Interactive Visualization Toolkits for Rich Internet Publications

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ABSTRACT
This study suggests the features of visualization toolkits which make it applicable for the development of interactive visualizations for the benefit of Rich Internet Publications (RIP). Features are identified by literature study and insights of the researchers. The features are categorized in five dimensions: Visual, RIP compatible, Interactive, Scientific, Ease of Development. Dimensions and features are included in a model in the form of a checklist. The checklist is applied on four existing toolkits: Tableau Public, Fusionchart Personal, Google Chart and Pivotviewer. The first two toolkits are qualified as very applicable for the development of this kind of interactive visualizations. The outcome of this comparison is validated by applying Tableau Public in ‘real world’ examples of publications and two running examples.

KEYWORDS: Rich Internet Publication, interactive visualizations, toolkit comparison, statistical data representation.

1. INTRODUCTION
Scientific visualizations in traditional publications are well-established since in most scientific discipline the statistics are presented in a visual manner. However, evolutions in the scientific communication landscape provide new kinds of publications and visualizations. Becker, Cleveland and Wilks (1987) predicted that “Upcoming computing capabilities provide a new medium for the invention of graphical methods for data analysis”. Today, computers are capable of hosting Rich Internet Publications (RIPs). RIPs are enhanced scientific online publications that can be accompanied by large datasets, photos, videos, interactive maps, and animations, which affect the structure and layout of the publication (Breure, Voorbij and Hoogerwerf, 2010). With RIPs scholars are capable of showing interactive visualization instead of the static visualization used in conventional scientific publications.

Interactive visualizations for the benefit of RIPs can be created by programming code, but a limited amount of scholars have programming skills. Another method to create these visualizations is by using a toolkit. The most well-known toolkit for making traditional static visualizations of statistics is IBM’s SPSS. Since version 10.0 this platform also supports the creation of interactive visualizations. But this doesn’t imply that these visualizations are suitable for the benefit of RIPs. Although RIP is still a concept, the scientific community is building on this concept to mature it.
The goal of this study is to identify the features toolkits should have, to create interactive visualization for the benefit of RIPs. Therefore our main research question is formulated as follows:

*Which features make a visualization toolkit applicable for the development of interactive visualizations for the benefit of Rich Internet Publications?*

To conduct thorough research with our available resources, we only study toolkits capable of creating visualizations of statistics (i.e. numeric) data. This excludes toolkits which are specialized in other domains, e.g. geographical and medical visualizations.

The authority on traditional data visualization is William S. Cleveland, he wrote about 119 books and papers and is well cited. Edward Tufte wrote the book ‘the visual display of quantitative data’ (Tufte, 1983) his main idea is to display as much data as possible but leave the graphs clean, i.e. don’t add unnecessary visuals this will distract the viewer. Both have conducted very relevant fundamental research on the topic of data visualization, but as their research is already a few decennia old, not all their conclusions about traditional visualizations are applicable to interactive visualizations to be used in RIPs. New research should be done on visualizations to be used in RIPs.

In the study results we will suggest a model in the form of a checklist. This checklist will help authors of RIPs in the quest of finding a toolkit to create a visualization for their scholarly work. They can easily compare features of a toolkit with this checklist, like we did in the validation part of this study. Toolkit developers can benefit from our work as they can implement the suggested features. Using this setup, this study has a practical as well as scientific contribution.

We will validate the compiled checklist by applying it to four existing toolkits. We will qualify each toolkit and validate the outcome by analyzing the current use of the toolkit.

2. **PROBLEM STATEMENT**

Often statistical data consist of data sets with samples measured on more than two variables. Such data is called high dimensional or multivariate data, and the number of variables is denoted with $p$. Because $p$ is generally greater than two, the traditional two-dimensional plots created by traditional statistical packages, do not adequately convey all the information contained in such data sets (Arns, Cook and Cruz-Neira, 1999). In traditional journal publication, by print, the more dimensions are included in a graph the more indistinctive it gets. Because digital web publishing allows interactivity with graphs, which will slice datasets, this is no longer a restriction (see Table 1).

<table>
<thead>
<tr>
<th>Visualizations in traditional publications</th>
<th>Interactive visualizations for use in RIP</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Static</td>
<td>- Interactive (dynamic)</td>
</tr>
<tr>
<td>- Only relevant data for research conclusion is published</td>
<td>- Whole data set available</td>
</tr>
<tr>
<td>- Two dimensional</td>
<td>- Reuse of data</td>
</tr>
<tr>
<td></td>
<td>- multi-dimensional</td>
</tr>
</tbody>
</table>
The definition of a toolkit given by Schroeder, Martin and Lorenzen (1996) is formulated as follows: “A toolkit is a set of tools designed to be used together for a particular purpose”. Toolkits can be very useful for the creation of visualizations they will reduce the amount of effort invested to create the final product. But the research field of RIP is rather young, and therefore there is no literature available about what kind of features a toolkit should have for creating visualizations for the benefit of RIPs. Such references are available however for traditional visualization tools, as described by Morse, Lewis and Olsen (2000). We introduce a checklist to qualify a toolkit to create visualizations for the benefit of RIPs.

3. RESEARCH DESIGN

This research paper follows a descriptive design to shape the findings for the research question. Our research is driven by our main research question. To visualize our research method, we use a process deliverable diagram (PDD) introduced by Weerd and Brinkkemper (2008), shown in Figure 1. A PDD has a left- and right-hand side. The left-hand side is the process view, based on a UML activity diagram and contains the actions of the method. The right-hand side is the deliverable view, based on a UML class diagram and contains the deliverables of the method. For our research, the left-hand side contains the actions carried out during our research and is connected to the deliverables created by those actions, on the right-hand side. Each deliverable is represented by a chapter in this paper.

We started our research by finding literature on (interactive) visualizations in the statistical domain and RIPs in general. The requirements we found from the literature for publishing a RIP, are used as a basis to make a list of features toolkits should have. We finalized the list of features by taking into account literature from a diversity of research areas that we thought are adding value to our feature list. After the creation of the feature list, we organized the features by putting them into categories, which we call dimensions. The complete list of function areas containing several features is derived into a checklist for evaluating toolkits.

The next step is to use the computed checklist and to validate it by evaluating existing toolkits. The checklist is only suitable for toolkits that compute interactive visualization and which can be exported for online use. Therefore we will select only toolkits to evaluate that satisfy these requirements. To have the biggest contribution to our research topic, we used toolkits that have growth potential, so readers can benefit from our findings.

The results section of our paper presents the findings of the evaluation of the four toolkits “Tableau Public” (www.tableausoftware.com/public), FusionCharts Personal (http://www.fusioncharts.com), “Google Chart toolkit” (http://code.google.com/intl/nl-NL/apis/charttools/) and “Pivotviewer” (www.microsoft.com/silverlight/pivotviewer/), where we explain the evaluated scores in more detail. After presenting the result of the evaluation, we analyze the outcome in the validation part of
the paper. Here we go more into depth of the founded checklist and work towards a conclusion. Our conclusion is given using this validation at the end of the paper.

The choice for the four toolkits is done on the different features and the potential the toolkits have. When searching the web for potential toolkits to use for our research, we saw a lot of toolkits and packages claiming to be a toolkit. Most of those toolkits and packages were just visualization libraries which can be downloaded and edited. Extensive code programming experience are required to make the visualizations. This is not the aim of our research, therefore we evaluated toolkits that make use of a graphical user interface to choose a visualization and fill in the data for the visualization. Although a graphical user interface is used in all of the evaluated toolkits, some little programming knowledge is still necessary to make some minor changes to the visualization and for putting the visualization into the RIP. The degree of programming knowledge needed, depends on the toolkit one uses and is incorporated into the checklist.

Figure 1: Process Deliverable Diagram of the research method
4. RESULTS

We have identified five dimensions, each of these covers a specific aspect of a toolkit. The following paragraphs elaborate this.

4.1 Visual dimension

Because we are studying the visualization of data, the first dimension we identified embraces the visual aspect of the toolkit. By data visualization we mean: the set of techniques used to turn a set of data into a clear perception of contained information. “It aims to give the data a meaningful representation by exploiting the powerful discerning capabilities of the human eye.” (Fisher, 1999).

We qualify a toolkit on the visual dimension by evaluating the following aspects:

- **Comprehensiveness**: Amount and variety of graphics to choose from e.g. bar-charts, motion-charts, histograms and scatter-plots.
- **Configuration**: The ability to configure the visualization by changing the design, layout and format.
- **Quality**: Tufte’s principles are also relevant for interactive visualizations, they should present eye pleasing and clean visuals with as much data as possible.

4.2 RIP compatibility dimension

Enhanced visualizations are a key feature according to Breure et al. (2010). This second dimension is obvious when developing interactive visualizations for the benefit of RIPs; the visualization has to be compatible with the RIP. Although a widely adopted feature list for RIPs does not exist, there are some features which are inevitable:

- **Browser independency**: some scientists work on restricted workstations and don’t have permissions to alternate their system settings. To be able to share knowledge with the whole scientific community, platform in-dependency is key. This feature implies that the visualizations created by the toolkit should be compatible on all common operating system and browser combinations and preferably without plug-ins.

- **Device independency**: Mobile devices, tablets and netbooks are generating significant traffic which makes it in-ignorable when developing for the web (Verkooij, 2010). The toolkit should be able to create visualizations that are compatible with these new devices. This will enable scientist to be mobile and will eliminate the restriction of location to access information.

- **Sustainable repository**: To ensure high availability of the valuable scientific data, the toolkit should host the visualization on a sustainable platform. Current evolutions which embrace sustainability are e.g. cloud-based and distributed platforms.

- **Interoperability**: To allow scientific community create semantic links between scientific resources, the visualizations should be built on an open platform to ensure interoperability with common infrastructures. It is advised to use a platform with an open format, on open source software and using standard ways of
documentation (Horik and Roorda, 2010). An Application Programming Interface (API) will enable interoperability.

Web publishing; RIP’s are based on web-based publishing, therefore toolkits should have the ability to publish the developed visualizations by the same means to the web and also make it easy to reference. A well adopted method of referring is to make an embeddable iFrame code widget and to create permanent links to the source.

4.3 Interactive dimension
Breure et al. (2010) introduced a new publication genre, which they call RIP. RIPs are enriched internet publications which include information integration, visualizations and exploration (i.e. non-linear reading). But as they stated: “RIPs do not constitute a sharply delimited category, but are part of a broad spectrum, which starts with regular enhanced publications closely resembling their printed counterparts, and ends with high-quality multimedia presentations having more in common with Web applications than with the conventional journal article” (Breure et al., 2010, page 1). They have distinguished two subcategories of RIP: RIP type I and RIP type II. RIP type I consists of tools to access and analyze data, and RIP type II encourages exploratory and non-linear reading. RIP type I and II should not only be used for presentation of data but should also enable the exploration of data by interactive actions. This leads to the third dimension, the interactive dimension. Shneiderman (1996) suggested a list of seven information actions that a user wishes to perform:

*History;* Keep a history of actions to support undo, replay and progressive refinement.

*Zoom;* Zoom in on items of interest.

*Details-on-demand;* Select an item or group and get details when needed.

*Filter;* Filter out uninteresting items.

*Overview;* Gain an overview of the entire collection.

*Relate;* View relationships among items.

*Extract;* Allow extraction of sub-collections and of the query parameters.

The use of conventions is very important when giving users the ability to execute these actions. The usability learning curve of the visualization can be dramatically reduced when using conventions for the interactive controls (Theus, 2002). Therefore we also qualify the intuitiveness of information actions in this dimension.

4.4 Scientific dimension
The scientific dimension embraces the scientific productivity of the visualization which is a requirement when publishing study results, these features will enable visualizations to be accepted as scientific resource.

*Data connection options;* Visualizations are rendered out of (live)data sources. Scholars use many different types of data sources, e.g. SQL databases, SPSS data files and Excel files. The toolkit should be able to connect to these data sources. Connections to live databases are preferred.
Export data; To stimulate further research, scientist should be able to reproduce and reuse the underlying data of the visualization, including Meta-data. A toolkit has to include an option to export this data e.g. export data to a Comma Separated Value (CSV), Extendable Mark-up Language (XML) files.

Annotate data points; Toolkits should allow RIP authors and readers to annotate interesting data points. This will help to enrich the meta-data of the study.

Discussion; Toolkits should allow scientific community to discuss the representation of the visualization. However, not all people will provide valuable scientific feedback, therefore a qualification system of commenter's should be applied (e.g. by integrating the professional social network linkedIN).

Calculate Statistics; Quantitative research requires statistic calculations to test hypothesis. The visualization should present the scientific calculations to help scholars make their conclusions.

Static export options; When research results are discussed offline, a printed version of the visualization is required. There should be a way to export a certain view of the visualization to a static form e.g. export to Portable Document Format (PDF) or image Scalable Vector Graphics (SVG).

4.5 Ease of development
As Breure et al. (2010) states, a set of tools is required to ease the job and to remunerate the extra effort. This dimension will represent the qualification of the invested resources needed to develop an interactive visualization. The comprehensiveness of a toolkit will decide whether a RIP author has to manually develop additional features to publish it in the RIP. This dimension includes the amount of skills and time needed to develop a visualization and the cost of the toolkit itself.

5. VALIDATION
The first step in validating our model, which includes the identified dimensions and related features, is to cross-check it against four existing toolkits. For validation purposes, we explicitly choose four toolkits where two are (at first sight) relatively good, one is medium and one is bad in creating visualizations for the purpose of RIP i.e. if we choose four well applicable toolkits the validation of the model would be limited to the high-end part. The following four toolkits were tested:

1. Tableau Public: is the free version of a commercial product which is fairly popular with over 50 thousand users. Visualizations created by this toolkit are already used by the Wall street journal, fifteen universities and eight science institutes. It also promotes itself as a business intelligence tool.

2. FusionCharts Personal: is the paid version of FusionCharts for non-commercial use. This toolkit produces “flashy” visualizations and is well adopted by multiple companies. On their website they state that this product is applicable for the visual representation of scientific data.

3. The Google Chart toolkit is based on Google’s architecture and is free for use. This API is only able to create interactive visualizations, but this tool is fully integrated with other Google tools to publish, share and integrate visualizations, which makes it a toolkit.
4. Pivotviewer is based on Microsoft Silverlight technology, there is a developer toolkit to develop a custom build Pivotview. There are some live examples on the web where this tool is being applied to display film and magazine catalogues.

We acknowledge that these toolkits are very different in the way of developing visualizations. However, this supports the importance of the ease of development dimension.

Table 2 presents a completed checklist of the dimensions and its features. Each toolkit is evaluated by manually testing to retrieve the required information. There is no hard formula for the grading of dimensions, the grade is determined by analyzing the outcome for that specific dimension. All dimensions are measured on a 5 point scale ranging from 1 to 5. Respectively the following labels are connected to the scale: None, Few, Some, Most, All of the aspects in the dimension are applied in the toolkit.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Feature</th>
<th>Tableau Public</th>
<th>Chart Toolkit</th>
<th>Fusion charts Personal</th>
<th>Pivotviewer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual</td>
<td>Amount of graphs/categories</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Configureable</td>
<td>18</td>
<td>19</td>
<td>45/9</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Quality</td>
<td>Fully</td>
<td>Fully</td>
<td>Fully</td>
<td>Limited</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>RIP compatible</td>
<td>Browser in-dependency</td>
<td>Javascript</td>
<td>Javascript</td>
<td>Flash 6</td>
<td>Silverlight</td>
</tr>
<tr>
<td></td>
<td>Device in-dependency</td>
<td>Javascript</td>
<td>Javascript</td>
<td>Flash 6</td>
<td>Silverlight</td>
</tr>
<tr>
<td></td>
<td>Sustainable repository</td>
<td>Tableau server</td>
<td>Google cloud</td>
<td>Local file</td>
<td>Local file/MS Azure</td>
</tr>
<tr>
<td></td>
<td>Interoperable</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Web publishing</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Interactive</td>
<td>Supported information</td>
<td>Most</td>
<td>Most</td>
<td>Most</td>
<td>Most</td>
</tr>
<tr>
<td></td>
<td>action</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Scientific</td>
<td>Data connection options</td>
<td>Access, Excel, text</td>
<td>Google data source</td>
<td>Databases, CSV, XML</td>
<td>Special XML</td>
</tr>
<tr>
<td></td>
<td>Export of data</td>
<td>CSVT</td>
<td>CSV</td>
<td>CSV</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Annotate data points</td>
<td>Author only</td>
<td>Author only</td>
<td>Author only</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Discussion</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Calculate statistics</td>
<td>Some</td>
<td>Some</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Static export options</td>
<td>PDF, img</td>
<td>Print website</td>
<td>PDF, img</td>
<td>Print website</td>
</tr>
<tr>
<td>Ease of development</td>
<td>Skills needed</td>
<td>Basic</td>
<td>Programming</td>
<td>Programming</td>
<td>Programming</td>
</tr>
<tr>
<td></td>
<td>Time needed</td>
<td>Little</td>
<td>Substantial</td>
<td>Substantial</td>
<td>Substantial</td>
</tr>
<tr>
<td></td>
<td>Cost of product</td>
<td>Public is free</td>
<td>Free</td>
<td>200 USD</td>
<td>Moderate</td>
</tr>
<tr>
<td>Overall rating</td>
<td>4.2</td>
<td>4.2</td>
<td>3.6</td>
<td>2.2</td>
<td></td>
</tr>
</tbody>
</table>

General remarks:
- Pivotviewer is based on Microsoft Silverlight, Microsoft will stop supporting Silverlight in favour of HTML5. The qualification of the RIP compatibility dimension is low, because it lack’s a sustainable repository.
- Data in Tableau Public cannot be saved locally, visualizations will always be publicly available on the web. With Tableau Desktop it is possible to save locally, but this product cost 999,- USD.
The overall rating of the toolkit is calculating by taking the mean of the dimension scores. Presented in Table 2 is the outcome of our evaluation of the four different toolkits. Tableau and Google Chart have the same overall rating and share the first place with 4.2 points. Fusion Chart is second with an overall rating of 3.6, followed by Pivotviewer with 2.2 points. The scores of the individual toolkits on the different dimensions is visualized in a spider chart depicted in Figure 2. The chart is designed to compare the toolkits. The surface between the points of each toolkit is the overall rating; the more surface it has, the higher the overall rating. The intercepts with the dimensions indicate the score for the amount of features implemented in the toolkit for that dimension. The spider chart indicates on each dimension which toolkit has implemented the most features of that particular dimension.

![Spider Chart](image)

**Figure 2: Comparison of four toolkits on five dimensions.**

The second step of validating our model is by comparing our evaluation outcome of the four toolkits to ‘real world’ examples. We analyzed how our evaluation reflects the usage of the toolkits in ‘real world’ publications. According to our evaluation Tableau and Google Chart should be the best choice for creating interactive visualizations.

In our search for publications of Tableau, we found that it is indeed widely used. For instance the Wall Street Journal (e.g. [http://blogs.wsj.com/venturecapital/2009/08/25/how-long-does-it-take-to-build-a-technology-empire/](http://blogs.wsj.com/venturecapital/2009/08/25/how-long-does-it-take-to-build-a-technology-empire/)) and Seattle Times (e.g. [http://seattletimes.nwsource.com/flatpages/businesstechnology/workerscompensationclaims.html](http://seattletimes.nwsource.com/flatpages/businesstechnology/workerscompensationclaims.html)) use Tableau for their online visualizations.

Although these publications in this journal and online newspapers are not exactly the same as RIPS, they have similar characteristics; both publish information in an enhanced online form to inform the visitors and both also utilize interactive visualizations to explain the information that is presented. Therefore we
can conclude from this analysis that Tableau is proven to be a good choice for making interactive visualizations and thus our evaluation about Tableau is sound.

In our search for ‘real world’ examples of Google Chart, we didn’t find any good examples. One reason for this can be the fact that the Google Chart toolkit is only available since February 11th of 2010 and also requires programming skills to produce the visualization. These two factors can influence the fact that Google Chart is not that popular (yet). Although we could not find Google Chart examples in the ‘real world’, we still think Google Chart toolkit has potential as we will later show in step three of our validation.

A third and last step in the validation of our checklist is conducted by creating visualizations with the top two toolkits from our evaluation (i.e. Tableau and Google Chart). In this last step we put the features we collected by analyzing the toolkits into practice.

<table>
<thead>
<tr>
<th>Month</th>
<th>Android</th>
<th>Blackberry</th>
<th>iPhone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>2</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Feb</td>
<td>3</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Mar</td>
<td>4</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Apr</td>
<td>4</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>May</td>
<td>5</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Jun</td>
<td>6</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Jul</td>
<td>6</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Aug</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Sep</td>
<td>8</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Oct</td>
<td>7</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Nov</td>
<td>15</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Dec</td>
<td>17</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>

The last step of our validation requires creating an interactive visualization of the data set shown in Table 3. To check whether our assumptions of the ease of development dimension are correct, we will only have one hour to make the visualizations as complete as possible.
The first toolkit we used is Tableau. Tableau has a desktop client user interface that can be downloaded. We choose to develop an interactive bar-chart to represent our test data set. As is shown in our running example accessible at http://www.timdeboer.eu/DIC.

The second toolkit, Google Chart, is web-based. To produce the chart, we had to navigate through Google’s Code Playground. As mentioned earlier, extensive programming knowledge is needed to create charts with Google Charts. We classify our programming knowledge as medium (i.e. we have some programming experience). A lot of additional features could be added, but in the limited timespan we used, this was not doable. The result is presented on http://www.timdeboer.eu/DIC.

As presented in our two test visualizations, there is some difference between them. Both have interaction with the user, but in the Tableau version the amount of interaction and exploration is much higher. Also the amount of features available in the Tableau chart are much more (e.g. downloadable data set, annotation, clickable dimensions). This is all due to the comprehensiveness of the Tableau application which has by default a lot of features integrated (i.e. ease of development). Google Charts is lacking in this area because it requires extra code (from the library) to add more features to the visualization. This practical experience with the two packages is the same as our (theoretical) expectations by means of our results from the checklist, therefore we conclude that our checklist offers a practical contribution.

6. CONCLUSION

Our main research question in this study is:

Which features make a visualization toolkit applicable for the development of interactive visualizations for the benefit of Rich Internet Publications?

Based on the literature study and own insights we identified seventeen features, categorized in 5 dimensions: Visual, RIP compatible, Interactive, Scientific and Ease of development. It can be concluded based on the ‘real world’ examples that our model is representing actual features which make toolkits applicable for the development of interactive visualizations for the benefit of RIP. The model can be used to help RIP authors search for a suitable toolkit and supports toolkit developers to get insight in the desired features for the benefit of RIP.

As presented in Table 2 and Figure 2, Tableau and Google Chart toolkit are the most suitable toolkit for the purpose of creating this kind of visualizations, with a high overall rating of 4.2 out of 5. The Google Chart toolkit is one point behind Tableau on the ease of development dimension, because it requires more technical skills. The Google Chart toolkit has one point in advance on the RIP compatibility dimension because it is hosted on an open platform. Therefore we would advise more technical scholars with programming skills to use the Google charts toolkit and less technical scholars to use Tableau.

The visual dimension, when accumulated, is the most mature. This can be explained by the fact that the traditional static visualizations are studied very thoroughly over the years as stated by Friendly and Denis (2001), which give the visualizations a sound scientific foundation. This study shows that the RIP evolution is not stemmed by lack of tool for visualization and shows that there is competition in this domain to support the future advances.
LIMITATIONS AND DISCUSSION

Our model can be extended by studying all possible options for each feature and assign them to a score. Then a formula to calculate the rating for each dimension can be created. By this way the resulting qualification is more rational.

The future of RIP is not yet set and the features within the RIP compatibility dimension are therefore determined based on our own insights. This dimension should be adjusted when the RIP evolution would change dramatically.

Further research could be conducted on which type of toolkit is optimal per research discipline. A couple of the dimensions will have more weight is such a study.

REFERENCES


