ISSN 2161-3974

JeSLIB 2018; 7(1): e1122
doi:10.7191/jeslib.2018.1122

Journal of eScience Librarianship
putting the pieces together: theory and practice

Full-Length Paper

Using the Visualization Software Evaluation Rubric to explore six freely available visualization applications

Thea P. Atwood[1] and Rebecca Reznik-Zellen[2]

[1]University of Massachusetts Amherst, Amherst, MA, USA
[2]University of Massachusetts Medical School, Worcester, MA USA

Abstract

Objective: As a variety of visualization tools become available to librarians and researchers, it can be challenging to select a tool that is robust and flexible enough to provide the desired visualization outcomes for work or personal use. In this article, the authors provide guidance on several freely available tools, and offer a rubric for use in evaluating visualization tools.

Methods: A rubric was generated to assist the authors in assessing the selected six freely available visualization tools. Each author analyzed three tools, and discussed the differences, similarities, challenges, and successes of each.

Results: Of the six visualization tools, two tools emerged with high marks. The authors found that the rubric was a successful evaluation tool, and facilitated discussion on the strengths and weaknesses of the six selected visualization pieces of software.

Conclusions: Of the six different visualization tools analyzed, all had different functions and features available to best meet the needs of users. In a situation where there are many options available, and it is difficult at first glance to determine a clear winner, a rubric can be useful in providing a method to quickly assess and communicate the effectiveness of a tool.

Correspondence: Thea Atwood: tpatwood@umass.edu
Keywords: visualization tool, rubric

Introduction

With the increased availability of the internet, better computers, and more data, there are a plethora of tools available to meet the myriad needs in data analysis and visualization. To help researchers and librarians more easily find a tool that might fit their requirements, we have compared six freely available software applications with the use of a rubric designed specifically to compare their functionality and openness. Rubrics can be helpful in facilitating communication, and providing a common language or set of criteria off of which all reviewers can base their experiences. In the case of a single reviewer, a rubric can help guide and quantify interactions with a visualization software. Ideally, a well-crafted rubric will indicate the top candidates for use, weeding out those that do not fit the selected criteria. For this article, only quantitative analysis tools were reviewed. If other forms of analysis were available, e.g., geographic information system (GIS) maps, those features were not included in the review.

From comparing the six tools, we discovered that free data visualization software applications offer a wide variability in terms of functionality, support, and operational features.

Literature Review

Data visualization is emerging as a new competency area for librarians, particularly those who work in research data management, research impact services, or assessment. The number of data visualization tools that are available is increasing regularly, and it is hard to keep up. For example, in 2016 and 2017 two lists were published that together identify 50 individual tools for data visualization (Suda and Hampton-Smith 2017; Huang 2016). A mechanism to evaluate and identify visualization tools would be useful.

Rubrics are standardized, multidimensional criteria for assessment commonly used in education for student scoring (Edutopia 2008). A meta-analysis of the effectiveness of scoring rubrics for performance assessment found that rubrics improve both intra- and inter-rater reliability (Jonsson and Svingby 2007). Within the library setting, rubrics are used to evaluate student learning of information literacy standards (Wilson and Angel 2017; van Helvoort 2017). Rubrics are also useful for evaluating tools in a standardized way. For example, rubrics have been used to evaluate instructional apps (Ok et al. 2016), thesaurus management tools (Mochon et al. 2017), and assignment marking software (Heinrich 2012). When researching a method to evaluate software, the authors found no articles evaluating visualization tools with a rubric. Usability studies and tracking technologies have been used to assess data visualization tools and techniques to provide feedback to designers (for example: Peng and Liao 2017; Li and North 2003; Ren et al. 2012); studies have evaluated the visualization capabilities of given tools (for example: Sopan et al. 2012); discipline-specific demonstrations of the effectiveness of data visualization techniques have been reported (for example: Cui et al. 2016; Boluri et al. 2016). However, a standard rubric to evaluate and compare general purpose data visualization tools from a user's perspective was not found in the literature.

This paper addresses this gap by introducing a rubric intended for librarians to evaluate and identify appropriate data visualization tools.

Methods

To create a tool to evaluate data visualization software in a standard way, the authors first

developed a scoring rubric, and then used that rubric to review selected data visualization tools. In an effort to ensure the rubric remains robust and flexible, the authors are open to the continued refinement, evolution, and derivatives of the rubric, especially as technology and needs continue to change.

Rubric

The authors developed a rubric, the Visualization Software Evaluation Rubric, using criteria that would help us decide whether a tool was responsive and flexible enough to meet our needs. It was also important to locate options that had a low barrier to entry and provided meaningful, dynamic visualizations, largely to help librarians locate a tool that would be straightforward to add to an instruction portfolio. To help guide the development of the rubric, the authors located two tools that provided the foundation for the rubric generated for visualizations: Ferdon and Poast's Educational Software Evaluation Instrument (2010), and iRubric's Education Software Evaluation Rubric (n.d.). These two rubrics provided a solid starting point for discussion, which helped foster a shared understanding rubric use and application.

Categories were created by discussing features the authors believed were important in visualization tool analysis, including how much data a tool could process, length of time required to orient to the tool, or previous knowledge requirements. Thirteen criteria were developed to evaluate tools holistically, including operational characteristics (processing power, login requirements, file types requirements, costs for full version, and data harvesting) and functional characteristics (ability to manipulate, support materials, ease of use, learning curve, reliance on previous knowledge, built-in analytics, output, and aesthetics). Scoring for each criterion ranges from 0 to 3, with 0 being Poor and 3 being Excellent. Examples of qualifications for each score are included on the rubric to facilitate consistency among raters.

The rubric has a bias toward open tools, scoring criteria such as free and open access to tools higher than costly access to full versions and login requirements. Further, criteria scored higher where they present fewer functional barriers to use (i.e., accepting a wide range of file formats). Therefore, a tool that may offer stunning visualizations but is counterintuitive to learn may receive a lower score than a tool that has a simple interface, but impeccable support and is intuitive to learn.

The Visualization Software Evaluation Rubric is available in Appendix A and online.

Review

To help facilitate a similar approach to each tool, the authors located a moderately sized, tidy, openly posted dataset. The dataset used to test each visualization was the data underlying the article by Piwowar, Day and Fridsma (2007), "Sharing detailed research data is associated with increased citation rate."

To select the tools to review with the rubric, we filtered lists of data visualization tools for those that had low or no barriers to use, meaning little to no coding, funding, or other restrictions impeded access to the tools. Of 50 unique tools identified by Suda and Hampton (2016), and Smith and Huang (2017), we chose those that offered a free version, had no knowledge

JeSLIB 2018; 7(1): e1122
doi:10.7191/jeslib.2018.1122

prerequisites in terms of coding or statistics, and were not tailored to one type of data or output, i.e., GIS (See Appendix B). Furthermore, we only evaluated the free version of each tool. While four of the six tools—Plot.ly, Tableau, datawrapper, Data Hero—offer greater functionality for a paid version, the focus of our work was on free tools, those that would be highly accessible to researchers and librarians exploring visualization techniques, and broadly approachable to students at all campuses, regardless of funding ability.

Authors each rated three of six tools using the rubric that was developed. The aim of the exercise was to foster communication around each tool, and develop a method to discuss important aspects in a critical and guided manner, rather than following initial instinct or first impressions. The authors did not seek to achieve inter-rater reliability, although a discussion of each of the rubric's categories prior to analyzing each tool helped ensure that both authors had a shared understanding of how to approach rubric use.

Results

Each tool was reviewed using the Visualization Software Evaluation Rubric. Of the six tools reviewed, one scored less than 15 out of a possible 39 points; three scored between 15 and 20 points, and two scored between 25 and 30 points. The maximum score was 28; the minimum score was 14; the average score was 19.5. Table 1 maps the individual scores for each software tool to the criteria, and applies a colored schema to quickly demonstrate areas where tools are successful and areas where tools are less successful, with green representing the highest score of three, and red representing the lowest score of zero.

Some trends became evident when comparing visualization software scores side-by-side; Table 1 exposes those trends, which are discussed further in the conclusion.

Table 1: Heat map of scores for each visualization application, listed from highest to lowest total score.

	rawGraphs	**Tableau Public**	**plot.ly**	**Data Hero**	**Datawrapper**	**visualizeFree**
Ability to Manipulate	*2*	*3*	*2*	*2*	*2*	*2*
Support Materials	*2*	*3*	*2*	*2*	*1*	*1*
Ease of Use	*2*	*0*	*2*	*3*	*3*	*1*
Learning Curve	*2*	*1*	*2*	*2*	*3*	*1*
Reliance on Previous Knowledge	*3*	*2*	*3*	*2*	*3*	*1*
Processing Power	*1*	*2*	*1*	*0*	*0*	*0*
Login Requirements	*3*	*2*	*2*	*0*	*0*	*0*
File Type Requirements	*2*	*2*	*0*	*1*	*0*	*0*
Cost for "Full" Version	*3*	*3*	*0*	*0*	*0*	*3*
Built-In Analytics	*1*	*3*	*2*	*1*	*0*	*1*
Output	*2*	*1*	*1*	*1*	*1*	*1*
Data Harvesting	*3*	*0*	*0*	*1*	*0*	*2*
Aesthetics	*2*	*3*	*2*	*1*	*2*	*1*
Total score	**28**	**25**	**19**	**16**	**15**	**14**

JeSLIB 2018; 7(1): e1122
doi:10.7191/jeslib.2018.1122

Tool Comparison

A detailed explanation of each tool's score is below. Tools are listed in numerical order, from highest to lowest ranking. For each tool, we provide a brief profile, the overall rubric score for the tool, the rubric itself, and an explanation of each criterion score. Appendix C contains the visualization output for each software reviewed.

rawGraphs

Profile: Developed in 2013 by DensityDesign Lab (http://www.densitydesign.org) at the Politecnico di Milano (Polytechnic University of Milan) and Calibro (http://calib.ro) in Milan, Italy, RawGraphs (http://rawgraphs.io) is an open source web tool that provides a solution to visualizing data in spreadsheet format. DensityDesign Lab focuses on researching visualizations, and visualizing ideas.

Rubric Score: 28/39

Table 2: Rubric scores for RawGraphs.

	Poor	Fair	Good	Excellent
Ability to Manipulate			*2*	
Support Materials			*2*	
Ease of Use			*2*	
Learning Curve			*2*	
Reliance on Previous Knowledge				*3*
Processing Power		*1*		
Login Requirements				*3*
File Type Requirements			*2*	
Cost for "Full" Version				*3*
Built-in Analytics		*1*		
Output			*2*	
Data Harvesting				*3*
Aesthetics			*2*	

Explanation of scoring

Ability to manipulate: 2 points
A flexible tool, RawGraphs provides control over size, colors, and offers multiple types of visualizations.

Support materials: 2 points
A great deal of supporting documentation is available to support users when they run into problems, but no clear guidance for the estimated turnaround time for any question. However,

a page covering frequently asked questions, tutorials, and access to a Google group are available for all users.

Ease of use: 2 points
RawGraphs is well labeled, but occasionally when a browser window was made smaller—for example, to compare your graph side-by-side with another document—the display became messy or jumbled. Drag-and-drop manipulation helps users understand how they are building their visualization.

Learning curve: 2 points
An interface that clearly explains what information goes where means that RawGraphs is straightforward to pick up and use. RawGraphs also seems to determine if a row contains numbers, strings, or dates. This helps users understand how they might visualize data by making available those visualizations that do not 'fit' the data type.

Reliance on previous knowledge: 3 points
RawGraphs requires no previous knowledge to begin creating and manipulating data, and offers an intuitive interface.

Processing power: 1 point
As a browser-based tool that stores data locally, RawGraphs purports to support as much data as your browser can handle. This does not provide the user with much information. Very large files may crash your operating system.

Login requirements: 3 points
No login is required for RawGraphs—users can immediately upload their data and begin visualizing.

File type requirements: 2 points
Support for several file formats, including TSV, CSV, DSV, JSON, XLS, and XLSX files, spreadsheets with multiple sheets, and the ability to copy and paste, affords users a good deal of flexibility when working with RawGraphs.

Cost for "full" version: 3 points
RawGraphs is entirely free.

Built-in analytics: 1 point
Very little analysis is offered to support visualizations. RawGraphs offers box plots.

Output: 2 points
RawGraphs offers unlimited exports—users do not need to sign in, save, or otherwise provide RawGraphs with any information. Further, it supports downloads in SVG, PNG, and JSON, and offers an embeddable SVG code for websites.

Data harvesting: 3 points
RawGraphs does not require a login, and all data are saved locally, meaning no user data is stored or harvested by RawGraphs.

Aesthetics: 2 points
With several styles available, ability to customize colors, RawGraphs can display beautiful visualizations easily. What is lacking in the interface is the ability to modify the font, though some of the issues (e.g., with font overlap) are mitigated by adjusting the size of the visualization.

Tableau Public

Profile: Tableau Public is just one of the products offered by Tableau Software, Inc., an established, multinational company whose mission is to "help people see and understand their data." Tableau Public is specifically intended for people to create and share visualizations online—with social networking features and a public gallery—so sharing visualizations is easy and community-driven. It is used by journalists, bloggers, students, hobbyists, and anyone interested in exploring data. Tableau Public provides 10GB of space to users at no cost, but all data workbooks and visualizations created with Tableau Public are publicly accessible.

Rubric Score: 25/39

Table 3: Rubric scores for Tableau Public.

	Poor	Fair	Good	Excellent
Ability to Manipulate				*3*
Support Materials				*3*
Ease of Use	*0*			
Learning Curve		*1*		
Reliance on Previous Knowledge			*2*	
Processing Power			*2*	
Login Requirements			*2*	
File Type Requirements			*2*	
Cost for "Full" Version				*3*
Built-in Analytics				*3*
Output		*1*		
Data Harvesting	*0*			
Aesthetics				*3*

Explanation of score:

Ability to Manipulate: 3 points
Users have an incredible amount of control over all aspects of the data and are able to modify formatting on all elements of the visualization, from field typing to chart typing, coloring, labelling, analytics, layout, creation of dashboards, and more.

Support Materials: 3 points
Tableau Public encourages learning and makes troubleshooting easy. They have video

tutorials, live trainings, a forum, FAQs, written documentation, and community resources.

Ease of use: 0 points
Small font sizes and menu icons makes Tableau initially difficult to read and navigate. Some time needs to be spent learning the interface before getting into data.

Learning Curve: 1 point
Basic graphs are fairly easy to create, but advanced work will take time to learn. Tableau has extensive documentation to support learning.

Reliance on Previous Knowledge: 2 points
You do not need to have previous coding or statistical knowledge to use Tableau Public, although experience with Excel or other visualization platforms would enable users to learn the system quickly and take advantage of advanced features and functions.

Processing Power: 2 points
Tableau Public's limit on file size is 15,000,000 rows per workbook.

Login Requirements: 2 points
Tableau Public functions with a downloadable desktop application; there is no need to login to create visualizations, but a user has to login to an account to save and post the visualization.

File Type Requirements: 2 points
Tableau Public accepts may data formats, including Google Sheets, Excel, TXT, CSV, JSON, OData, statistical data, spatial data, and web connectors.

Costs for Full Version: 3 points
Tableau public is free to use for all features, keeping in mind that all visualizations are public. Other versions of the software (Tableau Personal or Tableau Professional) have moderate per month pricing schedules.

Built-in Analytics: 3 points
Users can perform a wide range of analytical functions within Tableau Public, without having to import functions or preprocess data.

Output: 1 point
There are not many output options for Tableau Public. Users save to tableau public, which can be shared on social network or embedded into websites, then can download the visualization as a PDF or data (TXT) or image (PNG) files or the workbook itself.

Data Harvesting: 0 points
All data submitted to Tableau Public becomes public; Tableau does not claim ownership over data, but by using the services users are granting a non-exclusive license in all copyrights to the service. Users can delete data from their account/profile. Tableau collects personally identifiable information (PII) upon registration and does not sell, rent, or share PII with certain exceptions, and both Tableau and their affiliates will use cookies to collect usage information.

JeSLIB 2018; 7(1): e1122
doi:10.7191/jeslib.2018.1122

Aesthetics: 3 points
The flexibility over formatting means that users can create designs according to their own aesthetic preferences, although the default design settings are clean and visually appealing.

Plot.ly

Profile: Plot.ly[1] is a visualization tool developed by a company of the same name, headquartered in Montreal, Canada. Offered as a free (with limited features) or a subscription-based (full features) tool, plot.ly advertises itself as a tool for businesses and data science, though it is useful for any user interested in visualizing their work. Plot.ly is accessed via their website, https://plot.ly. Users are able to generate plots without logging in or creating an account.

Rubric Score: 19/39

Table 4: Rubric scores for Plot.ly.

	Poor	Fair	Good	Excellent
Ability to Manipulate			*2*	
Support Materials			*2*	
Ease of Use			*2*	
Learning Curve			*2*	
Reliance on Previous Knowledge				*3*
Processing Power		*1*		
Login Requirements			*2*	
File Type Requirements	*0*			
Cost for "Full" Version	*0*			
Built-in Analytics			*2*	
Output		*1*		
Data Harvesting	*0*			
Aesthetics			*2*	

Explanation of scoring:

Ability to manipulate: 2 points
Plot.ly offers a good deal of manipulation in graphics and with variables. Certain methods of customizing or manipulating a visualization, for example by changing colors for a data point, are only fully available in the “Pro” version.

Support materials: 2 points
Plot.ly has a wide array of support documentation available. On their “Support” page, users

1 The tool reviewed here is the web-based tool, not the R package of the same name.

can find tutorials with screenshots; however, this page was not easily located when in the dashboard itself. In fact, users must navigate to the main landing page prior to login to locate the full suite of support materials. A small text link at the bottom of the dashboard under "Resources" for "Community Support" only provides a link to the community site—similar to a forum—where users post questions or discoveries. So although this tool has a wide array of support available, the lack of exposure for this support makes it a less-than-ideal solution.

Ease of use: 2 points
Although Plot.ly is a fairly easy tool to use, it does not offer guidance when data is not uploaded correctly. There are many facets by which to customize your visualization, and many different ways to visualize data, which can make it a little more challenging to orient to the space.

Learning curve: 2 points
The multitude of options meant it took some time—20 to 30 minutes to orient to the tool, upload the data, and create the appropriate graph.

Reliance on previous knowledge: 3 points
An intuitive tool, Plot.ly requires little previous knowledge to develop a data visualization. Some understanding of statistics is required for the more advanced analysis features, however.

Processing power: 1 point
For the free version, users can upload files up to 50MB. This was not made clear in any documentation; this information is instead available in a forum post.

Login requirements: 2 points
Most features are available without a login, so users are able to upload and manipulate data without going through the process of setting up another login. However, if users wish to save or download the visualization they have created, account creation is required. Other features, like saving multiple visualizations privately, are unlocked with the "Pro" version. Note that users can only save one visualization privately with the free version.

File type requirements: 0 points
Plot.ly only accepts CSV or XLS files. No alerts were provided if the incorrect file format was uploaded; however, no data is displayed when uploading an incorrect file format. Further, Plot.ly only allows free users to connect to seven data sources, limiting use for users with a great degree of data sets to visualize. This number increases to 11 data sources for those upgrading to the "personal" plan, and up to 18 for the "student" plan.

Cost for "full" version: 0 points
Full "personal" version is either $33/month or $396/year. While not outrageous, this is often out of the realm of comfort for individuals who do not have access to funding to support the purchase of individual new tools (e.g., librarians, researchers without access to a large grant, graduate students). A student version is also available for $5/month or $59/year.

Built-in analytics: 2 points
Several analysis methods are available, including T-tests, ANOVA, and averaging. While the program works to ensure appropriate data type entry, e.g., guidance that a "moving average"

requires an x and y plot, Plot.ly provides no other statistical guidance. This is not unexpected, since Plot.ly does not advertise itself as an analysis tool.

Output: 1 point
Export is available in one file type—PNG. Users are required to sign up for an account, and must first save their work, in order to export files. More file types, including PDF, SBG, and EPS, are available in the upgraded version.

Data harvesting: 0 points
In reading the Terms of Service and the Privacy Policy, Plot.ly makes it clear that they work with Third Parties, who they may allow to read and write cookies to your browser, or may otherwise gather information, even if you do not interact with the Third-Party service.

Aesthetics: 2 points
Plot.ly is visually stunning and offers several options for customizing your visualization. Some aesthetic choices, like font choice or color customization, are limited to only "pro" users.

Data Hero

Profile: Data Hero is a cloud-based data visualization platform and self-service business analytics tool headquartered in Las Vegas, NV. Launched in 2012, Data Hero is intended for individual consumers, small companies, and developers. A key feature is the ability to link to multiple, cloud-based data sources such as Google Drive, Box, Survey Monkey, etc. Data Hero will automatically identify data types and make chart suggestions, but its interface makes it easy to explore data as well.

Rubric Score: 16/39

Table 5: Rubric scores for Data Hero.

	Poor	Fair	Good	Excellent
Ability to Manipulate			*2*	
Support Materials			*2*	
Ease of Use				*3*
Learning Curve			*2*	
Reliance on Previous Knowledge			*2*	
Processing Power	*0*			
Login Requirements	*0*			
File Type Requirements		*1*		
Cost for "Full" Version	*0*			
Built-in Analytics		*1*		
Output		*1*		
Data Harvesting		*1*		
Aesthetics		*1*		

Explanation of score:

Ability to manipulate: 2 points
Data Hero enables manipulation of primary chart components such as legends, axis titles and scales, data labels, and chart types. Choices for color palettes and chart types are limited.

Support materials: 2 points
A knowledge base is available that covers most functions, and a help request form is available (Data Hero will ask permission to see your data if requested). There are embedded prompts and explanations throughout a workflow and readily accessible help buttons.

Ease of use: 3 points
The user interface is well-designed. Prompts, cleanly-labelled buttons, and color-coding are easy to interpret and guide the user through data upload and the creation of a visualization. The dashboard function makes it very easy to see the visualizations that are associated with a given dataset(s).

Learning curve: 2 points
Data Hero is fairly intuitive, as intended. However, it does take some exploring to create a chart that may not be obvious from the data uploaded.

Reliance on previous knowledge: 2 points
One does not need much experience using other analysis or charting tools to make visualizations in Data Hero. Although some familiarity working with different data types might make learning the system a bit faster.

Processing power: 0 points
Free users of Data Hero are limited to file sizes of 2MB, although there are no limits on the number of files uploaded.

Login requirements: 0 points
Login is required to access data hero functions and accounts.

File type requirements: 1 point
Data Hero is designed to accommodate rectangular data files: Excel, Open Office, CSV, and tab-separated files only.

Cost for "full" version: 0 points
Enterprise accounts, which allow for the highest level of customization and sharing, are $500/ month. Intermediate accounts are $99/month for premium or $250/month for teams.

Built-in analytics: 1 point
Data Hero supports basic mathematical operations: sum, average, maximum value, minimum value.

Output: 1 point
Data Hero allows export of created charts as image files only (PNG). There is an option to make visualizations publicly available as well.

JeSLIB 2018; 7(1): e1122
doi:10.7191/jeslib.2018.1122

Data harvesting: 1 points
Data Hero does not claim ownership over any content uploaded. It does collect personal information for account set up and payment information; data may be shared with third parties that provide Data Hero services, but are not rented or sold to others. Data Hero does not have visibility into user account information, and it uses cookies to collect usage information.

Aesthetics: 1 points
The overall aesthetic of Data Hero is clean, and it offers a variety of chart types, but with a limited number of color palettes and no control over font.

Datawrapper

Profile: Datawrapper (www.datawrapper.de) is a web-based charting platform headquartered in Berlin, designed for and used primarily by journalists. Launched in 2012, Datawrapper has been developed to create quick data visualizations that are embed-ready for publication. In 2016, Datawrapper incorporated features to make it a mobile-first platform to accommodate growing smartphone readership of news media. With a minimalistic interface and intuitive, step-by-step processes, Datawrapper is easy to learn and use. Pricing is based on usage, but Datawrapper offers a free version of their platform, which provides basic graphing capabilities for a single user and 10K chart views. Additional packages can accommodate professional teams, unlimited chart views, and customizable branding.

Rubric Score: 15/39

Table 6: Rubric scores for Datawrapper.

	Poor	Fair	Good	Excellent
Ability to Manipulate			*2*	
Support Materials		*1*		
Ease of Use				*3*
Learning Curve				*3*
Reliance on Previous Knowledge				*3*
Processing Power	*0*			
Login Requirements	*0*			
File Type Requirements	*0*			
Cost for "Full" Version	*0*			
Built-in Analytics	*0*			
Output		*1*		
Data Harvesting	*0*			
Aesthetics			*2*	

Explanation of score:

Ability to Manipulate: 2 points
Datawrapper has a standard selection of chart types to choose from (bar, chart, line, pie, donut, area, scatterplot, and tables) and users of the free version are able to make simple modifications. For example, a user can modify field types (text, number, and date); select data fields for axes; make basic selections about sorting and labelling, but with limited control over design (i.e., color palettes). A strength is built-in annotation capabilities to include descriptive and source information.

Support Materials: 1 point
The Datawrapper Academy is a knowledge base that includes written tutorials for basic operations (i.e., uploading data) and working with graph types. Some "learn more" links on the charting interface return a 403 "forbidden on this server" error, which implies that they may be available to paying customers only. There is a contact form available.

Ease of Use: 3 points
Datawrapper is easy to use and navigate, as designed.

Learning Curve: 3 points
The interface is clean and minimalistic, very easy to read and see; there are helpful prompts and explanatory popups on options that makes the interface easy to learn.

Reliance on Previous Knowledge: 3 points
There is no need for any prior knowledge coding or statistical language.

Processing Power: 0 points
File-size limitations are not indicated; the free version would not accept a CSV file of 1MB.

Login requirements: 0 points
Users have to sign up/login to access even the free version.

File type requirement: 0 points
By design, Datawrapper will only accept CSV or Excel files. Users of the free version can also paste in columnar data from Excel. Although these formats are widely used, this may be limiting for some.

Costs for "full" version: 0 points
This product is priced in Euros, which will automatically increase the burden for North American and other users. Costs for the full versions range from $22 dollars per month for personal subscription to $570/month for enterprise accounts.

Built-in Analytics: 0 points
There are no built-in analytic functions with this product. Users have the option to include JavaScript or Excel functions when creating a new column, but need to have those functions articulated in advance.

Output: 1 point
The only output option with the free version is an embed code for inclusion on a website or content management system. Paid output options include PDF or image file.

Data Harvesting: 0 points
Datawrapper uses cookies and will collect and store personal information (email, payment information) on its site, although it does not sell or make personal information available to third parties. Content uploaded to Datawrapper is stored on their site, and they reserve the right to use created charts in their public gallery, but they do not assume ownership of any data uploaded or created by users. Users of free accounts do not have an option to delete charts or uploaded data, but can delete their accounts; it is not clear what happens to data when an account is deleted.

Aesthetics: 2 points
The default designs are minimalistic, but clean and modern looking, an advantage given the limited ability to modify design in the free version.

visualizeFree

Profile: visualizeFree, from InetSoft Technology Corp, is a visualization tool hosted in the cloud. visualizeFree professes to provide intuitive data exploration, discovery, and visualization, but for this article, only the visualization aspects of the tool were investigated. The tool made this simple to do, as visualization and exploration are divided into two different segments.

Rubric Score: 14/39

Table 7: Rubric scores for visualizeFree.

	Poor	Fair	Good	Excellent
Ability to Manipulate			*2*	
Support Materials		*1*		
Ease of Use		*1*		
Learning Curve		*1*		
Reliance on Previous Knowledge		*1*		
Processing Power	*0*			
Login Requirements	*0*			
File Type Requirements	*0*			
Cost for "Full" Version				*3*
Built-in Analytics		*1*		
Output		*1*		
Data Harvesting			*2*	
Aesthetics		*1*		

Explanation of score:

Ability to manipulate: 2 points
While the interface provides some challenges to manipulation, once a user understands how to interact with visualizeFree, there are a handful of options available. Users are able to modify input, text, color, and more.

Support materials: 1 point
Support materials are available, although they are challenging to locate. A moderated forum is available, although users need to sign in before being able to view the forum—so users interested in exploring what other users face when working with visualizeFree before signing up are unable to do so.

Ease of use: 1 point
The counter-intuitive interface makes visualizeFree a complex tool to work with. Unnecessary components, like creating a dashboard each time, were not adequately explained or encouraged, meaning it took a good deal of time to orient to the tool. visualizeFree also requires Flash to be installed, which is blocked by many current browsers.

Learning curve: 2 points
visualizeFree was a frustrating tool to work with—there are several steps a user must perform to get to a visualization, including first creating a dashboard, understanding how to load data into the interface, and recognizing which component from the drop-down menu will achieve the desired results. The extra features—while important for interactive visualizations—made for a tool that was not straightforward to interact with or learn from.

Reliance on previous knowledge: 1 point
Again, visualizeFree required a good deal of time to understand how to use the tool. If users are comfortable with an interface that requires an understanding of creating relationships in an online tool, then this may not be such a challenge.

Processing power: 0 points
Users are able to upload a file under 5MB.

Login requirements: 0 points
All features of visualizeFree are available only after login. It was initially challenging to find where the login button was located, and continued to be counter-intuitive after repeat visits.

File type requirements: 1 point
Users can upload either Excel files (XLS or XLSX), or files formatted as CSV or TDV.

Cost for "full" version: 3 points
visualizeFree is a fully free tool—no other versions are available.

Built-in analytics: 1 point
A handful of analytical operations are available to help support a visualization, though they are challenging to locate.

Output: 1 point
While visualizeFree is aimed at offering flexible, web-based visualizations, the strange interface hinders the tool's ability to provide high resolution, re-usable graphics for use outside of the intern et Export to Excel, Powerpoint, and PDF is supported.

Data harvesting: 2 points
visualizeFree does use cookies.

Aesthetics: 1 point
Some styling is available in visualizeFree, including a handful of chart types, colors, and fonts to select, but users are limited in the display of their outputs. Visualizations seem plain, however it must be noted that the features used to develop the interactive visualizations were not explored.

Conclusion

As an evaluation tool, the Visualization Software Evaluation Rubric promoted consistency in assessing and scoring 13 product characteristics that are considered important to librarians and researchers interested in data visualization tools, such as "processing power," "cost," and "ability to manipulate data." The rubric criteria cover both operational and functional characteristics, but are biased by design toward open tools and tools that present low barriers to use, as these attributes are critical for researchers and professionals with limited resources. The Rubric also provided an excellent method for generating a shared understanding of product characteristics and communicating findings between collaborators. Because both authors are geographically distant from one another, the rubric allowed for confidence in rater analysis, without needing to see the exact construction or output of each visualization tool, thereby creating efficiency in rating a number of different tools.

While the rubric proved beneficial for evaluating the six data visualization tools in this paper, this exercise revealed areas where refinement could improve its usefulness. For example, the criteria "ease-of-use" and "learning curve" have significant overlap and could be conflated; and for free tools, "ability-to-manipulate" may be out of scope for an assessment, as fully free and open resources may not have the breadth of resources backing them as for-profit tools or tools with extensive monetary support. These observations do not detract from the overall usefulness of the Visualization Software Evaluation Rubric, but future iterations should take these challenges into consideration. Further, future implementers of the rubric may seek to test inter-rater reliability.

Using a single data set with the goal of creating visualizations for the same data points in the different tools was helpful for exploring basic functionalities and data handling capabilities across tools, as well as for evaluating the quality of the visualized outputs. Consistent data helped the authors to focus on specific tasks while scoring each tool; the visualization outputs demonstrated quirks of each tool that may not have emerged in the assessment process, such as embedded branding or default cutoffs, as well as the visual impact of analysis and formatting choices. For future visualization software analyses, it would be beneficial to use the same data set to establish similarities between visualization software across analysis types. However, both authors noted the challenges of analyzing someone else's data, especially for a purpose that is quite unrelated to the data creator's intention.

The scores for the tools themselves fell in a range between 14—28 points. In general, those tools that reviewed poorly tended to score low on both operational and functional characteristics, for instance by requiring login to create or access visualizations, limiting file sizes and file types impacting overall processing power, and having challenging interfaces, which increases the learning curve for the tool. These limitations might make a difference for someone who needed to visualize a large and complex data set in a short timeframe. Tools that reviewed well, tended to score high across operational and functional criteria, specifically in making it easy to manipulate data, implementing a user friendly interface and processing capabilities, and eliminating login requirements to create or access visualizations. These tools also did well in offering support materials and aesthetics. A potential user could feel comfortable in turning to high-scoring tools to create visualizations with few barriers. Most tools did well in not requiring previous knowledge to access and use, and no tools stood out for output or export of the visualization, which may mean that for this rubric, these criteria should be revisited.

Based on this evaluation, visualizeFree (14 points) is the least favorable visualization tool reviewed, earning low scores for both operational and functional characteristics. The scores suggest that there is not much value gained for concessions in processing power and file type support, despite being one of the best cost options. The three tools that fell in the midrange in this analysis (Datawrapper, 15 points; Data Hero, 16 points; and plot.ly, 19 points) collectively scored low on operational characteristics, but tended to perform better on functional characteristics. Given that each of these tools are developed by small companies, this may speak to a balance between offering features and the organizational capacity to support them. RawGraphs (28 points) and Tableau Public (25 points) emerge as the most favorable tools to use both in terms of operational characteristics and functional characteristics. Tableau is developed by an established software firm and RawGraphs has a strong open source community behind it. Both tools scored well in operational and functional criteria, particularly for ability to manipulate, login requirements, file type requirements, costs, and aesthetics. Each of these facets is important in an open tool that is easy to manipulate and access. However, both RawGraphs and Tableau Public scored lower than some of their counterparts on the learning curve, and Tableau Public scored the lowest of ease of use. Perhaps the time investment one would make in using Tableau Public is balanced by its other strong features. Tableau Public offers a great deal of power when visualizing data, and scored among the highest in available support materials.

This work did not take into consideration tools that support qualitative analysis or GIS. However, as these are also valuable additions to any librarian's toolkit, freely available qualitative tools with a low threshold for entry should also be explored.

Finally, the Visualization Software Evaluation Rubric is the first rubric of its type—a rubric specifically designed to assess data visualization tools, with a bias towards openly available and well-documented tools. As data visualization continues to grow and advance, we imagine that there will continue to be a need for consistent methods to evaluate visualization tools. Through this exercise, we found that the rubric in its current version has potential, but there is also much room for improvement, and we welcome the involvement of the community and other stakeholders in advancing the rubric.

Supplemental Content

Appendices A, B & C
An online supplement to this article can be found at http://dx.doi.org/10.7191/jeslib.2018.1122 under “Additional Files”.

Acknowledgement

The authors would like to acknowledge the foundation for this article was participation in the Data Science and Visualization Institute for Librarians. Both authors attended DSVIL in 2017, and without this introduction, would not have had the shared experience necessary to pursue writing an article.

Disclosure

The authors report no conflict of interest.

References

Anders, Jonsson and Gunilla Svingby. 2007. “The use of scoring rubrics: Reliability, validity, and educational consequences.” *Educational Research Review* 2(2): 130-144. http://dx.doi.org/10.1016/j.edurev.2007.05.002

Bolouri, Hamid, Lue Ping Zhao, and Eric C. Holland. 2016. “Big Data Visualization Identifies the Multidimensional Molecular Landscape of Human Gliomas.” *Proceedings of the National Academy of Sciences of the United States of America* 113(19). http://dx.doi.org/10.1073/pnas.1601591113

Cui, Zhiyong, Shen Zhang, Kristian C. Henrickson, and Yinhai Wang. 2016. “New progress of DRIVE Net: E-Science Transportation Platform for Data Sharing, Visualization, Modeling, and Analysis.” In *IEEE Second International Smart Cities Conference: Improving the Citizens Quality of Life, Trento, Italy.* https://doi.org/10.1109/ISC2.2016.7580736

Edutopia. 2008. “How Do Rubrics Help?” *George Lucas Educational Foundation*. Published July 15. https://www.edutopia.org/assessment-guide-rubrics

Fearson, Susan and Steven Poast. 2012. “Educational Software Evaluation Instrument” *EDTECH 554: Managing Technology Integration in Schools* Session Six: Software Evaluation: Rubric. Last Revised March 28. http://edtech2.boisestate.edu/ferdons/554/554.html

Heinrich, Eva, and John Milne. 2012. “Applying a Framework to Evaluate Assignment Marking Software: A Case Study on Lightwork.” *Research in Learning Technology* 20(2): 16152. http://dx.doi.org/10.3402/rlt.v20i0.16152

Helvoort, Jos van, Saskia Brand-Gruwel, Frank Huysmans, and Ellen Sjoer. 2017. “Reliability and Validity Test of a Scoring Rubric for Information Literacy.” *Journal of Documentation* 73(2): 305-316. http://dx.doi.org/10.1108/JD-05-2016-0066

Huang, Roger. 2016. “31 Free Data Visualization Tools.” *Springbard Blog*. Published July 21. https://www.springboard.com/blog/31-free-data-visualization-tools

iRubric, user tmoyes. n.d. “Education Software Evaluation Rubric.” *RCampus*. http://www.rcampus.com/rubricshowc.cfm?code=L33864&sp=yes

Li, Qing, and C. North. 2003. “Empirical Comparison of Dynamic Query Sliders and Brushing Histograms.” In *IEEE Symposium on Information Visualization 2003, Seattle, WA.* http://dx.doi.org/10.1109/INFVIS.2003.1249020

Mochón, Gonzalo, Eva M. Méndez, and Gema Bueno de la Fuente. 2017. "27 Pawns Ready for Action: A Multi-Indicator Methodology and Evaluation of Thesaurus Management Tools from a LOD Perspective." *Library Hi Tech* 35(1): 99-119. http://dx.doi.org/10.1108/LHT-11-2016-0123

Ok, Min Wook, Min Kyung Kim, Eun Young Kang, and Brian R. Bryant. 2016. "How to Find Good Apps." *Intervention in School and Clinic* 51(4): 244-252. http://dx.doi.org/10.1177/1053451215589179

Peng, Chiu-Fang, and Wen-Hung Liao. 2017. "Evaluation of Interactive Data Visualization Tools Based on Gaze and Mouse Tracking." In *2016 IEEE International Symposium on Multimedia, San Jose, CA.* https://doi.org/10.1109/ISM.2016.0099

Piwowar, Heather A., Roger S. Day, and Douglas B. Fridsma. 2007. "Sharing detailed research data is Associated with Increased Citation Rate." *PLoS ONE* 2(3): e308. http://dx.doi.org/10.1371/journal.pone.0000308

Piwowar, Heather A., Roger S. Day, and Douglas B. Fridsma. 2007. "Data from: Sharing detailed research data is associated with increased citation rate." *Dryad Digital Repository*. http://dx.doi.org/10.5061/dryad.j2c4g

Ren, Jiansi, Jiantao Lu, Lizhe Wang and Dan Chen. 2012. "Data Visualization in Bioinformatics." Advances in Information Sciences & Service Sciences 4(22): 157. http://dx.doi.org/10.4156/AISS.vol4.issue22.20

Sopan, Awalin, Angela Song-Ie Noh, Sohit Karol, Paul Rosenfeld, Ginnah Lee and Ben Shneiderman. 2012. "Community Health Map: A Geospatial and Multivariate Data Visualization Tool for Public Health Datasets." *Government Information Quarterly* 29 (2): 223-234. http://dx.doi.org/10.1016/j.giq.2011.10.002

Suda, Brian and Sam Hampton-Smith. 2017. "The 38 Best Tools for Data Visualization." *Creative Bloq*. http://www.creativebloq.com/design-tools/data-visualization-712402

Wilson, Gloria and Katelyn Angell. 2017. "Mapping the Association of College and Research Libraries information literacy framework and nursing professional standards onto an assessment rubric." *Journal of the Medical Library Association* 105(2): 150-154. http://dx.doi.org/10.5195/jmla.2017.39