# THEORY ON DEMAND

# GOOD
# DATA

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# 16: THE FIELDNOTES PLUGIN: MAKING NETWORK VISUALIZATION IN GEPHI ACCOUNTABLE

## MARANKE WIERINGA, DANIELA VAN GEENEN, KARIN VAN ES AND JELMER VAN NUSS

## Introduction

The network visualizations humanities scholars and social scientists employ to communicate research findings are often imbued with a sense of objectivity. The impression is that these visualizations show facts about rather than interpretations of data. Consequently, suggestions have been made as to what kind of questions and contextual information need to accompany data visualizations. However, practical incorporation of answers to these questions in (academic) publications is absent. In this chapter we engage in and depart from tool criticism taking the most common academic network visualization software Gephi as our case in point. Problematically, Gephi saves only the spatialized network graph, whilst the steps taken and parameters of the algorithms used to get to the particular visualization go undocumented.

Tackling the software tool's 'epistemological affordances,' we elaborate on how the 'interpretative acts' of practitioners - knowingly and unknowingly - privilege certain viewpoints and perpetuate particular power relations. We consider how these can be made accountable in a pragmatic way through an application that supports those working with Gephi in taking procedural 'fieldnotes,' which enables scholarly positioning. By facilitating systematic documentation of the visualization and analysis process it allows for traceability of and reflection on the subsequent results. The application, thus, brings us closer to what can be characterized as 'good technologically mediated' practice in data-related research projects and helps us interrogate what being accountable in a scholarly context entails. We place the development of this plugin in an emerging practice of 'account-ability by design'.

Data visualizations are increasingly used for sense-making and communication in scholarly research.[1] Network visualizations, among the most complex data visualizations, are often seen as little more than unintelligible 'hair balls.'[2] Humanities scholars and social scientists nevertheless employ them to make palpable and communicate (abstract) research findings. These visualizations are often imbued with a sense of objectivity and give the impression

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1    Stephen Few, 'Data Visualization for Human Perception', in Interaction Design Foundation (ed.), *The Encyclopedia of Human-Computer Interaction*, 2nd edition, Aarhus: Interaction Design Foundation, 2014. https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/data-visualization-for-human-perception.

2    See e.g. Carlos D. Correa and Kwan-Liu Ma, 'Visualizing Social Networks', in Charu C. Aggarwal (ed.), *Social Network Data Analytics*, New York: Springer, 2011, pp. 307-26; Navid Dianati, 'Unwinding the Hairball Graph: Pruning Algorithms for Weighted Complex Networks', *Physical Review* 93.1 (2016); Hans-Jörg Schulz, and Christophe Hurter, 'Grooming the Hairball - How to Tidy up Network Visualizations', *IEEE Information Visualization Conference,* Atlanta, United States, 2013.

that they show facts about rather than interpretations of data.[3] Several scholars have made suggestions as to what kind of questions and contextual information need to accompany data visualization: most importantly, the decisions involved in making these data visualizations in order to shed more light on these interpretations.[4] In this contribution we focus on the case of Gephi. Gephi is a popular open-source software program for graph and network analysis used in the humanities and social sciences.[5] However, publications using the software rarely inform their readers about the applied settings and steps taken in the making of the network visualization.

We have taken a first step towards 'account-ability by design' in developing a plugin for Gephi, together with the Digital Humanities Lab of Utrecht University. With 'account-ability by design,' an ethnomethodologically inspired term, we refer to the built-in inspectability of tools providing researchers with adequate means to effectively assess these tools. The plugin's development is situated within a larger trend of other projects such as Datasheets for Datasets, Principles for Accountable Algorithms, and the Data Ethics Decision Aid that seek to make transparent and accountable the work that digital tools do.[6] More specifically, the plugin allows users to export the details of the working process including a time-stamped version of the graph file.

In this chapter we discuss how the 'fieldnotes plugin' helps to make Gephi network visualizations accountable. Logging the interaction of the researcher with the software can facilitate and stimulate scholarly positioning and reflection. To begin, we consider 'critical positioning' and its relation to the notions of reflexivity and accountability.[7] We discuss how reflexivity as an inherent quality of the epistemic process encompasses the opportunity to account for decisive (human and non-human) actions performed in the making of network visualizations. Here we take into account Gephi's (lack of) 'epistemological affordances', as Van Geenen terms it,[8] and demonstrate the need for logging explorative and 'interpretive acts' performed by the

*3*     Johanna Drucker, 'Humanities Approaches to Graphical Display', *Digital Humanities Quarterly* 5.1 (2011).

*4*     See e.g. Adam Kariv, 'Letting Data Speak for Itself', *Medium*, 2017, https://medium.com/@adam.kariv/ letting-data-speak-for-itself-80f1625a8ad1.; Helen Kennedy, Rosemary Lucy Hill, Giorgia Aiello, and William Allen, 'The Work That Visualisation Conventions Do', *Information Communication and Society* 19.6 (2016): 715-35; Karin Van Es, Nico Lopez and Thomas Boeschoten, 'Towards a Reflexive Data Analysis' in Mirko Tobias Schäfer and Karin Van Es, *The Datafied Society: Studying Culture through Data*, Amsterdam: Amsterdam University Press, 2017, pp. 171-82.

*5*     Mathieu Bastian, Sebastien Heymann and Mathieu Jacomy, 'Gephi: An Open Source Software for Exploring and Manipulating Networks' in *Proceedings of the Third International ICWSM Conference*, 2009, http://www.aaai.org/ocs/index.php/ICWSM/09/paper/download/154/1009.

*6*     Timnit Gebru, Jamie Morgenstern, Briana Vecchione, Jennifer Wortman Vaughan, Hanna Wallach, Hal Daumé III and Kate Crawford, 'Datasheets for Datasets' 2018, http://jamiemorgenstern.com/papers/ datasheet.pdf.; Nicholas Diakopoulos, Sorelle Friedler, Marcelo Arenas, Solon Barocas, Michael Hay, Bill Howe, H. V. Jagadish, et al, 'Principles for Accountable Algorithms. Fairness, Accountability, and Transparency in Machine Learning', http://www.fatml.org/resources/principles-for-accountable-algorithms.; Utrecht Data School, 'Data Ethics Decision Aid (DEDA)', Utrecht Data School, 2018, https:// dataschool.nl/deda/?lang=en.

*7*     Donna J Haraway, 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective', *Feminist Studies* 14.3 (1988): 586.

*8*     Daniela van Geenen, 'The Role of Software Tools in Critical Data Studies Practices. Studying the

use of Gephi, something which Johanna Drucker also argued for with regards to visualization in general.[9] This demonstration focuses on the default and adaptable settings of the ForceAtlas 2 layout algorithm using the example of the 'Les Miserables' data sample which comes prepackaged with Gephi.[10] Subsequently, we examine a sample of academic publications to address how media scholars are currently documenting their working processes in and with Gephi. It reveals that, despite having consequences for the analysis or presentation, a number of influential aspects of the working process are not thoroughly documented. Following this, we return to the plugin itself and explore its promises and pitfalls with regard to accountability. The plugin is a pragmatic but partial solution to making network visualization accountable in Gephi. In conclusion, we consider which work still needs to be done around account-ability by design. Although the development of the plugin is aimed at scholars in the humanities, it should be of relevance to scholars engaged with critical data studies more widely.

## Critical Positioning and its Prerequisites

Gephi has served as a notable example in several critical explorations that approach digital methods and tools not as mere instruments but as sites of study.[11] Bernhard Rieder and Theo Röhle, in their engagement with such 'sites of study,' call for a scholarly practice that oscillates between practical and critical work on the research material we investigate and the digital tools we employ.[12] Here they build on the notion of 'reflexivity' in both the traditions of the humanities and science and technology studies. According to Michael Lynch, this notion covers two things: Firstly, Lynch discusses the conscious activity of reflecting on the epistemic process, and in this course, the idea of generating 'objective knowledge'.[13] This idea of 'reflexivity' implies a kind of academic superiority put under scrutiny by Lynch. Secondly, he proposes a more general understanding of the term that includes the assumptions of the researchers of which they may not be actively aware. Donna Haraway, in this sense, calls for the 'critical positioning' of practitioners: the critical review of the bias they reflect on the research outcomes through their academic background and the interpretive choices they make during the research process.[14] The following section will explore the importance of

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Affordances of Gephi as a Sociotechnical System', in *Explorations in Digital Cultures: On the Politics of Datafication, Calculation and Networking.* Lüneburg: Meson press, forthcoming.

9      Drucker, 'Humanities Approaches to Graphical Display'.

10     Mathieu Jacomy, Tommaso Venturini, Sebastien Heymann, and Mathieu Bastian, 'ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software', *PLoS ONE* 9.6 (2014).

11     Johannes Paßmann, 'Forschungsmedien erforschen. Über Praxis mit der Mapping- Software Gephi', in *Navigationen. Vom Feld zum Labor und zurück* 1 (2013): 113-129; Bernhard Rieder and Theo Röhle. 'Digital Methods: From Challenges to Bildung', in Mirko Tobias Schäfer and Karin van Es (eds), *The Datafied Society: Studying Culture through Data*, Amsterdam: Amsterdam University Press, 2017, pp. 109-24.

12     Bernhard Rieder and Theo Röhle, 'Digital Methods: Five Challenges', in David Berry (ed.), *Understanding Digital Humanities*, Cham: Springer, 2012, pp. 67-84, p. 80.

13     Michael Lynch, 'Against Reflexivity as an Academic Virtue and Source of Privileged Knowledge', *Theory, Culture & Society* 17.3 (2000), 26-54.

14     Haraway, 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective', p. 586.

reflexive practice and how Gephi, through its affordances, makes it difficult to track and record how network visualizations are constructed. As such, we state, it constrains critical positioning.

## Reflexivity and Accountability

Working with software is a constant interaction between what the program allows, what the user does, and how the program responds to this. In other words, the interplay of human and non-human actors grants different kinds of agencies, or capacities to act, to both.[15] Sometimes these agencies are so intertwined it becomes difficult to locate who is acting upon whom or what.[16] We want to identify two of these agencies, which we believe are crucial in order to identify the (obscured) scholarly intentions at stake: the agency of the researcher, and the agency of the software. Focusing first on the agency of the software, Gephi is programmed in a specific way, thereby enabling particular actions and constraining others; it is 'inscribed' with (human) agency through its programming.[17] Scholars, in turn, can interact with this software in an analysis process in which they make particular (un)conscious choices stimulated by the (automated) methods and tools they use. For us, this dynamic, the interfacing between researcher and program is of interest, as it shapes the 'interpretative acts' researchers perform in their working practice, and thus, meaning-making with Gephi.[18] It is this dynamic which the plugin will help to document.

To better understand how Gephi structures, facilitates, and influences the working process, we propose to look at its affordances: the 'possibilities for action' presented to the user.[19] Questioning the affordances of software tools, understood as their designed and perceivable action possibilities,[20] directs the attention to the actions such tools allow for, or constrain, including their (hidden) politics.[21] An approach of critical affordance analysis is especially suited for Gephi,[22] which is presented as a tool for 'Visual Network Analysis'.[23] As such, Gephi's strength resides in allowing its users interaction with the underlying data and network through its graphical user interface. An investigation of Gephi's interface affordances allows for cutting critically through the interface level and revealing the tool's executable layers and

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*15*    Madeleine Akrich and Bruno Latour, 'A Summary of a Convenient Vocabulary for the Semiotics of Human and Nonhuman Assemblies', in Wiebe E. Bijker and John Law (eds), *Shaping Technology / Building Society: Studies in Sociotechnical Change*, Cambridge MA/London: MIT Press, 1992, pp. 259-64.

*16*    Adrian Mackenzie, *Cutting Code*. New York: Peter Lang, 2006, p. 10.

*17*    Ibid.

*18*    Drucker, 'Humanities Approaches to Graphical Display'.

*19*    Ian Hutchby, 'Technologies, Texts and Affordances', *Sociology* 35.2 (2001): 441-56, 444.

*20*    Ibid, 447-50, with reference to Donald Norman, *The Design of Everyday Things*. New York: Doubleday, 1990.

*21*    Matthew Curinga, 'Critical analysis of interactive media with software affordances', *First Monday* 19.9 (2014).

*22*    Van Geenen, 'The Role of Software Tools in Critical Data Studies Practices', forthcoming.

*23*    Tommaso Venturini, Mathieu Jacomy and Débora Pereira, 'Visual Network Analysis', Working Paper (2015), https://www.tommasoventurini.it/wp/wp-content/uploads/2014/08/Venturini-Jacomy_Visual-Network-Analysis_WorkingPaper.pdf.

their role in mediating the research material.[24]

Such a reflective attitude is important, for interpretive acts in Gephi are framed by particular 'situated knowledges'.[25] The notion of situated knowledges refers to how researchers are not neutral observers of reality. The epistemic claims they make reflect their social identity and situation. Scientific visualizations are a prominent example of such research outcomes. Haraway scrutinizes the objectified impression visualizations gain in research communication through a separation of information on their making process from the visual outcomes themselves. The notion of situated knowledge stresses the need to make bias in the knowledge production, and therefore, the manner in which this bias resonates in the interpretive practice of scholars, explicit. In other words, situated knowledge implies that one's ideas are rooted in a particular framework: a paradigm, a (socio-economic) background, a discipline, and so forth. All these aspects, which together make up one's situatedness, influence the kinds of interpretative acts one conducts. Moreover, in the case of Gephi, diverse kinds of situated knowledges deriving from particular academic fields are also *implemented by design* and *mobilized by means of the use of the tool*, such as the mathematical branch of graph theory, and the social sciences approach of social network analysis.[26] We focus particularly on the mobilization of situated knowledge in Gephi's usage and the way in which the plugin can enhance reflection on this.

As a tool that produces visual outcomes - in the shape of a network graph - Gephi is a perfect showcase to pose the question of the reflexivity of (algorithmic) knowledge instruments, or what becomes visible in comparison to the parts of the epistemic process that stay invisible. Reflexivity as an inherent quality of the epistemic process implies that we need an opportunity to *account for* all decisive (human and non-human) actions performed in this process. Accountability here is understood as accepting responsibility for one's actions, and thereby being - potentially - liable.[27] It differs from transparency which concerns disclosing information and privileges seeing over understanding.[28] Our concern, however, is not per se on one's liability, but on one's *account-ability*, which refers to, on the one hand, *being open to inspection* (transparency, if you wish), and on the other hand, *being competent in assessing the subject matter*.[29] Thus, the concept encompasses both the subject and object position of the word.[30]

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*24*   For an elaborate critical affordance analysis of Gephi see: Daniela van Geenen, *The Role of Software Tools in Critical Data Studies Practices. Studying the Affordances of Gephi as a Sociotechnical System* MA thesis, 2018, https://dspace.library.uu.nl/handle/1874/367489.

*25*   Haraway, 'Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective', pp. 581-590.

*26*   Rieder and Röhle, 'Digital Methods: From Challenges to Bildung', pp. 111, 117-9.

*27*   Helen Nissenbaum, 'Computing and Accountability', *Communications of the ACM* 37.1 (1994): 72-80.

*28*   Mike Ananny and Kate Crawford, 'Seeing without Knowing: Limitations of the Transparency Ideal and Its Application to Algorithmic Accountability', *New Media and Society* 20.3 (2018): 973-89.

*29*   Daniel Neyland, 'Bearing Account-Able Witness to the Ethical Algorithmic System', *Science, Technology, & Human Values* 41.1 (2016): 55.

*30*   Sara Eriksén, 'Designing for Accountability', *Proceedings of the Second Nordic Conference on Human-Computer Interaction* (2002): 179.

The hyphenated term, account-ability, was coined by Harold Garfinkel as an ethnometh-odological concept,[31] dealing with the 'observable-and-reportable', with practices of 'look-ing-and-telling,' and is very applicable to our situation.[32]

Part of being account-able rests with the documentation of one's research process, but also requires insight in how tools are used and why. As such, the account-ability we promote can be seen as a documentation of one's reflexivity: the researchers' ability to provide an account of what they have done. This is a first and necessary step in terms of legitimization of the outcome. Part of the knowledge production is delegated to Gephi. Thus, ideally, the decisions made by the researcher are informed by an understanding of the concepts and techniques mobilized by the software.

It is in the facilitation of further understanding about the analysis process that we situate the plugin: as a first step on the road to what we term 'account-ability by design.' The design process springs forth from an ethnographic, processual, and systematic engagement with the tool. The reflexive practice we envision for scholars working with the tool considers and offers information about the tools we use and the steps we take to analyze our data. In other words, we attempt to make the interpretive practices of scholars open for scrutiny - account-able - as part of their critical positioning. The lack of such documentation, which we expand on later in this paper, is partly due to the structure of the program itself, and resides in the need for and current lack of its 'epistemological affordances'.[33] The term is inspired by Lev Manovich's call for a 'software epistemology', that interrogates what knowledge is and becomes in relation to software.[34] Such a software epistemology should enable a dialogue on action possibilities that stimulate reflection on how software frames and shifts the production and distribution of knowledge, or in other words its epistemological affordances. To put it differently, epis-temological affordances are action possibilities the software tool should enable to enhance accountability. The availability of such action possibilities stimulates the reflective attitude of the researcher towards the epistemic process.

The notion of epistemological affordances allows us to think thoroughly about what is 'good technologically mediated' practice in the scholarly context.[35] Peter-Paul Verbeek's conception of the 'good technologically mediated life' poses the questions whether and how it is possible to 'design the morality of things'.[36] Verbeek advocates that we should adopt a 'limit-attitude'.[37] In Michel Foucault's description of the term, this ethos is defined by a critical scholarly atti-tude *from within* the 'field' in which one is working, constantly questioning the 'limits' of one's

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*31*   Harold Garfinkel, *Studies in Ethnomethodology*. Englewood Cliffs: Prentice-Hall, 1967.

*32*   Eriksén, 'Designing for Accountability', 179.

*33*   Daniela van Geenen, 'The Role of Software Tools in Critical Data Studies Practices', forthcoming.

*34*   Lev Manovich, *Software Takes Command,* New York/London: Bloomsbury, 2013, pp. 337-341.

*35*   Peter-Paul Verbeek, 'Resistance Is Futile: Toward a Non-Modern Democratization of Technology',
       *Techné: Research in Philosophy and Technology* 17.1 (2013): 91.

*36*   Ibid; Peter-Paul Verbeek, *Moralizing Technology. Understanding and Designing the Morality of Things*.
       Chicago/London: University of Chicago Press, 2011.

*37*   Verbeek, 'Resistance Is Futile: Toward a Non-Modern Democratization of Technology', pp. 81-2.

knowledge, which also involves the tools a scholar is employing.[38] In designing the fieldnotes plugin we strive to contribute to good 'computationally mediated' data research practice, by adopting a limit attitude with regard to a software tool such as Gephi. Below, we discuss how the affordances of Gephi actually (dis)allow documentation of the research practice with Gephi.

## Gephi's (lack of) Affordances

We discuss Gephi's action possibilities in terms of default functionalities and other, in social and technical ways, featured specifications.[39] Gephi's software affordances are promoted by the tool's graphical user interface as well as by the core team of developers, for instance, in official tutorials they share on the Gephi platform.[40] In order to have access to the full array of functionalities and explore the tool's affordances the application software requires data input. When a user opens Gephi the welcome pop-up window offers the opportunity to select one of the three exercise data samples the developers prepared for beginning users. For demonstration purposes, we will draw on the smallest of the three exercise samples: 'Les Miserables.gexf" composed of 77 nodes and 154 edges. The dataset is a graph file prepared in Gephi's own Graph Exchange File Format.[41] Users new to Gephi are encouraged to play with the dataset; the set is prominently placed on the welcome screen and in the 'Quick Start Guide', one of the few tutorials that is branded an 'Official Tutorial' by the Gephi core team.[42] The Les Miserables dataset appeals to the imagination of the user: The nodes represent the novel characters and the edges stand for these characters' co-appearances during the plot development of *Les Miserables*. However, in analytical terms the data sample is moderately 'inoperative' in its current form, such as the following demonstration will show.

Upon opening this dataset from the welcome screen, one is presented with the workable Gephi interface. The program offers the user three tabs: The 'Overview' tab (see Figures 1, 3-5) allows for spatializing and analyzing the data. The 'Data Laboratory' tab (Figure 2) houses the dataset and the metrics from preceding analyses (e.g. Modularity Class values, which classify nodes and group them together). Finally, the 'Preview tab' allows for finetuning the static output of the network graph. Looking at the graph in the Overview tab, we noticed that the network graph was prepared by the application of specific settings. Engaging with the software program and its practice set, however, does not clarify which steps have been taken to prepare the graph. The layout algorithm used and its parameters are not made explicit and related documentation is sparse.

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38    Ibid, in reference to Michel Foucault, 'What is Enlightenment?', in Paul Rabinow (ed.), *Ethics: Subjectivity and Truth*, New York: The New Press, 1997.

39    For this investigation we applied Gephi 0.9.2., the most recent release of the software tool at the time of writing this paper.

40    For the official website see: https://gephi.org/.

41    The 'Les Miserables' exercise sample builds on Donald Knuth's work on 'literate programming'. On his website, Knuth explains that he prepared the data sample as exercise material for "benchmark tests of competing methods." In Gephi the implementation of the sample can be similarly understood in such a benchmarking capacity: as experimental and comparative material for various analytical principles implemented in Gephi. See: Donald E Knuth, *The Stanford GraphBase: A Platform for Combinatorial Computing*, New York: ACM Press, 1993.

42    Gephi.org., 'Learn how to use Gephi.', https://gephi.org/users/.

The 'Quick Start Guide' tutorial is the only resource that provides the user with some clues about the preparation of the data sample. This tutorial recommends the application of an algorithm of the ForceAtlas series, layout algorithms that were specifically developed for Gephi.[43] To demonstrate how influential the choice for a layout algorithm and its particular properties is, we draw upon the Les Miserables data sample and the spatialization algorithm ForceAtlas 2, the successor of ForceAtlas. ForceAtlas 2 spatializes and clusters the graph based on degree, the number of edges a node possesses. The clustering, addressed by the term 'modularity', is facilitated by attraction forces of edges and repulsion forces of (unconnected) nodes.[44] It results in the visual clustering of nodes in which highly connected nodes are grouped together. This phenomenon of grouping together is amplified by the use of a community detection procedure, implemented in Gephi, coupled with node coloring. The 'Modularity Class' community detection algorithm generates metadata (see the fourth column in Figure 2). Starting from a single node, the algorithm 'snowballs' through the entire graph and assesses with which cluster each node has the most connections. Subsequently, it is possible to color and 'partition' these nodes based on the communities inferred by the algorithm (see Figure 1).[45]



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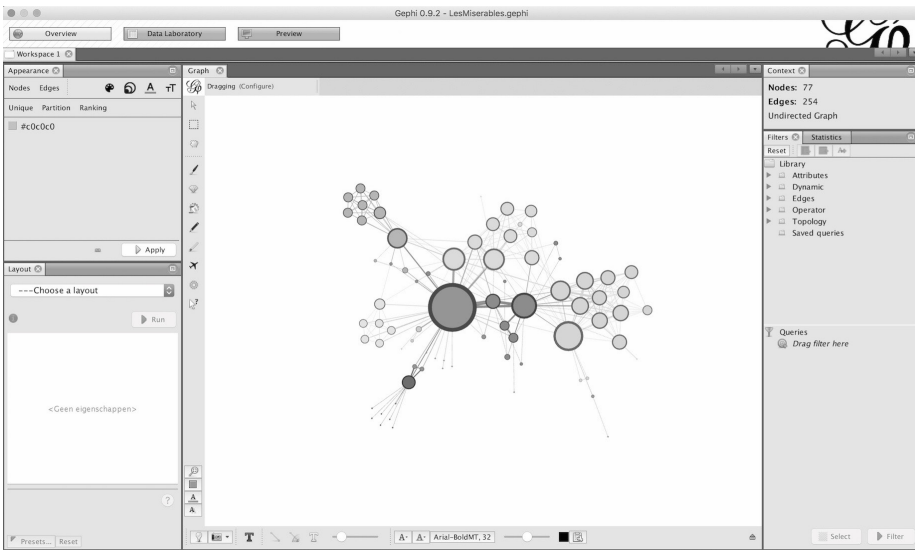
43    Jacomy, Venturini, Heymann, and Bastian, 'ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software'.

44    Ibid, 2-3.

45    See also the steps recommended in the 'Quick Start Guide' tutorial. For academic reference explaining the workings of 'Modularity Class' see: Vincent D Blondel, Jean-Loup Guillaume, Renaud Lambiotte and Etienne Lefebvre, 'Fast Unfolding of Communities in Large Networks', *Journal of Statistical Mechanics: Theory and Experiment,*10 (2008): 1-12.
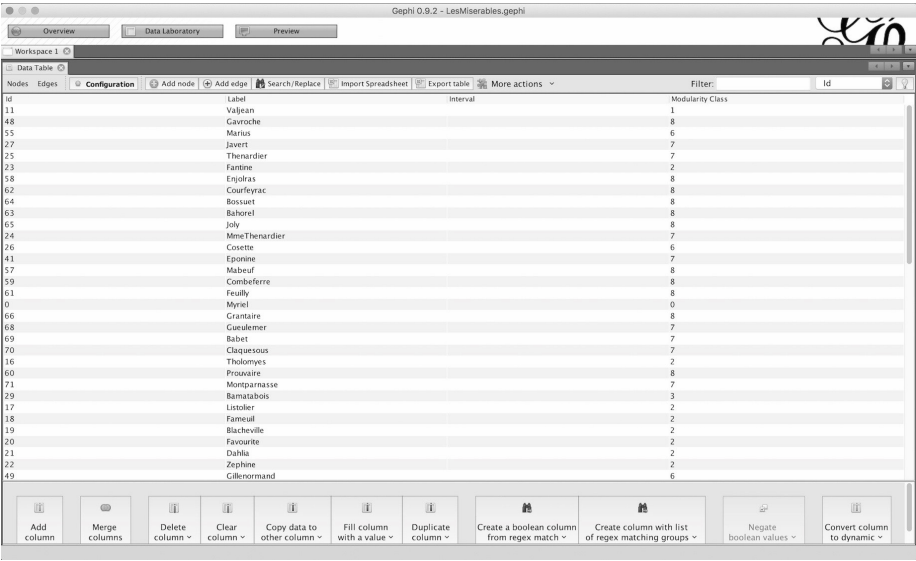
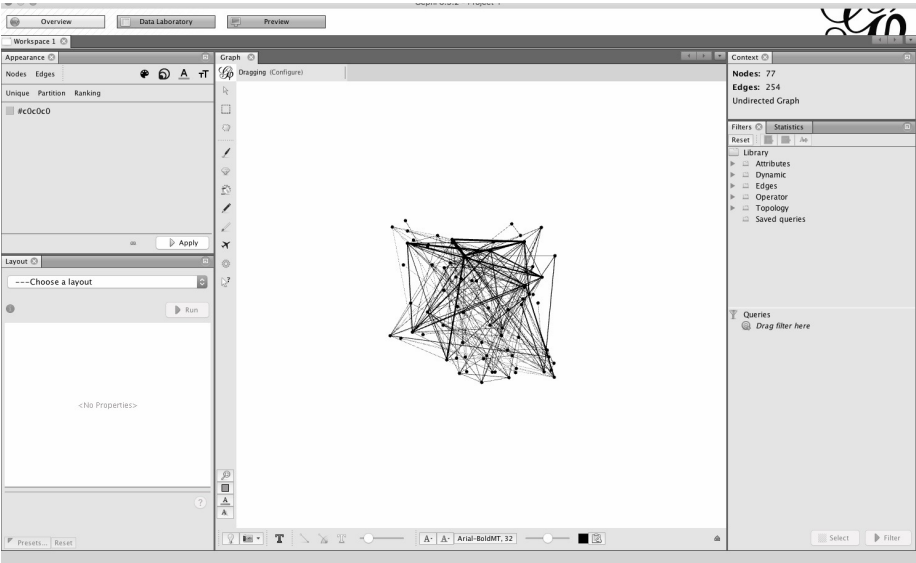*Figures 1 and 2: Gephi's 'Overview' and 'Data Laboratory' tabs after opening the Les Miserables dataset.*
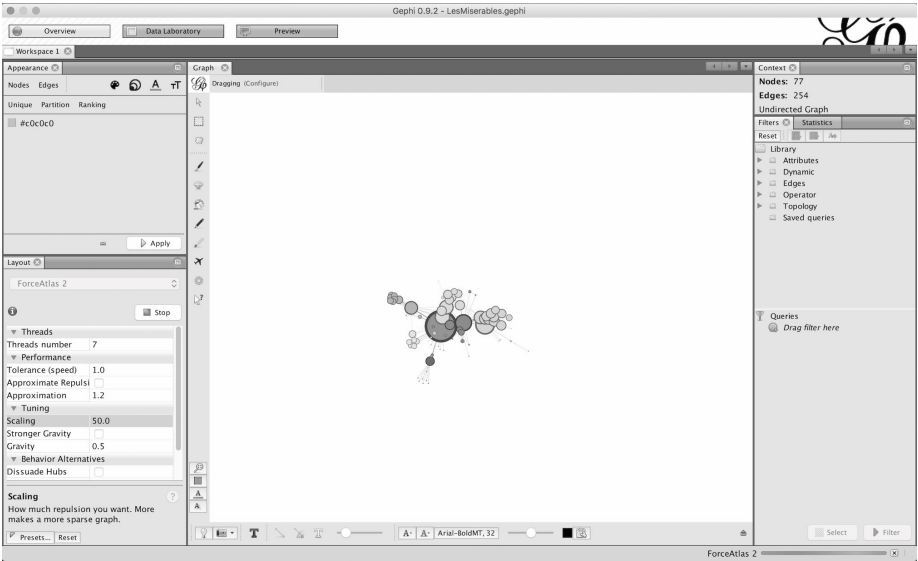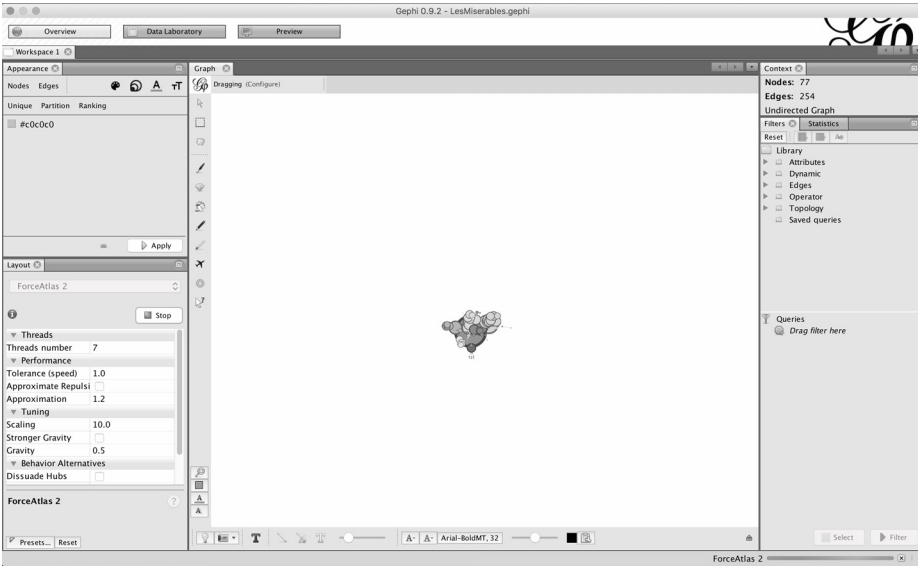


*Figure 3: The 'raw' Les Miserables sample.*

*Figures 4 and 5: ForceAtlas 2's default settings applied to the same 'Les Miserables' exercise sample, and after adjusting 'Tuning' and 'Behavior Alternative' settings such as the scaling (from 10 to 50) and the gravity (from 1.0 to 0.5).*

In order to stress the importance of recording the applied parameters, the figures above demonstrate how applying a particular layout algorithm and playing with its settings returns network graphs shaped in very specific ways: Figure 3 shows the Les Miserables graph in an unprepared, 'raw' state.[46] In the above figures (4 and 5) we applied ForceAtlas 2 to the prepared graph file and adjusted layout properties under ForceAtlas 2's subheadings of 'Tuning' and 'Behavior Alternatives'. Moreover, selecting "Behavior Alternatives" such as 'Dissuade Hubs' and 'Prevent Overlap' returns a graphical display similar to the starting position (Figure 1). While these adjustments of algorithm property values result in changed node positions in the graph file (GEXF), apart from that this action that changes the algorithm 'behavior' leaves no permanent trail. To be more specific, the work of the software and researcher cannot be traced back. This is exemplified by the lack of otherwise commonplace software features such as 'undo' and 'redo' options.[47]

Gephi's lack of epistemological affordances affect knowledge production. We focused on the default and adaptable settings of the layout algorithm to illustrate their influence on how the data is visualized as graph therein demonstrating the need for recording and accounting for explorative and interpretive activities. The integration of the 'Les Miserables.gexf' dataset reflects the politics of the developer's community: Gephi's sociological focus on community detection and, based on this calculation process, the visual clustering of the network graph.[48] Researchers need to be provided with the opportunity to scrutinize such politics in order to make sense of the interpretative acts performed in, and with, Gephi. We argue that a process of understanding can only be afforded to scholars through a combination of access to the applied parameters and a consultation of the documentation on the software tool.[49] The fieldnotes plugin is a practical solution that offers access to the applied parameters and in doing so can hopefully support Gephi's epistemological affordances. The plugin is needed because, as we demonstrate in the following section, academic publications using Gephi network visualizations only scarcely report the interpretative acts performed by the researcher(s).

## Network Visualizations Practices in Scholarly Discourse

About documenting the Gephi work process in academic publications, Axel Bruns writes:

> [T]he various visualization algorithms offered by the well-known, open source network analysis software Gephi, for example, are generally described in some detail in software guides and related literature, but relatively few of the scholarly publications

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46   The Quick Start Guide tutorial links to such a version of the data sample.

47   See e.g. Van Geenen, 'The Role of Software Tools in Critical Data Studies Practices' for related scholarly discussions, and the discussion feed on the Gephi Wiki that features the call for undo/redo specifications formulated by the Gephi community: https://github.com/gephi/gephi/issues/1175.

48   Most of the default layout algorithms implemented in Gephi are 'force-directed' and cluster the graph based on degree.

49   Documentation could be found, for example, in the academic paper that was published on, and provides insights into, the significance of the applied algorithm settings, see for instance: Jacomy et al, 'ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software'.

which draw on Gephi to visualize the social networks they study insert any substantive discussion of the benefits or limitations of the particular Gephi network visualization algorithms they have chosen, or of the specific visualization settings which were used to direct the algorithm itself.[50]

We presently seek to validate the observation that there is a lack of documentation empirically, which we find is a cause for concern. In order to gauge if and how scholars are currently discussing their research processes in Gephi, we inventoried a selection of articles which cite the developer's paper 'Gephi: an open source software for exploring and manipulating networks'.[51] Working in a media department ourselves, we decided to sample publications that mention [media].[52] For this selection process, we drew on Google Scholar. In total, 3,251 papers that cite Bastian et al. were found, of which 2,410 also mention [media].[53]

We collected the first 150 academic papers listed by Google Scholar, thereby practicing what Richard Rogers called 'search as research'.[54] Of these 150 papers, we selected the 16 papers stemming from media studies for an exploratory inventory. These papers were assessed on the documentation of the dimensions also logged by the plugin that we will introduce in detail in the next section. We noted on a scale of 0-2 whether the information was not at all (0), to some extent (1), or completely (2) present. Below the inventoried dimensions and their total count are listed.

| Dimension | Total count |
| --- | --- |
| Amount of nodes | 21 |
| Amount of edges | 18 |
| Layout algorithm applied | 21 |
| Settings algorithm | 0 |
| Filters | 12 |

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50  Axel Bruns, 'Faster than the Speed of Print: Reconciling 'Big Data' Social Media Analysis and Academic
    Scholarship', *First Monday* 18.10 (2013).
51  Bastian et al, 'Gephi: An Open Source Software for Exploring and Manipulating Networks'.
52  The block braces are used to denote a query. For an explanation on the nature of query notation, see
    Richard Rogers, 'Foundations of Digital Methods', in Mirko Tobias Schäfer and Karin Van Es (eds), *The
    Datafied Society: Studying Culture through Data*, Amsterdam: Amsterdam University Press, 2017, pp.
    75-94, p. 83.
53  Bastian, et al, 'Gephi: An Open Source Software for Exploring and Manipulating Networks'.
54  In order to minimize effects of personalization, we logged out of Google and used a clean installation
    of a normally unused browser, of which all cookies were deleted as an additional precaution. Books/
    book chapters, duplicates, and non-English work were excluded due to practical constraints. Rogers,
    'Foundations of Digital Methods', p. 76.

| | |
|---|---|
| Appearance N/E (explaining the ranking/partition elements in graph) | 24 |
| Color nodes | 15 |
| Color edges | 5 |
| Size nodes | 16 |
| Edge thickness/shape | 8 |
| Statistics used | 17 |
| Data lab manipulations | 1 |
| Preview settings | 1 |

*Table 1. Amount of times papers documented aspect of research project. N is 16, the greatest potential score is 32, lowest is 0.*

Our sample suggests that media studies papers drawing on Gephi frequently document the layout algorithm that was used and details on the partitioning of the graph. However, none of the papers in our sample reflected on the settings of those (layout) algorithms (e.g. whether scaling was set to 10 or 50). As demonstrated earlier, such settings should be described because of the influence they have on the presentation of the graph. Furthermore, the settings of the applied metrics such as the 'resolution' set for Modularity Class influence the outcome of the calculation process (e.g. more or less smaller communities) and, therefore, the (visual) clustering of the graph and identification of communities based on this clustering. The inventoried dimensions were classified according to three different degrees of attention to documentation: rich documentation, some documentation, and limited documentation. This categorization serves to show the disproportional attention particular aspects of the process receive, as per below.

| Rich documentation (>20) | Some documentation (10-20) | Limited documentation (<10) |
|---|---|---|
| Amount of nodes | Amount of edges | Settings algorithm |
| Layout algorithm applied | Filters | Color edges |
| Appearance N/E (explaining the ranking/partition elements in graph) | Color nodes | Edge thickness/shape |

| | Size nodes | Data lab manipulations |
|---|---|---|
| | Statistics used | Preview settings |

*Table 2. Spectrum of documentation.*

We discovered that a number of influential aspects of the working process are not document-ed (in detail), despite their fundamental consequences for the analysis or presentation. This includes documentation about the statistics and filters used, the settings of the algorithm applied, data lab manipulations, and the preview settings. These settings should be logged and open for scrutiny as part of an effort for scholarly positioning. Bruns has rightfully raised concerns about 'spatial limitations' in the publication of (big) data research that limit detailed documentation of tools, methods, and datasets.[55] As such we propose that at a bare mini-mum the most relevant settings for the particular network visualization, as established by the researchers working on the project, be included in a legend. It should also be accompanied by either the settings file itself or contact details to retrieve the said file.

## The Fieldnotes Plugin

Alluding to a long-standing tradition in field work and the related practice of taking thorough fieldnotes, we decided to baptize the practical contribution to making network visualization in Gephi accountable the 'fieldnotes plugin'.[56] In doing so, we also emphasize the need for more (ongoing) ethnographic work in the domain of digital methods and software tools, their use and development. The plugin is designed to be installed like any other plugin available for Gephi.[57] It can automatically log the following:

- Amount of nodes/edges;
- Algorithms used;
- Filters;
- Statistics;
- Preview settings;
- Time-stamped graph file (including information from Data Laboratory) in gexf format.

The log of the working process can be exported as a settings file (see for example the figure below). In this file, the particular parameters of each step are logged - not only the steps taken. For instance, if one uses a particular filter, besides the type of filter all properties associated with that filter are saved. The settings are exported as a .txt file and can therefore be opened

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55   Bruns, 'Faster than the Speed of Print'.
56   See e.g. James Clifford and Georg E. Marcus (eds), *Writing Culture: The Poetics and Politics of Ethnography,* Berkeley: University of California Press, 1986; Roger Sanjek (ed.), *Fieldnotes: The Makings of Anthropology,* Ithaca: Cornell University Press, 1990.
57   The project can be found on GitHub: https://github.com/UUDigitalHumanitieslab/gephi-plugins/tree/fieldnotes.

in a wide variety of text editors (e.g. Figure 6).

A limitation, which is important to note, is that we have not yet managed to extract the property values of the layout algorithm, which are influential settings. The back-end of Gephi did not allow for such implementation during the development time allotted, but it is foremost on our priority list for future development. Nevertheless, even with the limited functionality in logging this particular aspect, it still greatly speeds up the logging which would otherwise be done manually.

```
## General settings
isDirectedGraph: true
edgeCount: 3785
nodeCount: 2069
--------------------------------------------------------------------------------
## Filter settings
# filter 0: Edge Type
type: 0
# filter 1: Edge Weight
range: 1.0 - 4.0
--------------------------------------------------------------------------------
## Layout settings
# layout: ForceAtlas 2
scalingRatio: Not extracted
strongGravityMode: Not extracted
gravity: Not extracted
distributedAttraction: Not extracted
linLogMode: Not extracted
adjustSizes: Not extracted
edgeWeightInfluence: Not extracted
jitterTolerance: Not extracted
barnesHutOptimization: Not extracted
barnesHutTheta: Not extracted
threads: Not extracted
--------------------------------------------------------------------------------
## Statistics settings
statisticsModel: org.gephi.statistics.StatisticsModelImpl@5a337198
--------------------------------------------------------------------------------
## Preview settings
edge.show: true
node.border.width: 1.0
node.border.color: java.awt.Color[r=0,g=0,b=0]
node.opacity: 100.0
node.per.node.opacity: false
node.label.show: false
edge.label.show: false
edge.thickness: 1.0
edge.rescale-weight: false
edge.rescale-weight.min: 0.1
edge.rescale-weight.max: 1.0
edge.color: java.awt.Color[r=0,g=0,b=0]
edge.opacity: 100.0
```

*Figure 6. Example of settings.txt file*

Aside from the settings file, the plugin also automatically saves the graph file (GEXF) with a timestamp that matches the settings file's timestamp. Together these files serve as a complete snapshot of the graph. Additionally, the automatic saving functions as an extra failsafe for Gephi's omission of an undo button and is a hack to cope with the need to continuously save all steps during the working process.[58]

## What the Gephi Plugin Does and Does not Solve

The Gephi plugin is intended to make it easier to document the working process, yet it by no means covers all the problems (humanities) scholars face when working with Gephi. We will briefly highlight a couple of problems that will persist, and some others for which we believe the plugin to be a pragmatic solution to.

Several scholars have highlighted the need for a better understanding of the tools we use,

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58    See e.g. a related discussion on the Gephi Wiki: https://github.com/gephi/gephi/issues/1175.

and therefore, the algorithms we work with.[59] While we acknowledge the importance of such intimate tool understanding - for instance, in the case of statistical measures such as PageRank or algorithms like ForceAtlas 2 - our plugin does not facilitate better understanding of the algorithms themselves. The plugin limits itself to offering information on what parameters were used to influence their workings. Thus, it does not help to open the black box of the applied - in this case mathematical and social - principles themselves, but rather helps to give insight into the 'black box of data research,' by gathering the variables and procedures applied.

By tackling this black box of data research, we hope to stimulate communication between scholars both within research teams and in external communication. Documenting the variables used allows, for instance, for accessing and assessing particular research projects. By logging these, it also makes it easier for scholars to communicate and reflect on key parameters in their publications. As we have shown, much can be gained in this area. Nevertheless, the plugin does not immediately lead to a more reflective engagement with the Gephi working process. As the plugin logs properties automatically, it is still up to the researcher to reflect on the process; our contribution merely facilitates practices of critical positioning.

The plugin is not a fix for all issues arising around inspectability of data research projects. While it helps to make settings known, one still needs the dataset in order to be able to actually assess the research. Furthermore, one needs to know how that dataset has been created, under what circumstances, whether it is the original master version, or whether it has been filtered, in which way, and what motivated these choices.[60] *Seeing* a network graph, then, does not equal *understanding* the data sample and its (partially automatic) creation.[61] Some information on the Les Miserables data sample's preparation, for example, can be found in the Quick Start Guide, but extensive documentation is missing. In other words, the plugin is merely a way station on the road to critical positioning and account-ability by design.

Additionally, the exact way of arriving at particular settings is not always documented. Node size, for instance, can be set through partition or through manual settings. The approach used to get to different node sizes is not logged, only the size change. As discussed, due to the technical makeup of the program, we were not able to program the plugin in such a way that it logs everything we wanted to as of yet. For instance, the pop-up windows used in the case of statistics or splining, and the layout properties during the algorithm's runtime, were impossible to log in the scope allotted for the development of the plugin. It is something we hope to add in future versions.

In sum, we need to distinguish between tackling the black-box of creating network visualizations and that of the tool. Automatically logging the settings used in making the visualization

59   See e.g. Paßmann, 'Forschungsmedien erforschen. Über Praxis mit der Mapping- Software Gephi';
     Bernhard Rieder and Theo Röhle, 'Digital Methods: Five Challenges'; Rieder and Röhle, 'Digital
     methods: from challenges to Bildung.'.
60   Gebru et al, 'Datasheets for Datasets'.
61   Ananny and Crawford, 'Seeing without Knowing: Limitations of the Transparency Ideal and Its
     Application to Algorithmic Accountability'.

with the Gephi plugin, does the former, but not the latter. Rieder and Röhle rightfully point out that 'tools such as Gephi have made network analysis accessible to broad audiences that happily produce network diagrams without having acquired robust understanding of the concepts and techniques the software mobilizes'.[62] It is true then that the plugin does not make everyone domain experts, but merely makes it possible for domain experts and other researchers to *better communicate about the process*,[63] and in that, critically position themselves and their research activities. For us, this is what is at stake in account-ability by design. Automating logging processes can assist the researchers in their reflexive process, but the required reflection on the epistemic process remains a human activity.

## Conclusion

In this chapter we introduced the fieldnotes plugin for Gephi, which allows the taking of procedural 'fieldnotes.' By facilitating systematic documentation of the visualization and analysis process, it allows for traceability of and reflection on the subsequent results. By mapping the interaction between the software tool and the researcher, we facilitate a reflexive approach to one's research practice. We situate the development of the plugin in what we call the road to 'account-ability by design.' Recently there have been a number of pragmatic contributions which similarly allow for 'methodological reflexivity' and account-ability, which share a similar vision on what is good computationally mediated scholarly practice.[64]

For us being account-able rests in part with the documentation of one's research process, but it also requires insight in how tools are used and why. The need for the documentation was demonstrated with an exploration of the application of (different properties of) the ForceAtlas 2 algorithm and modularity clustering in the case of the Les Miserables data sample. We have also shown that documentation in scholarly papers drawing on Gephi is in many instances quite poor or nonexistent.

We see the Gephi plugin as a pragmatic solution which only partially aids in account-ability. The plugin enables tracking the interaction between researcher and program but does not address other crucial matters (e.g. why particular choices were made or providing more insight in the workings of an algorithm). The application brings us closer to good computationally mediated practice in data-related research projects and helps us interrogate what being accountable means in a scholarly context. Yet, it needs to be seen as just one step towards the end goal of 'account-ability by design'. The plugin maps the analysis process, which facilitates better documentation in scholarly communication.

The development of the plugin fits in the tradition of research documentation. In the case of network visualization, we argue that many different forms of process documenting can still be explored. Due to practical constraints, we abandoned the idea of accompanying the plugin

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62    Rieder and Röhle, 'Digital methods: from challenges to Bildung'.
63    In the same line as Gebru et al, 'Datasheets for Datasets'.
64    Rieder and Röhle, 'Digital methods: from challenges to Bildung'; see e.g. Datasheets for Datasets, *Principles for Accountable Algorithms.*

with a list of questions to the researcher to kickstart methodological reflexivity. We consider the development of such (an) accompanying document(s) as a fertile strand of further research. One of such promising strands is, for instance, recording the graph simulation, or more dynamic forms of communication, which demonstrate how the analysis process unfolds over time and based on which choices. With regards to further development of Gephi, we argue in particular for the implementation of the legend module. This was already pitched by Heymann in 2012 and announced on the roadmap for the Gephi 1.0 version that is yet to come.[65]

## Acknowledgements

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