

Enhancing Usability of Open Government Data Portals: Bridging the Gap with User-Centric Visualizations

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Abstract

Open Government Data (OGD) has gained substantial interest in recent years due to its potential benefits in promoting transparency, accountability, and citizen engagement. However, various challenges and barriers hinder its effective implementation. It was found that one critical concern revolves around the usability of OGD portals, as governments often struggle to make data accessible and understandable to the public, especially to those with no experience with working with data. To address this problem, this Master thesis adopts a Design Science Research Methodology approach, with the goal of proposing a generic solution to enhance user engagement with data exploration using Business Intelligence (BI) tools. A demonstration was conducted to illustrate the proposed solution, involving the creation of visualizations in Power BI for three programs administered by the Portuguese governmental agency ANI. Subsequently, an evaluation of these visualizations was undertaken through an interview process involving 10 participants. Notably, the participants were divided into three distinct groups: those with no experience in working with data, individuals with experience in data analysis but limited exposure to BI tools, and experts proficient in Power BI. The findings revealed a clear division in user interaction based on participants' experience levels. While participants succeeded in extracting the required information from the visualizations, challenges were observed regarding interactivity and intuitiveness, particularly for those with limited exposure to data analysis and BI tools.

Keywords: Open Data, Open Government Data, Open Data Portal, Innovation, Business Intelligence

1. Introduction

In the dynamic digital era of the 21st century, the sharing of information drives progress, influencing innovation, decision making, and societal evolution. Open Government Data (OGD) initiatives represent government's commitment to transparency, empowering citizens by granting access to government data and fostering collaboration, innovation, and public accountability.

Data holds immense value, representing information in its rawest form and serving as the foundation for knowledge and insights. The evolution of data reflects human progress, transitioning from handwritten records to digital formats in today's era of "big data", where massive datasets are generated and processed at an unprecedented scale (Noveck, 2016; Schrock, 2016). The internet and ICTs have revolutionized data sharing and delivery,

prompting governments worldwide to make their data publicly available to enhance transparency and accountability [3], [4], [5].

The shift towards "open government", exemplified by President Obama's Memorandum on Transparency and Open Government in 2009, played a pivotal role in advancing OGD initiatives. This commitment to transparency set an example for governments globally, leading to the establishment of OGD portals like Data.gov in the United States. Obama's principles of participation and collaboration continue to guide open data initiatives worldwide, fostering a culture of openness and accountability in government operations [6], [7], [8].

1.1. Motivation

The motivation for this work lies in the need to improve the quality, accessibility, and

understandability of OGD portals. Despite the increase in OGD initiatives, many portals still fall short in terms of usability, mainly due to the lack of efforts to make data accessible and understandable for users without experience in working with data. The primary issue is that government agencies often focus on merely disclosing data without ensuring its quality and usability. This lack of attention to user experience hinders the full potential of OGD to foster transparency and public accountability.

This thesis advocates for a change in how OGD initiatives are implemented, emphasizing that making data accessible and easy to understand should be the top priority. By focusing on interaction design and usability, this study aims to ensure that OGD portals provide a seamless and satisfactory user experience, empowering citizens through clarity and comprehension.

1.2. Research Methodology

This thesis adopts the Design Science Research Methodology (DSRM) for its adaptability and iterative approach, suitable for Information Systems (IS) and Information Technology (IT) research [9].

1.3. Organization

This article is organized as follows: section 2 presents the research problem and in section 3 the research proposal is described. Section 4 describes the demonstration phase and in section 5 the evaluation is developed. In section 6, the conclusions are defined.

2. Systematic Literature Review

A systematic literature review (SLR) is undertaken to critically examine and synthesize the current state of knowledge within the field of study.

The literature is consistent in terms of the benefits that arise from the adoption of OGD. It was observed that the main purpose of OGD is to increase transparency and accountability in governance. By publishing data, governments can provide citizens with access to information about government operations and activities, which allows citizens to hold their officials accountable for their actions. Increasing citizen participation and promoting economic growth are also two major objectives of OGD initiatives.

Despite the significant benefits of OGD initiatives, there are also several challenges that governments face in publishing data. Nevertheless, while the potential challenges in publishing data are noteworthy, they are not the primary concern of OGD. The main obstacle lies in the lack of usability of OGD portals, as users face

numerous barriers when attempting to utilize OGD. Consequently, this lack of usability prevents governments from perceiving the benefits of implementing OGD initiatives, discouraging them to take action. However, by designing OGD portals to meet usability requirements and providing a user-friendly experience, governments can encourage people to use them, leading to the realization of the advantages associated with OGD. Therefore, there has been an emergence of papers providing lists of requirements for creating an OGD portal and frameworks to evaluate their usability. [13] has provided a comprehensive set of requirements, nevertheless, these requirements have been mentioned in other papers as well, indicating a consensus among researchers regarding the crucial aspects of OGD portal design.

Recent studies have been highlighting the limited understandability of the data by citizens and the importance of the implementation of visualization tools to manage this problem. Many individuals lack the necessary skills to work with raw data, preventing them from accessing and analyzing the information effectively. Consequently, the literature draws special attention to the prominent role of visualization tools in helping citizens make sense of the data provided. It becomes crucial for governments to resort to the use of visuals and dashboards to help present the data in a way that is more understandable and accessible to a broader audience, without requiring citizens to possess specialized technical skills or download datasets in their raw form. By using visualization tools, governments can make their data more accessible and engaging to citizens, promoting transparency and accountability in government operations.

3. Research Problem

In the perspective of OGD Initiatives, the availability of data represents a significant step towards transparency. However, a critical challenge arises as the mere provision of data does not automatically ensure increased transparency, especially when the design and implementation of open data portals do not align with the diverse expectations of users [10]. This discrepancy brings to the forefront a fundamental issue that this research seeks to address: the gap between data availability and effective transparency in OGD.

In the business domain, users make use of information stored in databases to extract knowledge, driving decision-making processes, identifying trends, and gaining a competitive advantage. Translating this dynamic to the public sector, OGD initiatives aim to empower citizens by providing access to government data by making it available in OGD portals that serve as

digital gateways to a wealth of information, fostering collaboration, innovation, and public accountability [11]. The process of making data available in OGD portals involves extracting information from various sources, such as government databases, organizational records, and public records. This raw data, which can be in formats like Excel, CSV, XML, JSON, or others, is then transformed into a suitable format and loaded into the portal using platforms like CKAN and Socrata [12]. This data is then accessible to users who navigate the portal interface to explore, analyze, and potentially extract valuable insights. However, the effectiveness of these portals is hindered by the absence of robust visualization tools, representing a lack of investment in enhancing the understandability of data which limits user interaction and engagement.

Visualization plays a pivotal role in translating complex datasets into easily understandable insights. There is a diversity of potential users of OGD and while certain user groups are accustomed to working with raw data and may prefer unaltered datasets, the majority of citizens don't have the knowledge necessary to work with raw data and require additional support in making sense of the data presented.

Although platforms such as CKAN and Socrata incorporate some visualization features, their scope is limited, not being able to address the diverse needs of users. These platforms, while serving as the backbone of OGD portals, provide visuals that are static and lack interactivity. This limitation hinders the user experience, discouraging citizens from exploring and interacting with the data.

This research problem involves the intricate relationship between data provision, citizen engagement, and the challenges faced by users in navigating OGD portals. Bridging the gap between data availability and effective transparency requires not only making data openly available but also investing in tools and features that enhance its comprehensibility. Grasping these various challenges is crucial for effectively implementing OGD initiatives and reaching the main objectives of transparency and empowering citizens.

4. Research Proposal

4.1. Objective

The main objective of this thesis was to provide a solution to the research problem addressed. More specifically, this thesis proposes the integration of Business Intelligence (BI) tools to create user-friendly visualizations that are accessible and comprehensible to a wider audience enhancing the usability of OGD portals.

4.2. Potential benefits of BI tools

In this section, the potential benefits of integrating BI tools into OGD portals will be defined. This phase explains why this solution is being suggested, clarifying how using BI tools can help solving the usability issues.

Business Intelligence (BI) tools are software applications, such as Power BI, Tableau, and Qlik-View, designed to transform data into useful insights [14]. Various sectors have adopted these tools due to their capacity to:

1. **Transform Raw Data:** BI tools excel in extracting, transforming, and loading (ETL) data from diverse sources into a unified, structured format. This transformation is a critical step in making data suitable for analysis and visualization.
2. **Analyze Data:** The analytical capabilities of BI tools empower users to uncover patterns, trends, and correlations within datasets. Advanced algorithms and data modeling facilitate in-depth analysis.
3. **Create visualizations:** Perhaps the most distinctive feature of BI tools is their ability to create visually compelling and interactive data visualizations. These visualizations simplify complex data, making it more accessible and comprehensible to users.
4. **Enable Data Interaction:** BI tools offer interactivity, allowing users to explore data, filter results, and drill down into details, fostering a deeper understanding of the information.
5. **Facilitate Reporting:** The reporting capabilities of BI tools enable the generation of customized reports and dashboards that present data in a user-friendly manner.
6. **User Accessibility:** BI tools are designed with a focus on user accessibility, ensuring that individuals with varying levels of technical expertise can utilize them effectively.

The potential benefits of BI tools integration in OGD portals are multifaceted. By harnessing these tools, government agencies can:

- **Enhance Data Accessibility:** Transform raw government data into user-friendly visualizations, enabling users to access and interpret data with ease.
- **Simplify Data Understanding:** Create visualizations that turn complex datasets into clear, comprehensible representations.
- **Foster User Engagement:** Engage users with interactive dashboards and reports, encouraging exploration and interaction with government data.
- **Support Evidence-Based Decision-Making:** Empower policymakers, researchers,

and citizens to make data-driven decisions by providing them with actionable insights.

- **Bridge the Usability Gap:** Address the usability issues that have been a part of OGD portals, making government data more accessible to all.

4.3. BI tool implementation steps

The crux of the research lies in the implementation of BI tools within OGD portals. This phase outlines the three fundamental steps involved in the process:

Step 1: ETL (Extract, Transform, Load)

The ETL phase is the initial step in the implementation of BI tools. It involves a sequence of operations [14]:

1. **Data Extraction:** In this stage, data is extracted from diverse sources, often in different formats, including databases, spreadsheets, and APIs.
2. **Data Transformation:** The extracted data is then transformed into a uniform format. Data transformation activities encompass data cleaning, structuring, and standardization to ensure consistency and accuracy.
3. **Data Loading:** The transformed data is loaded into the BI tool's data warehouse, creating a centralized repository for analysis and visualization.

The ETL process sets the stage for comprehensive data analysis and visualization, ensuring that the data is in a format that leads to user-friendly presentations.

Step 2: Data Analysis

Following data preparation, the BI tool proceeds to the data analysis phase. BI tools offer analytical techniques and algorithms to uncover valuable insights within the datasets:

1. **Exploratory Data Analysis (EDA):** EDA techniques, including data profiling, summary statistics, and data visualization, are employed to gain a first understanding of the data, identifying trends and patterns.
2. **Statistical Analysis:** Statistical tests and models are applied to investigate relationships, correlations, and dependencies within the data.
3. **Advanced Analytics:** Advanced analytics techniques, such as "What-if scenarios" that allows you to predict what might happen in the future.

The data analysis phase plays a pivotal role in extracting meaningful insights from the transformed data, which will subsequently inform the creation of user-friendly visualizations.

Step 3: Creation of Reports and Visualizations

The culmination of the BI tool implementation process is the creation of user-friendly reports and data visualizations. This phase leverages the capabilities of the BI tool to design compelling and informative presentations of the analyzed data:

1. **Dashboard Design:** Dashboards serve as the user interface for interacting with data. They are designed to present key insights and visuals in a single, customizable view.
2. **Visualization Development:** Various types of visuals including charts, graphs, maps, and infographics, are crafted to convey information effectively. The choice of visual depends on the nature of the data and the insights to be communicated.
3. **Interactivity:** BI tools offer interactive features that allow users to explore data dynamically. Filters, slicers, and drill-down options enhance user engagement.
4. **Accessibility:** Accessibility considerations, such as screen reader support, color contrast, and font size, are integrated to ensure inclusivity.

The creation of user-friendly dashboards and visualizations is the ultimate goal of the BI tool implementation. These visualizations should empower users, including regular citizens, to explore, understand, and derive insights from government data effortlessly.

5. Demonstration

In this chapter, the demonstration step of the Design Science Research Methodology (DSRM) will be addressed, presenting the practical application of BI tools in improving data accessibility in the context of OGD Initiatives. This chapter provides a detailed illustration of the BI-driven visualizations created during the research, focusing on three key programs of a Portuguese governmental agency - *Agência Nacional de Inovação* (ANI): SIFIDE, PT2020 and HEurope.

5.1. ANI – Agência Nacional de Inovação

ANI - *Agência Nacional da Inovação* is a Portuguese governmental agency that aims to support scientific and technological innovation in Portugal. ANI occupies a central position in the

relationship between science and economy, promoting the sharing of knowledge through co-operation and collaboration between institutions and companies.

ANI's primary data repository resides in OutSystems serving as the initial source of information. However, due to certain constraints, the direct uploading of data from OutSystems to Power BI proved unattainable. As a result, a transitional step involves extracting the data from OutSystems and storing it in Excel sheets that can be uploaded in Power BI.

While the ideal scenario was to perform the ETL operation directly within Power BI, technical limitations prevented this seamless integration. Consequently, the ETL stage continues to be executed during the extraction process to Excel sheets.

Visualizations were made for three programs supported by ANI:

1. **SIFIDE:** SIFIDE – *Sistema de Incentivos Fiscais à I&D Empresarial* is an initiative to provide tax incentives for research and development (R&D) in the business sector.
2. **PT2020:** The PT2020 program refers to the Partnership Agreement between Portugal and the European Commission that establishes programming principles that guide Portugal's economic, social, and territorial development policy during the specified period.
3. **HEurope:** The HEurope program is dedicated to fostering the internationalization of higher education institutions and research centers in Portugal. It is in operation from 2021 to 2027 and came to replace the H2020 program that was active from 2014 until 2020.

5.2. Tool – Power BI

The tool selected for creating the visualizations was Power BI for its user-friendly interface and robust features, making it ideal for both visualization creators and users. It supports data import from various sources, transformation through Power Query, and the creation of customizable reports and interactive dashboards. ANI had previously established Power BI visualizations for these programs, streamlining the ETL phase. The pre-existing visualizations served as the starting point, with the foundation ETL already completed. The main focus was to update the data and optimize visual representations for a more engaging interface. More interactive features were incorporated in order to improve the user experience, leveraging Power BI's flexibility.

5.3. Demonstrations

The objective of these demonstrations was to effectively communicate key project characteristics, including the number of applications, types of companies involved, investment details, and other pertinent metrics.

The visualization structure for the three programs comprises four main pages: Cover, Summary, Report, and Website Link.

The Cover Page, represented in Figure 1, serves as an introduction, offering a succinct overview of ANI and introducing the program. This initial page establishes the context for stakeholders to comprehend the purpose and significance of the following pages.



Figure 1 - Cover page

The Summary Page, represented in Figure 2, serves as a centralized hub for key indicators and KPIs related to the program, designed for quick reference. "Card" visuals highlight essential metrics and Additional visual elements, such as column charts and area charts, offer a graphical representation of data trends.

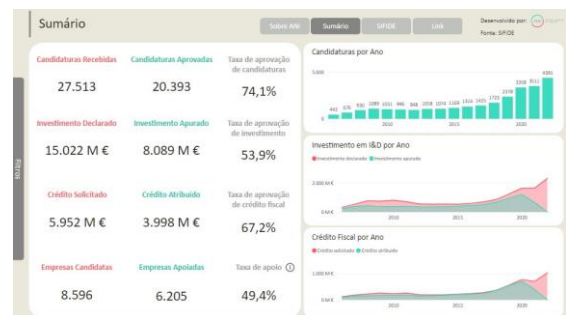


Figure 2 - Summary page

The Report Page, represented in Figure 3, offers a more detailed exploration. This page includes a variety of visuals such as column charts, bar charts, pie charts, tables, and maps. Interactive features like tooltips provide additional details when hovering over visuals. In some charts, users are also given the possibility to disaggregate and aggregate information using the drill-down/drill-up feature, depending on the desired level of granularity.

The Report pages for the SIFIDE and PT2020 visualizations share a similar structure, each divided into two sections: the “Received Applications” section and the “Approved Applications” section.



Figure 3 - SIFIDE Report page

In contrast, the HEurope visualization report page has a different structure due to variations in data extraction from OutSystems to Excel. Instead of extracting the original data, only the results were captured, limiting the granularity of information available for visualization and thereby restricting the level of interactivity achievable in Power BI. Consequently, the HEurope visualization Report page, represented in Figure 4, is divided into two sections: "Analysis per Year" and "Analysis per Theme."

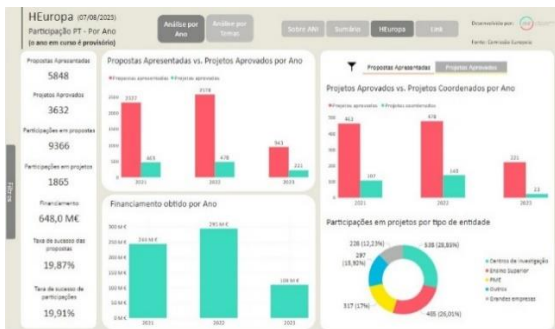


Figure 4 - HEurope Report page

The Summary and Report pages include a filter pane, allowing users to filter all information on a page by specific categories.

The final page, the Link page represented in Figure 5, exclusively contains a link to the official program’s website, offering users direct access to additional information and resources.



Figure 5 - Link page

The design of each page prioritizes seamless navigation, with buttons facilitating movement between the Cover, Summary, Report, and Website Link Pages. The interactive features included in the visuals enhance user engagement and data exploration, ensuring a user-friendly experience.

6. Evaluation

In this chapter, the methodology for evaluating the efficiency of visualizations developed for the three ANI programs is outlined. According to [15], there are two paradigms for evaluation studies: artificial evaluation and naturalistic evaluation. Artificial evaluation involves controlled experiments, simulations, and theoretical arguments to test design hypotheses, aiming to prove or disprove the utility of design artifacts. In contrast, the naturalistic evaluation assesses the performance of a solution in its real environment, embracing the complexities of human practice within organization through methods such as case studies, field experiments, surveys, and ethnography. This study aligns with the naturalistic evaluation paradigm by conducting interviews with participants of varying familiarity with data analysis tools and Power BI, aiming to understand how the visualizations perform in real-world scenarios.

6.1. Sampling and Data collection

Unlike statistical surveys, which prioritize statistical reliability through probability sampling, qualitative studies aim to explore the diversity of phenomena within the target population. Qualitative research emphasizes the need to capture the diversity of the phenomenon under study within the target population. Rather than aiming for a large random sample, qualitative sampling prioritizes purposive selection to ensure coverage of all relevant varieties of the phenomenon, a concept known as saturation (Jansen, 2010). In qualitative surveys with open-ended questions, each response is unique, necessitating a focus on diversity in the sample to ensure comprehensive coverage of the population under

study. By prioritizing diversity over quantity in sampling for qualitative research, researchers can achieve a comprehensive understanding of the phenomenon under study. This approach allows for the exploration of rich, nuanced insights and ensures that the research findings are grounded in the diverse perspectives and experiences of the target population (Jansen, 2010). Therefore, the selection for this study aimed to ensure a diverse representation of individuals with varying levels of familiarity with data analysis tools, educational backgrounds, professions, ages, and genders. A total of 10 interviewees participated in the evaluation process, providing diverse perspectives on the effectiveness of the visualizations across the three programs.

Participants with limited or no experience with working with data were included to assess the accessibility of the visualizations to a wider audience, particularly focusing on the common citizen who may encounter difficulties in understanding data presented on portals.

On the other hand, participants familiar with data analysis were also included. Those who have knowledge of working with data but are inexperienced with Power BI or similar business intelligence tools were included to evaluate the intuitiveness of the tool and its effectiveness in improving data navigation. Experts in both data analysis and Power BI usage were included to gather constructive feedback and suggestions for improvement from experienced users.

Furthermore, participants from various educational backgrounds and professions were included to capture a broad range of perspectives and insights. This is also related to the varying levels of knowledge in working with data due to the specific skills, training, and experiences acquired within each field or discipline.

Participants with different age groups were also included to explore potential age-related differences in interaction with the visualizations and to assess the impact of age on usability and effectiveness. Lastly, both male and female participants were included to ensure gender diversity within the sample.

6.2. Data Collection

Data was collected during the interviews. The interviews were conducted in person, allowing for direct observation of participants' reactions and behaviors. Observations were made regarding participants' navigation patterns, their ability to locate desired information within the visualizations, and the time taken to complete assigned tasks. Throughout the interviews, participants were encouraged to verbalize their thoughts and experiences, articulating any challenges or difficulties encountered while

navigating through the visualizations. This verbal feedback offered additional context and depth to the observations made during the interview sessions.

At the end of the interview, participants were asked to complete a questionnaire aimed at evaluating the user-friendliness and intuitiveness of the visualizations, as well as their experience with Power BI as a tool. It was also asked feedback on aspects such as preferred features, challenges encountered, and suggestions for improvement.

Experts in working with Power BI were not asked to find information, but rather just explore the visualizations and provide constructive feedback while exploring.

6.3. Results

Gender was found not to impact interactivity with the visualizations. However, the analysis revealed a distinct difference between the elderly participants and those in other age groups. This was expected, as working with technology is more challenging for the elderly group.

Furthermore, participants' level and type of education, as well as their profession, were found to have an impact. Nevertheless, these factors are correlated with the level of expertise in data analysis.

So, the evaluation of results places particular emphasis on discerning differences among participants with varying levels of experience in working with data.

Completion of tasks

All participants successfully found the required information within the visualizations. However, participants with limited experience in working with data required additional guidance from the interviewer to access certain types of information. A common complaint among all participants was the drill-down and drill-up feature. Participants with no experience in working with data required guidance to locate and activate this feature from the action bar. Participants with some experience in data analysis could activate the feature with assistance, although taking longer than it should. Despite the presence of an information icon intended to provide guidance on how to use this feature, most of participants did not recognize its purpose clearly, indicating its lack of explicitness. This hindered participants' ability to utilize the feature effectively, highlighting the need for improved clarity in user interface design. Experts in Power BI acknowledged the feature's lack of intuitiveness. One participant who regularly works with Power BI admitted not using the feature

frequently, and he wasn't totally familiar on how to use it. It was then concluded that this feature may not be suitable for visualizations intended to be used by individuals who have no experience with Power BI.

Exploration and Time Efficiency

Participants with no experience in working with data spent less time exploring the visualizations but required more time to locate the required information. Initially, there was some hesitation among these participants in exploring the visualizations deeply, possibly due to feeling overwhelmed by the amount of information provided and a lack of familiarity with using such platforms. However, once the questions were posed and they started to navigate to find the information, they became more comfortable with the software. In contrast, experienced participants didn't find the amount of information overwhelming and navigated the visualizations more swiftly, leveraging their familiarity with data analysis tools to expedite information retrieval. Some information was found in tooltips when hovering over charts. Participants who didn't explore the visualizations deeply took longer to understand that they could access additional information by hovering over charts, while those who explored the visualizations understood this feature. A suggestion made by participants with experience in data analysis was to provide information on the additional details available within each chart.

Design

Participants provided predominantly positive feedback regarding the overall organization of the visualizations, expressing appreciation for their user-friendly and intuitive nature. They particularly enjoyed the clarity of the charts and commended the effectiveness of the titles. However, they also offered constructive suggestions for improvement.

Some participants with experience in data analysis recommended enhancing the visibility and prominence of the buttons labeled "*Candidaturas Recebidas*" ("Received Applications") and "*Candidaturas Aprovadas*" ("Approved Applications"), treating them more like prominent titles rather than mere buttons. This suggestion implies that participants felt these elements were crucial focal points within the visualization interface and should be visually emphasized to draw users' attention effectively. However, experts in Power BI did not encounter issues with these buttons, quickly grasping their purpose and function within the visualization interface.

It was also suggested among the participants the inclusion of a "clear all filters" button allowing users to reset filters effortlessly, bigger font size across the interface to improve readability and ensure a more user-friendly experience, and the inclusion of a comprehensive quick guide outlining all functionalities offered by Power BI, aiming to familiarize users with the tool's capabilities and enhance their overall navigation experience.

Among the experts in Power BI, the feedback provided included:

- **Static Header:** Maintaining a static header across all pages improves user experience with visualizations. However, a trade-off may be necessary between a static header and optimizing page layout. For instance, on the "Summary" page a smaller frame was used compared to the report page, that had to accommodate more detailed information, so optimization of the pages was prioritized.
- **Graphs for Evolution of Success/Approval Rates:** Experts found charts showing the evolution of success/approval rates per year valuable for providing insight, noting their effectiveness in conveying relevant information.
- **Consistency in Colors and Charts:** Experts emphasized the importance of consistency in the use of colors and charts.

The overall feedback from the experts was positive across the visualizations. They expressed satisfaction with the simplicity and clarity of summary pages, noting their effectiveness in conveying information concisely. Additionally, the report pages received praise for their structural layout and intuitiveness, facilitating smooth navigation and comprehension. They appreciated the transparent presentation of data, leaving no ambiguity on what information users are viewing. Suggestions for improvement mainly focused on enhancing the user experience, reflecting a constructive approach to refinement.

7. Conclusion

The motivation for this work arose from the challenges faced by Open Government Data (OGD) portals in presenting data in an easily understandable manner for all citizens. Despite the growing interest in OGD initiatives worldwide, the potential benefits have not been fully realized due to a lack of awareness and inability among lay citizens to use the data. Governments have struggled to make OGD accessible, often disclosing data without considering the needs of regular citizens who may lack technical skills or knowledge. This work aims to

leverage visualization tools to enhance user experience and facilitate data exploration for individuals of varying backgrounds and expertise levels.

Following the Design Science Research Methodology (DSRM), the study involved creating visualizations for three key programs of ANI (SIFIDE, PT2020 and HEurope) using Power BI, focusing on user-friendliness, interactivity, visual appeal, and ease of use. Interviews were conducted with participants to evaluate the effectiveness of these visualizations in enhancing data accessibility and user experience. The findings highlighted the significant role of visualization tools in making data more accessible and user-friendly, although several areas for improvement were identified. Some concerns raised by participants with low expertise did not appear to be problematic for experts, who found the interface intuitive. Nevertheless, the primary objective of this work was to enhance user interaction for those with limited expertise. Therefore, even if experts did not perceive certain issues as problematic, the feedback from less experienced users was given significant consideration to address their needs effectively.

A limitation of this work was the limited number of iterations to optimize the visualizations fully. More iterations would have refined the visualizations further, addressing identified improvements from the interviews. Another limitation was the sample used for evaluation. Participants were unfamiliar with ANI's programs or specialized terminology, posing a challenge in assessing the visualizations' effectiveness. Additionally, the inability to directly connect ANI's database in OutSystems to Power BI hindered the examination of Power BI's efficiency in performing ETL processes. Despite these limitations, the study demonstrated the potential for improving data accessibility and usability, providing valuable insights into the challenges and opportunities in this domain.

Future research could delve deeper into developing comprehensive open data portals, considering more aspects beyond visualization. Integrating diverse data sources into a unified platform and ensuring compatibility across different data formats and systems are crucial. Collaborative efforts between researchers, policymakers, and technologists are essential to drive innovation in open data portals. Leveraging emerging technologies such as machine learning and natural language processing could unlock new possibilities in data exploration and analysis. This thesis represents a foundational step towards enhancing data accessibility and visualization within governmental open data portals, with ample opportunities for further

research and innovation to promote transparency, accountability, and informed decision-making in the public sector.

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