Tell Me How My Open Data Is Re-used: Increasing Transparency Through the Open City Toolkit

Auriol Degbelo

Institute for Geoinformatics, University of Münster, Münster, Germany

Carlos Granell

Institute of New Imaging Technologies, Universitat Jaume I, Castellón de la Plana, Spain

Sergio Trilles

Institute of New Imaging Technologies, Universitat Jaume I, Castellón de la Plana, Spain

Devanjan Bhattacharya

NOVA Information Management School (NOVA IMS), Universidade Nova de Lisboa, Lisbon, Portugal

Jonas Wissing

Institute for Geoinformatics, University of Münster, Münster, Germany

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AUTHORS

Auriol Degbelo [a]
Carlos Granell [b]
Sergio Trilles [c]
Devanjan Bhattacharya [d]
Jonas Wissing [e]

AUTHOR BIOS

[a] Institute for Geoinformatics, University of Münster
degbelo@uni-muenster.de
Auriol Degbelo is postdoctoral researcher at the Institute for Geoinformatics, University of Münster, Germany. His current research interests include semantic integration of geospatial information, re-use of open government data, and interaction with geographic information.

[b] Institute of New Imaging Technologies, Universitat Jaume I
carlos.granell@uji.es
Carlos Granell currently holds a 5 year Ramón y Cajal post-doctoral fellowship at the UJI of Castellón, Spain. Before re-joining GEOTEC in 2014, he worked for 3 years as a post-doc in the Digital Earth and Reference Data Unit of the European Commission's Joint Research Centre (JRC), and was a post- and pre-doctoral researcher during the period 2003-2010 at the Universitat Jaume I of Castellón, from which he holds a Ph.D. (2006). His research interests lie in multi-disciplinary GIS, model web, and spatial analysis and visualization.

[c] Institute of New Imaging Technologies, Universitat Jaume I
strilles@uji.es
Sergio Trilles received his PhD in Integration of Geospatial Information from the Jaume I University in 2015. He had the opportunity to work four months as researcher in the Digital Earth and Reference Data Unit of the European Commission's Joint Research Centre (JRC). Currently, he is a postdoc researcher at the GEOTEC group.

[d] NOVA Information Management School (NOVA IMS), Universidade Nova de Lisboa
dbhattacharya@novaims.unl.pt
Devanjan Bhattacharya holds a PhD in Geomatics Engineering and his research interests are in applications of geoinformatics for societal challenges, geohazard management, smart cities, and spatial technologies. He is currently a post-doctoral manager of EU H2020 project GEO-C at NOVA IMS, Universidade Nova de Lisboa, Lisbon, Portugal.

[e] Institute for Geoinformatics, University of Münster
jonas.wissing@uni-muenster.de
Jonas Wissing is a student assistant at the Institute of Geoinformatics (ifgi) at the University of Münster, Germany. He is currently studying a Bachelor of Science in Geoinformatics and a Bachelor of Science in Information Systems at the University of Münster.

ABSTRACT

The open data movement has been gaining momentum in the recent years, with increasingly many public institutions making their data freely accessible. Despite much data being already open (and more to come), finding information about the actual usage of these open datasets is still a challenge. This chapter introduces two tools of the Open City Toolkit (OCT) which tackle this issue: a tool to increase transparency, and interactive guidelines. Interviews with city council employees confirmed the utility of the transparency tool. Both tools can be used by city councils (for planning purposes), and users interested to know more about the value of current open datasets (for information purposes).

KEYWORDS

Open Government Data; Open Data Re-use; Transparency; Interactive Guidelines; Dashboard Visualization

HIGHLIGHTS

- Dashboard to visualize apps and dataset usage in a city context
- Visualization of spatial locations from which apps and datasets are accessed
- Interactive guidelines as problem-solution patterns to communicate open data-based innovations
- Interactive guidelines to empower citizens to participate in and shape the future of their cities

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LIST OF ABBREVIATIONS
Application Programming Interfaces (APIs)
Information and Communication Technology (ICT)
Open City Toolkit (OCT)
System Usability Scale (SUS)
Uniform Resource Locator (URL)

INTRODUCTION

The open data movement has been gaining momentum in the recent years, with increasingly many public institutions making their data freely accessible. Open data is improving government around the world, empowering citizens, creating new economic opportunities, and solving big public problems (see Young & Verhulst, 2016). As of May 2018, the Open Data Inception (opendatainception.io) [1] lists no less than 2,600 open data portals all around the world; the US Open Data Portal[2] lists about 190,000 datasets available; the European Union Open Data Portal[3] offers about 12,000 datasets; the data portal of the Australian Government[4] contains about 57,000 datasets; and the UK's open data portal provides about 45,000 datasets to browse through. These figures are indicative of the amplitude of the open data movement. The term 'open' may have different interpretations (for a recent review, see Pomerantz & Peek 2016), but is used in this chapter to denote data "that anyone can freely access, use, modify, and share for any purpose"[5].

Open data has also attracted a significant amount of scholarly attention in recent years. A detailed presentation of open data ecosystems in Europe was done by Schade, Granell and Perego (2015). Attard, Orlandi, Scerri and Auer (2015) provided a systematic survey of open (government) data initiatives with a detailed description of processes within the open government data lifecycle. Taking Chile as a case study, Gonzalez-Zapata and Heeks (2015) identified two main types of stakeholders of open government data: primary stakeholders (i.e., politicians, public officials, public sector practitioners, international organizations) and secondary stakeholders (i.e., civil society activists, funding donors, ICT providers, academics). Susha et al. (2015) organized workshops with experts from the field of open government and open data to identify factors influencing the success or failure of open data initiatives. They provided a list of 47 success factors for open data publication and 18 success factors for open data use. Hartog et al. (2014) interviewed different types of stakeholders (e.g., civil servants, data source holders, and policy makers) to uncover the 'readiness' for open data of two governmental bodies: the municipality of The Hague, and the province of South-Holland. Citizens' motivations to participate was the subject of (Wijnhoven, Ehrenhard, & Kuhn, 2015), where the authors found that strong belief that their suggestions will be applied correctly, perception of fun, and ideology (i.e., the person's attitude towards civic duties) are key factors of citizen engagement in open government projects. Additional work in the context of open government data has looked into open government portals' support for transparency and political accountability (Lourenço, 2015), openness and maturity indices for e-government (Veljković, Bogdanović-Dinić, & Stoimenov, 2014), a measurement framework to quantitatively assess the quality open government data (Vetrò et al., 2016), and visualization tools for open government data (Graves & Hendler, 2013), to name but a few.

Despite much attention of the scholarly community, many datasets being already open and more to come, finding information about the **actual usage** of these open datasets is still a challenge. Platforms such as CKAN offer a plugin (i.e., the *stats* extension[6]) to retrieve summary statistics about the most viewed datasets. This is valuable information, but there is still a need for techniques, which enable re-use tracking beyond dataset views. Rate of re-use was mentioned in (Attard, Orlandi, & Auer, 2016) as one of the aspects of open data value creation not sufficiently addressed at the moment. Benitez-Paez *et al.*, (2018) found the lack of re-use examples to be one of the issues encountered by users while navigating open data portals. Having more information about the re-use of open datasets is critical to unveil their true value as: "[o]pen data on its own has little intrinsic value; the value is created by its use" (Janssen, Charalabidis, & Zuiderwijk, 2012). Open data re-use information is also necessary for effective planning in the city context. For instance, it provides public institutions with a better idea of the types of datasets that are highly demanded (and by whom), and helps them prioritize the types of datasets to curate or regularly update.

This chapter introduces two software tools intended to advance the state of the art on open (government) data re-use: a tool to increase transparency, and interactive guidelines. The tools tackle the re-use problem at two levels: automatic re-use tracking (the former) and re-use documentation (the

[1] https://opendatainception.io/ (last accessed: May 19, 2018).
[2] https://www.data.gov/ (last accessed: May 15, 2018).
[3] http://data.europa.eu/euodp/en/home (last accessed: May 15, 2018).
[4] http://data.gov.au/ (last accessed: May 15, 2018).
[5] http://opendefinition.org/ (last accessed: May 15, 2018).
[6] http://docs.ckan.org/en/ckan-2.7.3/maintaining/tracking.html (last accessed: May 15, 2018).

latter). Both tools are part of the Open City Toolkit (OCT), a collection of datasets, tools, services, specifications and guidelines to deliver services based on open data that are useful for citizens, businesses and governing bodies (Degbelo, Granell, et al., 2016). The OCT combines technology-driven and citizen-centric strategies. It purports, as indicated in (Degbelo, Bhattacharya, Granell, & Trilles, 2016), to address the lack of integrated and open collections of software components to realize smart cities.

OCT TRANSPARENCY TOOL

The OCT transparency tool is useful to answer the questions: what are datasets available in my city? How often are these datasets used? And which apps use these datasets? An essential technical means of realizing this is the use of semantic Application Programming Interfaces (APIs). The design of semantic APIs and their different layers were discussed in detail in (Degbelo, Trilles, et al., 2016). The main features of the OCT transparency module are:

- App registration: each developer (individual or organization) can register its app by getting an API key. This API key is used later to identify apps which access some datasets;
- Dataset registration: through this functionality, developers can register their own dataset to the OCT transparency module, so as to make it visible to other users (e.g., citizens, city councils, companies, developers);
- Logging: this functionality involves recording all activities related to an app (i.e., topics of datasets accessed, frequency of access, spatial locations from which the datasets are accessed).

As a proof of concept for the idea, eight web applications were created based on existing open government data (e.g., population, migration and referendum data). The applications and the process of their creation were presented in (Degbelo & Kauppinen, 2018). The datasets used are available on Zenodo (https://doi.org/10.5281/zenodo.293201). Figure 1 presents a dashboard visualization illustrating information about dataset usage provided by the OCT transparency tool. The tool also informs about the places from which an app has accessed datasets, and places from which datasets were called (see Figure 2). It is a dashboard in the sense of (Matheus, Janssen, & Maheshwari, 2018) who define dashboards as “the visualization of a consolidated set data for a certain purpose, which enables to see what is happening and to initiate actions”. The next subsections report on some tests about the usability, usefulness and scalability of the tool.

USABILITY

Two rounds of usability tests were conducted in February 2017 and October 2017. Each of the round involved seven people, leading to a total of 14 usability test participants. The usability tests were summative (see Lewis 2014 for a definition of summative usability), focusing on efficiency and effectiveness. In the first round, students were asked to register an app and a dataset, and provide informal feedback about their experience doing so. Their feedback was integrated in the development of the second version of the transparency tool, which was used during the second round of tests. In this second round, participants were asked to register their app, register a dataset, and build their first OCT app. The three tasks were completed successfully by all seven participants in less than 30 minutes (see Figure 3). The SUS (System Usability Scale) score for the participants was 67.14, which means (following the scale introduced in Bangor, Kortum, & Miller, 2009, 2008), that the participants rated the usability of the OCT transparency module as “ok”. Using SUS as usability questionnaire is suitable in this case, because previous work (Brooke, 2013; Sauro, 2013; Tullis & Stetson, 2004) pointed out that it produces acceptable results even with a small number of participants.

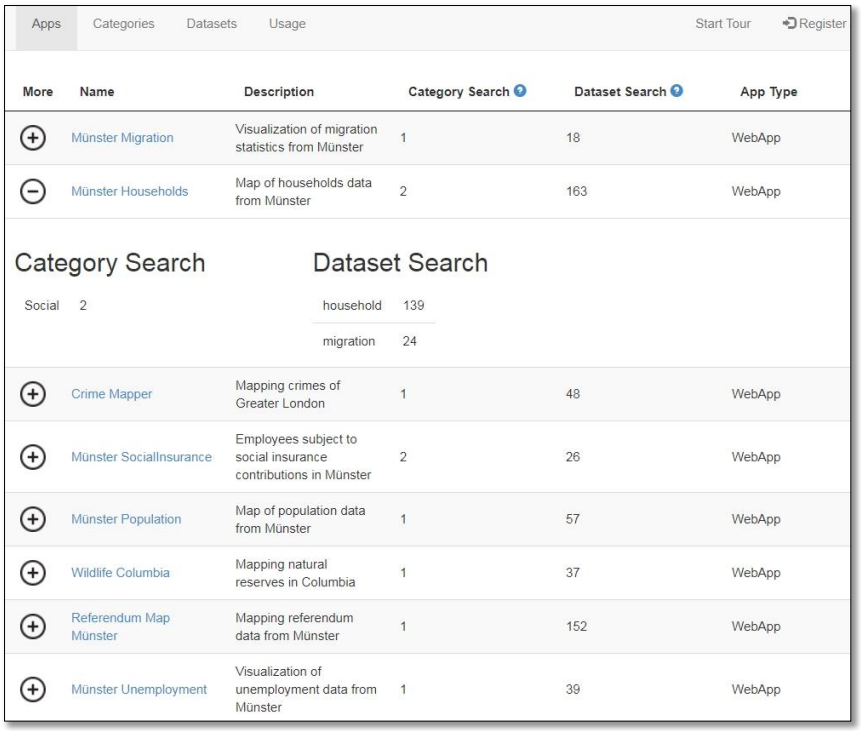

Figure 1: Dashboard visualization about datasets usage provided by the OCT transparency tool.

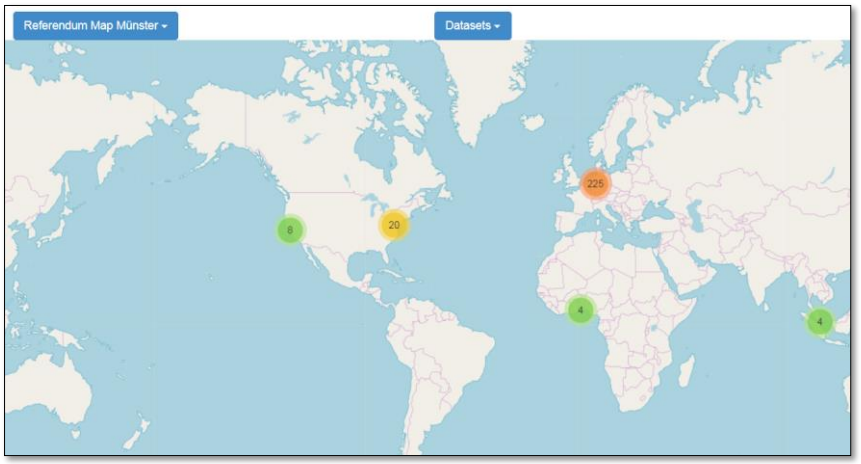

Figure 2: Example visualization of spatial locations from which one specific app (i.e., Referendum Map Münster) is accessed.

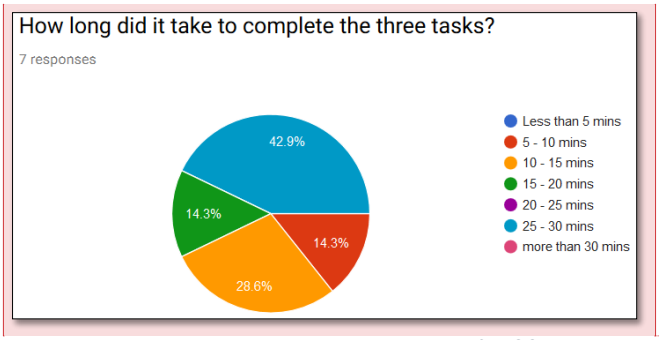

Figure 3: Registering an app, a dataset, and building one's first OCT app can be done within 30 minutes.

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UTILITY

Eight semi-structured interviews of employees from two different city councils (Lisbon and Münster) were conducted in October 2017[7]. The purpose of the interviews was to 1) gather insights from people working on (or having worked with open data) about the importance of open data re-use for city councils; and 2) collect some feedback from domain experts on the OCT transparency tool. Participants were recruited through snowball sampling (for a description of the sampling method, see Lazar et al. 2010). The OCT transparency tool was used as probe during the interviews.

The interview protocol was adapted from (Roth, 2009), and included an introductory question, five key questions, and an ending question. The first three key questions were: 1) How important is information about open data re-use for your institution? 2) What are you currently doing to collect information about open data re-use? 3) What issues do you face while collecting information about open data re-use? 4) In your opinion, what could be the benefits of the module for open data re-use? And 5) In your opinion, what could be the limitations of the module for open data re-use? Questions 4) and 5) were asked after showing an introductory video of 90 seconds about the tool.

The interviews lasted in average about 30 minutes. Table 1 reports on the results of questions 4) and 5), which are directly related to the transparency tool. The table illustrates that the participants, overall, saw more pros than cons. The pros often mentioned included: feedback to the city council about popularity of datasets, and an easier discoverability of datasets. Cons often reported included meta(data) maintenance (existing apps and datasets must be registered again on the tool to be made visible), as well as the current lack of quality checks by the tool. There is no guarantee that data saturation[8] has been reached with the sample of eight participants, that is, that the eight interviewees have listed all possible pros and cons pertaining to the tool. This notwithstanding, their feedback is useful: the pros mentioned validate the utility of the tool, while the cons point at areas where work is still needed in order to facilitate its adoption in the city context.

Participant ID	Current Role	Advantages Mentioned	Limitations Mentioned
#1	Head of department	a) Data publishers can get some feedback about most popular datasets and categories b) Knowledge about most popular categories can inform about the types of datasets to make open	Data and metadata maintenance
#2	Project manager	a) Knowledge about datasets, which the city council does not need to publish b) Knowledge about most popular categories can inform about the types of datasets to make open	Maintenance

[7] The ideal number of participants for interviews is purpose-dependent (see e.g., Guest, Bunce, & Johnson, 2006), but a common range is between 8-15 participants (Lopez & Whitehead, 2013). When doing qualitative research, "the 'richness' of data collected is far more important than the number of participants" (Lopez & Whitehead, 2013).
[8] See (Fusch & Ness, 2015) for a brief introduction to data saturation.

		c) Asking new questions (e.g., why someone access datasets from a place?)	
#3	Team leader	a) Facilitate discoverability of datasets b) Show politicians that open data is the way to go	None
#4	Manager open data portal	See datasets and apps which are used	a) Module currently lacks information quality checks b) Module currently lacks verification of data
#5	Technical lead	Helps understand data use	a) No verification b) Coherency of the data
#6	Head of division	Easier discoverability of datasets	Module currently lacks notifications to users about crashes, and data additions
#7	Head of library	Easy to gather statistics about the data that is being used	No answer
#8	Geologist	Information about data usage	No idea

Table 1: Interviewees' feedback about the OCT transparency tool.

SCALABILITY

Several tests were conducted to assess the performance of the platform under a growing number of requests. The tests measured the response time of simultaneous database accesses on the system. Each test involved a group of queries to the endpoint of the API. Each group of query was executed five times, and the response time was averaged over the five executions. The tests simulated 1, 5, 10, 25, 50, 100, 250, 500 and 1000 concurrent uses respectively. The data packets retrieved was kept constant (7KB) during the whole test sessions. As Figure 4 suggests the scalability of the platform is better-than-linear. The code source of the application is available on GitHub (https://github.com/geo-c/OCT-Core).

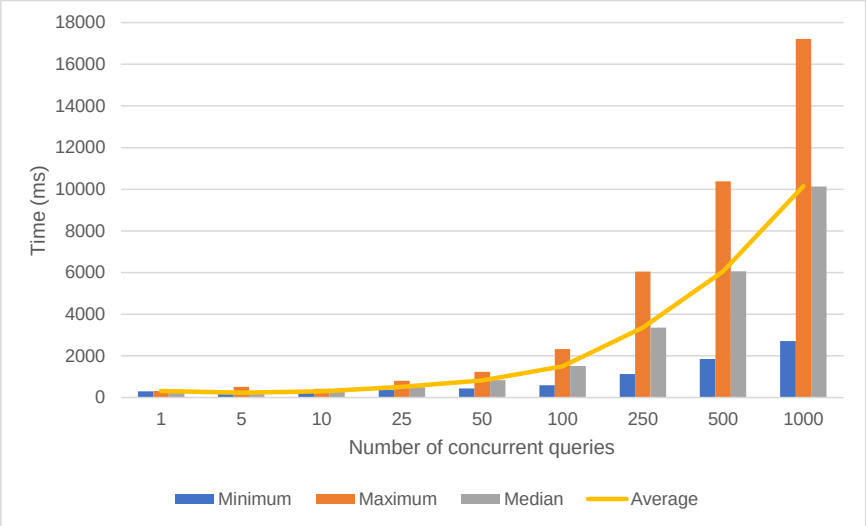

Figure 4: *The OCT Transparency Tool in reaction to growing instances of concurrent requests*

OCT INTERACTIVE GUIDELINES

While the OCT transparency tool enables the monitoring of cities' open datasets usage, the OCT interactive guidelines tool deals with the following question: what can I do with all these datasets? The

main audiences of both tools are different: decision makers, data publishers and managers are typically the focus of the OCT transparency tool. Of course, citizens can also seek for the impact of open datasets. Yet, they often measure the usefulness and impact of open datasets through a different lens, namely 'how can open data sets enhance their daily activities'? Both tools are complementary, addressing open data usage and open-data-based innovations (though the interpretation of these two terms may vary depending on the target stakeholders).

THE NEED FOR GUIDELINES

We can explain the role and purpose of the OCT interactive guidelines by borrowing an analogy from MIT researcher Cesar Hidalgo, who compared open data sites and supermarkets[9]: "Imagine shopping in a supermarket where every item is stored in boxes that look exactly the same. Some are filled with cereal, others with apples, and others with shampoo. Shopping would be an absolute nightmare!" Hidalgo argued that most, if not all, open data sites are organised like arrays of "brown boxes" in supermarkets, i.e., arrays of links to public datasets that quite often are published as they were collected. This way, most of these sites look like they are only addressing a small portion of the whole population: those with technical skills (programmers, researchers, etc.) or professionals (e.g., data-driven journalists, civic agents, etc.), i.e., those few specialists who are able to handle and transform datasets to tell stories to the rest of people. The OCT has a CKAN-based module (not introduced in this chapter, see Degbelo, Bhattacharya, et al., 2016) which is not that far off this strategy; research resources are registered and made publicly available as endpoints that can be queried via well-documented data access and retrieval APIs. The expected stakeholders of the CKAN-based OCT module are other scientists, researchers and civic hackers/programmers who feel comfortable (programmatically) handling open data and coding.

If we do not consider the tech elite, which is the remaining 95% of the population (Kankaraš, et al., 2016), open data sites become difficult to understand (see e.g., Benitez-Paez et al., 2018; Beno, Figl, Umbrich, & Polleres, 2017). Returning to Hidalgo's analogy of the supermarket, imagine you (citizen) are asking for "cannelloni" in the food section and the clerk delivers you a bag with all the raw ingredients to cook them yourself. Like most of the open data sites, open data is delivered in the way in which it was collected. Next, you look again at the clerk and order cannelloni "ready to be eaten", because you do not have time or do not know to cook them. Like most open data sites, open data is not delivered in the way it can best be used and/or understood. Rather, open datasets are often delivered with no clue on how to process them, manage them, or, even worse, whether they can be useful for citizens at all. In sum, citizens demand "ready-to-consume, easy-to-understand products" rather than raw ingredients like open datasets. Sometimes these products take the form of apps, or can be expressed as interactive guidelines. The OCT interactive guidelines tool seeks to make city problems and subsequent actions understandable to citizens.

Most open data sites do not deliver elaborated stories that emerge from the combination of their contained open datasets. However, most people are looking for stories ("cannelloni") that can be easily comprehended ("eaten"). In case people want to know the details (e.g., raw ingredients to cook cannelloni themselves), they can directly download or access data sets through the corresponding data access API. What we pursue here is the design and creation of "stories" that bring together, behind the scenes various datasets and other types of resources and transform them into interactive city

[9] What's Wrong with Open-Data Sites--and How We Can Fix Them, by Cesar Hidalgo. https://blogs.scientificamerican.com/guest-blog/what-s-wrong-with-open-data-sites-and-how-we-can-fix-them/ (last accessed: Oct 4, 2017).

guidelines, which help a large portion of the society to understand their benefits and impacts regardless the complexity of the details.

The OCT interactive guidelines tool is intended to help city stakeholders walk through a story. On one hand, the term “guidelines” is seen as narratives that refer to problem-solution patterns by presenting challenges, benefits and impacts in an understandable manner, i.e., everyone may share and refer to when talking to others. Problems may be of diverse nature, such as social, mobility, environment, and cultural; solutions may involve a combination of datasets, code, apps, services and any other relevant resource that helps to sort out the current problem. On the other hand, the qualifier “interactive” underlines the ability of users to dynamically explore (to certain degree) the guideline through a set of blocks for different purposes such as graphs, plots creation, maps visualisation, custom JavaScript code, p5 code (a sort of JavaScript wrapper for processing), and the inclusion of text and markdown formats. We intentionally avoid static guidelines, as in the form of tutorials or paper-based posters, to let stakeholders engage dynamically with the content of the visual narratives.

CONCEPTUAL ARCHITECTURE

Figure 5 shows the conceptual architecture to materialise the OCT interactive guidelines tool. Designers of stories are one type of users. These could be for instance researchers, data journalists, or data publishers: they use “storytelling” formats for creating visual and interactive narratives of how smart city solutions are being installed and deployed in cities. That is, they design and tell stories based on external or own datasets and other research resources. The tool provides an edit mode to create and easily update each story and publish it into the catalogue of guidelines (Figure 6). Citizens are the second type users. They can pick a guideline from the catalogue and explore it through interactive elements at their disposal. For example, via interactive plots, charts and maps, and through on the fly annotations as a way to provide feedback about the story being visualised (this feature will be released shortly). The source code of the OCT interactive guidelines tool is also available on GitHub (https://github.com/geo-c/OCT-Guidelines).

Technically, each guideline is stored as a markdown file (like a regular text file). Markdown tags specify the sections of a guideline, and keep information about the author, last update, title and a list of data sources used. To ease the process of creating guidelines, the tool provides a range of templates with predefined sections and style. Each guideline is exportable as a regular markdown file for offline edition, which may be uploaded again later on. Besides, a guideline contains a collection of interactive elements (codified as JavaScript snippets). Currently, the supported elements are graphs and plots, custom JavaScript code, maps and text; adding annotations is part of an ongoing work.

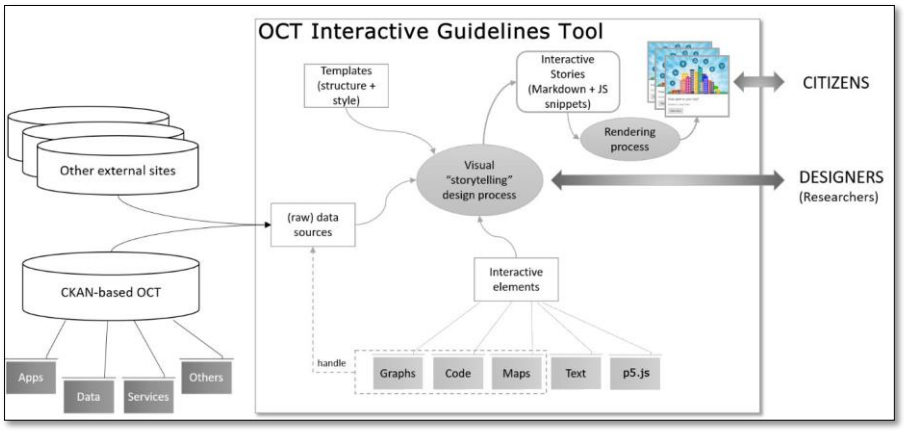

Figure 5: Architecture of the OCT interactive guidelines tool

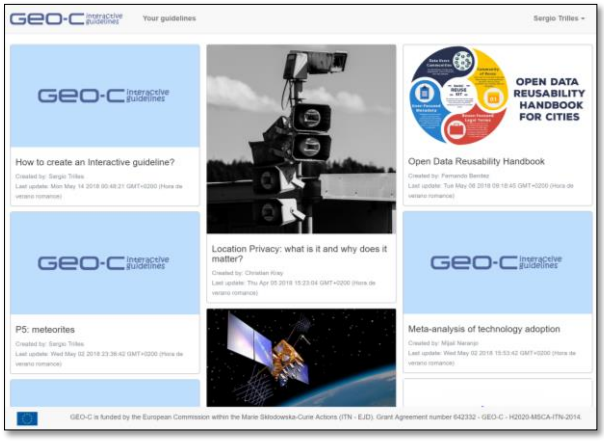

Figure 6: Catalogue of interactive guidelines showing examples of OCT interactive guidelines

These interactive elements are able to handle data sources, both deployed in a CKAN-based instance platform and published elsewhere. For example, a graph can take as input a data source available in the OCT catalogue, permitting users to interact with the graph, and thereby with the associated data source. Furthermore, any resource registered in the OCT catalogue (http://giv-oct.uni-muenster.de:5000/) is potentially an input source for interactive guidelines by only specifying its access point (e.g., URL). Moreover, interactive guidelines can be registered in the OCT catalogue as any other public and open resource. This way, the OCT interactive guidelines tool augments the capabilities of the OCT catalogue, to deliver not only datasets, but stories to a wide range of stakeholders. On the down side, designing compelling, understandable, and thought-provoking guidelines requires authors with proven communication and design skills so that the intended messages are effectively transmitted to the public.

Examples of these interactive guidelines are available at http://elcano.init.uji.es/guidelines. At the moment of this writing, there are ten guidelines; some of them are like "tutorials" to guide user creators

to use and combine the different available blocks. Others intent to help stakeholders to solve particular problems or show a list of suggestions to follow. For instance, the guideline “Location Privacy: what is it and why does it matter?” attempts to communicate to citizens the importance and implications of sharing the location using smartphones. The “Checklist and tools when publishing open data” guideline tries to explain what an open data needs to earn some stars of Tim Berners Lee’s five star model (Berners-Lee, 2006). To achieve that, some blocks such as text and p5.js blocks are used. The latter blocks are particularly useful to provide interactivity to the guidelines (e.g., they help to generate buttons, where users can click and see what each star category means).

In sum, the interactive guidelines do not specifically target technologically savvy people such as open data advocates and programmers. These guidelines aim to inform people about problems that matter in their cities, making them understandable, and presenting potential solutions. Interactive guidelines, when designed as effective narratives, can raise awareness about certain problems that matter to citizens, even to the point to persuade and reframe thinking. In this sense, interactive guidelines could have an educational footprint in the long run.

CONCLUSION

There is an increasing amount of open datasets available through open government portals, but still much work to be done to inform about the actual usage of these open datasets. This chapter has introduced two software components to enable progress on this issue: the Open City Toolkit transparency module, as well as interactive guidelines. The former aims at informing about the rate of open data re-use and the latter purports to communicate innovations ensuant on open data. The chapter has presented the key ideas behind the two components, and (evolving) prototypical implementations illustrating them. The work introduced is relevant to open data publishers and citizens at large.

Immediate directions for future work, based on the feedback from the participants, include further improving the usability of the tool, and devising means to automatically check the quality of the datasets. Developing metrics for (subjective) aspects of data quality such as ‘fitness for purpose’, ‘trustworthiness’ or ‘understandability’ is a challenge, but other aspects of quality such as ‘dataset availability’ or ‘dataset currency’ are easier to assess, and can be implemented. Automatically recommending (possibly) relevant datasets to new apps registering on the OCT transparency tool seems also a promising direction for future work.

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REFERENCES

Attard, J., Orlandi, F., & Auer, S. (2016). Value creation on open government data. In *2016 49th Hawaii International Conference on System Sciences (HICSS)* (pp. 2605–2614). Koloa, Hawaii, USA: IEEE. http://doi.org/10.1109/HICSS.2016.326

Attard, J., Orlandi, F., Scerri, S., & Auer, S. (2015). A systematic review of open government data initiatives. *Government Information Quarterly*, *32*(4), 399–418.

http://doi.org/10.1016/j.giq.2015.07.006

Bangor, A., Kortum, P., & Miller, J. (2009). Determining what individual SUS Scores mean: Adding an adjective rating scale. *J. Usability Studies*, *4*(3), 114–123.

Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the system usability scale. *International Journal of Human-Computer Interaction*, *24*(6), 574–594. http://doi.org/10.1080/10447310802205776

Benitez-Paez, F., Degbelo, A., Trilles, S., & Huerta, J. (2018). Roadblocks hindering the reuse of open geodata in Colombia and Spain: A data user's perspective. *ISPRS International Journal of Geo-Information*, *7*(1), 6. http://doi.org/10.3390/ijgi7010006

Beno, M., Figl, K., Umbrich, J., & Polleres, A. (2017). Open data hopes and fears: determining the barriers of open data. In P. Parycek & N. Edelmann (Eds.), *2017 Conference for E-Democracy and Open Government (CeDEM)* (pp. 69–81). Krems, Austria: IEEE. http://doi.org/10.1109/CeDEM.2017.22

Berners-Lee, T. (2006). Linked Data - Design issues. Retrieved May 18, 2018, from http://www.w3.org/DesignIssues/LinkedData.html

Brooke, J. (2013). SUS: A Retrospective. *Journal of Usability Studies*, *8*(2), 29–40.

Degbelo, A., Bhattacharya, D., Granell, C., & Trilles, S. (2016). Toolkits for smarter cities: a brief assessment. In R. García, P. Caballero-Gil, M. Burmester, & A. Quesada-Arencibia (Eds.), *UCAmI 2016 - 10th International Conference on Ubiquitous Computing & Ambient Intelligence* (pp. 431–436). Las Palmas, Gran Canaria, Spain: Springer International Publishing. http://doi.org/10.1007/978-3-319-48799-1_47

Degbelo, A., Granell, C., Trilles, S., Bhattacharya, D., Casteleyn, S., & Kray, C. (2016). Opening up smart cities: citizen-centric challenges and opportunities from GIScience. *ISPRS International Journal of Geo-Information*, *5*(2), 16. http://doi.org/10.3390/ijgi5020016

Degbelo, A., & Kauppinen, T. (2018). Increasing transparency through web maps. In P.-A. Champin, F. L. Gandon, M. Lalmas, & P. G. Ipeirotis: (Eds.), *Companion of Proceedings of the Web Conference 2018 - WWW '18* (pp. 899–904). Lyon, France: ACM Press. http://doi.org/10.1145/3184558.3191515

Degbelo, A., Trilles, S., Kray, C., Bhattacharya, D., Schiestel, N., Wissing, J., & Granell, C. (2016). Designing semantic application programming interfaces for open government data. *JeDEM - EJournal of EDemocracy and Open Government*, *8*(2), 21–58.

Fusch, P. I., & Ness, L. R. (2015). Are we there yet? Data saturation in qualitative research. *The Qualitative Report*, *20*(9), 1408–1416. http://doi.org/1, 1408-1416

Gonzalez-Zapata, F., & Heeks, R. (2015). The multiple meanings of open government data: Understanding different stakeholders and their perspectives. *Government Information Quarterly*, *32*(4), 441–452. http://doi.org/10.1016/j.giq.2015.09.001

Graves, A., & Hendler, J. (2013). Visualization tools for open government data. In S. Mellouli, L. F. Luna-Reyes, & J. Zhang (Eds.), *Proceedings of the 14th Annual International Conference on Digital Government Research - dg.o '13* (p. 136). Quebec, Canada: ACM Press. http://doi.org/10.1145/2479724.2479746

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods*, *18*(1), 59–82. http://doi.org/10.1177/1525822X05279903

Hartog, M., Mulder, B., Spée, B., Visser, E., & Gribnau, A. (2014). Open data within governmental organisations. *EJournal of EDemocracy and Open Government*, *6*(1), 49–61.

Janssen, M., Charalabidis, Y., & Zuiderwijk, A. (2012). Benefits, adoption barriers and myths of open data and open government. *Information Systems Management*, *29*(4), 258–268. http://doi.org/10.1080/10580530.2012.716740

Lazar, J., Feng, J. H. J., & Hochheiser, H. (2010). *Research methods in human-computer interaction*. John Wiley & Sons.

Lewis, J. R. (2014). Usability: lessons learned … and yet to be learned. *International Journal of Human-Computer Interaction*, *30*(9), 663–684. http://doi.org/10.1080/10447318.2014.930311

Lopez, V., & Whitehead, D. (2013). Sampling data and data collection in qualitative research. In Z. Schneider, D. Whitehead, G. LoBiondo-Wood, & J. Haber (Eds.), *Nursing and Midwifery Research: Methods and Critical Appraisal for Evidence-based Practice* (pp. 124–140). Elsevier Health Sciences, London.

Lourenço, R. P. (2015). An analysis of open government portals: A perspective of transparency for accountability. *Government Information Quarterly*, *32*(3), 323–332. http://doi.org/10.1016/j.giq.2015.05.006

Matheus, R., Janssen, M., & Maheshwari, D. (2018). Data science empowering the public: data-driven dashboards for transparent and accountable decision-making in smart cities. *Government Information Quarterly*. http://doi.org/10.1016/j.giq.2018.01.006

Pomerantz, J., & Peek, R. (2016). Fifty shades of open. *First Monday*, *21*(5). http://doi.org/10.5210/fm.v21i5.6360

Roth, R. E. (2009). A qualitative approach to understanding the role of geographic information uncertainty during decision making. *Cartography and Geographic Information Science*, *36*(4), 315–330. http://doi.org/10.1559/152304009789786326

Sauro, J. (2013). 10 things to know about the system usability scale (SUS). Retrieved May 17, 2018, from https://measuringu.com/10-things-sus/

Schade, S., Granell, C., & Perego, A. (2015). Coupling public sector information and public-funded research data in Europe: A vision of an open data ecosystem. In C. Reddick & L. Anthopoulos (Eds.), *Information and Communication Technologies in Public Administration: Innovations from Developed Countries* (pp. 275–298). Routledge.

Susha, I., Zuiderwijk, A., Charalabidis, Y., Parycek, P., & Janssen, M. (2015). Critical factors for open data publication and use: A comparison of city-level, regional, and transnational cases. *EJournal of EDemocracy and Open Government*, *7*(2), 94–115.

Tullis, T., & Stetson, J. (2004). A comparison of questionnaires for assessing website usability. In *Proceedings of the Usability Professionals Association (UPA) 2004 Conference* (pp. 7–11). Minneapolis, Minnesota, USA.

Veljković, N., Bogdanović-Dinić, S., & Stoimenov, L. (2014). Benchmarking open government: An open data perspective. *Government Information Quarterly*, *31*(2), 278–290. http://doi.org/10.1016/j.giq.2013.10.011

Vetrò, A., Canova, L., Torchiano, M., Minotas, C. O., Iemma, R., & Morando, F. (2016). Open data quality measurement framework: Definition and application to Open Government Data. *Government Information Quarterly*, *33*(2), 325–337. http://doi.org/10.1016/j.giq.2016.02.001

Wijnhoven, F., Ehrenhard, M., & Kuhn, J. (2015). Open government objectives and participation motivations. *Government Information Quarterly*, *32*(1), 30–42. http://doi.org/10.1016/j.giq.2014.10.002

Young, A., & Verhulst, S. (2016). *The global impact of open data - key findings from detailed case studies around the world* (1st ed.). O'Reilly Media, Inc.