The VisTools Marketplace: An Activity to Understand the Landscape of Visualisation Tools

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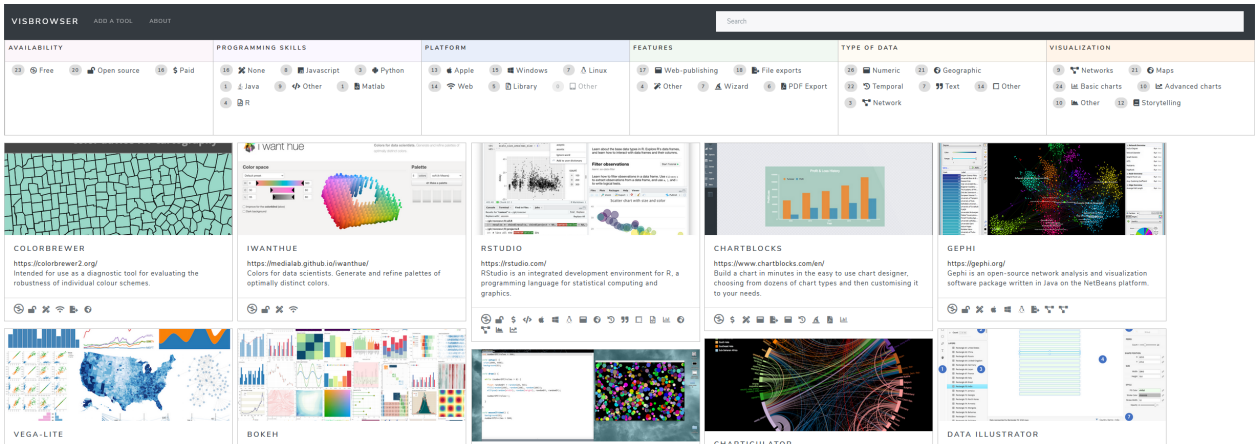

Figure 1: The *VisBrowser* (`https://vistools.net/`) interface showing facets (top) and results (bottom).

Abstract

This paper presents the *VisTools Marketplace*, a learning activity to engage learners in understanding tools for visualisation and sharing individual knowledge about tools. With the growing number of tools for data exploration and the creation of visualisations, e.g., for visual communication, it is important to provide bespoke learning resources and teach learners the diversity and individual characteristics of tools. Our activity follows a peer-learning approach and is structured into two parts: a discussion among 'experts' about known tools and their experience with these tools; and a discussion phase in which 'novices' discuss with 'experts' and try to place tools within a simple framework. Preliminary feedback from running this activity as part of an online course with professionals indicates high engagement and lasting discussions.

1 Introduction

There are countless tools for creating data visualisations—some tools guide the user through the visualisation creation from start to finish, others only help with parts of the process, such as selecting colour schemes, some offer graphical user interfaces, others require advanced coding skills. Particularly for data visualisation novices, this tool landscape is challenging to navigate. We present the *VisTools Marketplace*, a learning activity using the *VisBrowser* (Fig. 1), an online collection of visualisation tools. During our activity, participants learn what criteria to look for when selecting a tool, guided by relevance to the task they wish to use it for and their skillset. The *VisBrowser* provides a faceted tool overview that allows users to drill down to the subset that meets some or all of their needs, and support informed choice of the most suitable tool(s).

The *VisTools Marketplace* was developed in the context of *DataVis Online*, a 5-week course on data visualisation for professionals held at the University of Edinburgh in summer 2020. While delivered online to increase accessibility, the course takes a hands-on, learning by doing approach, with interactive sessions delivered synchronously in a virtual classroom to supplement self-directed learning. The *VisTools Marketplace* activity supports a key learning outcome for the course: moving from a focus on learning tools to a focus on identifying functionality available in a range of tools to support different tasks along the data visualisation process or pipeline. This approach requires participants to select tools that optimise their individual capability, and/or that allow them to create an individual learning path in which they are able to acquire new skills that allow them to deliver, ultimately, visualisations that meet their end users' needs.

Our activity has four learning goals:

- L1. **understand the range of tools** and their characteristics;
- L2. **understand that there is no perfect tool** that supports all tasks in creating and using visualisations; different tools support different tasks and stages in the visualisation process or workflow;
- L3. **learn how to explore functionality** available for a specific context or activity;
- L4. **learn how to think critically** about functionality required for a given workflow, and how to evaluate which tools satisfy these requirements.

We continue the paper with a brief review of current approaches to tool selection for visualisation (Section 2). To provide the context in which the activity was carried out, we summarise the structure of the *DataVis Online* course in Section 3 and introduce the *VisBrowser* in Section 4. Section 5 describes the *VisTools Marketplace* activity and how it uses the *VisBrowser* as a learning resource. We discuss our initial findings in Section 6, looking also at how lessons learnt by the course organisers fed into subsequent activities in the course, and

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the contribution of the activity to participants' learning journies.

2 Visualisation and Tool Selection

A number of commercial and freeware tools, APIs, and libraries are in use for data visualisation across research and commercial institutions. Some of the most well-known commercial tools, including Tableau and Microsoft PowerBI, as well as popular open-source or freeware tools such as D3.js [2] and RAWGraphs [7], originated from research.

We are not aware of any reviews or taxonomies that attempt to capture the data visualisation tool landscape in its entirety. For interactive, analysis-focused visualisations, Heer & Shneiderman [4] introduce a taxonomy of tools that support fluent and flexible use of visualisations. Recognising challenges related to tool usage, Bigelow et al. [1] explore difficulty iterating between different tools while refining a visualisation. Walny et al. [14] examine situations where the available tools do not cover all stages of the creation process, i.e., 'gaps' between tools.

Outside of academia, attempts to list, classify, and organise visualisation tools are more frequent. There are multiple websites providing large, annotated and coarsely-grouped collections of visualisation tools and resources, e.g., Kirk's resource collection, the datavisualization.ch collection, or the Keshif gallery. Rost [11, 12] compares different tools in a series of blog posts, describing the process of recreating the same chart in each. More informal tool discussions can be found on Twitter, for example in a recent thread on tools to use for a data visualisation class [6], and in specialised Slack communities such as the Data Visualization Society Slack or the D3.js Slack community.

However, without knowing what to look for and being able to clearly define one's needs for a particular visualisation project, these large catalogues of tools do not necessarily help visualisation novices in their decision on what tool to use. Advice on this is scarce—Geere reports on different practitioners' approaches to choosing tools [3], but does not provide clear guidance. In a review of business intelligence-focused data visualisation tools [10], the authors provide some advice on how to choose a tool, though this is more focused on choosing a tool for organisations, rather than individuals.

Overall, it remains challenging for novices to navigate the large tool landscape and to determine which tool best suits their existing skills and goals for visualisation projects or processes. The following sections describe how we structured the *DataVis Online* course and the *VisTools Marketplace* activity to enable participants to make informed choices for tool(s) to use in their data visualisation projects.

3 The DataVis Online Course

The *VisTools Marketplace* and the *VisBrowser* were trialled as part of the *DataVis Online* course, which ran for 5 weeks from 15 June 2020. The course design employed a flipped classroom approach [8, 13] to support constructive, collaborative, albeit self-directed learning by adult learners. To qualify to take the course, whose goal was to improve visual literacy in the workforce by teaching the theory and practice of the fundamentals of data visualisation, participants were required to have professional experience beyond school (secondary or tertiary). While no previous knowledge or experience with data visualisation was required, applicants were asked to demonstrate interest in using data to support knowledge-driven tasks and/or communicate a story.

Because of the value in bringing multiple perspectives to the visualisation process [5, 9], an important component of the course design was diversity in participants and appeal to a global audience. In practice, though, for administrative reasons admission was restricted to residents of Scotland and the EU. Over 130 individuals registered interest in the course, of which more than 50 eventually participated in the course. Up to the week prior to the course starting, 59 of those who registered interest provided information on their use of visualisation techniques and tools, along with new techniques they wished to learn, through a survey. The cohort who participated in the course overlaps with the 59 who responded to the survey.

This paper was completed in the final week of the taught component of the course, when participants were focused on reviewing their understanding of theoretical concepts, assessed through online quizzes matched to each week's topics, and finalising assignments and their individual projects. Over the five week period, using video lectures with corresponding reading material, interactive, synchronous tutorials and study and Q&A sessions, participants covered a series of topics:

Week 1: **Foundations** in visualisation and design thinking
Week 2: **Visualisation design:** visual variables, perception, exploratory data analysis, tools, etc.
Week 3: **Visualisation techniques:** networks, geodata, etc.
Week 4: **Specific Applications:** data-driven storytelling, physical visualisation, and digital humanities
Week 5: **Advanced topics:** interaction and evaluation.

While optional, the majority of participants took part in the interactive tutorial sessions set up to reinforce the theory by following the process of carrying out a visualisation project, built on the iterative, user-centred design lifecycle. Prior to the *VisTools Marketplace* activity, participants had been introduced to visual, exploratory data analysis (EDA), defined the briefs for their individual projects and created initial design sketches. The *VisTools Marketplace*, which took place during a two-hour tutorial in Week 2, took into account both course delivery to this point and the information collected prior to the course on participants' experience and learning goals.

4 The VisBrowser

The *VisBrowser* is a web interface (Fig. 1) to search and browse visualisation tools. It is designed as a crowdsourced tool marketplace, where anyone can submit new tools as well as reviews and learning resources (e.g., tutorials) for tools already listed. The *VisBrowser* provides six facets (*availability, programming skills, platform, features, type of data, visualisation*), each containing between three and seven categories into which tools may fall. The displayed tools can be filtered using these categories, e.g., a user may want to view only tools where the *availability* is *open source* or *free*, excluding *paid* tools. Each tool is listed with a screenshot, a brief description of its functionality, and symbols representing the tool's classification along the six facets. Clicking one of these tool 'cards' brings up additional information about the tool, including reviews and tutorial recommendations. The user is also recommended *similar tools*, which are determined based on which other tools have similar classifications along the six facets to that selected.

At the onset of the *DataVis Online* course, the number of tools hosted on the *VisBrowser* was deliberately limited to 20 manually curated tools. There were several reasons behind this decision. First, we wanted to provide participants with a representative selection of tools without making them feeling 'lost' in the number of tools. Secondly, we wanted to provide only those tools that were familiar to at least one of the course organisers or teaching assistants to be able to provide help to course participants. Lastly, we wanted to encourage participants to add tools they had previously used or which they came across during the course, to establish a 'sharing culture' of knowledge and experiences among participants.

5 The VisTools Marketplace Activity

The tutorial was designed to explore the *VisBrowser* as part of a wider discussion on tools, conceptualised as the *VisTools Marketplace*. The core idea of this activity is to engage learners in *(i)* knowledge exchange about tools they are familiar with and *(ii)* discussion of tool characteristics and workflows. To that end, the activity is structured into two parts: an *experts discussion* and a *novice discussion*. To support these steps, participants use the *VisBrowser*, introduced through

a live demonstration, following a video demonstration shared as part of the week's lecture materials.

The data collected, before the tutorial session, on participants' previous experience with data visualisation techniques and those that they wished to learn more about was fed into the planning for breakout groups. This allowed the discussion to fit both participants' previous experience with tools, and also allow for exploration of tools they were unfamiliar with but had an interest in exploring. A detailed plan of our activity is described below.

Step 1: Introduction (10 minutes)—At the start of the session participants are given a brief demo of the *VisBrowser*. They then sign up for breakout groups in a shared document, wherein they get to explore tools they are unfamiliar with and would like to know more about. We created groups for, e.g., tools for temporal, high-dimensional, and basic charts; geographic and spatio-temporal data; visual storytelling; and networks, trees and hierarchies.

Step 2: Experts Discussion (20 mins)—Learners break out into groups (of 3–5) to discuss their existing experience with tools. They are given a link to a shared slide deck containing the *tool matrix*. The tool matrix (Fig. 2) is a simple conceptual framework to group and discuss visualisation tools, created by one of the authors as part of a lecture on visualisation tools. Learners locate tools along two dimensions which describe the user- and task-centred process followed, ranging from `coding` via `designing` to `using` and from `generic` to `specific` respectively. These dimensions roughly capture *(i)* the effort and coding skill required to use a tool and *(ii)* the specificity of a tool, i.e., whether it offers a wide range of visualisations for different data types, or is focused on a specific data type. This simple conceptual framework supports critical discussion of tools, to help learners understand and evaluate the trade-offs between different kinds of tools.

Instructions for learners: Within your groups (based on existing previous experience), discuss:

- Which tools do you know and have you used?
- Which tools does the *VisBrowser* contain related to your area of expertise and experience?
- Are the tools you identified earlier in the *VisBrowser*?
- What was positive and negative about the tools you have used?

Groups are asked to prepare a brief presentation containing the matrix and one slide of pros and cons. Also, each group is asked to nominate three people to discuss their exchange with 'novices' in the following tutorial section, to describe some tools to others.

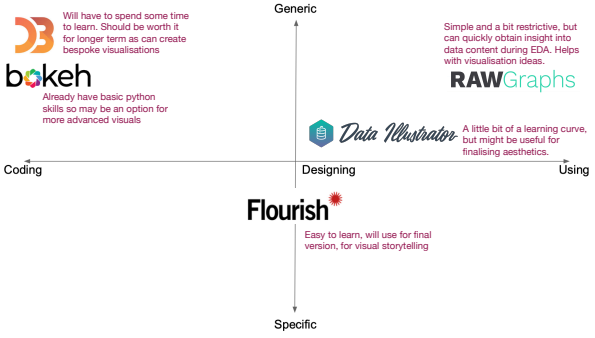

Figure 2: Annotated copy of the *tool matrix*, illustrating how participants selected and categorised tools. A small minority directly included justification for their choices on the matrix as in this example.

Step 3: Class Discussion (20 mins)—Learners return to the main classroom to report back on their discussions. They present the tools they have discussed, sharing the completed matrix and the pros and cons of the tools they have used.

Additional questions for discussion:

- Which tools did your group discuss?
- Was your tool on *VisBrowser*?
- Which new tools did you find on *VisBrowser*?

Step 4: Novice Discussion (25 + 25 mins)—Learners now move into new breakout groups to discuss the tools within their interest area that they would like to learn. They are given the opportunity to attend two or more different groups depending on what they have signed up to in Step 1. One of the experts, nominated by each group in Step 2, remains in their respective group to support novices in the first round. In the second round, another expert covers this group.

Instructions for learners: Within your chosen interest groups, referring to the matrix completed earlier by experts:

- Have you used any of the tools listed?
- Play with that tool and the resources available.
- Report on pros and cons of your experience.
- Search for similar tools in the *VisBrowser*.
- Reflect on the learning resources available for learning a particular technique or tool.
- How did you learn the tool? (Experts can provide insight.)
- Share learning resources and upload them to *VisBrowser* for consideration.

Step 5: Class Discussion (5-10 mins)—Learners return to the main classroom for the final discussion. Each group briefly comments on the tools they have learned about and tried out.

Questions for learners (to feed also into homework):

- Reflect on your choice of tool(s). Would you consider using other tools based upon recommendations? Both from other users and from *VisBrowser*?
- What are the important criteria when choosing a tool?
- Do the available learning materials make a difference when it comes to selecting a tool?

Post-tutorial homework—Following on from the activity participants were asked to choose and review two tools based on exploration or previous experience, and to submit a tool to the *VisBrowser*. They were also required to annotate the *tool matrix*; this required identifying up to three tools that met all or a subset of the requirements for their project, and placing these in the relevant quadrants of the *tool matrix*.

6 Preliminary Findings and Discussion

The current range and pace of evolution of tools makes it hard for end users and teachers to stay up to date. Instead, focusing on individual learners' experience in tool usage, including learning experience, documentation material, and other practical issues, represent a constructive approach for any visualisation course. Below, we discuss some findings and reflections on the activity. A more in-depth analysis of the specific learning experience is ongoing and will be supported by individual interviews once the course is completed. We are also conducting a longitudinal study to understand how the course and our activity helped participants beyond the course.

Did participants engage during the activity?—In general, course participants engaged well during the two-hour activity. The course design restricts tutorials to no more than 30 participants in the online classroom; it was run twice, with 15-20 participants in each session. Participants engaged with tools in a number of ways: with the tool matrix, with *VisBrowser*, and through discussion boards.

Was discussing tools with the Tool Matrix helpful?—Participants used the group-completed tool matrix and the *VisBrowser* as a starting point for learning about tools within the specific groups. The tool matrix helped participants discussing tools' features and workflows. For example, tools that support multiple stages in the visualisation process, e.g., the generation of basic and advanced charts or create customisable visualisations using a variety of input data types, were those most likely to be placed in different quadrants. As illustrated in the additional annotation in Fig. 2, participants' reviews reflected the process and results of EDA using their

selected dataset(s), peer feedback during the *VisTools Marketplace* activity, and increasing understanding of the theory underlying visualisation techniques and the visualisation pipeline. Future iterations of our activity could involve tool matrices with alternative axes (e.g., storytelling vs. exploration) or asking participants to come up with their own groupings. In such a case, it might be interesting not to include any tool grouping within the corresponding lecture, or run the activity before the lecture.

How did discussions unfold?—Discussions continued beyond the tutorial session. For example, one facilitator posted a question that was raised in one of the breakout groups to the course Slack workspace to make it public to everyone in the course. This additional communication channel was highly appreciated during the course and regularly used to carry over discussions started during tutorials. The question resulted in a healthy number of responses and debate as to which tool was best for approaching these particular issues. A number of additional tools were also proposed (L1).

How to create groups for the activity?—We had groups organised around tools for specific data types, e.g., networks, time, and approaches, e.g., *(visual) storytelling and communication*. This allowed participants to discuss tools relevant to their interests and course projects. An alternative we didn't try – groups around specific tools. We think this could make sense if a course covers a very specific—i.e., limited—set of tools. One challenge we discussed in planning the activity was how to get the novice discussions going. In particular, how to answer questions the 'experts' could not answer. Course organisers and tutorial assistants observe breakout discussions, allowing them to contribute to the discussion where required, to fill in these gaps. The key aim of our activity remained *(i)* to enable and encourage discussion of a potentially large group of tools, without being dependent on the experience and skills of the teaching team, *(ii)* explicitly including, rather, the experience of participants, to include different voices.

Did *VisBrowser* support the activity?—Engagement with *VisBrowser* as a learning tool was supported through faceted search, submitting reviews and tools, and browsing similar tools. After the tutorial, 12 additional tools and 45 reviews were submitted to the *VisBrowser*. One area that lacked engagement was the submission of tutorial recommendations for tools. In future iterations, we plan to re-think the way this feature is currently implemented, as well as how we can engage participants in sharing tutorials they have tried. We plan to make the *VisBrowser* public and eventually open source, encouraging the inclusion of additional features to support search, browsing, and learning.

Did the activity help learning and thinking about tools?—Prior to the activity, most participants had experience with some tools. However, as highlighted by one participant, charts are often chosen based on tool functionality, rather than the design rationale to effectively visualise a dataset or to solve a specific visualisation problem. For example, one participant remarked that they had not realised a particular tool would be able to produce a data visualisation matching their needs. Preliminary feedback indicates that our approach helps participants in thinking about goal first, i.e., the visualisations, features, and workflows; then to narrow down the choice of tools, e.g., with the help of facets in *VisBrowser*; and eventually seek specific advice and tutorials (L2, L3). Again, including and posting tutorials in *VisBrowser* seems to be helpful in supporting this task. A key finding, highlighting the importance of context, was the elimination of tools that otherwise met requirements, because of accessibility or installation requirements and, especially for web-based tools, data privacy and/or business process sensitivity.

How to engage participants with little tool experience—Working with professionals meant experience of tools related to specific work tasks and their domain. If the activity were taught to, e.g., students, a different set of tools might be known. Moreover, especially if the activity audience misses tool experience, we suggest complementary activities, tool demos, and step-by-step tutorials.

7 Conclusion

This paper described an activity to engage novices with tools in visualisation. The activity is aimed at exchange between learners and based on discussion and peer-learning, while requiring some experience with tools among the learners. In the specific context of an online course for professionals, our activity was successful in sparking discussion and exchange about tools. Our activity should be seen as complementary to other, more structured activities that help novices using tools. For learners with some experience, the activity encourages them to share their knowledge and complement their experience through exchange with other experts; for novices, it provides pointers and points of contact to navigate the ever growing landscape of visualisation tools.

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