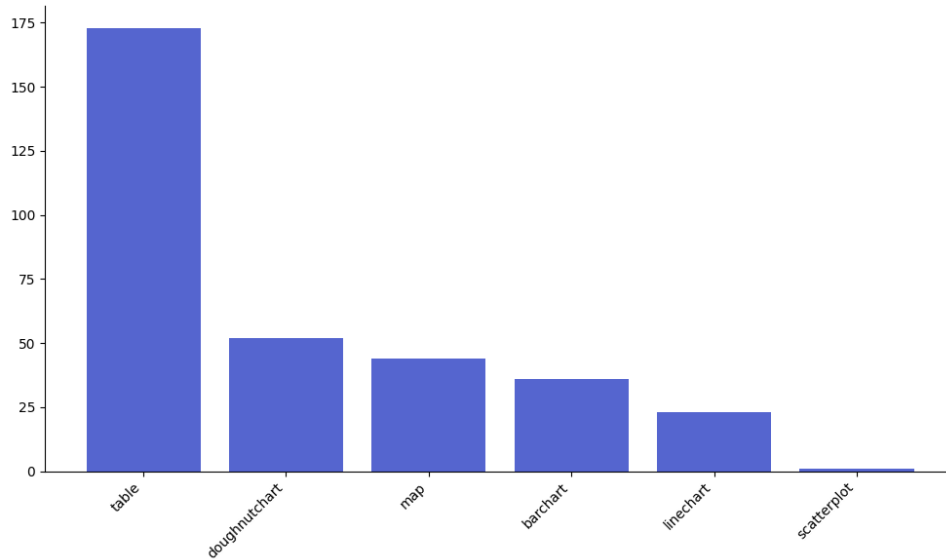


Figure 2: Distribution of data visualisation usage in data stories.

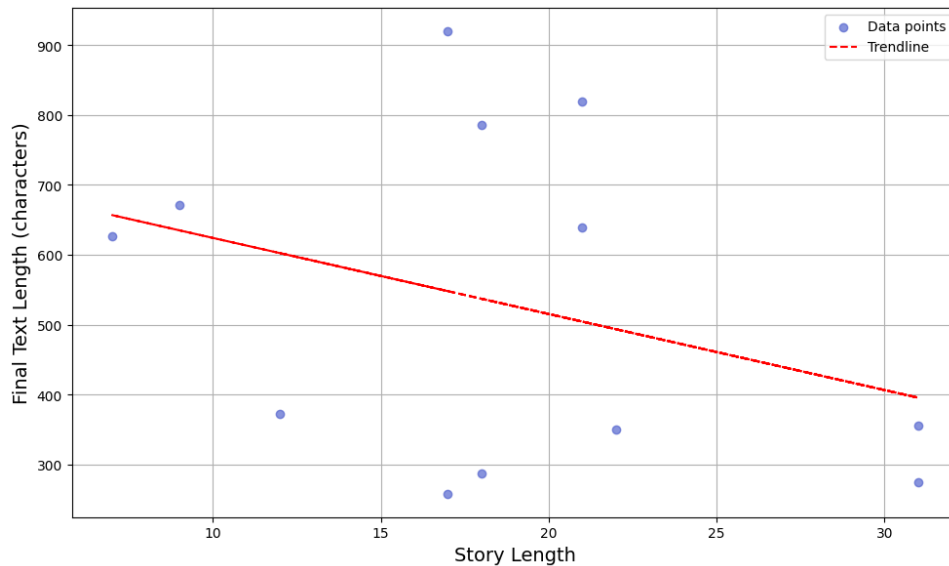


Figure 3: Negative correlation between the length of a story and the length of the last text component.

5. Evaluation

Student feedback provided valuable insights into their experiences using MELODY, highlighting both strengths and areas for improvement [22]. Figure 4 categorizes the sentiment extracted from feedback into four main topics, namely: communication strategies, data sources, general reflections, and MELODY usage, with sentiments classified as positive, neutral, or negative.

- **Negative feedback.** Challenges with incomplete or inconsistent data sources are a common frustration. Students frequently encountered gaps in data quality or availability, requiring them to refine their queries iteratively. Technical issues with the platform, such as usability challenges or bugs, and the steep learning curve also emerged as areas of concern.
- **Positive feedback.** Students praised MELODY’s ability to facilitate communication through its diverse visualisation tools. They found the platform effective for structuring and presenting their data stories, as it enabled clear and engaging storytelling. Several students also reported

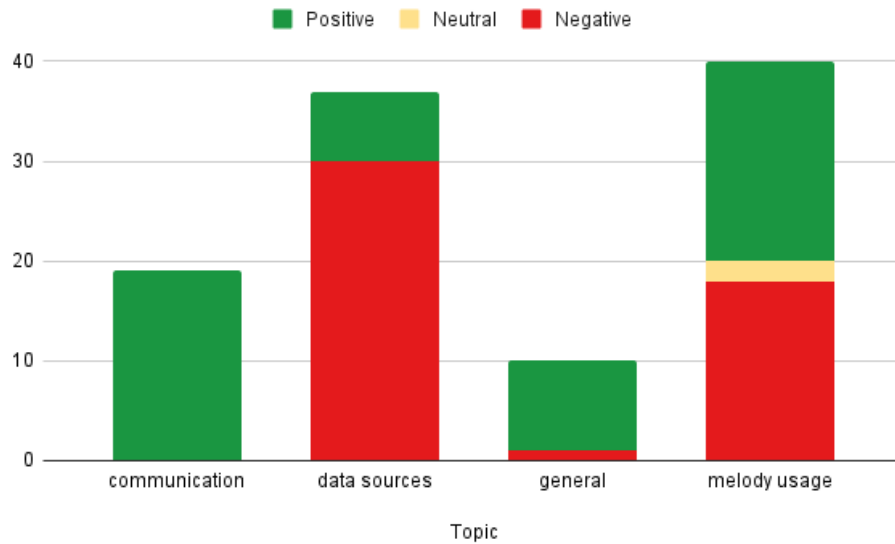


Figure 4: Sentiment analysis of students' feedback.

that visualising data through charts enabled them to identify inconsistencies, facilitating iterative query refinement and improving their analysis quality.

- **Neutral feedback.** Responses included suggestions for improving MELODY's interface and workflow, particularly to simplify navigation and add features (e.g. add timelines, more save options).

The distribution of sentiment values highlights the dual nature of learning with tools like MELODY. While they foster creative engagement with data, they also pose challenges that emphasise the importance of robust support systems and improved tool design capable of coping with problems often derived from the issues related to data sources.

6. Discussion and conclusion

This study provides an exploratory analysis of how students engage with MELODY to construct data-driven stories. In particular, the evaluation addresses students' perception of their learning experience and how the usage of a WYSIWYG tool supported them in their journey. Our findings reveal key patterns in how students use visual and textual elements to structure narratives, highlighting both opportunities and challenges in leveraging digital storytelling for Semantic Web education.

The patterns observed in element usage analysis reveal important insights into how students engage with visual and textual storytelling tools. On the one hand, the preference for simpler visualisation formats, such as tables and bar charts, suggests that students gravitate toward visual tools that feel intuitive and accessible, that are considered less error-prone in understanding [23, 24] and that usually do not require extensive data literacy skills to design them and then appreciate results. On the other hand, more advanced visualisation techniques (e.g. scatterplots) would require extensive data analysis skills to map research questions to adequate charts. Tools like MELODY can therefore accommodate varying levels of technical expertise and ensure inclusivity for novice users while fostering data visualisation literacy through practical, user-friendly formats.

The interplay of text blocks and visualisations shows different levels of understanding of the role of text in a narrative flow. Although the placement of text elements highlights their importance in narrative flow, it is worth noting that students' use of text often seems supplementary to the visualisations. The usage of text descriptions as concluding elements in many stories is also noteworthy. While we do not present an analysis of the text content, it suggests that students used it to summarise or contextualise

prior visualisations. This practice suggests an emerging understanding of narrative structure, where text and visuals complement each other to create a cohesive story. Encouraging students to more deliberately integrate these components and experiment with more complex visualisations could further enhance their data storytelling skills [3].

The feedback analysis highlights the dual nature of using tools like MELODY for educational purposes. The platform's strengths lie in its ability to make abstract data tangible and enable critical and creative engagement through visual storytelling. Notably, students reported that visualising data helped them identify inconsistencies, facilitating query refinement and fostering essential problem-solving skills [7]. However, working with real-world data proved to be an iterative and sometimes frustrating process, particularly due to incomplete or inconsistent datasets and technical usability limitations. These findings highlight an important reality: while visualisation tools facilitate engagement with data, they also require students to navigate challenges that mirror real-world data analysis scenarios—a valuable aspect of learning data literacy.

A broader pedagogical implication emerges from the balance between textual and visual storytelling. While students showed an initial understanding of how these elements can complement one another, many narratives relied heavily on visuals, with text playing a minor role. Research suggests that combining textual explanations with visuals enhances both comprehension and engagement [3, 15]. This observation points to the need for pedagogical frameworks that guide students in blending descriptions and visuals effectively. Future iterations of MELODY-based courses could explore strategies to encourage students to develop more integrated storytelling techniques, ensuring a more balanced use of text and visuals.

This study was conducted within a single master's course, which limits the generalizability of findings. The homogeneous sample of students, all enrolled in the same program, introduces potential biases and limits broader applicability of our results. Future research will explore several key areas:

- A follow-up study will compare data stories created without MELODY, assessing whether MELODY provides unique benefits in developing data literacy and visualisation skills in a Semantic Web environment.
- Expanding the research to students with varying levels of expertise will provide insights into how MELODY supports different learning trajectories, from beginners to advanced users.
- Investigating how students' storytelling and visualisation skills evolve over time through repeated exposure to MELODY will help refine its role in Semantic Web education.

In conclusion, this study demonstrates how data visualisation and storytelling strategies, facilitated through tools like MELODY, can effectively bridge the gap between learning Semantic Web technologies and developing data literacy skills. By enabling intuitive exploration and narrative creation, these approaches empower students to engage with data-driven storytelling in a meaningful way. While challenges related to platform usability and workflow were identified, such difficulties also reflect the reality of working with real-world datasets. Future work will focus on expanding the research on how visualisation and storytelling impact data literacy in different learning contexts.

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References

- [1] A. Miller, Data Visualization as Participatory Research: A Model for Digital Collections to Inspire User-Driven Research, *Journal of Web Librarianship* 13 (2019) 127–155. doi:10.1080/19322909.2019.1586617.

- [2] E. A. Vance, D. R. Glimp, N. D. Pieplow, J. M. Garrity, B. A. Melbourne, Integrating the Humanities Into Data Science Education, *Statistics Education Research Journal* 21 (2022). doi:10.52041/serj.v21i2.42.
- [3] K. McDowell, M. J. Turk, Teaching data storytelling as data literacy, *Information and Learning Sciences* 125 (2024) 321–345. doi:10.1108/ILS-06-2023-0068.
- [4] L. Bowler, C. Shaw, Trends in data literacy, 2018-2023: a review of the literature, *Information Research an international electronic journal* 29 (2024) 198–205. doi:10.47989/ir292822.
- [5] J. E. Raffaghelli, “Datificazione” e istruzione superiore: verso la costruzione di un quadro competenze per una rinnovata Digital Scholarship, *Excellence and Innovation in Learning and Teaching - Open Access* (2021). doi:10.3280/exioa0-2021oa11132.
- [6] C. Yan, H. Wang, X. Luo, Knowledge mapping of data literacy: A bibliometric study using visual analysis, *Journal of Librarianship and Information Science* (2024). doi:10.1177/09610006241285512.
- [7] S. Evenstein Sigalov, R. Nachmias, Investigating the potential of the semantic web for education: Exploring Wikidata as a learning platform, *Education and Information Technologies* 28 (2023) 12565–12614. doi:10.1007/s10639-023-11664-1.
- [8] C. D’Ignazio, R. Bhargava, Creative Data Literacy: A Constructionist Approach to Teaching Information Visualization, *Digital Humanities Quarterly* 12 (2018). URL: <https://dspace.mit.edu/handle/1721.1/123473>.
- [9] J. F. Barber, Digital storytelling: New opportunities for humanities scholarship and pedagogy, *Cogent Arts & Humanities* 3 (2016). URL: <https://doi.org/10.1080/23311983.2016.1181037>. doi:10.1080/23311983.2016.1181037.
- [10] G. Renda, M. Daquino, V. Presutti, Melody: A Platform for Linked Open Data Visualisation and Curated Storytelling, in: *Proceedings of the 34th ACM Conference on Hypertext and Social Media, HT ’23*, Association for Computing Machinery, New York, NY, USA, 2023, pp. 1–8. doi:10.1145/3603163.3609035.
- [11] V. L. Cross, M. N. Imundo, C. M. Clark, M. Paquette-Smith, Is There a Main Effect? Improving Data Literacy Using Practice Examples and Peer Collaboration, *Psychology Learning & Teaching* 23 (2024) 172–188. doi:<https://doi.org/10.1177/14757257231220057>.
- [12] K. McDowell, Storytelling wisdom: Story, information, and DIKW, *Journal of the Association for Information Science and Technology* 72 (2021) 1223–1233. doi:10.1002/asi.24466.
- [13] A. Vázquez-Ingelmo, A. García-Holgado, S. Verdugo-Castro, R. Therón, F. J. García-Peñalvo, Data visualization and domain knowledge: Insights through focus groups of researchers in Spain, *Computers in Human Behavior* 155 (2024) 108162. doi:10.1016/j.chb.2024.108162.
- [14] T. L. Shreiner, Students’ Use of Data Visualizations in Historical Reasoning: A Think-Aloud Investigation with Elementary, Middle, and High School Students, *The Journal of Social Studies Research* 43 (2019) 389–404. URL: <https://doi.org/10.1016/j.jssr.2018.11.001>. doi:10.1016/j.jssr.2018.11.001.
- [15] C. York, Exploratory Data Analysis for the Digital Humanities: The Comédie-Française Registers Project Analytics Tool, *English Studies* 98 (2017) 459–482. doi:10.1080/0013838X.2017.1332024.
- [16] A. Hogan, The Semantic Web: Two decades on, *Semantic Web* 11 (2020) 169–185. doi:10.3233/SW-190387.
- [17] R. Bhargava, E. Deahl, E. Letouzé, A. Noonan, D. Sangokoya, N. Shoup, Beyond Data Literacy: Reinventing Community Engagement and Empowerment in the Age of Data, Technical Report, Harvard Humanitarian Initiative, MIT Media Lab and Overseas Development Institute, 2015. URL: <https://dspace.mit.edu/handle/1721.1/123471>.
- [18] N. Gershon, W. Page, What storytelling can do for information visualization, *Communications of the ACM* 44 (2001) 31–37. URL: <https://doi.org/10.1145/381641.381653>. doi:10.1145/381641.381653.
- [19] M. Daquino, G. Renda, M. Grasso, D1.10: Polifonia Web portal – 2nd Version, Technical Report, 2024. URL: <https://zenodo.org/records/11120387>.

- [20] G. Lodi, L. Asprino, A. G. Nuzzolese, V. Presutti, A. Gangemi, D. R. Recupero, C. Veninata, A. Orsini, Semantic Web for Cultural Heritage Valorisation, in: S. Hai-Jew (Ed.), *Data Analytics in Digital Humanities*, Springer International Publishing, Cham, 2017, pp. 3–37. URL: https://doi.org/10.1007/978-3-319-54499-1_1.
- [21] T. Burrows, L. Cleaver, D. Emery, E. Hyvönen, M. Koho, L. Ransom, E. Thomson, H. Wijsman, Medieval Manuscripts and Their Migrations: Using SPARQL to Investigate the Research Potential of an Aggregated Knowledge Graph, *Digital Medievalist* 15 (2022). URL: <https://journal.digitalmedievalist.org/article/id/8064/>. doi:10.16995/dm.8064.
- [22] G. Renda, M. Daquino, MELODY Data Stories and Anonymous Student Feedback Dataset, 2024. doi:10.5281/zenodo.14499992.
- [23] J. Heer, M. Bostock, Crowdsourcing graphical perception: using mechanical turk to assess visualization design, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '10*, Association for Computing Machinery, New York, NY, USA, 2010, pp. 203–212. doi:10.1145/1753326.1753357.
- [24] W. S. Cleveland, R. McGill, Graphical perception: Theory, experimentation, and application to the development of graphical methods, *Journal of the American statistical association* 79 (1984) 531–554. doi:<https://doi.org/10.2307/2288400>, publisher: Taylor & Francis.