



UNIVERSITY OF LEEDS

This is a repository copy of *Transparent Dashboards: Open data practices for promoting competition-as-motivation in business dashboards*.

White Rose Research Online URL for this paper:

<https://eprints.whiterose.ac.uk/219438/>

Version: Accepted Version

Proceedings Paper:

Hadiprawoto, T.R. and Ridley, A.L. orcid.org/0000-0002-2676-7125 (2023) *Transparent Dashboards: Open data practices for promoting competition-as-motivation in business dashboards*. In: *Proceedings of the 2023 IEEE 16th Pacific Visualization Symposium (PacificVis)*. 2023 IEEE 16th Pacific Visualization Symposium (PacificVis), 18-21 Apr 2023, Seoul, Korea. Institute of Electrical and Electronics Engineers (IEEE) , pp. 142-146. ISBN 979-8-3503-2124-1

<https://doi.org/10.1109/pacificvis56936.2023.00023>

This is an author produced version of a conference paper published in *Proceedings of the 2023 IEEE 16th Pacific Visualization Symposium (PacificVis)*, made available under the terms of the Creative Commons Attribution License (CC BY), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

Reuse

This article is distributed under the terms of the Creative Commons Attribution (CC BY) licence. This licence allows you to distribute, remix, tweak, and build upon the work, even commercially, as long as you credit the authors for the original work. More information and the full terms of the licence here:

<https://creativecommons.org/licenses/>

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.



eprints@whiterose.ac.uk
<https://eprints.whiterose.ac.uk/>

Transparent Dashboards: Open data practices for promoting competition-as-motivation in business dashboards

Triana R. Hadiprawoto*
Universitas Indonesia

Arran L. Ridley†
University of Leeds

ABSTRACT

Dashboards are a common and familiar format of data visualization and are deployed in a number of fields and across domains, such as business, medical and health, learning analytics, and urban analytics, amongst others. In this paper, we conduct interviews with users of business dashboards, in particular, performance dashboards and scorecards, in order to gain an understanding of how they might be used in daily practice. We discuss how dashboards are not only used, as the literature suggests, to gain a quick understanding of the data but are deployed, by making the data available to everyone, as a means of motivating the users through creating a competitive framing of the data. We discuss the implications of this and how our findings can inform and support approaches to dashboard design, implementation, and usage.

Keywords: data visualization, dashboards, motivation

Index Terms: Human-centered computing—Visualization—Visualization theory, concepts and paradigms—;

1 INTRODUCTION

Whilst dashboards are somewhat ubiquitous these days, they could be considered to be under-researched in the data visualization research field [22]. Dashboards are utilised in a number of fields and across domains, such as business [9], medical care [3], learning analytics [6], urban analytics [16], and more. This paper investigates how business dashboards are utilised in the actual setting and context of their usage, and how dashboards might not just be deployed just as a means of viewing and understanding data but as a means to motivate users through competitive means.

The data was collected via semi-structured interviews with 11 business dashboard users who were questioned on their daily activities involving dashboards and what role the dashboard played in these activities. The authors then subjected the data to an iterative thematic analysis, wherein several key themes emerged.

We discuss these key themes that emerged from the data: the openness of the data; the use of the dashboard as a means to generate motivation through competition, and the user characteristics. The findings reveal that rather than restricting access to the data based on user groups the data is made available and visible to all users. This openness contributes to the dashboard being utilised as a means to motivate the users. This can be viewed as an attempt to promote competition, wherein, the public display of sales figures, reinforced with incentives, is intended to increase performance amongst the users of the dashboard. This approach to *competition-as-motivation* has implications across different teams and levels of teams, with some detrimental outcomes. Beyond these key findings, we discuss other themes that emerged including the role of age and job role and experience in the utilisation of competition as a means of driving motivation.

*e-mail: triana.rh@ui.ac.id

†e-mail: arranridley@gmail.com

We also consider the implications these findings have on the designing of dashboards. In particular, we consider how these findings challenge the notion that dashboards are utilised for quick analysis that augments the decision-making process and their use as a means of competition-driven motivation needs to be considered.

2 RESEARCH QUESTIONS

We take on the assumption that a business dashboard is used, first and foremost, to disseminate information and monitor business performance through key performance indicators (KPIs). However, when data on a dashboard is open and available to a wide scope of users, who not only have access to more data but the additional context that drives competition to users. As such, it leads to asking the following questions:

- Do business dashboards do more than just allow the user to monitor data at a glance, and instead, through the practice of open data, utilise competition between users to improve or generate sales?
- What are the implications of this utilisation of competition driven by the openness of the data on dashboard use and the design of dashboards?

3 RELATED WORK

3.1 Dashboards and their purpose

One definition of a dashboard is that it is a visual display of important information to achieve one or a number of objectives, usually arranged on a single screen so the information can be monitored at a glance [10]. Another perspective from Wexler et al., [24] defines it as a “visual display of data used to monitor conditions and/or facilitate understanding”. Sarikaya et al., [22] found, through a survey of literature related to dashboard use, that the term dashboard was used quite broadly to refer to a variety of types of entities, and challenged the prevailing stereotype held by the data visualization community.

Dashboards are often associated with business organisations, wherein we might think of a business dashboard as a visual display of key performance indicators (KPIs) and other important data related to a company’s operations. These dashboards might be designed to provide a high-level overview of a business’s current performance and support individuals in developing an understanding of the environmental situation surrounding their business sphere [18] and enhance overall performance [15]. As with other forms of dashboards, these would typically include a variety of charts, graphs, and other visualizations that make it easy for managers and other stakeholders to quickly understand the state of the business and identify areas that may need attention.

In business literature, dashboards and scorecards are seen as the convergence of two distinct fields: performance management and business intelligence (BI) [8]. Performance management consists of “measuring progress toward achieving key goals and objectives in order to optimize individual, group, or organizational performance” [8] whilst BI combines data gathering, data storage, and knowledge management with analytical tools to present complex internal and competitive information to planners and decision-makers” [19]. Within this context, business dashboards can be defined as “multilayered

performance management systems, built on a business intelligence and data integration infrastructure, that enable organizations to measure, monitor, and manage business activity using both financial and non-financial measures” [8].

3.2 Insights, action-ability, and beyond

The definitions of a dashboard and what it is used for discussed above state the need for a dashboard to be designed to allow for quick data extraction. This reflects some of the approaches and definitions found within data visualization literature. Definitions of data visualization draw upon its ability to amplify cognition [5] or aid in people carrying out tasks more effectively [17].

Beyond this, data visualization can also provoke an emotional or affective response [14, 23], or prompt the audience to take an action, such as donate to a charity. The audience may be more reactive or responsive to data visualization if the subject matter relates to them on a personal level [20].

3.3 Users of Dashboards

For Sarikaya et al., [22] the “visual and functional aspects of a dashboard typically reflect the intended audience, their domain and visualization experience, and their agency relationship with the data”. Knowing what an intended audience wants is therefore important when it comes to the design of a dashboard. User studies are a common means of evaluating and testing the effectiveness of data visualization tools [1]. Whilst in an ideal setting the dashboard would be designed to accurately reflect the needs and requirements of the intended audience, access to end-users is often a difficult and negotiated experience [21], and as such user testing may not include the intended users [13].

For example, where simulated users are detailed (i.e., masters students as stand-ins for real users), Clark [7] found that when the information load was high users were less likely to engage in exploratory activities. He also noted that tactical dashboards (dashboards designed for in-depth analysis) may “lead managers to place less emphasis on exploratory activities and more emphasis on exploitative activities”. When more information is shown to the user, the more likely it is that individuals will select which data they prefer to process making it possible for them to be biased on which data they prefer to focus on rather than undertaking the desired exploration of the data.

As such, end-users of dashboards remain under-researched and more studies detailing how dashboards are used in the context of their real-life use are necessary.

4 METHODOLOGY

The data for this study was collected via semi-structured interviews, of 30 minutes length, with 11 participants (see: Table 1), of whom 7 were female and the other 4 male. The ages of the participants ranged between 30 and 40 years old age. The participants are based in Indonesia and were recruited by social media and snowball sampling, wherein an interviewee would recommend a mutual contact. They were recruited from a variety of industries and positions of seniority. The participants who responded to the interview results were selected where two criteria put in place were met: (1) those who work in sales or marketing areas and (2) use a business dashboard daily. The questions asked were based on their use of a business dashboard and how it influenced both themselves and other employees in daily use.

An example of the questions asked included: (1) Are you familiar with what a business dashboard is? Do you make use of one on a daily basis? (2) Can you describe what the dashboard displays (3) Does the dashboard require you to sign in? What data is available to you and what might be restricted? (4) How is the dashboard being used to evaluate performance? (5) How does that affect your motivation? What do you think is the impact of such actions towards competition?

Participant	Gender	Role	Industry
1	Female	Head of Strategic Planning	Alcoholic Beverage
2	Female	Head of Planning, Reporting, and Finance	Dairy
3	Female	Account Manager	SAAS Startup
4	Female	Head of Sales	Digital Solution Agency
5	Male	Regional Sale Manager B2B	Automotive
6	Male	Regional Channel Manager	Beverage
7	Female	GM Planning - Modern Trade	Beverage
8	Female	Marketing Strategic Analytics Manager	Telecommunications
9	Male	GM Consumer Brand	Engine Car Oil
10	Male	Trade Marketing Manager	Cosmetics
11	Female	Strategic and Planning Manager	Technology

Table 1: Participants in study

A thematic analysis of the interview transcripts was then conducted by both authors, wherein the data was coded in an iterative approach by the authors resulting in the emergence of various themes. The primary themes were related to dashboard usage, such as: user access, data (availability of), workflow, and the participants’ personal or individual characteristics. From these primary themes there emerged sub-themes related to: competition, motivation, transparency, and age and experience. As such the themes: the openness of the data; the dashboard is used as a means of generating competition; and the various levels that the dashboard and its data had influence over; are discussed in the following section.

5 DISCUSSION

5.1 Openness or transparency as a tool for motivation

A central tenet of data visualisation benefits is its capacity to shine an objective light on data [11, 13, 25]. Data visualizations and their inherent characteristics are often associated with truthfulness and objectivity. One way data visualization practitioners do this is through the inclusion of data sources [13]. Data can be made visible, accessible, or open through a linked dataset, or through open data initiatives (see for example the Open Data Institute: <https://theodi.org/>) which invite the audience to interrogate the data.

Depending on the size and scope of a dashboard there can be myriad users and user tasks that the dashboard is required to cater for. When working with designers clients can create user groups and limit access to particular parts of a dashboard based on these user privileges. Clients can indicate a preference for all of the data to be made available to all of the users [21]. Openness when discussed in the context of a dashboard, also draws upon the discussion of truthfulness and objectivity in data visualization literature. Transparency and making the data open to all can be seen as a positive, wherein making all data visible imbues the dashboard with a sense of trust and truthfulness, whilst also giving the potential for users to make decisions and take actions based upon a more complete context.

Various respondents referred to the concept of transparency and the data being visible to many different parties. Examples of this visibility include sales data being displayed on screens at every sales office in the country, sales data being available to other teams across

the organisation, and the sales data is made visible at a monthly town all meeting by the director of the company. This visibility and sharing of data were seen as positive by a majority of those interviewed, believing that this visibility provided a motivating factor for them. Another positive associated with making all data available to all dashboard users fosters a sense of mutual awareness between divisions and regions and about the achievements of each team and individual. Additionally, those who come bottom of the leaderboard for sales might be incentivised to seek advice from others to improve their sales. This perceived sense of failure might also lead to sales teams or individuals conducting internal analysis or evaluation to uncover the reasons behind their position in the sales leaderboard. For one dashboard user, the dashboard is seen less as a means of generating competition and more for generating collaboration cooperation between teams, in the form of high-performing teams supporting the low-performing teams.

This operationalization of sales data to promote internal competition between sales teams could be considered a form of gamification. Gamification is defined as “a process of enhancing services with (motivational) affordances in order to invoke gameful experiences and further behavioral outcomes” [12] and applies to instances where employees are incentivised by the awarding of prizes for finishing top of the leaderboard. Therefore, whilst open data practices, i.e., making the data in the dashboard available to a wider set of users, prove to have benefits in the form of motivating some users to improve their sales figures and seek out other employees for advice and input, it can also have unintended consequences when it is treated as a competition that needs to be won, rather than as dashboards might be designed for - gaining an understanding or an insight into the data.

5.2 Competition as a detrimental practice

Transparency and making data available to users is a conscious decision taken by those in control of the dashboard. A dashboard is designed by those in a position of power within a company i.e. in managerial positions, who therein take decisions on what data is available, who uses it and what role the dashboard plays in the wider context of work undertaken within the company. The decision to make data available, particularly sales data, is seen as having beneficial qualities, such as motivating workers to improve their sales figures. This is done through a mixture of rewards and incentives and a sense of shame or failure that might be felt for having below-par sales figures. Whilst this public display of failure can motivate some, it can also prove to be detrimental to the morale of workers and have unintended consequences for the company.

In one scenario, due to the competition between teams, some of the teams performing worse would attempt to ‘ride on the success’ of the top performers (P4). These teams may be selling different products so the worse-performing would put pressure on the top performers to sell a bundle of products that would include the products under their remit to boost sales. As a result of instances such as those referred to by P4, who self reports as a top performer, stated that there is a reluctance among the top performers to update the actual progress of their work.

The visibility of sales data from other teams might not prove to be motivational but instead, arouse suspicion from other teams. P6 reported that sales teams might be suspicious if other teams from different regions perform better than them. Subsequently, they might suspect that other teams might have received additional marketing support unavailable to them, giving them an unfair advantage. As such, it could promote a poor group dynamic between groups and work counter to the intention of it being motivational.

Dashboards requiring manual input of data can be subverted, i.e., incorrect or misleading data may be input or data is omitted. How data is connected to the dashboard is considered part of a data visualization design process, yet this tends to deal with specifications

of the metrics and the source of and access to data. The veracity and quality of data are highly important in business dashboards as this data can be instrumental in decision making processes. As such, if the data is manipulated due to the pressure faced by users due to their figures being publicly displayed, the results can not only be lower motivation in employees but also there is the possibility of incorrect data being used in decision-making processes.

It was also noted that not all team members are equally motivated by the information provided on the dashboards. For example, older employees, who are considered less tech-savvy, do not feel the pressure of having their performance made visible through the dashboard because they are not active users of it. However, younger employees who are more aware of the technology, buy into the significance of the display of their performance through the dashboard, as it acts as a form of performance review and acts as a means of signifying their quality.

Therefore, competition driven by open data practices, rather than acting as a motivator for performance, can be the catalyst for detrimental practices. These detrimental practices, caused by conflict generated by the gamification of sales figures [4], may have more consequences than merely affecting employee morale and can also impact the company’s business side. An example of this can be found where the employees may withhold data due to negative experiences with the data being readily available and this lack of data may have consequences when it comes to decisions made, with potential financial implications.

5.3 Intra, inter and extra-level motivation

Dashboards can generate competition between individuals or teams within a company and between companies in the same industry. As discussed above the dashboard works to create competition and provide motivation, and conversely, demotivation, between individuals and teams within a company but where there is only one sales team the dashboard instead the dashboard motivates by displaying the data of rival companies.

The data also provides indirect motivation in the instance of the dashboard used by P5, who works for an automotive company. The dashboard here provides sales figures for cars sold by dealerships, differentiated by region. The business dashboard is provided to the sales team in each region but not to the dealer. Hence, it is perceived as a tool to monitor dealer performance and a communication tool to motivate dealers to reach incentives. So, whilst the dealers working in the car showrooms do not engage with the data or the dashboards themselves, they are part of the dynamics of competition - dashboard users motivated by the competition incentivise the dealers which in turn creates better sales figures for the dashboard users.

A sense of competition can also be generated when data dashboards display performance between brands (from other companies) were sales within areas and divisions tend to be stable and internal competition is not apparent. The internal portion of sales can be highly measured and the proportion between regions is clearly defined, hence internal competition is nonexistent.

As such competition-driven motivation can have implications across different levels of a company. The competition driven by these dashboard practices encourages not only competition but also cooperation wherein users are encouraged to seek out help from other departments or seek to incentivise other employees in pursuit of improving their sales figures.

6 IMPLICATIONS FOR DESIGNING DASHBOARDS

Current definitions of dashboards mainly draw upon the requirement for dashboards to provide the means for quick analysis for decision-making. Our data reveals that the data contained in dashboards are not only deployed for decision-making and guiding business decisions but are also utilised as a means of promoting competition

and as a mean of motivating employees. This, therefore, has potential implications on our understanding of the design process for producing a dashboard.

In the design of dashboards, designers first negotiate with the client to build up an understanding of the requirements and potential outcomes of a project. Clients, therefore, have input in this early process outlining what is required of the dashboard. Designers also explore the needs of the end-users through interviews and workshops resulting in documents such as user roadmaps, which outline what the user journey might be in using the dashboard. As such, dashboard design is a mixture of both the overall business and commercial needs of the client as well as the general needs and requirements of the user.

Designers may not have full access to the actual data when designing data visualization products, including dashboards [21], and as such may not have the full context available for how this data may be utilised on the client side. This is particularly relevant in this instance as the sales data is not only used as a means of informing business decisions but also to motivate users through its display. If dashboard sales data is being utilised beyond the expected context of informing users of sales figures and is instead being used as a means of motivation, then this may require the dashboard to be structured or designed differently. There may be conflicting goals for this display of data that do not match what the designers assumed the dashboard would be utilised for.

We may also raise issues of ethics and disclosure in how the dashboards are actually deployed. In particular, we may consider this in relation to how dashboards may be seen purely to display data relevant to making quick business-related decisions, yet they may, in practice, be utilised by management as a means of generating motivation through competition. As such, making data available to all employees may indicate a form of data provenance, i.e., to build trust or as a display of transparency. However, it can also be viewed as a tactic to expose data relating to individuals - i.e. their performance which can have a detrimental effect on morale or even potentially mental health if this performance is closely linked with self-belief or self-worth. As such, a designer might need to be aware of these implications when designing a dashboard, and where a client might disclose this alternative use of KPIs the designer could probe or make assumptions that this may be the case and design with this in mind.

As such, in terms of the proposal of specific design guidelines more research is required into the impact of this practice of utilising sales data to motivate users through the generation of competition. It can however be speculated ahead of further research that this phenomenon would need to be made explicit in the design process, preferably at the outset in any form of design brief that outlines the aims and objectives of the project. The suitability of colour choice, for example with red signifying negative, and green signifying positive not only has implications for the display of sales data but also when utilized for promoting motivation wherein the positive and negative signifiers can also provoke feeling of negativity or positivity with the user. In short, further research into the implications of these findings is necessary for the proposal of design guidelines due to the potential for harm that could arise from the ill-considered implementation of them.

7 LIMITATIONS AND FURTHER DIRECTIONS

In addition to the phenomenon discussed above, there were several other points of interest that emerged. Amongst these extra themes of interest were: the use of colour in the dashboard; the response to competition-driven motivation based on age; and the response to competition-driven motivation based on job role and experience.

Some users reported that the data displayed in their dashboards were colour-coded to signify negative values. The default setting for dashboard displays is for the values to be displayed in black but

there are instances where red is used to signify underperforming values such as negative growth. This is an additional dimension to how competition or motivation is generated, not just the simple act of displaying the data but also signifying positive and negative - relating to the users' performance.

Whilst red is known to be used to mean that something is in deficit, as in the idiom 'in the red', being used to signify a warning, it has different connections and meanings in different cultures. For example, red can also be considered a lucky colour, or a colour of purity. Therefore we can make the assertion that colour choice is not universal, and can also have unintended implications when trying to communicate further information. As such, further data collection can incorporate questions pertaining to colour usage and selection in the dashboards taking into consideration the impact that colour can have on users' decision-making [2].

Another factor that could be considered in further data collection relates to age. Findings from the interviews indicate that age influences how employees see what is beneath the numbers displayed on the dashboard. Younger employees from Gen Z and Millennial generations, who have seen the integration of technology in their lives from a very young age, are more likely to perceive the dashboard as a tool for performance review. They are prone to be more reactive to the displayed data. The dashboard and its data are seen as a representation of themselves in which poor or high-level performance signifies the quality of work, and therein their own qualities. This phenomenon, however, does not occur among older employees. A dashboard is a novelty for this group of employees. They are not used to the public display performance, and hence the intended use of such a dashboard (e.g., to motivate) does not transpire well in this group. Due to the role of age and experience not being observed directly but based on the observations of those interviews further research is required into the effect of age and experience on, not only general dashboard use, but in the deployment of sales data as means of generating motivation.

Beyond age, another factor to consider is that of job role and experience, for example from our data there appears to be a difference in attitude between those from a sales background versus those from a marketing background, specifically in the context of key account management performance. Individuals with vast experience in sales, tend to be more sales-focused and very number-oriented. Meanwhile, individuals with a background in marketing tend to also focus on qualitative measures such as relationships, brand awareness, etc hence lowering their sensitivity toward sales-specific KPIs.

A limitation of this study would be the small sample size of the participants. To reinforce the significance of the findings discussed above as well as explore the other themes that emerged during the analysis the authors plan to undertake further interviews with dashboard users and conduct a larger-scale survey in the form of a questionnaire.

8 CONCLUSION

In this paper, we demonstrate the need to understand how dashboards are utilised beyond their intended and expected usage. Dashboards are expected to aid in comprehension and give users the ability to quickly access data in order to make informed decisions. However, our findings indicate that dashboards are also utilised to promote competition with the aim of motivating users through the public display of sales data across all teams in the company. This has implications for how we comprehend dashboard design and as such needs to be taken into consideration when creating dashboard design guidelines.

Our findings also indicated that there may be different factors such as age, job role and experience, and the colour selection within the dashboard that might also have an effect on the effectiveness of dashboards to evoke comprehension and elicit motivation from its users. As such, future work will explore these additional factors and

seek to measure what, if any, impact they have on dashboard use. A larger scale in-depth interview comprising both users and designers will help to better triangulate the motivation behind the transparent dashboard design and its usage. Furthermore, an avenue to build on the qualitative data is through quantitative research using a survey in order to generalise the finding and test our propositions.

REFERENCES

- [1] E. W. Anderson, K. C. Potter, L. E. Matzen, J. F. Shepherd, G. A. Preston, and C. T. Silva. A user study of visualization effectiveness using eeg and cognitive load. *Computer Graphics Forum*, 30:791–800, 6 2011. doi: 10.1111/j.1467-8659.2011.01928.x
- [2] P. Bera. How colors in business dashboards affect users’ decision making. *Communications of the ACM*, 59(4):50–57, 2016.
- [3] J. Bernard, D. Sessler, J. Kohlhammer, and R. A. Ruddle. Using dashboard networks to visualize multiple patient histories: a design study on post-operative prostate cancer. *IEEE transactions on visualization and computer graphics*, 25(3):1615–1628, 2018.
- [4] R. Brouwer. When competition is the loser: The indirect effect of intra-team competition on team performance through task complexity, team conflict and psychological safety. In *2016 49th Hawaii International Conference on System Sciences (HICSS)*, pp. 1348–1357. IEEE, 2016.
- [5] S. K. Card, J. D. Mackinlay, and B. Shneiderman. *Readings in information visualization: using vision to think*. Morgan Kaufmann Publishers Inc., 1999. doi: 10.1002/wics.89
- [6] S. Charleer, J. Klerkx, E. Duval, T. D. Laet, and K. Verbert. Creating effective learning analytics dashboards: Lessons learnt. In *European conference on technology enhanced learning*, pp. 42–56. Springer, 2016.
- [7] B. Clark. Marketing dashboards, resource allocation and performance. *European Journal of Marketing*, 2020.
- [8] W. Eckerson. Tdwi best practice report: Deploying dashboards and scorecards. Retrieved from TDWI—*Transforming Data With Intelligence*: <https://tdwi.org/articles/2006/10/23/deploying-dashboards-and-scorecards-report-excerpt.aspx>, 2006.
- [9] S. Few. *Information dashboard design: The effective visual communication of data*, vol. 2. O’Reilly, 2006 ed., 2006.
- [10] S. Few and P. Edge. Dashboard confusion revisited. *Perceptual Edge*, pp. 1–6, 2007.
- [11] S. Few and P. Edge. What ordinary people need most from information visualization today. *Perceptual Edge: Visual Business Intelligence Newsletter*, pp. 1–7, 2008.
- [12] J. Hamari, J. Koivisto, and H. Sarsa. Does gamification work?—a literature review of empirical studies on gamification. In *2014 47th Hawaii international conference on system sciences*, pp. 3025–3034. Ieee, 2014.
- [13] H. Kennedy, R. L. Hill, G. Aiello, and W. Allen. The work that visualisation conventions do. *Information, Communication Society*, 19:715–735, 2016. doi: 10.1080/1369118X.2016.1153126
- [14] H. Kennedy, R. L. Hill, W. Allen, and A. Kirk. Engaging with (big) data visualizations: Factors that affect engagement and resulting new definitions of effectiveness. *First Monday*, 21, 11 2016. doi: 10.5210/fm.v21i11.6389
- [15] M. T. Krush, R. Agnihotri, K. J. Trainor, and E. L. Nowlin. Enhancing organizational sensemaking: An examination of the interactive effects of sales capabilities and marketing dashboards. *Industrial Marketing Management*, 42(5):824–835, 2013.
- [16] D. Lee, J. R. A. Felix, S. He, D. Offenhuber, and C. Ratti. Cityeye: Real-time visual dashboard for managing urban services and citizen feedback loops. In *Proceedings of the 14th International Conference on Computing in Urban Planning and Urban Management (CUPUM)*, Cambridge, MA, USA, pp. 7–10, 2015.
- [17] T. Munzner. *Visualization Analysis and Design*. CRC Press, 2014.
- [18] M. Nadj, A. Maedche, and C. Schieder. The effect of interactive analytical dashboard features on situation awareness and task performance. *Decision support systems*, 135:113322, 2020.
- [19] S. Negash. Business intelligence. *Communications of the Association for Information Systems*, 13:177–195, 2004. doi: 10.17705/1CAIS.01315
- [20] E. M. Peck, S. E. Ayuso, and O. El-Etr. Data is personal: Attitudes and perceptions of data visualization in rural pennsylvania. *Conference on Human Factors in Computing Systems - Proceedings*, 2019. doi: 10.1145/3290605.3300474
- [21] A. L. Ridley. A sociocultural approach to data visualisation evaluation: understanding the role of a large-scale tool-based approach to evaluation within the commercial production process, 2021.
- [22] A. Sarikaya, M. Correll, L. Bartram, M. Tory, and D. Fisher. What do we talk about when we talk about dashboards? *IEEE Transactions on Visualization and Computer Graphics*, 25:682–692, 1 2019. doi: 10.1109/TVCG.2018.2864903
- [23] Y. Wang, A. Segal, R. Klatzky, D. F. Keefe, P. Isenberg, J. Hurtienne, E. Hornecker, T. Dwyer, S. Barrass, and al An Emotional. An emotional response to the value of visualization. *IEEE Computer Graphics and Applications*, 39:8–17, 2019. doi: 10.1109/MCG.2019.2923483i
- [24] S. Wexler, J. Shaffer, and A. Cotgreave. *The Big Book of Dashboards: Visualizing Your Data Using Real-World Business Scenarios*. John Wiley Sons, 2017.
- [25] R. N. Zambrano and Y. Engelhardt. Diagrams for the masses: Raising public awareness – from neurath to gampinder and google earth. pp. 282–292. Springer Berlin Heidelberg, 2008.