

Dicrev-Dash: Proposal for the Design, Creation and Evaluation of a Dashboard for Data Visualization

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Abstract

Today there are large amounts of data that are difficult to understand in spreadsheets or textual reports, so data visualizations have become an easy and fast way to convey the ideas or objectives that you want to achieve with that data. The objective of this article is to propose a methodology for creating dashboard data visualizations, taking into account the fundamental steps in the creation of a data methodology. To this end, the following question has been posed: What are the phases that must be considered to create an efficient and effective data visualization? This question will be answered in this article with the elaboration of the proposed methodology. Having said all the above, it is proposed to follow and prove this methodology in the future to create a dashboard of data visualizations for the learning analytics observatory.

Keywords

Dashboard, visualization, creation, design, evaluation, proposal, methodology.

1. Introduction

Data is the new oil, and in its natural form without proper treatment it is pretty useless. To provide value, data must be processed, analyzed, and evoke action based on what it can reveal [1]. However, today, there is a phenomenon called “information overload”, which is directly related to the increase in data that needs to be processed [2]. This problem could be addressed through dashboards that are intuitive and easy to understand. A dashboard is a set of data visualizations that visually present the most important information necessary to achieve one or more objectives [3]. The advantage of dashboards is that they bring together multiple data sources in a single interface. Which means that you can visualize valuable data quickly and thus reduce the amount of time spent making decisions.

Unfortunately, the development of visualization dashboards requires hard work to define metrics, understand indicators and express them graphically in order to tell a story by providing not only information but knowledge. Additionally, a good visualization dashboard must consider human perception, bring information to life and ensure action. Another problem in developing a visualization dashboard is the lack of agreement on how it should look and what it should do.

In this regard, and based on a review of the literature on methodologies, methodological proposals and best practice guides on the construction of visualization dashboards from 2009 to 2021, information was found that tries to guide users in the process of building a dashboard. Some methodologies focus

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more on making clear the objectives of the dashboard construction, always taking into consideration the goal to be achieved, while others emphasize the importance of considering the audience and their respective needs.

However, to the best of our knowledge, based on the literature review, it has been observed that there is no methodological proposal for the design and implementation of visualizations that encompasses the entire process involved in the construction of a dashboard. That is, starting from the conception of the idea, continuing with the design and implementation and ending with the evaluation, going through an integral process oriented to any type of user, whether they have experience or not.

In this article we present a methodological proposal called Dicrev-Dash, for the design, creation and evaluation of data visualization dashboards oriented to users (developers and non-developers) who wish to develop a dashboard. The methodological proposal has the following phases (see Figure 1): 1) Analyze and identify audience requirements, 2) Establish the dashboard objective, 3) Data preprocessing, 4) Dashboard structure, 5) Dashboard design, 6) Dashboard implementation and 7) Dashboard evaluation.

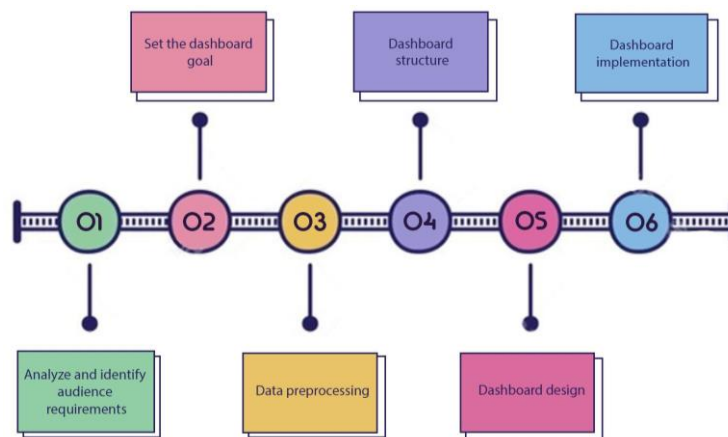


Figure 1: Phases of Dicrev-Dash.

The article has the following structure: section II presents the related work about the multiple methodologies, methodological proposals and “facto” guides for the creation of dashboard visualizations, section III presents the phases of the methodological proposal called Dicrev-Dash and finally in section IV the conclusions are presented.

2. Related work

This section presents the related work of methodologies, methodological proposals and “facto” guides that have been used to develop data visualizations and visualization dashboards.

A methodological proposal proposes steps or phases that are not yet proven, i.e., it does not yet become a methodology as such. Several methodological proposals have been put forward by authors [4, 6, 7, 8, 11, 13, 14, 15].

A “facto” guide is a set of steps based on good practices, it works in many cases, but not in all. Authors [5, 9, 10, 12, 16, 17] have published several guides; many of them are the compilation of good practices when creating a dashboard of visualizations.

The company Juice [4] presents a guide that addresses key concepts and provides practical advice for creating a dashboard. It is oriented to people who want to create a dashboard and consists of 3 parts:

1) Foundation, 2) Structure, 3) Information design. The main disadvantage of this proposal is that it does not provide guidance on the implementation and evaluation phase of the dashboard.

Stephen R. Midway [5] proposes some principles in order to respond to the problem that many visualizations present information incorrectly. This guide has some concepts that are more technical than others, but in general, anyone can apply these principles: 1) Diagram, 2) Appropriate software, 3) Use effective geometry and show data, 4) Colors, 5) Include uncertainty, 6) Panel, 7) Data and models, 8) Simple images, 9) Infographics, 10) Opinion. The most obvious disadvantage in this guide is that it consists only of design criteria for how the dashboard should look.

The methodological proposal of Suryatiningsih, B. Hariyanto and A. Ardiyanti [6] aims to develop an operational dashboard and consists of the following phases: 1) Requirement's identification, 2) Planning, 3) Prototype design, 4) Prototype review, 5) Implementation process, 6) System testing. One of the drawbacks of this proposal is that the last two phases do not provide further details on how to carry them out.

VRops is a methodological approach to create dashboards proposed by M. Jusko [7] in which design and usability techniques related to the end user are addressed to the general public. It has the following steps: 1) Defining the objective, 2) Planning the workflow, 3) Knowing the data, 4) Choosing widgets, 5) Planning interactions, 6) Test-driving, 7) Refining and maintenance. The most obvious disadvantage in this proposal is the evaluation phase, as it does not provide information on how to approach this phase.

Generalitat de Catalunya [8] presents a 3-phase guide with the objective of representing complex information in a graphical and efficient way in a dashboard, mainly addressed to the departments that make up the Generalitat, but also to the general public. The 3 phases that make up this guide are: 1) Strategy, 2) Data, 3) Design. The disadvantage of this proposal is the number of phases, since phase 3 only addresses the issue of the audience, definition of objectives and data preprocessing.

Andy Cotgreave [9], Technical Evangelist at Tableau, proposes 6 practices in order to create dashboards. It is aimed at the general public and these practices are: 1) Knowing the data, 2) Combining data, 3) Choosing metrics, 4) Visualizations, 5) Using the data, 6) Sharing. This guide is only a compilation of best practices for dashboard creation, but it does not show the detailed process to obtain a dashboard and how to evaluate it.

Isaac Sacolick [10] provides some practical standards when creating data visualizations, the objective is to know the design strategies for the creation of data visualizations. Therefore, the author proposes the following standards: 1) Prepare the data, 2) Identify the audience, 3) Establish types of graphics, 4) Drive the narrative with visual elements, 5) Iterate on the data and designs. The disadvantage of this "facto" proposal is that like the previous author they are good practices to keep in mind when creating a dashboard.

Cole Nussbaumer [11] in her book entitled *Storytelling with data*, provides a practical guide to telling a story through data. It is aimed at the general public, these key lessons are as follows: 1) Understand the context, 2) Choose a visual display, 3) Eliminate clutter, 4) Focus attention, 5) Think like a designer, 6) Tell a story. The only obvious disadvantage in this approach is that it doesn't have a dashboard implementation and evaluation phase.

S. Evergreen and C. Metzner [12] propose a guide consisting of design principles for developing a dashboard of visualizations, focused on a general audience. They consider aspects such as: simplifying visualizations, presenting visualizations together with the associated text. In addition, they recommend not to overload the screens with too much text. It provides advice on the effective use of color. It is considered that this proposal has the weakness of not considering the audience and the absence of an evaluation phase of the dashboard.

M. Kintz [13] presents a methodological proposal with the objective of designing a process-oriented dashboard to help users focus more on business processes and real objectives. This proposal is focused

3. Phases of the methodological proposal for the design, creation and evaluation of data visualization dashboards

The following section deals with the elaboration of a methodological proposal for the design, creation and evaluation of data visualization dashboards oriented to users (developers and non-developers) who wish to create a dashboard. The phases that make up this methodological proposal are presented below.

3.1. Analyze and identify audience requirements

The objective of this phase is to take into account the knowledge of the audience in terms of experience, expectations, skills about the end users of the resulting dashboard. Then, some key questions are established to identify the type of audience and their needs.

1. Who is the consumer of the dashboard? Consider the types of audience a dashboard can target.
2. What information do they need? It is very important to consider the main function of the dashboard and what the audience can do from it, as all audiences are concerned about the same issue, but the information needs are different depending on their perspective.
3. Do they have prior knowledge about data visualizations? It is important to know the audience's level of familiarity with data visualizations, for example, if the audience is news, it would be advisable to include traditional graphics that are easy to understand.
4. What are your expectations? Viewer expectations have a high level of relevance because it depends on how viewers will be able to take action or make decisions from the visualizations.

3.2. Set the dashboard target

In this phase, the purpose to be achieved with the dashboard is established. In general, there are three types of dashboards, each one oriented to different audiences and objectives. Each type of dashboard is detailed below [17].

1. Operational: used to monitor processes or data in real time. Compared to other types of dashboards, this one is updated more frequently, sometimes even on a minute-by-minute basis, and contains much more detailed information.
2. Strategic: used to monitor the status of KPIs and is updated less frequently than the operational dashboard. They are used to make projections of the future. The level of complexity of this type of dashboard is high.
3. Analytical: used to analyze large volumes of data to identify trends or predict results. They are of great help when setting targets based on historical data. The level of complexity of this type of dashboard is normal.

In case the objective and type of dashboard is not clear, the following information may be helpful to identify the scope, purpose and type of dashboard [4].

1. Scope of the dashboard: refers to the level of granularity that the dashboard can have.
 - a. General: displays all necessary information.
 - b. Specific: focuses on a specific function, sector, process, etc.
2. Time: refers to the data that will be displayed on the dashboard as a function of time.
 - a. Historical: displays old data to identify possible trends.
 - b. Real-time: displays data as they occur.
3. Level of data detail: refers to the data to be considered for the dashboard development.
 - a. Low: only the most important data are presented without going into much detail.

- b. High: allows you to drill down into much more detailed data to obtain more information.

3.3. Data preprocessing

When processing the data, you can start by performing an exploratory analysis of the data and obtain certain descriptive statistics, since the important thing at this level is to understand the data.

3.3.1 Identification and understanding of variables

In this phase it is important to know the data, to understand them so that the ideas that are going to be captured in graphs make sense. It is also necessary to understand the variables, for which you can make use of measures such as: mean, standard deviation, minimum and maximum value that can take, and identify values that may be outside a range.

3.3.2 Data cleansing

In this phase you could start by eliminating the variables that are redundant, i.e., they are not very useful for the visualization. Then, identify the columns that have too many null values in order not to take them into account at the time of visualization, for which a minimum threshold can be established depending on the situation, for example: consider that the columns with more than 40% do not have null values. At this level the threshold can be increased or decreased.

3.3.3 Eliminate outliers

At this stage, the values identified in the first stage can be eliminated and values that may negatively affect later on can be forgotten. After performing these steps, a correlation analysis between variables can be performed in order to obtain the relationship between the variables to be used in the visualizations. Scatter plots, histograms or boxplots can also be used to understand the relationships and distributions of the data.

3.3.4 Integration of data from other sources

Then there is a phase of data integration with other sources, where there are several approaches depending on the scale and purpose of the visualizations. For this, Excel can be used as an integration tool as it is very feasible to combine simple and small data. Similarly, data can be combined using SQL techniques. One of the best-known ways to integrate data is ETL, having as steps: data extraction, data transformation and data loading.

3.4. Dashboard structure

In this phase, the structure of the dashboard is diagrammed, which will implicitly tell the audience the sequence they should follow throughout the dashboard. A low-fidelity wireframe should be created, that is, a sketch with a low level of detail in black and white, giving importance to the structure of the dashboard but not its appearance.

3.4.1. Dashboard skeleton

It consists of drawing a kind of imaginary grid on the dashboard, with the objective of placing the different graphics on these grids. Grids help to achieve an effective alignment, since it is necessary to organize a large amount of information in a fluid way.

It is recommended to draw a grid to create the dashboard, then place the graphics in each of those spaces. When all the graphics are in place, then start resizing those sections and when finished remove the grid.

1. Top left corner: several studies indicate that people tend to scan a page starting from the top left corner, so due attention should be given to this area on the dashboard.
2. Center: this is also an area of utmost importance, so you should place one of the most relevant graphics that the dashboard will contain to attract the attention of the audience at first glance.

3.4.2. Choosing the right graphics according to the objective

It is important to start by defining that a dashboard can be designed in several ways, so there is no one way that can be considered right or wrong, it will always be correlated with the requirements you have and the objectives you want to achieve.

In order to choose the right charts, the purpose and type of dashboard must be taken into account. Having said all this, some recommendations can be given when choosing certain graphics depending on the situation:

1. View relationships: scatter chart, bubble chart or network chart are recommended, which are mainly used for correlation and distribution analysis.
2. Making comparisons: it is recommended to use column and line charts, for example: bar chart, line chart, pie chart, circular area chart, where the X-axis represents the time variables, line charts should not show more than 5 values and bar charts, not more than 7 values.
3. Viewing parts of a whole: pie charts are useful for demonstrating the proportional composition of a variable over a static time period, and distinguish certain cases [18], including: pie chart, stacked column chart, donut chart.
4. Show the distribution of the data: this type of graphs helps to show how the variables are distributed over time, thus identifying outliers, the normal trend and the range of information in their values. Among the graphs that can be used are: scatter charts, histograms, bell curves, etc.

3.5. Dashboard design

Based on a black and white wireframe, the following points should be taken into consideration:

3.5.1. Visual properties

A visual property is one that is processed in spatial memory without conscious action. These properties can be exploited to facilitate the audience's understanding of the dashboard and prevent them from consciously processing all presented data [19]. In the following, we define one of the most important properties to consider:

- Color: is one of the most important and essential tools in a dashboard. With its correct use, the dashboard will be more understandable, clear and direct, while its misuse leads to confuse the audience of the message you want to convey. It is recommended to use color in a moderate way, starting with a gray dashboard, and gradually adding color in those parts where you want to highlight a graphic or information. The most basic way of using color is to work the dashboard with the same tone and make variations in its saturation and brightness to achieve lighter and darker tones.

3.6. Dashboard implementation

This phase has been divided into two perspectives, one oriented to non-programmers, i.e., people who do not know how to write code, and the other directed to those who have programming concepts. In Table 2 and 3 below, multiple tools are detailed with a brief description. It should be mentioned that the tools presented in both tables were chosen based on the most known and used tools in the data visualization environment.

Table 2

Tools oriented to non-programmers

Tool	Description
Tableau	It has multiple graphics. Extensive documentation. Provides tools that help the effective use of color.
Power BI	Compatible with multiple sources and databases. Drag and drop functionality.
Grafana	It has multiple graphics. Extensive documentation.

Table 3

Tools oriented to programmers

Tool	Description
Chart.js	Wide variety of graphics. Interactive, animated and responsive graphics.
D3.js	JavaScript library. Wide variety of graphics. Easy customization.
Google Charts	Graphics embedded in a web page. Easy and customizable. Requires some JavaScript knowledge.

3.7. Dashboard evaluation

In this last phase, the aim is to evaluate the dashboard, therefore, the focus of this evaluation must go hand in hand with the objective of the dashboard, the impact and motivation of the audience and finally the usability of the dashboard must be taken into account. This phase will depend entirely on the focus and objective of the dashboard, therefore, the criteria to be taken into account vary in most cases.

Two approaches can be taken for the evaluation, one in a general way evaluating the usability of the dashboard and the second approach evaluating each one of the visualizations that make up the dashboard.

3.7.1. General approach

To evaluate the usability of the dashboard, it is recommended to use questionnaires already tested and evaluated by experts, such as: System Usability Scale (SUS) [20], Post Study System Usability Questionnaire (PSSUQ) [21], Questionnaire for User Interaction Satisfaction (QUIS) [22], etc.

Based on the aforementioned questionnaires, a survey should be created in any tool, the most commonly used being Google Forms.

3.7.2. Specific approach

Another point to keep in mind is that each of the visualizations that make up the dashboard can be evaluated individually, for which the following criteria are recommended:

1. Usefulness: Is the information presented in the visualization relevant to the audience?
2. Appropriateness: Is the visualization appropriate for the information presented?
3. Support: Does the visualization have extra useful information?
4. Comprehension: Did the audience understand the objective or message of the visualization?

4. Conclusions

In this research, the works related to data visualization dashboards between 2009 and 2021 have been presented. As it could be observed, most of the works focus more on making clear the objectives pursued by the construction of the dashboard, while others give more importance to the aspect that a dashboard should have.

From this literature review, it has been determined that there is no methodological proposal for the design and implementation of visualizations that encompasses all the stages that are considered important in the construction of a data visualization dashboard.

The Dicrev-Dash methodological proposal presents 7 phases that seek to guide users (developers and non-developers) in the process of building a dashboard of visualizations. For this, the phase of analyzing and identifying audience requirements talks about the importance of knowing the experience and requirements of the audience, in the phase of establishing the objective of the dashboard the different types of dashboards that exist are presented, in the phase of data preprocessing the exploratory analysis of the data is emphasized, the dashboard structure phase deals with how the information will be distributed, the design phase focuses on basic design principles, the implementation phase provides some tools to create a dashboard and finally the evaluation phase indicates certain criteria to be taken into account to evaluate the final dashboard.

As a future work, it is expected to test and validate this methodological proposal through the construction of a learning analytics observatory with the objective of verifying the effectiveness of the methodological proposal described in this work.

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