

ESCOLA POLITÉCNICA
PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIA DA COMPUTAÇÃO
DOUTORADO EM CIÊNCIA DA COMPUTAÇÃO

CLAITON MARQUES CORREA

**AN APPROACH FOR DESIGNING AND EXPLORING
CUSTOMIZABLE NARRATIVE DATA VISUALIZATIONS**

Porto Alegre
2023

PÓS-GRADUAÇÃO - *STRICTO SENSU*



Pontifícia Universidade Católica
do Rio Grande do Sul

**PONTIFICAL CATHOLIC UNIVERSITY OF RIO GRANDE DO SUL
SCHOOL OF TECHNOLOGY
COMPUTER SCIENCE GRADUATE PROGRAM**

**AN APPROACH FOR DESIGNING
AND EXPLORING
CUSTOMIZABLE NARRATIVE
DATA VISUALIZATIONS**

CLAITON MARQUES CORREA

Doctoral Thesis submitted to the Pontifical
Catholic University of Rio Grande do Sul
in partial fulfillment of the requirements
for the degree of Ph. D. in Computer
Science.

Advisor: Prof. Milene Selbach Silveira, Ph.D.

**Porto Alegre
2023**

Ficha Catalográfica

C824a Correa, Claiton Marques

An Approach for Designing and Exploring Customizable Narrative
Data Visualizations / Claiton Marques Correa. – 2023.

140p.

Tese (Doutorado) – Programa de Pós-Graduação em Ciência da
Computação, PUCRS.

Orientadora: Profa. Dra. Milene Selbach Silveira.

1. Data Visualization. 2. End-User Development. 3. Narrative. 4.
Human-Computer Interaction. 5. Customization of Visualizations. I.
Silveira, Milene Selbach. II. Título.

Elaborada pelo Sistema de Geração Automática de Ficha Catalográfica da PUCRS
com os dados fornecidos pelo(a) autor(a).

Bibliotecária responsável: Clarissa Jesinska Selbach CRB-10/2051

CLAITON MARQUES CORREA

**AN APPROACH FOR DESIGNING AND
EXPLORING CUSTOMIZABLE NARRATIVE DATA
VISUALIZATIONS**

This Doctoral Thesis has been submitted in partial fulfillment of the requirements for the degree of Ph. D. in Computer Science, of the Computer Science Graduate Program, School of Technology of the Pontifical Catholic University of Rio Grande do Sul

Sanctioned on August 23, 2023.

COMMITTEE MEMBERS:

Prof. Vânia Paula de Almeida Neris, Ph.D. (PPGCC/UFSCar)

Prof. Carla Maria Dal Sasso Freitas, Ph.D. (PPGC/UFRGS)

Prof. Márcio Sarroglia Pinho, Ph.D. (PPGCC/PUCRS)

Prof. Milene Selbach Silveira, Ph.D. (PPGCC/PUCRS - Advisor)

I dedicate this thesis to my parents. Without their love and everlasting support, nothing of this would have been possible.

ACKNOWLEDGMENTS

I want to express my gratitude to my supervisor, Professor Milene Selbach Silveira, who guided me through this journey. Her ideas, commitment, openness, and availability to discuss my research and concerns took me further.

I want to thank Professor Derek Reilly for accepting me for six months as a visiting graduate research student at Dalhousie, Canada. The experience abroad opened possibilities in my research of visual data narratives. I also want to thank the GEM Lab research group for welcoming me and for our good moments together.

I want to express my gratitude to the undergraduate students who helped me reach significant results along this journey (Carolina Fração and Eduardo Bernardon). Thanks for your effort and dedication to this research.

I also want to thank CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil) for the financial support (Code 001). I am grateful to IFFar (Instituto Federal Farroupilha) for the work license.

I am also grateful to my family and friends. In particular, Mairon, with whom I shared many thoughts concerning the Ph.D. journey. Thanks for always being available to listen to me. I must share my gratitude to Tiago Martins, whose friendship and partnership in research projects helped me have ideas to my doctoral project's initial drafts. I also want to thank Carmen, Diego, and Mariana. Thanks for the time we spent together.

Finally, thanks for all that, even not mentioned here, directly or indirectly, contributed to the completion of this thesis.

UMA ABORDAGEM PARA PROJETAR E EXPLORAR VISUALIZAÇÕES NARRATIVAS CUSTOMIZÁVEIS DE DADOS

RESUMO

A crescente quantidade e diversidade de dados têm desafiado os pesquisadores de visualização de dados. Um dos desafios é como apresentar esses dados aos usuários de forma clara e fácil em diferentes domínios. Nos últimos anos, as visualizações narrativas foram propostas como uma abordagem para apresentar os dados em um formato de história, a fim de facilitar a compreensão do usuário. Transformar dados em um formato compreensível por humanos exige que os designers selecionem técnicas de visualização e outros elementos visuais adequados à sua intenção comunicativa. Por outro lado, os usuários finais podem ter diferentes necessidades e preferências em relação a como os dados são apresentados ou organizados. Neste cenário, a Programação por Usuário Final pode ser considerada um tópico promissor a ser combinado com as pesquisas em visualizações narrativas para atender às necessidades dos usuários finais. Esta tese segue esse caminho, ao apresentar uma abordagem para auxiliar os designers de visualizações no planejamento de visualizações narrativas com recursos de customização com os quais os usuários podem realizar atividades de customização ao explorá-las. Para construção desta abordagem, foram realizados estudos, incluindo revisões sistemáticas, grupos de foco, e sessões de brainstorm, a fim de investigar a exploração, customização e definição de elementos narrativos, além de estudos com usuários sobre o planejamento e exploração de narrativas customizáveis. Como principais resultados, reportam-se as análises de como a abordagem proposta apoiou os designers no planejamento das narrativas e de como os recursos de customização ajudaram os usuários finais a explorar as narrativas. Pelos estudos realizados, a abordagem foi considerada útil e pode auxiliar os designers de visualizações tanto na identificação dos elementos narrativos a partir dos dados quanto na definição de como os usuários finais podem customizar uma visualização narrativa.

Palavras-Chave: visualização de dados, desenvolvimento por usuário final, narrativas, Interação Humano-Computador, Customização de visualizações.

AN APPROACH FOR DESIGNING AND EXPLORING CUSTOMIZABLE NARRATIVE DATA VISUALIZATIONS

ABSTRACT

The increasing quantity and diversity of data have challenged data visualization researchers. One of the biggest challenges that emerged is how to present data to users clearly and easily in different domains of applications. In recent years, narrative data visualizations were proposed to present the data in a story-like form that may improve the user's understanding. Transform data in a human-comprehensible format requires designers to select visualization techniques and other visual elements suitable to their communicative intention. On the other hand, the end-users of visualizations may have varying needs and preferences in how data is presented or organized. In this scenario, End-User Development is a promising topic to be blended into narrative data visualization research to address end-users' needs. This thesis follows this path and presents an approach to assist visualization designers in planning narrative data visualizations with customization features with which users can perform customization activities to explore the narrative. We carried out studies, including systematic reviews, focus groups, and brainstorming sessions, to investigate the exploration, customization, and definition of narrative elements, and based on these studies, we outlined an approach. After defining it, we conducted user studies focusing on planning and exploring customizable narratives. As main results, we report the analysis of how the proposed approach aided designers in planning the narratives and results related to how customization features aided end-users in exploring the narratives. The approach was considered useful and can assist the visualization designers properly both in identifying the significant narrative elements from data and defining how the end-users can customize a narrative visualization.

Keywords: data visualization, end-user development, narrative, Human-Computer Interaction, customization of visualizations.

LIST OF FIGURES

Figure 1.1 – Research roadmap	17
Figure 2.1 – First stage of the research	18
Figure 2.2 – Learning cost of programming languages. Adapted from Fischer et al. [56]	19
Figure 2.3 – The four periods of EUD studies. Source: Correa and Silveira [30] . .	20
Figure 2.4 – The seven narrative genres	24
Figure 2.5 – Models of narrative. Adapted from Segel and Heer [111]	25
Figure 3.1 – Second and third stages of the research	28
Figure 3.2 – Process of designing narrative data visualizations with exploratory techniques.	30
Figure 3.3 – Studies triangulation to define the customization in narratives	36
Figure 3.4 – The three interactive genres and their components: from the left to the right: annotated chart, partitioned poster, and slide-show	38
Figure 3.5 – Layers of information considered in this research stage. Source: the author	46
Figure 3.6 – Iterations performed to build the process	46
Figure 3.7 – Process to transform data into customizable narrative visualization.	51
Figure 3.8 – Customizable narrative data visualization model	53
Figure 4.1 – Fourth stage of the research	55
Figure 4.2 – Stages of the focus group	56
Figure 4.3 – Stages of the workshop sessions	62
Figure 4.4 – Scene with options to customize the narrative	63
Figure 4.5 – Options of column 1	63
Figure 4.6 – Options of column 2	64
Figure 4.7 – Options of column 3	65
Figure 4.8 – Options of column 4	65
Figure 4.9 – Options of column 5	65
Figure 4.10 – Options of column 6	66
Figure 4.11 – Default narrative instantiated for the workshop	67
Figure 4.12 – Narrative customized by G9	69
Figure 4.13 – Narrative customized by G6	70
Figure 5.1 – Examples of narratives for virtual and web applications	78
Figure A.1 – Amount of selected studies per performed iteration	101

Figure A.2 – Snowballing procedure performed during the review. Adapted from
Borges et al. [10] 103

LIST OF TABLES

Table 2.1 – Characterization of narrative genres by Borges [11]	27
Table 3.1 – Focus group participants	29
Table 3.2 – Participants choices	33
Table 3.3 – Design patterns related to tailoring [7]	39
Table 3.4 – Association between the design patterns and the narrative genres . .	42
Table 4.1 – Focus group participants	56
Table 4.2 – Workshops participants	62
Table 5.1 – Visual narrative instantiations	75
Table B.1 – Selected EUD papers ordered by year	104
Table C.1 – Narrative visualization papers	110

CONTENTS

1	INTRODUCTION	14
1.1	GOALS	15
1.2	RESEARCH ROADMAP	16
1.3	THESIS STRUCTURE	16
2	BACKGROUND	18
2.1	END-USER DEVELOPMENT	18
2.2	NARRATIVE DATA VISUALIZATION	22
2.3	CONSIDERATIONS ABOUT THIS CHAPTER	27
3	TRANSFORMING DATA INTO CUSTOMIZABLE NARRATIVE DATA VISUALIZATION	28
3.1	EXPLORATION IN NARRATIVE DATA VISUALIZATIONS	29
3.1.1	STUDY DESIGN	29
3.1.2	RESULTS	31
3.1.3	CONSIDERATIONS ABOUT THE STUDY	33
3.1.4	THREATS TO VALIDITY	35
3.2	CUSTOMIZATION IN NARRATIVE DATA VISUALIZATIONS	36
3.3	DEFINITION OF THE CUSTOMIZABLE NARRATIVE DATA ELEMENTS	43
3.3.1	SCENARIO	44
3.3.2	DATA USED	44
3.3.3	MAPPING THE ELEMENTS OF CUSTOMIZABLE NARRATIVE DATA VISUALIZATIONS	45
3.4	PROCESS STRUCTURE	50
3.4.1	UNDERSTANDING THE PROBLEM	51
3.4.2	DEFINING THE MESSAGE	51
3.4.3	STRUCTURING THE NARRATIVE	52
3.4.4	IMPLEMENTING THE NARRATIVE	54
3.5	CONSIDERATIONS ABOUT THIS CHAPTER	54
4	APPLYING THE CUSTOMIZABLE NARRATIVE PROCESS	55
4.1	PLANNING A CUSTOMIZABLE NARRATIVE DATA VISUALIZATION	55
4.1.1	STUDY DESIGN	56
4.1.2	RESULTS	58

4.1.3	CONSIDERATIONS ABOUT THE STUDY	60
4.2	EXPLORING A CUSTOMIZABLE NARRATIVE DATA VISUALIZATION	61
4.2.1	STUDY DESIGN	61
4.2.2	RESULTS	68
4.2.3	CONSIDERATIONS ABOUT THE STUDY	71
4.3	THREATS TO VALIDITY	73
5	DISCUSSION	74
6	FINAL REMARKS	80
6.1	CONTRIBUTIONS OF THIS THESIS	81
6.2	FUTURE WORK	82
6.3	LIMITATIONS OF THE WORK	83
6.4	ACADEMIC JOURNEY	83
6.4.1	PUBLICATIONS	83
6.4.2	VISITING GRADUATED RESEARCH STUDENT (VGRS)	84
6.4.3	PARTICIPATIONS IN ACTIVITIES/EVENTS	85
	REFERENCES	87
	APPENDIX A – Protocols of the systematic reviews conducted	99
A.1	END-USER DEVELOPMENT (EUD)	99
A.1.1	METHODOLOGY	100
A.2	NARRATIVE DATA VISUALIZATION	102
	APPENDIX B – Papers selected during the literature review on End-User Development - EUD	104
	APPENDIX C – Papers selected during the literature review on Narrative Visualizations	110
	ATTACHMENT A – Information and Consent Form- Focus Group 1	117
	ATTACHMENT B – Information and Consent Form - Focus Group 2	120
	ATTACHMENT C – Information and Consent Form - Workshop	124
	ATTACHMENT D – Ethics Committee Approval	128
	ATTACHMENT E – Ethics Committee Approval for the Amendment	132

1. INTRODUCTION

Data visualization is everywhere. Technological advances have increased the quantity and diversity of data generated in the so-called Big Data era. Due to this, data visualization became part of contemporary society as a means to enhance data comprehension and analysis. Indeed, data visualization is one of the significant Big Data challenges that have attracted academic researchers' interest in handling them [100].

Tools are available for designing visualizations that help to illustrate a point or discovery. These tools offer a range of techniques for visualizing data, including tables, bar charts, line charts, bubble charts, and histograms, among others. The Information Visualization community has been engaged in an ongoing debate about improving data visualizations, leading researchers to investigate various methods over time [79].

In recent years, narrative¹ data visualizations were proposed to present data in a story-like form that may improve data understanding. In a seminal work, Segel and Heer [111] reported a design space for narrative visualizations that comprises three dimensions: genre, visual tactics, and narrative structure tactics. Each dimension presents features to assist designers in telling stories with data (a.k.a. storytelling).

Within the topic, many studies explored different perspectives to convey stories, such as visualization techniques and design patterns for narratives [6, 116], or they overviewed characteristics of telling stories with data [10]. In addition, some studies explored other media² to deliver the narratives. For example, Lee et al. [81] explored settings such as wall displays, smartwatches, and Virtual Reality (VR) and Augmented Reality (AR) headsets.

These different forms of conveying stories offer affordances for building narratives. However, it is commonplace that presenting data in a way that people can easily understand requires choosing the proper visualization techniques and methods, regardless of the medium used [133]. As such, thinking about ways designers can create stories from data is becoming more important.

The visualization literature has already addressed the subject of transforming data into visual narratives. Lee and colleagues [83] discussed this process and the ethical concerns of narratives. They outlined the steps of discovering insights, transforming them into a narrative, and effectively conveying that narrative to an audience. Most recently, Zhang and colleagues [133] proposed a framework to assist designers in preparing visual narratives comprising steps like planning the message, composing the information units, and mapping them to visual aesthetics. Throughout the work, the authors showed how they mapped data into visual representations that assembled a story.

¹Series of events, facts given in a certain order [111].

²In this paper, we refer to media as the channel or tools used to deliver the story.

Both beforementioned studies focused on approaching the development of narratives from the designers' perspective. They lack studies investigating how end-users (the viewers) of this content experience a narrative visualization from the very end-user perspective.

In this sense, supporting viewers interacting with narrative data visualizations is also as important as supporting designers in developing them because viewers, the end-users of visualizations, are essential in the visualization ecosystem as they are the intended audience for designers. As end-users of visualizations, they have varying needs and preferences in how data is presented or organized. Therefore, they require applications that enable them to adjust the presented information to meet their needs.

In this scenario, End-User Development (EUD) emerges as a feasible research topic to be aggregated into data visualization. EUD is a research topic formally defined as a set of methods, techniques, and tools to allow end-users of software that are not professional developers, at some point, to create, modify, or extend the software to their needs [84]. Users' actions in EUD can be categorized into customization or modification. The former encompasses activities to choose predefined system behavior. Whereas the latter encompasses actions that allow users to create or modify the software.

Blending narrative data visualization and EUD may offer a research path to developing data visualization where the end-users can explore the data and customize the narrative to a specific context of use.

In this thesis, we followed this path. Throughout the next chapters, we will address fundamental studies we conducted. As the main result of our journey, we developed an approach to assist designers in planning narrative data visualizations with customization features, which we call customizable narrative data visualizations.

The remainder of this chapter is organized as follows. Section 1.1 presents our goals. Section 1.2 shows our research design. Finally, Section 1.3 shows how the chapters of this thesis are organized.

1.1 Goals

This research aims to support information visualization designers in planning customizable narrative data visualizations. In this pursuit, we will create an approach that enables designers to identify key narrative elements and define customizable features for the visualization.

The specific goals are defined as follow:

- understand the EUD environments in the context of software design;
- recognize the state of the art of narrative data visualizations;

- understand how visualization designers employ exploration techniques to design a narrative;
- define an approach to support designers in planning customizable narrative data visualizations;
- investigate how the process support both designers and end-users of narrative data visualizations.

1.2 Research roadmap

We structure our research into four stages. In the first one, **Understanding the problem**, we conducted studies addressing EUD and narrative data visualization. In the second one, **Exploring the potential solutions**, we explored aspects of customization in narratives and triangulated the results obtained. In the third, **Defining the narrative approach**, we explored and identified the significant elements of our process to assist designers of narratives. Finally, in the last stage, **Applying the customizable narrative process**, we conducted user studies to design and explore customizable narrative data visualization models. Figure 1.1 shows our research roadmap.

1.3 Thesis Structure

We organized this work into six chapters. Following, we briefly describe the five remaining chapters.

- **Chapter 2** presents the background of our work. The topics addressed in this Chapter are End-User Development (EUD), and Narrative Data Visualization. Finally, we also point out some initial remarks on our contribution.
- **Chapter 3** addresses the studies we conducted to transform data into a customizable narrative data visualization. First, we present a study investigating the exploration in narrative data visualizations. We then address the customization in such visualizations. Finally, we present how we defined the elements of our process.
- **Chapter 4** presents the studies where we applied the customization narrative process. We present two studies: the first aimed to plan a customizable data visualization attended by data visualization researchers; the second dedicated to exploring customizable narrative data visualizations attended by end-users.

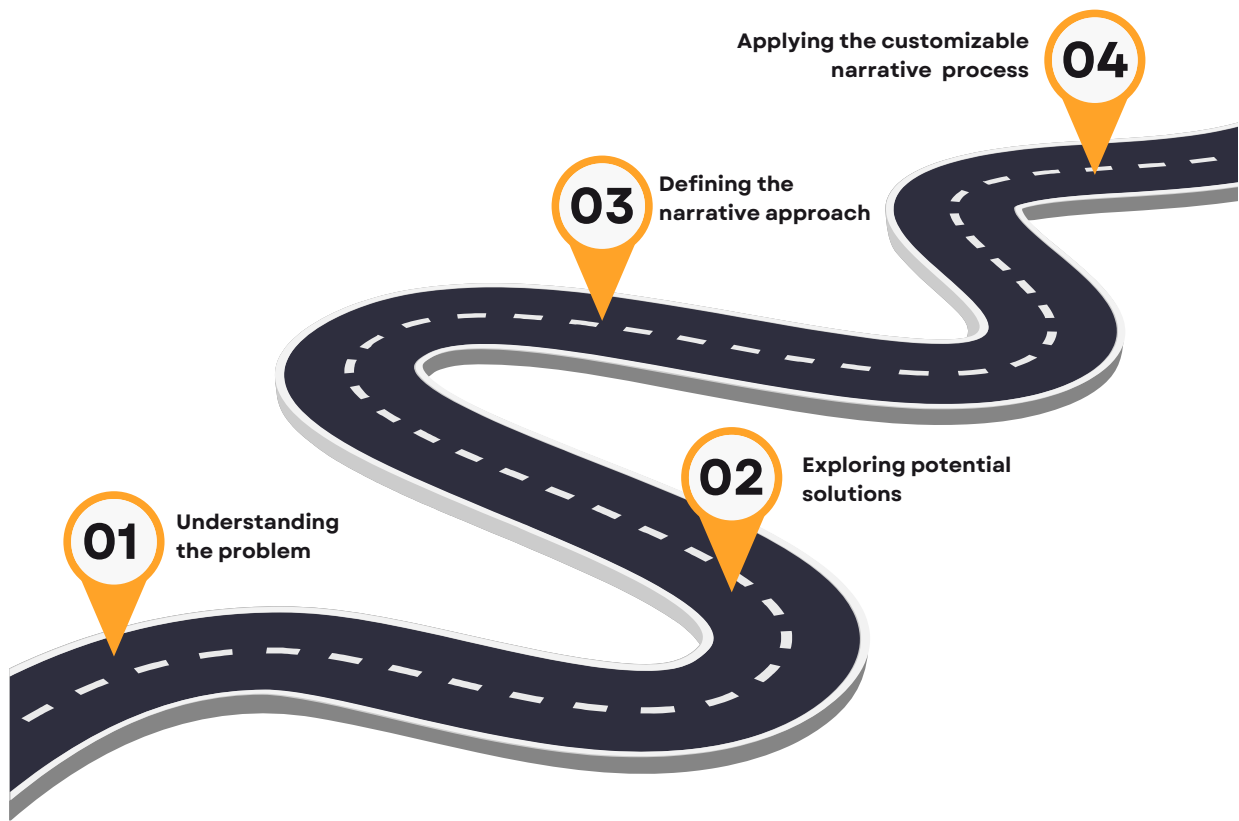


Figure 1.1 – Research roadmap

- **Chapter 5** points out the general discussion over our approach by discussing two instantiations of our process and showing application examples.
- **Chapter 6** presents our final remarks, research contributions, future works, limitations of our research, and the academic journey traversed during the Ph.D. period.

2. BACKGROUND

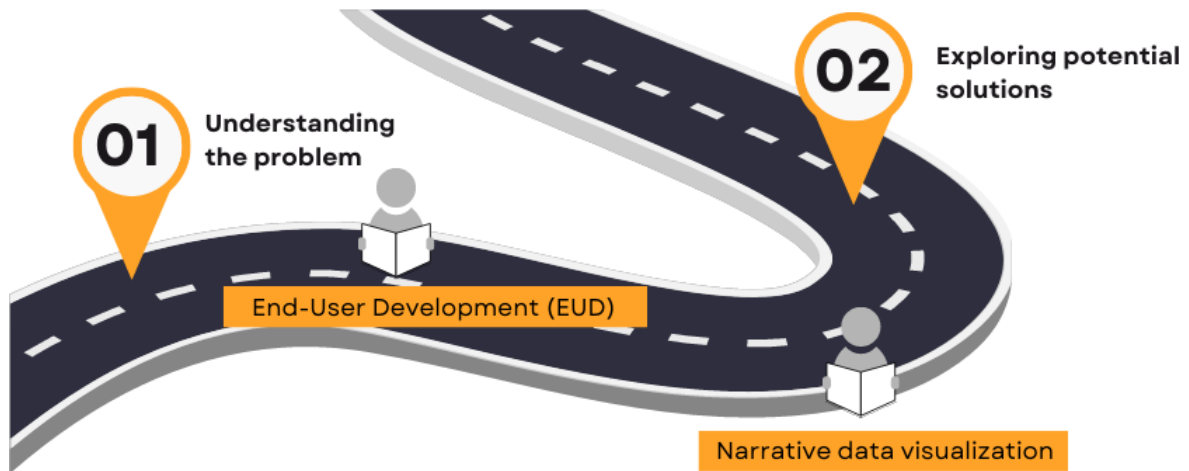


Figure 2.1 – First stage of the research

In this chapter, we are at the first stage of our journey (Figure 2.1 illustrates our location). So, we present the significant concepts that underpin our research. Section 2.1 presents End-User Development (EUD) and the main ideas that underlie this topic. Section 2.2 addresses narrative data visualization and compares this type of visualization to some traditional data visualization techniques. Finally, section 2.3 provides reflections on the relations between the concepts presented. This section sheds light on ideas that aided us in the conception of our contribution.

2.1 End-User Development

As a general goal, the software aims to meet users' needs from a specific domain. Hence, one of the development teams' tasks is gathering information to meet these needs. However, it is well-accepted that new demands may arise during the applications' usage as users get familiar with their resources [54]. So, naturally, collecting information from stakeholders can only handle some demands at first. As a consequence, the system must evolve to follow new needs.

The situation above sheds light on the need to consider software development in which the end-users can perform actions to make their applications fit their new demands. Over the years, researchers have studied approaches to empower end-users to perform meaningful actions, such as tailoring their software. In this work, we assume tailoring as defined by Kahler and colleagues [75]. They described tailoring as the term for modifying an application to meet the user's context.

The studies addressing this subject refer to End-User Development (EUD). EUD is a topic within Human-Computer Interaction (HCI) formally defined as a set of methods, techniques, and tools to allow software users who are not professional developers to create, customize, modify, or extend the software at some moment [84]. In the nineties, Nardi [95] coined the end-user programming term to describe a set of advanced activities with which users can get involved when using their software.

At this point, it is helpful to distinguish software customization from software modification. Lieberman and colleagues [84] defined these terms as follows. Software customization encompasses activities that allow users to choose predefined system behavior. Examples of customization include changing the color font, type, or other properties. These changes can occur through an explicit user action or a system response to a user action, such as in responsive applications. On the other hand, software modification involves actions that imply creating or modifying the software. Visual programming, programming by demonstration, macros, and script languages are examples of this category.

Another aspect of EUD involves the learning cost of a programming language and its scope of use. Figure 2.2 shows a mapping where the cost and scope range from high to low. In this mapping, Fischer et al. [56] showed that languages such as Java and C++ are set with a higher scope and cost of learning. The EUD ideal context is the one that combines the high scope and low cost of learning.

		Cost of learning	
		High	Low
Scope	High	Java C++	EUD ideal Excel macros
	Low	Domain engineering languages Hardware design	Office applications Domain-specific languages Customization Adaptation

Figure 2.2 – Learning cost of programming languages. Adapted from Fischer et al. [56]

The research evolution led to a distinction among the different concerns in end-users activities once they are unaware of software development. Thus, they are not expected to replace system programmers or software engineers. Hence, this maturity raised End-User Programming (EUP) and End-User Software Engineering (EUSE) as correlated fields.

EUP encompasses activities that involve users in computer programming. So, it relates to the ideas proposed by Nardi [95]. EUSE, in its turn, focuses on software quality guarantee procedures [77]. Thus, its focus is on applying software engineering approaches to end-user activities. EUD has taken a broader meaning, covering methods, situations, and social-technical environments to empower users to craft software artifacts and be independent of high-tech scribes [54].

The research on EUD addressed a variety of subjects in the course years. In addition, it attracted many researchers worldwide to collaborate to evolve the topic. We identified the significant trends that emerged from EUD research from 1997 to 2020 [30]. This work identified four trends named emerging needs for tailoring, designing of tailorable systems, EUD environments, and broadening EUD concepts. Figure 2.3 shows the trends identified and the important topics that emerged in each of them.

Emerging needs for tailoring	Designing of tailorable systems	EUD environments	Broadening EUD concepts
2000 - 2004	2005 - 2009	2010 - 2014	2015 - 2020
Tailoring as collaboration Direct activation Design for change SSW methodology Meta-design	Performance of EUD systems UI patterns to support tailorable systems Diversity of participants in EUD environments Meta-design guidelines	Interface models for runtime adjustments Culture of participation Mashups applications E-government applications EUD activities and roles taxonomy	EUD for IoT devices EUD and Progressive Web Apps System properties valued by end-users Meta-design for games development

Figure 2.3 – The four periods of EUD studies. Source: Correa and Silveira [30]

The first period, **Emerging needs for tailoring**, shows that researchers were working to determine the purpose of tailoring actions, develop methods for users to customize their applications, and inform them about the available tailoring functions.

Developing applications with customizable capabilities was necessitated by the inability to collect all user requirements during the design phase. Additionally, technological advancements have opened up new avenues for user engagement and application development by designers.

A shared vision from this trend is that the distinction between users' and developers' roles started to get blurred due to ongoing changes in the relationship between users and applications and users and content. However, the authors noticed that although users could perform meaningful activities, they would likely refrain from engaging in programming activities. Hence, tailoring was said to encompass actions to modify the system during its use by means that do not involve writing codes [94].

The second period, **Designing of tailorable systems**, highlights various issues related to systems with tailoring capabilities, focusing on technical aspects and stakeholder communication. The goal of an EUD-like application is to enable users to adapt

systems at a level of complexity suitable to their skills, transitioning from easy-to-use systems to easy-to-develop ones [84].

Regarding approaches to enable end-users to adapt their applications, one work in this trend investigated design patterns suitable for tailoring user interaction activities. Baranauskas and Neris [7] presented 13 design patterns addressing situations where one may want to extend or adapt the application to some particular context.

In a similar vein, Dittrich et al. [43] reported five tech aspects that system developers must be aware of when developing software with customizable features. They are usability, deciding what parts of the system must be adaptable (and how to design for it), system performance, software engineering for end-users, and how the software development changes with tailoring.

Concerning the diversity of users involved in EUD, Fischer et al. [58] and Costabile et al. [37] established frameworks that describe the different types of participants developing and designing the tools they use. Similarly, Costabile et al. [35] addressed the communication among different stakeholders engaged in such environments.

The trend of **EUD environments** involves studies aimed at creating software solutions that are more flexible and user-friendly. This trend also includes studies on developing EUD environments for web and mobile applications and exploring the different roles and activities of end-users.

The works generally concern mashups and domain-specific solutions, e.g., e-government services. Regarding the issues dealt with, the tools try to approach communication gaps pointed out by Costabile et al. [36] or the system congruence in tailorable tools addressed in the second trend.

Regarding the actions a user can commit when conducting tailoring activities, Cabitza et al. [19] proposed a taxonomy that specializes EUD into inward EUD and outward EUD. Inward and outward specializations encompass situations where users tailor artifacts for a community they also belong to or external communities, respectively.

In the last period, **Broadening EUD concepts** expanded concepts related to EUD, addressing EUD-like approaches for Internet of Things (IoT) and web applications and presenting some improvements in mashup applications development.

Fischer et al. [54] reviewed studies employing the meta-design framework in the range of ten years. They also investigated meta-design implications supporting different domains. Concerning other mashup tools, Desolda et al. [40] presented the EFESTO platform that distinguishes it from other proposals by considering the end-user mental model for user composition reported in the literature. This approach tries to overcome some mashup difficulties (e.g., complexity of composition paradigm) identified in previous studies.

This period also contains studies investigating EUD and meta-design framework employment to game development [64], website (re)design activities [70], and the trade-offs of enabling users to perform meaningful activities, i.e., customizing, adapting, or creating new digital artifacts [53].

2.2 Narrative Data Visualization

Data visualization is one of the challenges of the Big Data era [20, 63, 100]. Aside from providing an enhanced comprehension, good data visualizations may engage users in further exploring the data once they can analyze them within a meaning [67, 69, 124, 125].

A visual representation takes the viewer to novel insights, allowing them to compare and observe patterns [69]. The variety of data visualization techniques is large: tables, bar charts, line charts, and bubble charts, among others, are some examples of most traditional techniques that can be used as standalone or combined, aiming to raise particular interpretations of data.

To make these interpretations, data analysts employ data visualization tools that make it possible to build dashboards whose primary goal is to explain a specific point or discovery. Although these dashboards are helpful in examining the data, they usually require some expertise and data literacy to be utilized [48]. Thus, researchers began exploring alternatives for data visualizations to smooth the interpretation learning curve of the dashboards.

Considering that humans have used stories to convey information, many authors started to investigate the use of storytelling as a way to improve users' engagement, interaction, and comprehension from data visualization [12, 41]. Indeed, blending narrative with data visualization has been an effective way of giving meaning to the data [49]. Furthermore, employing narrative elements in data visualization can offer ways to explain specific subjects not reached by traditional techniques.

According to Zhang and colleagues [133], narrative visualization differs from regular data visualization in specific phases while developing the visualization. For example, in regular visualization, the visual choice is based on the characteristic of variables, whereas the narrative involves defining information units and a narrative structure to the visualization.

Regarding this structure, in a seminal study, Segel and Heer [111] characterized the components involved in narrative visualization. Throughout the analysis of 58 case studies from online journalism, blogs, videos, and visualization research, they organized the design space of narrative visualization into three dimensions: **genres, visual nar-**

rative tactics, and **narrative structure tactics**. Each dimension comprises resources that together aid the storytellers¹ in conveying a message.

In the first dimension, Segel and Heer [111] identified seven **genres** for narrative visualization: magazine style, annotated chart, partitioned poster, flowchart, comic strip, slide-show², and film/video/animation. Essentially, they hold ways to organize and present information to viewers. They primarily vary in terms of the number of frames, i.e., the number of different scenes, how they can be applied to represent time and space, and the ordering of visual elements. By organizing the information differently in the space, these genres also influence how a user can explore a narrative. For instance, whereas a slide-show follows a linear path, a partitioned poster tends to present a loose reading ordering. An important aspect of the genres is that they are not mutually exclusive; thus, they can be combined to convey more complex narratives.

Figure 2.4 shows the seven narrative genres identified by Segel and Heer [111]. The upper right side of each genre contains its identification. The partitioned poster is characterized by having multi-view visualization. There is no constraint to arranging these views, i.e., they can have the same size or vary if some information must be emphasized.

The slide-show is described as having different visual scenes of the story combined with a progress bar to indicate the length of the visualization. The annotated chart is characterized by having a single visualization aided by annotations that explain and highlight the points of the story. The comic strip resembles traditional comic strips, with multiple frames containing texts or images that tell the story. The flowchart usually describes a process flow, a hierarchic structure, or other information that can be shown as a flow. The magazine style resembles a magazine structure containing images and texts to convey a story. Finally, the film/video/animation is used in cinema, tv, and other mediums suitable for this content.

The second dimension, **visual narrative tactics**, concerns visual mechanisms that assist and facilitate the narrative. This dimension is organized into three categories: *visual structuring*, *highlighting*, and *transition guidance*. *Visual structuring* refers to mechanisms that communicate the structure of the narrative, such as a progress bar, checklist, or progress tracker. *Highlighting* refers to devices that direct the viewer's attention to particular elements in the story, such as color, size, or motion. Finally, *transition guidance* concerns mechanisms for moving between visual scenes, such as animated transitions, without disorienting the viewer.

The third dimension, **narrative structure tactics**, comprises non-visual mechanisms that assist the narrative. This dimension is also organized into three categories: *ordering*, *interactivity*, and *messaging*. *Ordering* refers to the ways of arranging the path

¹The term storyteller in this work means a designer building a narrative visualization.

²In this work, we use slide-show to refer to the narrative genre and slideshow to refer to the model of narratives.

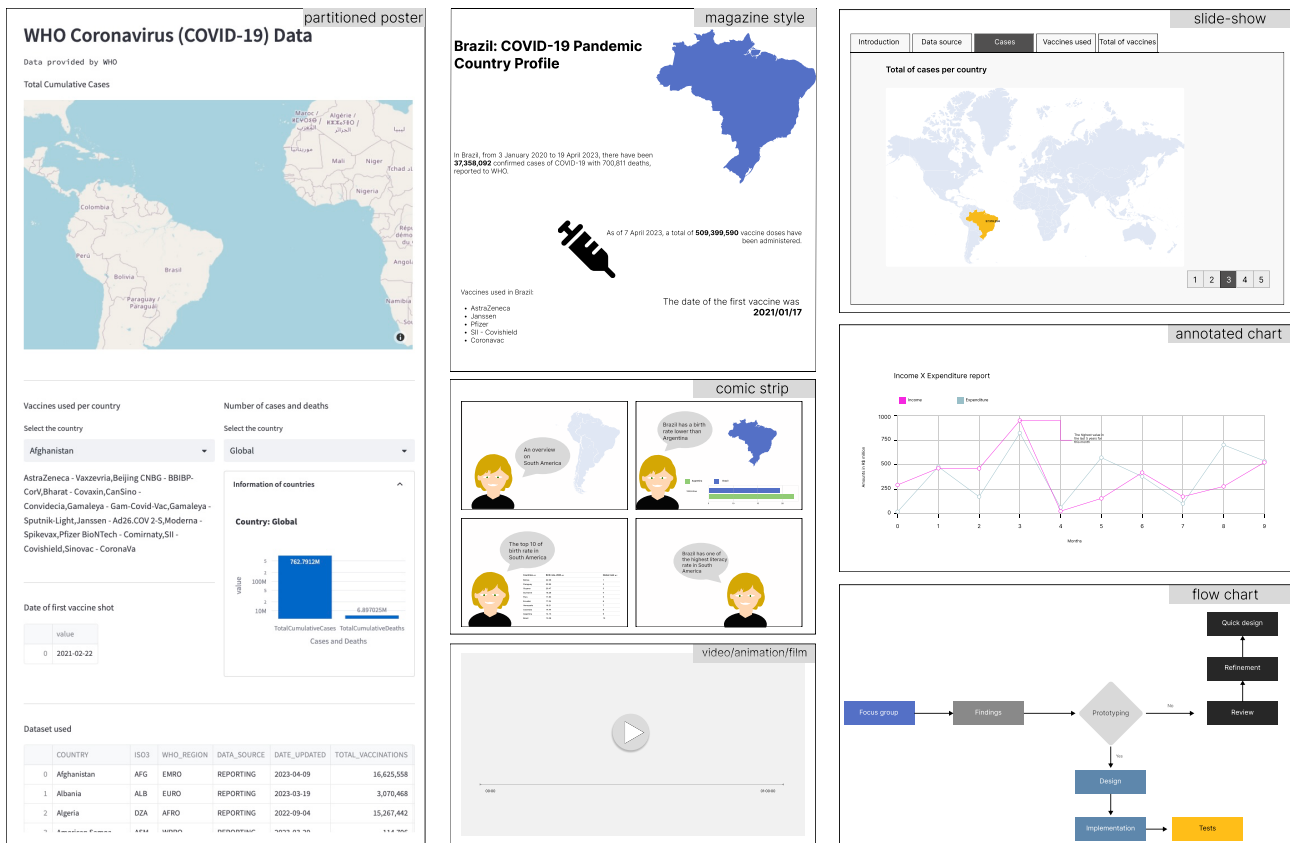


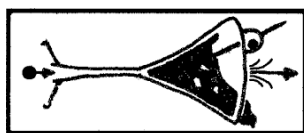
Figure 2.4 – The seven narrative genres

taken through the visualization. The author can describe this path (linear): it can be random when a path is suggested (random access), or the user can select a path among multiple alternatives (user-directed). *Interactivity* refers to different ways a user can manipulate the visualization, such as filtering, selecting, or searching. Finally, *messaging* refers to how a visualization communicates observations and commentaries to viewers, such as labels, captions, headlines, or annotations.

Also, according to the authors, narrative visualization differs from the concept of telling history [111]. Text or video histories usually show a sequence of events and progression. In contrast, data visualization is similar because it can be organized in a linear sequence but offers interactivity, which can instigate one to seek alternative explanations.

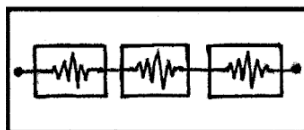
In addition to this design space, Segel and Heer [111] defined models to balance narrative visualizations between *author-driven* and *reader-driven* approaches. According to them, a purely author-driven approach has a linear path that relies heavily on messaging and has no interactivity. On the other hand, a reader-driven approach has no prescribed ordering of images, no messaging, and a high degree of interactivity. Figure 2.5 presents these models.

Following the studies in the field, Hullman and Diakopoulos [71] explored the rhetoric in narrative visualization and how it frames the data to convey a particular message. Their work presents a framework that organizes the discussion into two dimensions:



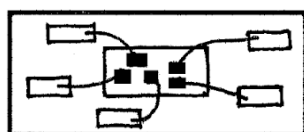
Martini glass structure

This structure is an approach where the author creates a single-path narrative using text, questions, or annotations. After this stage, the reader can interact with the data, explore different paths, and explore the story. This structure resembles a martini glass, with the stem as the author's narrative and the widening mouth as the reader's interactive exploration. This structure is commonly used in interactive visualizations and mixes both author and reader-driven approaches.



Interactive slideshow

This structure is a format that incorporates interaction within each slide of a typical slideshow presentation. It allows users to explore particular points of the presentation before moving on to the next stage. This model provides a balanced mix of author-driven and reader-driven approaches and works well for both complex datasets and narratives.



Drill-Down story

This structure presents a general theme and allows users to choose among particular instances of that theme to reveal additional details. So, it emphasizes the reader-driven approach, allowing the user to determine what stories are told and when. However, significant amounts of authoring are still required to determine possible types of interaction, candidate stories to include, and details for each story.

Figure 2.5 – Models of narrative. Adapted from Segel and Heer [111]

editorial layers and **rhetoric techniques**. The former dimension comprises four layers used to convey meaning: data, visual representation, textual annotations, and interactivity. These layers represent the visual representation of the information that viewers have access.

Combined with this visual representation, the storytellers can employ specific rhetoric techniques from the second dimension to prioritize certain interpretations. The authors have identified techniques such as omitting or informing data provenance, representing uncertainty, obscuring results from visualization, and using contrast, emphasis, metaphors, classification, and metonymies in the second dimension.

Kosara and Mackinlay [79] overviewed narrative visualizations and observed that this research involves other fields beyond computer science, such as psychology and social sciences. Their contribution is to provide a broad perspective about the research directions regarding storytelling approaches and affordances, evaluation, how to make the visualization memorable, annotations and highlights, interactivity, and what to learn from other disciplines.

Narrative visualizations aim to make information accessible and engaging [83]. It's important to note that visualizations, whether narrative or not, can offer both explanatory and exploratory capabilities that enhance communication. In this pursuit, Thudt and colleagues [119] identified three exploratory layers for narrative visualization: view, focus, and sequence along which exploration can vary. Flexibility in these dimensions lets readers exploit how the data is displayed, change the subject of the narrative, and adjust

the information order. Techniques such as filtering, selecting, zooming, and panning can be used to provide flexibility in focus and sequence layers.

The *view* can be flexible by allowing users to manipulate how the data is arranged in the visualization. The designers can also provide multiple separate views, coordinated views, and animated transitions to provide flexibility in this dimension. The *focus* can be flexible by allowing users to filter, select, and zoom the visualization. The visualization must offer sufficient data so the readers can choose their focus to make it possible. The *sequence* can be flexible by allowing users to determine order or aspects of order. Examples of techniques are scrolling forwards and backwards, or next and back buttons.

Regarding this topic, we ran a systematic review to identify fundamental elements for telling stories with data (see Borges and colleagues [10])³. Our study revealed the most commonly used genres, tools, and application domains. Slide-shows, comic strips, and annotated charts were found to be the most used genres. Storytellers often use D3.js, Tableau, and Adobe Illustrator as tools to create narratives. As for application domains, examples included culture, education, journalism, and Open Government Data.

In order to deepen the understanding of narrative visualizations, Borges [11] investigated how the genres proposed by Segel and Heer [111] are composed. She described the genres as a structure composed of components. These components, in their turn, contain texts, images, visualization techniques, and even other genres. Besides, a component can contain more than one element.

According to this component characterization, the genres can be single or multi-component. For example, genres such as magazine style, flowchart, and annotated charts are defined as a single component genre. On the other hand, genres such as partitioned poster, comic strips, and slide-show are recognized as multi-component. In addition, she identified how other researchers used the genres in terms of interactivity. Thus, she found that genres partitioned poster, annotated charts, and slide-show were commonly used to include interactive features. The other genres described in the literature were typically non-interactive. Table 2.1 summarizes these findings.

In the context of this thesis, we will base the tailoring behavior of narrative data visualization genres (Segel and Heer [111]) on the component structure proposed by Borges [11]. In addition, once we are considering narratives where the end-user can customize the content, we will focus on the three interactive narrative genres, i.e., partitioned poster, annotated chart, and slide-show.

³The protocol of this study can be found in Appendix A

Table 2.1 – Characterization of narrative genres by Borges [11]

Genre	Structure	Can contain	Interactivity
Annotated chart	Single component	-	Yes
Comic strip	Multi-component	-	No
Flowchart	Single component	-	No
Magazine Style	Single component	Annotated chart Flowchart	No
Partitioned Poster	Multi-component	Magazine style Annotated Chart Flowchart	Yes
Slide-show	Multi-component	Magazine style Annotated chart Flowchart Partitioned poster	Yes

2.3 Considerations about this chapter

The approach presented in this work is based on narrative data visualization and EUD concepts. Regarding our studies on EUD, we explored the design patterns for flexible user interaction to investigate how they could assist end-users in tailoring a narrative visualization. Considering our studies on narrative data visualizations, we explored the design space proposed by Segel and Heer [111], i.e., genres, visual tactics, and narrative structure tactics. In the case of genres, we adopted the perspective that they are organized as a structure of components containing visualization techniques or even other genres [11].

Data visualization researchers have already considered the process of transforming data into stories. Lee and colleagues [83] discussed this process, considering the steps of finding insights, turning the insights into a narrative, and communicating to an audience. Most recently, Zhang and colleagues [133] proposed a framework to assist designers in preparing visual narratives considering the steps of planning the message, composing the information units, and mapping them to visual aesthetics. Their contributions are valuable in the scope of structuring a narrative. However, our work differentiates by adding customization features to this process of transforming data into narratives, enabling end-users to explore personal goals in narrative visualizations.

3. TRANSFORMING DATA INTO CUSTOMIZABLE NARRATIVE DATA VISUALIZATION



Figure 3.1 – Second and third stages of the research

In this chapter, we reach our journey's second and third stages. Figure 3.1 illustrates our location. Throughout our route, we conducted user studies and studies in collaboration with other researchers (represented by icons with three people on the road). First, in Section 3.1, we present a focus group conducted with data analysts to investigate the employment of exploratory structures and genres in narrative visualizations. The results of this focus group represent steps toward decisions taken to raise our proposal. Section 3.2 presents the design space adopted for the customization of the narratives. We based our design space on design patterns for customizable interfaces [7] that best fit data visualization and the perspective of narratives genres as a structure of components proposed by Borges [11]. Finally, Section 3.3 describes the iterations we performed to outline the process to assist designers in planning customizable narrative data visualizations. In this creation process, we linked the previous results obtained from our research to hands-on activities of a project we participated in as a visiting graduate research student at Dalhousie University, Canada.

3.1 Exploration in narrative data visualizations

In this part of our research, we investigated how designers employ narrative genres and exploratory features to provide users with alternatives to explore the narrative designed. By exploratory features, we mean interactive elements in the narrative that enable the users to customize what is being shown or select other data to display or customize other aspects of the narrative. In addition, we aimed to understand how participants of the study perceived the narrative elements under the view of providing flexibility to narrative. This study was based on the narrative genres presented by Segel and Heer [111] and the exploratory layers depicted by Thudt and colleagues [119].

We chose the focus group methodology^{1 2} due to its usefulness in raising diverse issues and enabling participants to put forward their perspectives [113]. Moreover, it is suited to obtaining initial feedback on new concepts and generating ideas [78].

3.1.1 Study design

A total of six participants attended the focus group. Table 3.1 shows the participants' identification, gender, position, and years of experience they have with data visualization. The sample was defined by convenience.

Table 3.1 – Focus group participants

Participant	Gender	Position	Experience
P1	M	Software Developer	5
P2	M	Researcher	5
P3	M	Software Developer	2
P4	F	Researcher	2
P5	F	Data Analyst	5
P6	M	Researcher	4

The participants show a diverse background in data visualization regarding the activities they have experience in and the years of experience reported. Half of the participants work in the IT industry, developing data visualization solutions for a large variety of purposes. The remaining participants belong to academia and conduct research in data visualization.

We organized the focus group in rounds of activities and discussions. The session encompassed five tasks and three questions concerning the tasks plus two closure ques-

¹The reader is referred to Correa and Silveira [31] for full access to the outcomes of this study.

²Project number 54348321.1.0000.5336 approved by Ethics Committee (CEP/PUCRS)

tions. The data used in the activities were retrieved from Our World in Data³. Before we proceed to the first round, we explained the general goals of our study and required all participants to read and sign the consent form. The first round consisted of questions to map the participants' profiles. Following, we presented the significant concepts regarding exploratory narrative visualizations. Then, we proceeded to the round in which we explained the tasks proposed. The participants had about 50 minutes to perform the group activity. Finally, they discussed four questions regarding their perception of the exploratory narrative concepts and how they could provide readers with customizable resources during the interaction.

We held the session remotely because in-person activities were not reestablished on the scheduled date. Besides allowing us to invite participants from other cities and states, the remote study allowed us to reach a more diverse participants profile. This aspect would be more challenging if we conducted the study in person once it may require participants' dislocations to the place of the study. We used Zoom⁴ for the remote meeting and Figma⁵ for the activities to conduct the session.

The audio and video interaction of the session were recorded for analysis purposes. To analyze the results, we employed thematic analysis, which is a suitable approach to identify, analyze, and find data patterns [14].

We organized the Figma into five layers. Four of five contained resources to plan the narrative. We named them as *visual structure*, *visualization techniques*, *exploratory layers*, and *dataset*. The fifth layer was the *narrative' design*, in which we put the participants' choices for the narrative' design as they spoke aloud their design decisions. Figure 3.2 shows the process of designing a narrative.

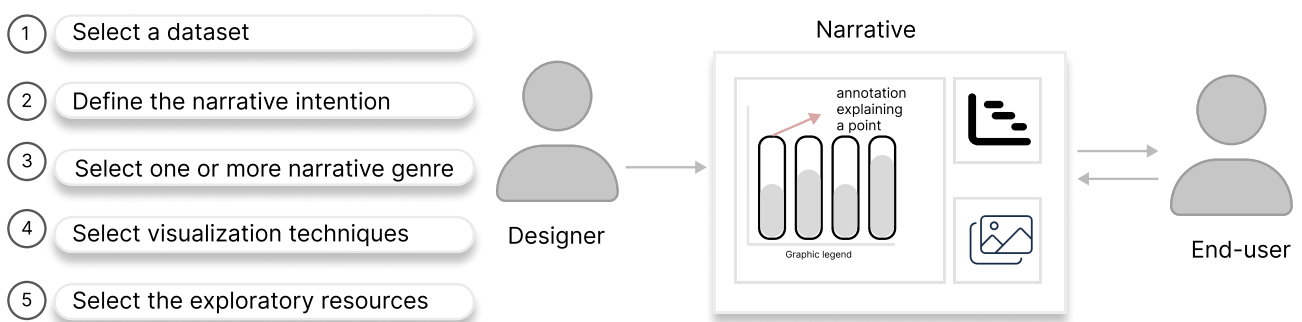


Figure 3.2 – Process of designing narrative data visualizations with exploratory techniques.

Following, we present the tasks performed by participants:

T1: Define an intention for the narrative considering the dataset presented;

³<https://ourworldindata.org/>

⁴<https://zoom.us/>

⁵<https://www.figma.com/>

T2: Pick up one or more narrative data visualization genres;

T3: Pick up visualization techniques to show the data selected;

T4: Considering the narrative built and the exploratory layers and techniques, define what resources will be employed to provide readers with forms to experience the narrative from other perspectives;

T5: Justify the choices.

After achieving the above tasks, the participants were asked to talk about the following topics:

- Perceptions about data visualization and narrative data visualization;
- Perceptions concerning exploratory narrative visualizations;
- How the narrative genres could provide users with different perspectives of a narrative;
- Interactions techniques that can be used by designers to create exploratory narratives.

The closure questions addressed the participants' opinions of the readers' skills required to interact with a narrative data visualization and if they had any additional contributions to the topic. In the next subsection, we present our results.

3.1.2 Results

We categorized our findings into four topics: the use of exploratory layers, providing readers with explicability facilities, the relation between narrative genres and exploratory layers, and the narrative's target public. The topics summarize the participants' comments during the focus group.

The **use of exploratory layers** addresses participants' opinions about how they could use the three layers (focus, view, and sequence) to tell a narrative. From the three layers presented, P3 and P6 choose the *focus* and *view*. In addition, P6 enhanced that the layers can be combined once they complement one another. In this wake, P3 said that using two or more layers is more appropriate. According to her, it provides the end-users with more information. On the other hand, P5 commented that even though the layers can be combined, there are situations in which they cannot be used. For example, regarding the narrative built, they chose the partitioned poster and annotated chart genres. In her

opinion, these genres could not be used with the sequence layer. In addition, these genres can be combined with more broad ones, such as the slide-show genre.

Regarding the layers, P2 added that the sequence could be used for the cases in which the designer realizes that it is better to split the narrative into separated points. Moreover, for P2, the layer focus is the foremost opportunity to dive the end-user into the narrative.

Concerning the conceptual meaning of the layers, P1 asked the other session participants what they understood as the sequence in a narrative. He asked whether a slider allowing the readers to explore data evolution over time could be considered to belong to the sequence exploratory layer. P5 replied, commenting that the sequence fits the situations in which the slide-show genre is employed, i.e., the story is organized as a sequence of separated points. P2 reinforced that the interacting technique mentioned by P1 belongs to the exploratory layer of focus.

The **providing readers with explicability facilities** encompasses participants' remarks on the need to aid the end-users while interacting with the narrative. For example, during the narrative design planning, P5 observed that although they have picked up visualization techniques, genres, and other narrative techniques to tell a story, they should consider providing users with explicative facilities. According to P5, these explanations should be placed in specific narrative points or moments. Otherwise, the narrative would become a group of visualizations without relations within a partitioned poster. In addition, P5 added that these explanations should state the initial perspective of the narrative and its intent. Then, while interacting with the exploratory resources, the readers would be able to compare the initial narrative state with the one he/she reached after the exploration.

Following the debate, P3 inquired how these explanations would be shown within the narrative, i.e., whether they form an initial introductory page before the partitioned poster or placed in the partitioned poster themselves. P5 replied that these explanations should appear altogether the other information in the visualization. The idea behind it is to provide end-users with the narrative context. Therefore, these explanations should be fixed in the partitioned poster to maintain the narrative context and intent. In other words, it means that the remaining partitioned poster information will be updated by readers, except the explanatory ones. P6 agreed that these explanations should contain generic information to instigate the readers' inferences.

The **relation between narrative genres and exploratory layers** contains participants' reasoning about how the genres could be matched to exploratory layers. In this sense, P6 commented that the layers of focus and view were more suitable to the genre (partitioned poster) they chose. In addition, P6 provided a counterexample explaining that the layer focus would hardly be combined with a comic strip once this

genre does not allow filtering, for example. P3 agreed that each genre could contain resources from one or more layers or even could not contain any.

The **narrative's target public** concerns about for whom the narrative is being developed. By arguing the importance of the three exploratory layers, P2 highlighted that as essential to define what exploratory resources will be provided is to identify the narrative's target public. Hence, P2 argued that the exploratory layer of the sequence is the most suitable to cover a broader target public once it allows the designer to decouple the narrative into different parts that support the story. By adopting this strategy, the designer can provide initial information that explains meaningful points, which is interesting for layman readers on the topic.

Regarding this subject, P5 mentioned users' data literacy area, a topic aimed at investigating how users understand data visualization. She said that, to her knowledge, no research seeks to investigate the users' literacy regarding narrative techniques. In addition, such research would provide the designer with information to assist the decision-making process of planning and designing a narrative. P2 complemented P5 speech adding that the designer is responsible for guiding the reader through the story. Due to this, the designer should not expect any reader's training on the topic but interest. P3 highlighted the study required to identify such required training. Because even whether the visualization is made as simple as possible, it is impossible to infer that it will reach users' expectations.

Table 3.2 presents what the participants chose during the session. For example, to convey the story they selected the partitioned poster and annotated chart genres.

Table 3.2 – Participants choices

Task	Choice
Select a dataset	Worldwide Education Expenditure
Define the intention	Budget per capita and childhood education per country relation
Select the genres	Partitioned poster and annotated chart
Select the visualization techniques	Bar chart and drill-down
Select the exploratory resources	Focus and view

3.1.3 Considerations about the study

During the session, the participants engaged in planning a flexible narrative to provide end-users with exploratory resources to allow them to customize to their needs the story presented. Thus, they could experience their story to some extent.

Figure 3.2 shows the process of planning an exploratory narrative data visualization. The designer follows five steps to define how the narrative should appear. At each

step, the designer can select from a bundle of resources which ones he or she wants to use. On the other hand, the end-users take advantage of the exploratory options placed in the narrative to customize their experience.

While performing the tasks, the participants analyzed the possibilities that each genre may provide. Initially, they considered employing the slide-show to build a narrative with the progression of the information shown. The participants' intention was first to introduce some concepts to readers, then let them proceed with the exploration (a *martini glass* structure). However, after a round of arguments, they decided to plan the narrative using the partitioned poster.

The primary reason for this choice is that the participants realized that the partitioned poster is versatile, i.e., it can accomplish one or more visualizations, images, or texts that aid the narrative. Hence, the participants also decided to combine an annotated chart with the partitioned poster to provide users with a visualization containing the explanation of the data exhibit. Nevertheless, the participants lack a structure that informs the readers about the visualization context and the designer's intentions.

Considering this situation, the participants decided to customize the partitioned poster with explainable resources. They assumed that these parts of the narrative should not be updated when the readers change some visualization parameters. By deciding on this characteristic, the participants shed light on the importance of keeping readers aware of the context of the narrative. In this scenario, it may be worth investigating whether aid systems could be employed associated with a partitioned poster to inform readers of the context.

Following the activities, we identified another research opportunity. While defining which layer they would employ to provide narrative flexibility and consequently allow the users to explore the story, the participants justified the choice. They opted for focus and view. Although they recognized the significance of the three layers, they commented that focus and view layers best fit a partitioned poster.

The focus layer provides designers with resources to plan the story to let readers access a particular set or subset of the data shown and the aspects of data that are shown, such as aggregation. In addition, this layer encompasses interacting techniques such as filtering, selecting, and drill-down. Whereas, according to Thudt et al. [119], the flexibility in the view could be reached by providing views that show separately the same data side by side. We can argue that the partitioned poster planned during the focus group naturally accommodates this flexibility once it allows the designer to place visualizations side by side.

According to the participants, the former is essential to provide users with the feeling of an agency concerning the narrative; the latter is essential to provide some interesting interactive resources, such as drill-down. Hence, considering the choices taken,

one perspective is to address studies investigating how the exploratory layers could be combined with the narrative genres.

One significant point raised during the sessions was the end-user profile. As a general assumption, they stated that the designer should not expect technical skills from readers. At this point, we agree with them once one of the primary goals of EUD is to allow users non-skilled to perform advanced tasks. In addition, we can assume that the participants were planning a visualization for users belonging to the same community (inward). Although we cannot take it for granted, this assumption may reduce the cognitive burden required to interact with the visualization.

This study helped us to understand how the exploratory layers can be used to add flexibility to narrative visualizations. We then combined these layers with the design space for the narratives of Segel and Heer [111] in our process. Besides, we considered the suggestion that emerged during the session to add static components to the narratives that account for readers' awareness of the narrative's context and intention.

Finally, as posed by Thudt et al. [119], the designers of the narratives must carefully evaluate whether the readers will engage with an exploratory visualization. It leads us to consider Visual Analytics (VA) methods [9, 68] to evaluate the user interaction with narratives.

3.1.4 Threats to validity

The following points summarize the main threats to the validity of this study and the strategies we followed trying to overcome them.

- **Sampling bias:** Selecting participants for a focus group may not represent the more expansive population of interest. In our study, we sought to select a diverse profile of participants regarding background and years of experience. By doing this, we aimed to capture a widening range of perspectives and experiences.
- **Group dynamic:** Group interactions within the session may influence an individual's responses. The remote session may influence the individual's responses, as well. In our study, we took advantage of lessons learned in conducting studies in remote settings acquired due to the pandemic [28].
- **Results:** The results represent our interpretation of the textual analysis information. To mitigate the interpretation bias, we held meetings among the authors to discuss the analysis produced.

3.2 Customization in narrative data visualizations

In this part of the research, we were interested in understanding and specifying what actions end-users may perform to customize the narrative presented. Hence, to define how the narrative genres can be customized, we anchored our work in the perspective of the narrative genres as structures composed of components [11], in the design patterns for flexible interfaces [7], and in findings from our previous study.

Figure 3.3 illustrates the studies we triangulated to describe the customization in narrative data visualizations. By carrying out this analysis, we defined how to use the design patterns for flexible interfaces to add customizable features to narratives. As a result, we had a set of design patterns associated with each narrative genre.

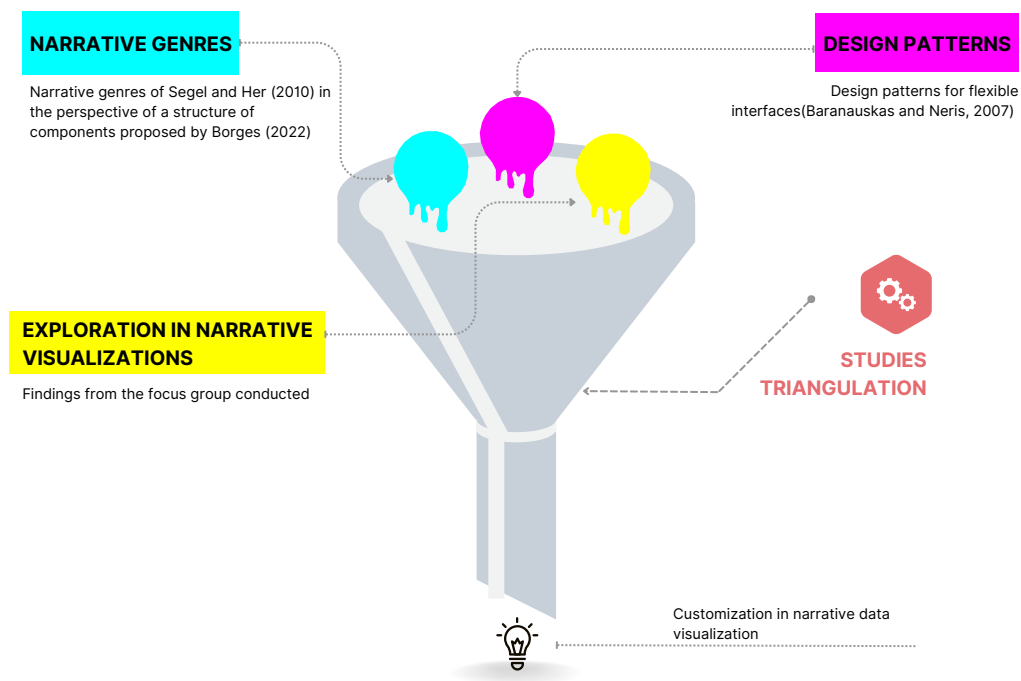


Figure 3.3 – Studies triangulation to define the customization in narratives

Before we present this association, and to improve readers' comprehension of what we propose, we will present the significant aspects of each study we considered to obtain our result.

The first point we analyzed regarding the partitioned poster, annotated chart, and slide-show narrative genres was what type of communicative intention may be reached with them. To perform this analysis, we considered the description presented by Borges [11]. We used this description of the genres to clarify what type of communicative intention can be reached with each one. We also used this characterization to define con-

straints of how the end-users can customize the narrative genres without stepping out of these communicative intentions. Following, we describe this characterization.

- **Partitioned Poster:** This genre allows the designer to simultaneously present multiple visualizations of a narrative once it is a multicomponent genre. It can show a story's different perspectives or diverse information thereof. In this genre, there is no set order that readers need to follow in order to understand the story. Hence, they can explore the narrative freely.
- **Slide-show:** This genre is also a multicomponent one. However, it allows the designer to present the narrative in a determined order by splitting it into tabs. This order may represent a designer's suggestion for the story progression.
- **Annotated chart:** This single-component genre allows the designer to present one visualization from the narrative with annotations explaining essential points of the story. It is useful when designers want to use annotations to explain their communicative intention to readers.

We then expanded this characterization to approach the combination possibilities of the genres designers can make while designing a narrative. We describe it in the following.

- **Partitioned poster + annotated chart:** The combination of these genres permits the designer to display multiple visualizations from a narrative aided by explanations that conduct the users to an interpretation. Thus, this combination enables the user to explore the narrative in a free way (partitioned poster) but also lets the designer place explanations over a visualization to highlight some narrative intention.
- **Slide-show + annotated chart:** This combination allows the designer to develop a narrative with a suggested progression that, at some point in the story, presents one or more visualizations with explanations (annotated chart) that present some designer's point of view.
- **Slide-show + partitioned poster:** This combination permits the development of a narrative that shows the story progressively and, at some point, lets the users explore the narrative freely by showing multiple visualizations through a partitioned poster.

The second point we considered to describe how each genre may be customized is the component structure defined by Borges [11]. We also considered the design space of narratives [111]. Figure 3.4 illustrates the three interactive genres and their components. It is important to note that, in the case of multicomponent genres, the component size

ratio can vary according to the designers' decision. From the left to the right: annotated chart, partitioned poster, and slide-show.

Each component can hold visualization techniques, such as texts, images, charts, or another genre. This characterization enabled us to associate the genres with flexible interface design patterns.

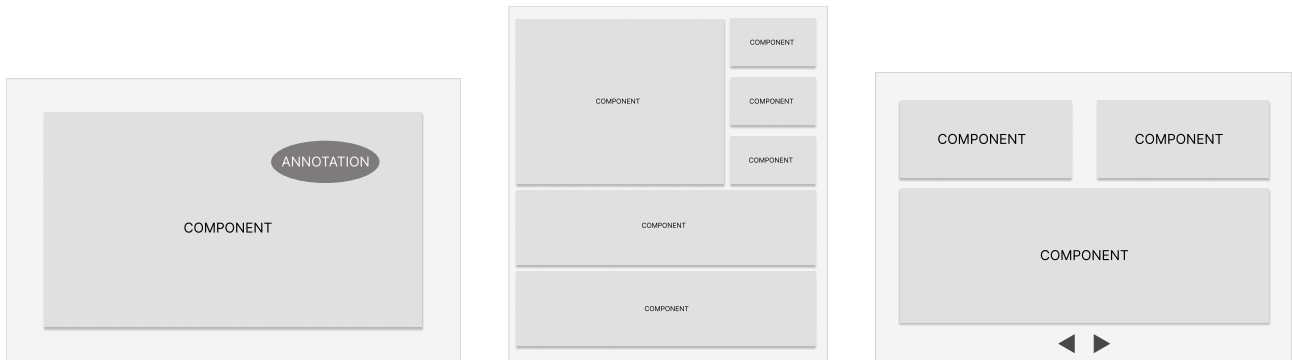


Figure 3.4 – The three interactive genres and their components: from the left to the right: annotated chart, partitioned poster, and slide-show

In the study we conducted to investigate the exploration of narrative visualizations, our findings provided additional strategies to apply to the dimensions of visual narrative and narrative structure defined in the design spaces of narratives [111]. The exploratory layers of focus and view chosen by participants can be associated with the visual narrative and narrative structure.

For example, from the view layer, we can use separate views, coordinate views, or data transformation, i.e., aggregation or normalization, to allow users to explore different visual structures of the story. In the focus layer, we can use zooming and panning and drill down to let the user change the story's focus.

Concerning the design patterns, we selected four suitable for use in combination with the narrative genres, considering their communicative intention and component structure. Table 3.3 shows the design patterns chosen, the problem they address, and the solution.

Table 3.3 – Design patterns related to tailoring [7]

Design pattern	Problem	Solution
Bookmarks	The artifact is large or complex. How can the artifact support the users' need to navigate through it in ways not directly supported by the artifact by default	Let users make a record of their points of interest, so that they can easily go back to them later
Customized Windows	Users want to have personalized content	Users can customize what is displayed in the interface, represented by a set of windows, or take it away
Drag and Drop Modules	The user needs to re-arrange the layout on a web page directly with the mouse	Give to users drag and drop modules
Group and Items	There are two sets of items with many-to-many connections. User typically does not benefit from a generic design showing all the groups where a single item belongs, and all the items that belong to a selected group in the same view	Good solutions to Groups and Items problems depend on the user's goals. Typically, in addition to viewing the groups and items, the user must be able to edit both of them
Master and Instances	User has created several copies of an object. There are two kinds of changes he faces in the future: changes that apply only to this specific object, and changes that apply to all of the objects	User has created several copies of an object. There are two kinds of changes he faces in the future: changes that apply only to this specific object, and changes that apply to all of the objects

Design pattern	Problem	Solution
Movable panels	The page has several coherent interface pieces that do not really need to be laid out in one single configuration; their meanings are self-evident to users, regardless of their location on the page	Let the user move the UI pieces around the page at will. Save the layout for the next time the user resumes using the software, especially if it's an important part of his daily life
Personal object space	There are many things that the user needs ready access to, such as working surfaces, documents, objects, or tools. How should the items in question be organized?	Allow users to place things where they want, at least in one dimension but preferably in two. Start out with a reasonable default layout, however. Permit stacking, moving, grouping, aligning, "neatness" adjustments, sorting, and other layout operations
Personalized 'my' site	Users have a need to define their own page elements	Create a part of the site that belongs to a user and that is controlled by that user. First log in and then present a customized personal section. Usually the pages are built up using 'modules' that the users have selected. Users can change which modules they want and in which layout and graphical presentation
Placeholder	User needs to return to a target directly	The user chooses a single target from a set of data and saves a shortcut (bookmark) to it





Design pattern	Problem	Solution
Pile of items	The user creates objects by picking them from an infinite stack of objects, i.e. the pile that is like a factory producing objects	To create an object, the user either drags it from the pile, or he selects the pile and clicks somewhere, where the object can be created. The pile where the objects come from does not need to be static; the user may edit the properties of the pile to create different kind of objects
Scripted action sequence	The user needs to perform the same sequence of actions over and over and over again, with little or no variability. How can the artifact make repetitive tasks easier for the user?	Provide a way for the user to "record" a sequence of actions of their choice, and a way to easily "play them back" at any time. The playback should be as easy as giving a single command, or pressing a single button, or dropping the action object onto a control of some kind. The user should be able to give the sequence a name of their choice
User Annotations	The artifact is complex and difficult to learn. How can it help users to understand from one session to another	Support ways for users to add their comments and other annotations to the artifact. Besides, allow the users to place those annotations close to where they are needed
User Preferences	How does the artifact present the actions that the user may take	Allow the users to pick up their own setting for things like fonts, and colors schemes

Given the design patterns [7], we analyzed how we could use them to enable end-users to customize the narrative genres. This analysis considered the problem each design pattern intends to solve, the characteristics of each narrative genre from the component perspective, and their potential suitability for data visualization context. For example, the **User preferences** pattern is reasonable for users who want to change the color scheme

of some chart placed in a component. In contrast, **Personalized object space** does not fit into the context of narrative visualizations once the users do not handle different objects they should keep organized while interacting with the narrative, for example.

The same criteria were observed in the other patterns. They were not considered when the problem they aimed to solve did not mirror any potential actions users may perform considering the narrative genres. Table 3.4 shows the association we reached by analyzing this issue. We present the design patterns, the strategy we envisioned, and the target genre. We explain each association made and the user constraints restricting how genres can be customized.

Table 3.4 – Association between the design patterns and the narrative genres

Design Pattern	Strategy	Target Genre
 Bookmarks (creation of labels)	Allow the users to bookmark points of interest in the narrative	Slide-show
 Customized Windows	Allow users to change the events presented in the narrative by customizing the components instantiated	Partitioned Poster
 User Annotations	Allow users to make personal annotations on the visualizations presented	Partitioned Poster Annotated Chart Slide-show
 User Preferences	Allow user to change the scheme color of the charts	Partitioned Poster Annotated Chart Slide-show

The **User Preferences** pattern enables users to change the scheme color of the charts placed in the components of the genres. This feature is available in all narrative genres and can be associated with components of the genres that display information through a graphical representation. Another resource available in all genres is the **User Annotations** patterns. This feature enables readers to make and delete annotations on the information presented. It is essential to highlight that users cannot delete comments made by designers. The annotations made by designers are predefined by default during the development of the narrative.

Following, we have patterns that are available in only one narrative genre. The **Customized Windows** is a pattern available only in the partitioned poster. It allows the users to change the visualizations shown in the narrative for others within the narrative's scope by exchanging the genre's components. It takes advantage of the concept of genres as a structure of components to allow the users to customize what components are displayed. Finally, the **Bookmark** pattern is available in the slide-show genre. It allows users to bookmark points in the narrative. It can be helpful for narratives with a significant

quantity of tabs. An ancillary structure must be created by bookmarking points of the narrative to allow users to access their bookmarks.

As seen in Table 3.4, some actions, represented by the design patterns, are not enabled in some genres. It occurs because constraints emerged while we described the genres' characteristics and the result of each action in the narrative. By making this analysis, we concluded that some actions, if enabled, may lead users to mischaracterize the communicative intention of the designer.

A clear case of this situation occurs if the customized windows were available for genres such as a slide-show or annotated chart. Imagine a situation where the designer enables this resource to the mentioned genres. For example, regarding the slide-show, the user could change the visualization shown in a specific presentation tab. However, the slide-show represents a narrative genre with a presentation order predetermined by the designer. By exchanging the visualizations shown, the user would affect the order predetermined by the designer, causing a mischaracterization of the communicative intention of the narrative. The same is true if we consider the annotated chart. In these cases, the user should not be able to exchange the visualization presented in the narrative for another one.

These relations represent combinations we realized as suitable considering the characteristics of the genres. That said, in cases where the designer combines two or more narrative genres, it is possible to enable the customized window within a slide-show. For example, in light of the proposal of genres as a structure of components, it is valid that a slide-show can hold a partitioned poster in one of its tabs. Thus, the pattern of the customized window would be available in the tab holding the partitioned poster.

3.3 Definition of the customizable narrative data elements

In this part of the research, after we looked into the traits of exploration and customization in narrative data visualizations, we delved into the elements that make up those narratives. We collaborated with researchers from the Graphics and Experiential Media (GEM)⁶ Lab at Dalhousie University, Canada, for six months to conduct this investigation. Our team comprised researchers in Virtual and Augmented Reality, Information Visualization, Architecture, Anthropology, and Human-Computer Interaction, working in a project to capture what aspects are significant for quality in places of education.

We participated in the "Quality in Canada's Built Environment" project during the cooperation. This project is an interdisciplinary effort between researchers aiming to capture what aspects are significant for quality in places of education. These aspects comprise information such as people's personal experiences in physical spaces, architectural

⁶<https://gem.cs.dal.ca/>

details and regulations, and observing people's behavior in building spaces. By capturing these aspects, the researchers envision uncovering features that enhance quality and that shall be considered in future building projects in Canada.

Our team focused on elements of this project that we could use to build narrative data visualization. Hence, we defined a research scenario to describe our study context. Within this context, we described four layers of data we had to reason about narrative possibilities. Given these layers, we performed iterations to explore elements that helped us build a story. As a result, we outlined a process that lists a story's components and enables designers to plan customizable narrative data visualizations.

To ease readers' comprehension, in the following topics, we first present the research scenario of the project, the data captured during the period, and the iterations that led us to define the phases and steps of our process. Finally, we present the process structure.

3.3.1 Scenario

In the context of understanding what aspects are significant in built environments, we organized the project into four layers of information that can provide pertinent information about how users experience the built environment. We named the four layers: **perceived space**, **designed space**, **observed space**, and **lived space**. These layers comprise data from spatial analysis, documentary analysis, space observations, and stakeholder interviews. We seek attributes or other general characteristics from these layers that may contribute to community living and learning spaces.

Then, using storytelling to analyze these data, we aim to uncover how the spaces contribute to people's daily routines regarding learning and appropriating the spaces.

3.3.2 Data Used

Each data layer is designed to provide valuable insights into the quality and well-being of the building space. Below, we will outline the specific information that each layer contains.

- **Perceived Space:** This layer contains measures based on the floor plans of the buildings. These values indicate how a point within the physical space is open or visible.
- **Designed Space:** This layer contains data about the floor plans and legal regulations that help understand the architecture's intentions.

- **Observed Space:** This layer contains data obtained from non-intrusive information that shows activities such as studying, eating, and chilling performed by people attending the observed spaces.
- **Lived Space:** This layer contains information about people's personal experiences while they attended a physical space analyzed.

Figure 3.5 illustrates the interior of the Goldberg Building at Dalhousie University, where we can see different layers related to physical space. The first layer, **observed space**, focuses on recognizing people's activities in that environment. The data of this layer is obtained through non-intrusive observations of people attending the physical space. These observations include identifying and categorizing what people used to do while in the building according to the period observed. The second layer, **lived space**, is based on personal experiences in that physical space that can provide additional information about the environment. The data of this layer is obtained through interviews with people attending the physical space. These interviews aim to identify how people use the environment designed for them and their personal experiences attending the building.

The **designed space** layer helps us understand how the physical space was intended to be used, which can help explain the furniture arrangement, for example. The data from this layer is obtained through the analysis of official documents and regulations of the building spaces. We assume this documentation can provide information regarding the expectations and intentions of architectures that worked in the physical space design. Finally, the **perceived space** layer is a projection obtained from analyzing the physical space using the Depthmap X ⁷ tool. This tool is designed to enable the researchers to understand social processes within the built environment. By creating a map from the floorplan of a building, we can analyze attributes like openness and connectivity to recognize characteristics of the physical space to predict how attendees use the space.

3.3.3 Mapping the elements of customizable narrative data visualizations

Here, we present the iterations we performed to identify the customizable narrative data visualization elements. These elements help designers plan narratives in which the readers can customize their content without stepping out of the designer's communicative intention. We started by investigating general characteristics to convey visual narratives. Then, at each iteration, we improved our understanding, leading us to unroll the requirements of the process. By doing these iterations, we also defined design intentions that represent the fundamentals of the process. Figure 3.6 briefly depicts the iterations performed and what was developed at each.

⁷<https://www.spacesyntax.online/software-and-manuals/depthmap/>

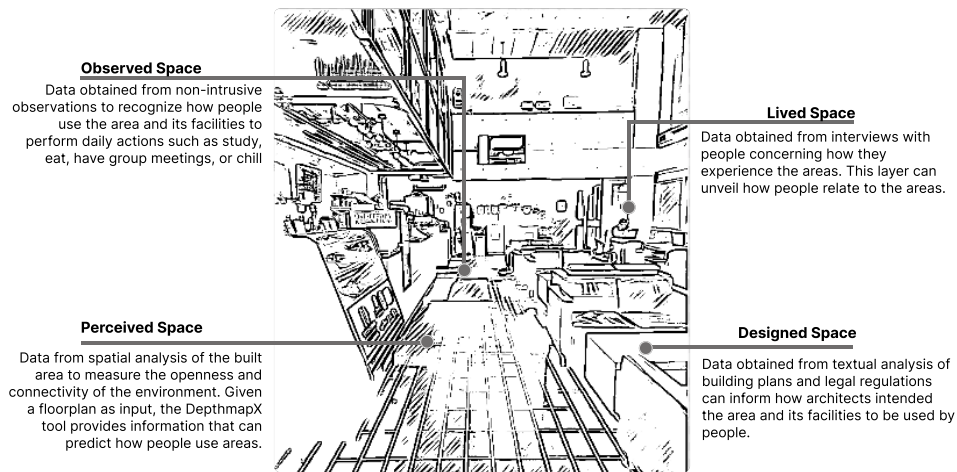


Figure 3.5 – Layers of information considered in this research stage. Source: the author

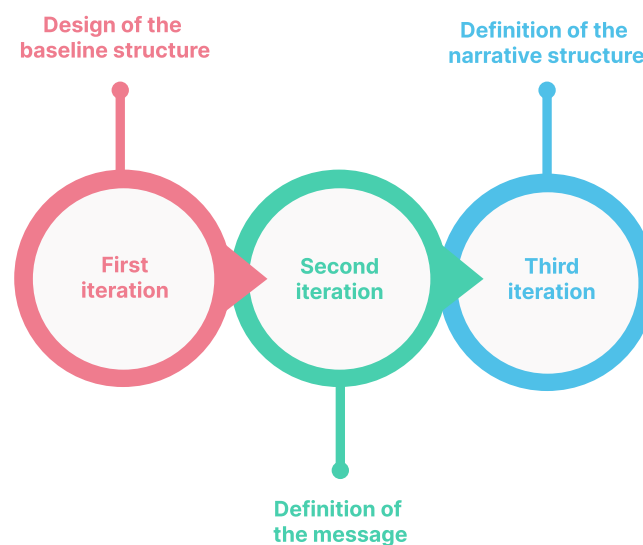


Figure 3.6 – Iterations performed to build the process

First iteration: definition of the baseline structure

Through this iteration, we aimed to converge basic storytelling concepts, data visualization techniques, and design patterns for tailoring interfaces into a unified approach.

We initially searched for prior studies addressing the storytelling process to accomplish this task. As a result, we found three studies that meet this criterion [62][133][83].

In the first study, Fu and Stasko [62] started out intending to aid sports journalists in constructing narratives from a set of sources about statistics of NBA matches. First, they sought to find how massive data are made available to writers. Then, they went on to develop a strategy to support their task. The process defined by the authors has three main stages: understanding the problem, designing potential solutions, and field deployment and evaluation. As a result, they developed two interactive visualization applications that helped journalists to analyze data from NBA matches.

In the second study, Zhang and colleagues [133] developed a framework that supports the process of visualizing data as a data story to communicate data to general audiences in informal contexts. They gathered concepts from digital storytelling, serious games, and data visualization to conduct the study. Their storytelling approach has three main stages: plan the message, compose the information units, and map the composition into visual representations. Each stage of the framework has steps that support visual content creation based on the information obtained from data analysis. As a proof of concept, they developed a prototype to convey a story about energy consumption in Australia.

In the third study, Lee and colleagues [83] reported a process for transforming data into stories that comprise three phases: explore the data, make a story, and tell a story. Through the process, the data analyst assembles story pieces retrieved from the database into a narrative. Besides, the authors also discussed implications for ethics in storytelling. The paper's main contribution is to widen the structure of the scope of a visual data story.

These works allowed us to organize the first ideas of how delineate a process that allows designers to transform data into customizable narrative data visualizations. One significant discussion by Zhang and colleagues [133] is about the differences between ordinary and narrative data analysis. They advocated that the process of building narratives is based on information units, i.e., a concept that encapsulates key information that needs to be delivered to the audience. This information is crucial considering the context of our study. Given that the narrative is based on key information presented to the viewers, we must be aware of having a step to cope with the definition of key information or events of the story.

Based on the three works above contributions and the preliminary data we had available, we started to build our process within the scope of our study. Initially, we defined a first phase that comprises the datasets explored to obtain information and build the narrative. Then, we named it *understanding the problem*.

From the understanding of the problem, we defined a step (**collect data**) in which the designer will have access to the datasets concerning some subject or domain of interest. Hence, it is essential to reinforce that the traditional data analysis process is out of the scope of this work. So, we assumed that the data collection process and the procedures to clean the data were already performed at this point, and the data was ready to be used.

During this iteration, we realized we needed to obtain essential elements from the dataset to design the narrative. Then, we described our first design intention, which stands for *the process must allow the identification of information units that aid the narrative*.

Second iteration: definition of the message

In the previous iteration, we realized that we needed to identify key information from the dataset(s) taken to build the narrative. Therefore, after we described the first design intention, we defined a new phase of *defining the message* to encapsulate this design intention. Hence, this is the stage where the designer will define the primary elements of the narrative (**identify the narrative elements** step). We started this iteration by searching for studies that could help us define the structure of the message conveyed through the visualization. At this point, we found the definition of the steps of this stage in the works of Cruz and Machado [38] and Trichopoulos and colleagues [121].

Cruz and Machado [38] advocated that a story is a representation of a fable. A fable is organized as a sequence of events, chronologically sorted, and lived by actors. They proposed an engine that transforms fables into stories. This engine has a set of narrative elements. We based the elements of our narrative on the set proposed by Cruz and Machado [38], i.e., events, actors, time, and location. The elements jointly permit the definition of whom the story is about (actor), what information is conveyed (events), and what time it occurs - it can be at any scale such as hour, months, the shift of the day (time), and where the story happens (location).

After defining our model of elements to assemble the story, we looked at the first available dataset: the **perceived space**. This dataset contains data obtained from space syntax analysis. We tried to retrieve from this dataset the elements for a narrative. However, we realized that the information stored needed to be more representative to be used as a source to build our narrative. Through this attempt, we learned that before we define the elements of the narrative, we must define the goal of the narrative, i.e., our communicative intention.

Based on our perception of the need to clarify the communicative intention underlying the visualization, we defined an additional step within the phase of defining the message to cope with this task (**define the communicative intention** step). Before defining the elements of the narrative, i.e., actor(s), event(s), time, and location, the designer should determine what the narrative is intended to communicate. It becomes more accessible for the designer to choose the narrative elements after determining their communicative intention.

Going forward in our development, after defining those steps, we analyzed the work done and reasoned about what was needed to craft a narrative within our scope. We realized that we needed a form to define how the events of our narrative should be displayed once visualization techniques used in narratives effectively convey an intended message. Then, considering that visualization techniques are necessary to hit this goal, we defined another design intention: *each event from the narrative being developed has to be associated with one or more visualization techniques*. By associating each event

with visualization techniques, we can provide the users with customization features once they can choose different visualizations for the same event, for example.

Third iteration: structuring the narrative

We reached the third iteration, having a handful of pieces of the narrative defined. Given that we defined the communicative intention and narrative elements, such as actors and events, we realized we had enough information to define how the narrative would be presented to viewers. Hence, we defined a phase of *structuring the narrative* dedicated to defining crucial structures of the narrative. Considering the design intention defined in the previous step, we included a step in which the designer will associate each event with one or more visualization techniques in this phase (**define the visualization techniques** step).

At this point, to gather ideas for our process, we brainstormed with our research team what visualization techniques could be used regarding the four layers considered during our design creative process and the research scenario. A total of six participants attended the activity. Five of them were computer science graduate students researching storytelling for virtual settings. One of them was a senior researcher interested in AR/VR applications.

The brainstorming session lasted an hour and a half, and the participants made several suggestions concerning the end-users of the visualization and ways to convey the story. Regarding the techniques, they suggested arrows, a text box, and other elements that could explain the narrative to users. They also mentioned world clouds to present the data from the **lived space** layer and heat maps placed on the ground of the physical space to display the data from the **perceived space** layer. In most suggestions, the participants assumed that the narrative would be implemented in a virtual setting.

Then, considering we were working in a mixed team with diverse skills and backgrounds but that had a shared interest in visual narratives, we described another design intention to converge the different perspectives raised during our brainstorming: *the process must allow the planning of a narrative regardless of the medium it will be deployed*. Therefore, we encapsulated it in a step to **define the narrative components**. We use the design space for narrative visualizations from Segel and Heer [111]. However, other studies addressed narratives in different settings and can be considered examples of potential applications for narratives planned with our process. For example, Spierling [115], and Singh and colleagues [114] present the development of narratives regarding virtual settings. In addition, Lee and colleagues [81] widen these settings by discussing narratives for tablets, smartwatches, desktops, and wall displays.

These works allowed us to identify other visual tactics and interaction techniques that can be used in virtual settings to give viewers agency in what they explore in the

visual narrative and how the events can be placed to allow exploration of the narrative. We claim that our process is suitable enough to accommodate the definition of narratives for settings such as web applications or virtual environments.

Considering the goal of this work, which is to allow end-users to customize the visualization presented, we described another design intention and a step to cope with it. We defined the following design intention: *the process must enable the planning of narratives in which customization behavior is allowed so end-users can tailor their content without stepping out of the designer's communicative intention.*

To address this last design intention, we added a step (**define the tailoring capabilities**) to our process where the designer will define how the viewers can customize some aspects of the narrative displayed.

Finally, we reviewed the information and defined that we were ready to implement the narrative after following all those steps. To cope with this goal, we defined the last phase of our process as implementing the narrative. This phase addresses the implementation of the narrative considering the suitable language and methods related to the target deployment medium.

3.4 Process structure

Through our iterative process with the data, we discovered key elements in constructing a narrative. Our findings were sorted into distinct phases and steps, resulting in a useful guide for designers to plan personalized narrative data visualizations. Figure 3.7 shows the process we developed to assist designers in planning customizable narrative data visualizations.

The process has four phases and six steps the designer must follow to plan a customizable narrative. We adopted a circle design to represent that the designer can go forward or backward while planning a narrative visualization. For example, when defining the communicative intention and identifying the narrative elements, if the designer realizes that an additional dataset is required to achieve their intention, they can return to the previous step. The dashed line after the last step (implementing the narrative) represents that it is possible to perform another round of planning. Following, we explain the steps within the phases.

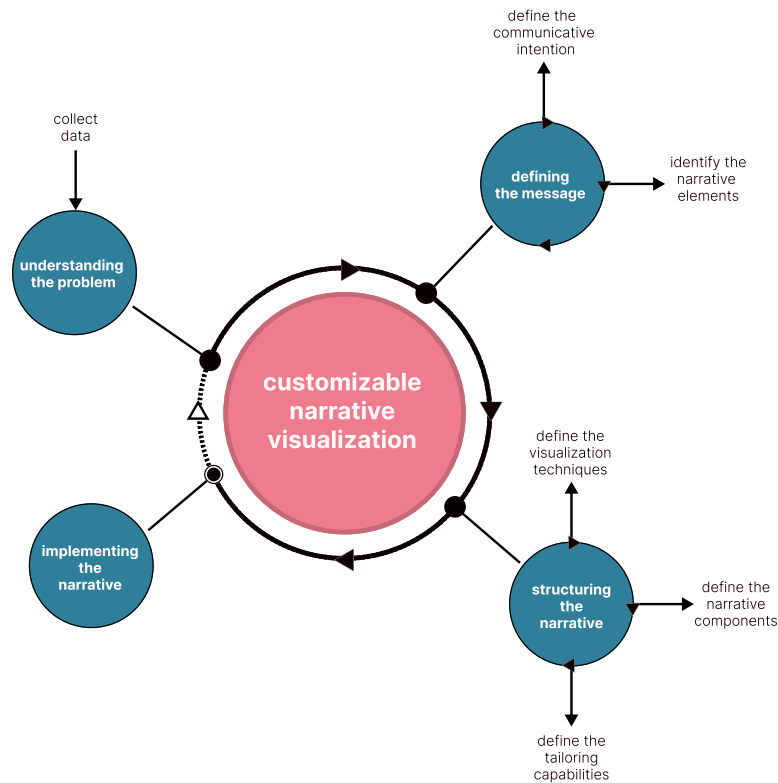


Figure 3.7 – Process to transform data into customizable narrative visualization.

3.4.1 Understanding the problem

This phase is dedicated to collecting relevant information related to a subject. It may involve collecting public datasets, conducting interviews, or other methods to gather data. We defined the step of collecting data to cope with it.

In the **collect data** step, the data can be gathered through various methods such as user studies. It is worth noting that we do not cover the data analysis process needed to prepare the data for building the narrative since it is beyond the scope of our research. So, we assume at this stage that data is cleaned and all transformations are done.

3.4.2 Defining the message

This phase involves defining a communicative intention regarding the data retrieved in the previous step and identifying narrative elements that anchor the story. The following two steps cope with this goal.

In the **define the communicative intention**, the narrative designer defines his/her communicative intention through the narrative, i.e., what message will be conveyed to the viewer. Defining an intention and unveiling what can be done with the data

collected is important once it will support defining the next steps of the process in terms such as visualization techniques and narrative genre. In addition, by defining a communicative intention, the designer can make the data more understandable to the viewers.

In the **identify the narrative elements**, the designer identifies the narrative elements from the data sets collected. To guide the designer, we adopted the framework proposed by Cruz and Machado [38]. Thus, the narrative's *actor(s)*, *event(s)*, *time*, and *location* must be identified. The actor is the entity from whom the narrative is about. The events are information that can be displayed through graphic visualization and support the communicative intention. Finally, the time and location refer to where and when the story occurs.

3.4.3 Structuring the narrative

This phase comprises the steps the designer must follow to define how the narrative will be displayed and how end-users can customize it. The following three steps account for this definition.

In the **define the visualization techniques**, the designer defines how the narrative elements previously defined will be shown to readers. Visualization approaches include techniques such as text, line charts, bar charts, scatterplots, and tables. In many cases, more than one visual representation may be suitable for a single event [76]. Consequently, it is possible to define multiple techniques for a single event. In this sense, to provide readers with alternative points of view or ways to explore the story, the designers can let the viewers choose which visual representation they want to see an event. The output of this step is a group of narrative elements and their visualizations.

The **define the narrative components** is the step where the designer has to choose what narrative components will be used in the story. This step considers the design space defined by Segel and Heer [111]. The design space presented by them comprises three dimensions: *genre*, *visual narrative tactics*, and *narrative structure tactics*. Once we are addressing narratives in which end-users may engage in customizing the narrative, we enclose the genre options to those that can contain interactive interface resources, i.e., *partitioned poster*, *slide-show*, and *annotated chart*. To handle these genres, we adopted the structure defined by Borges [11] in which each genre can contain one or more components to organize its content. The remaining dimensions are used as defined by Segel and Heer [111]. Therefore, in our approach, each component will hold a narrative element aided by visual and structural tactics.

Figure 3.8 illustrates the customizable narrative data visualization model. Each blank rectangle represents elements defined during our proposed process. The arrows indicate the relation between these elements.

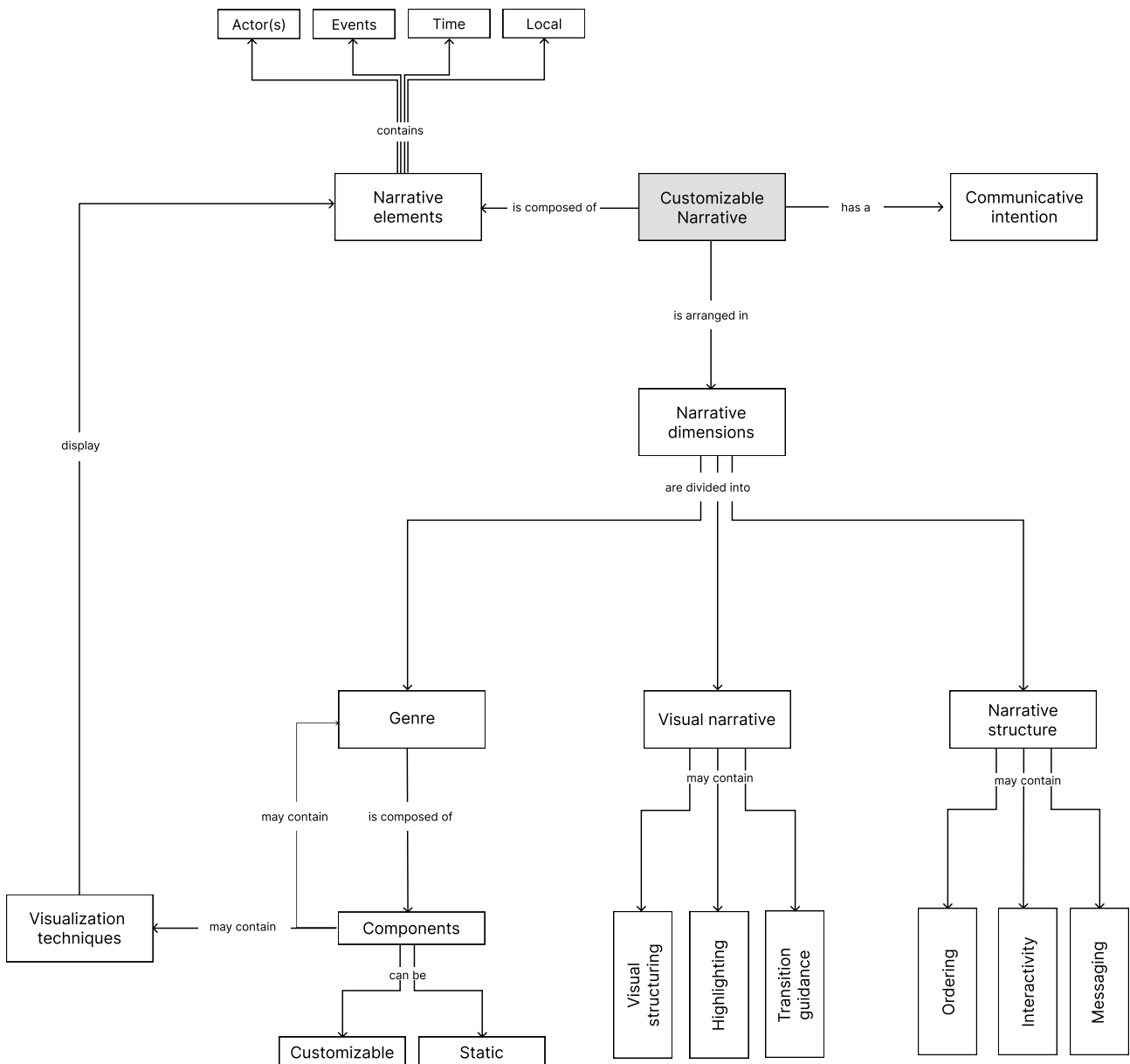


Figure 3.8 – Customizable narrative data visualization model

In the **define the tailoring capabilities** step, the designer defines what tailoring design patterns will be provided to users to let them customize the narrative. To support the designer, we analyzed the design patterns for tailorable applications shown by Baranauskas and Neris [7]. Hence, they can choose the patterns of *user preferences*, *user annotations*, *customized windows*, or *bookmarks*. This choice follows the previous association in this work between the design patterns and the narrative genres. In addition to defining these tailoring features, the designer must define which narrative components will not be customizable. End-users cannot customize these components once they support the narrative context and intent.

3.4.4 Implementing the narrative

This phase represents the step where the designer will prepare the narrative to be built and presented to the final audience. This step involves considering the technical requirements to build up the story. Within these requirements, we can mention the ones needed to ensure the tailoring behavior of the narratives.

3.5 Considerations about this chapter

Through this chapter, we presented our journey to create a process to assist designers of narratives in planning a narrative data visualization with customizable features.

Our first study helped us comprehend how the exploration layers could be used to expand the techniques options combined with the design spaces dimensions of visual tactics and narrative structure defined by Segel and Heer [111]. In addition, after hearing from the designers, we realized that a customizable narrative must have non-customizable components to maintain the story's context. These components vary according to the genre employed. In the case of a partitioned poster, it can be reached by fixing one or more of its components. Concerning the slide-show, it can be done by avoiding changes in one or more of its tabs. The strategy of how to balance non-customizable and customizable components is a designer's duty.

The second study was essential for defining how end-users could customize each narrative genre. By taking advantage of design patterns [7] and the genres' perspective as multi and single components [11], we could envision opportunities to make the genres more flexible. To ensure we could blend these studies without mischaracterizing the designer's communicative intention, we first analyzed what can be reached with each genre regarding communicative goals. We ended up having an association between the design patterns and genres that are suitable for data visualization.

Finally, our last study gathered the essential elements for planning a narrative with customization features. We could investigate these elements throughout our collaboration abroad by interacting with data from a project involving 14 Canadian universities. In addition, we could investigate narratives in contexts of virtual settings. This interaction resulted in a process suitable for planning narratives regardless of the target setting.

4. APPLYING THE CUSTOMIZABLE NARRATIVE PROCESS

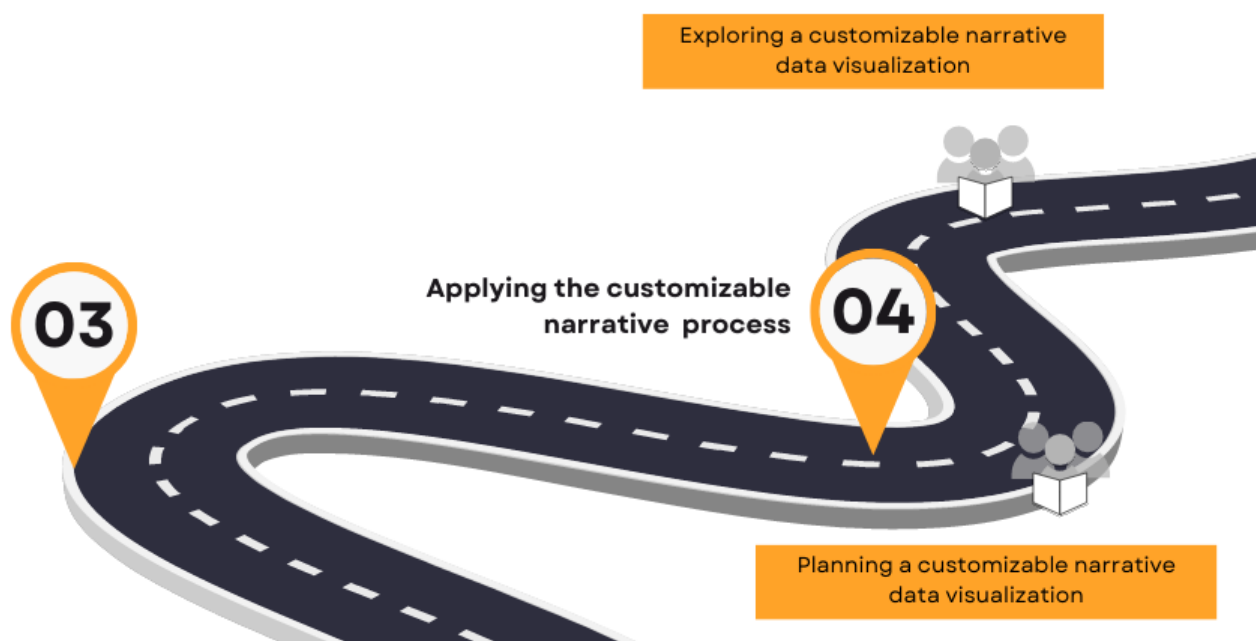


Figure 4.1 – Fourth stage of the research

In this chapter, we reach our journey's last stage. Figure 4.1 illustrates our location. In this stage, we conducted user studies (represented by icons with three people on the road) in which we applied our process. We held two studies: a focus group session to analyze how visualization researchers planned a narrative using the process created and a workshop conducted with the general public to identify how participants use the tailoring resources to explore the narratives.

4.1 Planning a customizable narrative data visualization

In this part of our research, we held a focus group session to analyze how the attendees of our study planned a customizable narrative with the assistance of the process we proposed¹. In addition, we aimed to understand how they perceived the customization resources available to tailor the narrative genres.

We chose the focus group method due to its usefulness in raising diverse issues and enabling participants to put forward their perspectives [113]. Moreover, it is suited to obtaining initial feedback on new concepts and generating ideas [78].

¹This study is also part of the research project entitled Support to the Design of Narrative Visualizations. Project number 54348321.1.0000.5336 approved by Ethics Committee (CEP/PUCRS)

4.1.1 Study design

We held the session remotely to ease participants' invitations from other cities and states. Moreover, remote studies offer the advantage of scheduling flexibility and the facility of recording all users simultaneously at a low cost [29]. We used Zoom for the remote meeting and Google Solutions to record the participants' responses. A total of six participants attended the session. Table 4.1 presents the participants' identification, genre, position, and years of experience researching data visualization. The sample was defined by convenience.

Table 4.1 – Focus group participants

Participant	Gender	Position	DataVis experience
P1	F	Researcher	9
P2	M	Researcher	4
P3	F	Researcher	2
P4	F	Software Developer	3
P5	F	Data Analyst	3

The participants in this study have varied backgrounds in data visualization. Three of them are currently conducting research on the topic at Brazilian universities. The other two work in the IT industry, with one specializing in software development and the other in data analysis solutions.

We organized the focus group session into five stages. Before starting the first stage, we provided an overview of our study's objectives and presented the consent form. Those who agreed to the terms outlined in the form were requested to sign it before proceeding with the activity. Figure 4.2 illustrates the session stages.

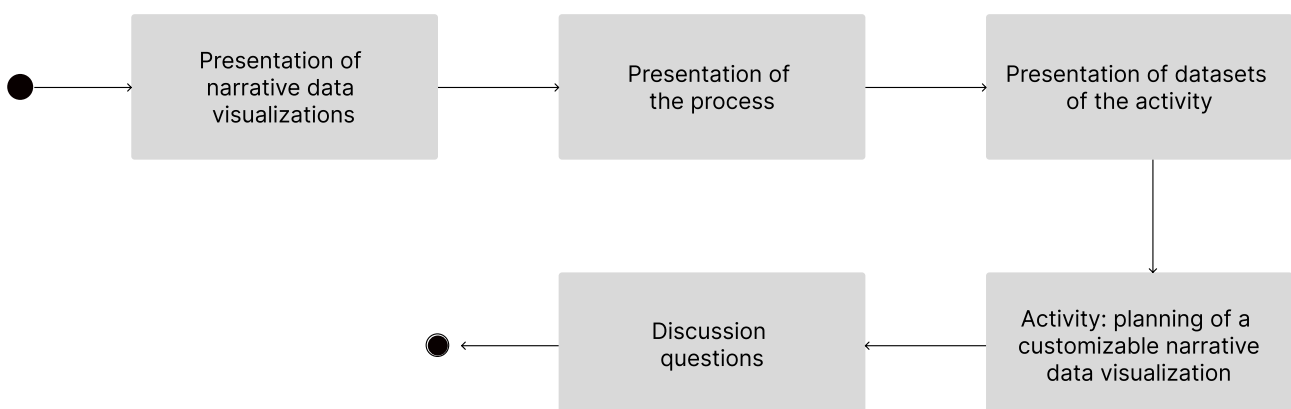


Figure 4.2 – Stages of the focus group

The first stage, the **Presentation of narrative data visualizations**, was intended to present the significant narrative data visualization concepts to the participants.

Throughout this stage, we contextualized narratives within the data visualization field and introduced the design space proposed by Segel and Heer [111]. We focused on the dimension of narrative genres. We also introduced the perspective of genres as a structure of components that contain information [11].

In the second stage, the **Presentation of the process**, we provided users with information about the phases and steps of our process to aid them in planning a customizable narrative. We discussed each part of the process and highlighted how we use the design patterns for flexible user interaction and the structure of components of the genres to make them more customizable.

The third stage, the **Presentation of the datasets of the activity**, comprised the introduction to the data available for the activity. We present two datasets addressing the COVID-19 pandemic provided by the World Health Organization (WHO) ². The first one contained information on the number of cases and deaths due to the virus. It also contained information regarding the number of cases in the last seven days and 24 hours. This period is related to the day we retrieved the data for the session. The second dataset contained information about the number of vaccines shot in each country aggregated by people with one, two, or who completed the vaccination scheme. It also contained the names of the vaccines administered in each country.

In the fourth stage, the **Planning of a customizable narrative data visualization**, we presented the task participants should engage in during the session:

- *T1*: Considering the set of data provided, plan a narrative following the process presented. At each step, record the decision made on the document available.

We used Google Docs to record the narrative planned by the participants during the session. So, the participants' decisions were registered for each step of the process. The narrative instantiated is shown in the next section. In addition, the audio and video interaction were recorded for analysis purposes. To analyze the results, we employed thematic analysis, which is a suitable approach to identify, analyze, and find data patterns [14].

Finally, the fifth stage, the **Discussion questions**, was dedicated to answering the eight questions we proposed to participants. Five of the eight questions aimed to map the participants' profiles. The remaining questions were related to participants' perceptions of the process:

- *Q1*: Perceptions about the use of the process to plan the customizable narrative visualization.
- *Q2*: Perceptions about the tailoring techniques provided during the session.
- *Q3*: Suggestions to enhance the process.

²<https://covid19.who.int/data>

4.1.2 Results

This Subsection summarizes the results obtained from the focus group with data visualization professionals. We categorized our findings into **narrative preferences**, **process structure**, and **help system for designers and end-users** to ease the reader's comprehension.

The category of **narrative preferences** addresses participants' choices and comments during the session. The participants' comments address their opinions regarding the choices taken while they followed the phases and steps of the process. They do not address opinions about the process by itself.

At the beginning of the session, the participants analyzed the datasets available to decide the communicative intention of the narrative. During this analysis, they verified what information could relate one dataset to another. P4 suggested the field region as a key to relating the number of cases and deaths to the number of vaccines offered. In this matter, P1 said that the *information on vaccines administrated could be shown when the reader clicks on a country, for example, as additional information in the story.*

P1 proposed a story with a temporal progression of cases and deaths. However, P2 realized that the information given in the dataset did not enable them to build such temporal relations. P4 added that information about the number of cases and deaths in the last 24 hours and week could be helpful to combine to unveil the rate of deaths.

P2 weighed the opinions given and proposed *to show the current landscape of cases and deaths worldwide by region.* In addition, *they could relate the vaccination effects and specific vaccines in different regions of the WHO map.* To justify his choice, P2 mentioned that time was not available in the interval required to build a temporal progression, so they must use the key field to convey a story.

During the phase of structuring the narrative, P3 suggested a map to visualize the events once they can organize the information considering the WHO region. P2 agreed and added that a scatter plot could help demonstrate correlations between cases and deaths. Following, P1 added that *a heatmap would be interesting to allow the use of color grades to demonstrate the intensity of the numbers.* About visualization techniques, P1 and P2 propounded using bar charts to compare the number of cases and deaths by country or WHO region.

Following these choices, the participants proceeded to the next step, where they had to consider which of the three narrative genres would convey their narrative. P1 said she thinks the slideshow and partitioned poster combination is interesting. According to her, the slideshow allows them to split the story into a set of tabs within the slideshow, where each tab title is a chapter. In addition, P1 added that they could use a bar chart

with annotations (*annotated chart genre*) to explain specific points of the narrative. P2 concluded that the choices made turn the narrative quite flexible.

P4 advocated enabling users to reorder or hide tabs they do not want to see. P1 agreed and mentioned that ordering is a resource defined in the seminal work of Segel and Heer [111]. P4 commented that *letting users reorder tabs would be functional in slideshows where the tabs do not represent the story's progression*. P2 argued that *conversely, i.e., in cases where the tabs hold for the progression of the story, allowing the user to reorder them could cause mistakes in the communicative intention*. To conclude this idea, P4 recommended replacing the bookmarking pattern for ordering.

P4 said that *the user preferences patterns should also let the user change the font size, font type, and elements proportion, e.g., in the case of a partitioned poster, let users resize one component to highlight it*. P2 and P1 followed her suggestion.

The category of **process structure** concerns participants' opinions and comments about the process and its usefulness in helping them plan a narrative. The participants were also asked to reason about improvements to the process.

In P1's opinion, the process fulfilled the expectations. However, she emphasized that *the participants required more information during the session to understand what must be done at each process step*. "I agree with P1's opinion and also think that placing the defining narrative components before the one dedicated to the visualization techniques would improve the understanding of the process" (P3). At this point, P3 suggested changing the order in which the process steps are placed. By observing how they interacted with the process, she suggested that the visualization techniques should be defined after the general structure of the story.

P4 said the process helped in planning the narrative. In addition, she mentioned that *while they went through the steps, they also were thinking about the final product and put themselves in the end-user role*. As an improvement, she mentioned visual examples to support designers in the process flow.

Following P4's opinion, P2 complemented how our approach split the process of planning a customizable narrative was suitable enough. Besides, he also said that *although they were already thinking about the final product at the beginning, following the process steps helped to organize the narrative's basic structures before they could reach the final narrative plan*.

Finally, the topic of **help systems for designers and users** concentrates on opinions and comments from the participants about the need for more information to enable the process to reach a broader audience.

P1 mentioned the importance of a help system to support designers using the process. In addition, she enquired about how it would be made available to people interested in the work. Another point highlighted is that the general audience needs to

learn the specific terms of the Information Visualization field. Regarding this, P2 added that *these specific terms used in the process might be reshaped to a more everyday vocabulary to make it easily understood*. He concluded that this change requires mapping between the original and new terms.

4.1.3 Considerations about the study

In this study, we focused on investigating how our process supports the creation of narrative content based on information gained from data analysis. So, this section discusses our observations during the session and addresses possible solutions to approach improvements participants suggested, such as means to provide designers with assistance to understand the process and its steps and add new tailoring options.

While the participants were going through the process and setting the information for each step, we noted that since the first one, they started to think about how the final product would be. Indeed, according to P1, defining the story-like content in each step also requires reasoning about how this content will be made available in the final product in terms of implementation. So, naturally, the narrative instantiation comes along with how they can code the decisions made. While true, the participants agreed that the process split the steps required to define the narrative properly and forced them to consider each detail.

P3 suggested changing the order of the steps in structuring the narrative. We observed that when the participants reached the step of defining the visualization techniques, they decided to proceed to the definition of the narrative genre. They felt secure in doing that because the process allows forward and backward movements. We believe that it occurs because the genres represent the basic structure of the narrative, and the definition of what visualization techniques will be used to show the events depends on the genre used. The process flow allows this situation once it allows to move through the steps.

Another suggestion during the session was adding a different resource to let readers reorder or hide some tabs in the slideshow genre. We explained that this situation could mischaracterize the communicative intention defined by the designer once the slideshow represents a predetermined order of the narrative, regardless of the possibility that users have to skip tabs.

One more point raised during the activity is that the slideshow can be only a structure that shows multiple events from a narrative without being tied to a progression or dependency between them. We agree with this point of view but also believe that a slideshow has a predetermined order of facts. We consider that Segel and Heer's [111] hybrid models (*martini glass*, *interactive slideshow*, and *drill-down*) cover this situa-

tion. Hence, when defining the slideshow with a martini glass structure, the users cannot change the order or hide some tabs from the slideshow. Otherwise, when the tabs do not contain a story progression, these resources for reordering or omitting tabs might be available. We plan to add additional information in the process to approach this topic.

Finally, one important suggestion is to provide means of assistance for designers and end-users. Indeed, during the session, we observed that participants required explanations about what had to be done in the steps. In this regard, one suggestion was to change the technical terms to more common ones to ease the understanding of a broader audience. Hence, we consider the development of a toolkit to support the designers in the process' usage.

Throughout this study, we observed that the process aided the participants in planning a narrative properly. Although the process is described as a sequence of steps, which may indicate an ordering, the participants proceeded and went back through them when they felt they needed to obtain more details or refine previous decisions. This behavior reflects the real world of designing visualizations. The suggestions made regarding using the narrative genres show the field's richness and point out aspects for improvement of our process.

4.2 Exploring a customizable narrative data visualization

In this part of our research, we held workshop sessions with end-users to observe how they use the customizable features to explore a given narrative. We designed a narrative data visualization based on the partitioned poster genre to run these studies. This choice relies on the partitioned genre being considered optimal due to its characteristic of presenting multiview narratives.

We choose to conduct a workshop once this method is suitable for producing reliable and valid data about the domain regarding processes such as organizational change and design [99].

4.2.1 Study design

In order to achieve our objective, we held two workshop sessions with IT undergraduates from the Pontifical Catholic University of Rio Grande do Sul (PUCRS) and one with IT and Graphical Design graduated students. The sessions were attended by 45 people organized into nine groups. Five of nine attended the first session, three the second, and one group the last one. Table 4.2 summarizes the group's profile in terms of the category of the students and courses. The sample was defined by convenience.

Table 4.2 – Workshops participants

Group	Category	Courses
G1 to G5	Undergraduate students	Computer Science, Information Systems, and Software Engineering
G6 to G8	Undergraduate students	Data Science and Artificial Intelligence
G9	Graduated students	Computer Science, Graphical Design, and Analysis and System Development

To conduct the sessions, we used Figma and Google Forms tools. Figma was used to build the narratives' prototype and simulate the customization design space. We decided to construct prototypes once our main focus was to analyze whether the customization facilities could enable end-users to explore the narrative. Google Forms was used to store participants' profiles and to register their experience attending the session.

We organized the workshop sessions into five stages. Before we proceed to the first stage, we explained the general goals of our study and required all participants to read and sign the consent form. Figure 4.3 illustrates the five stages.

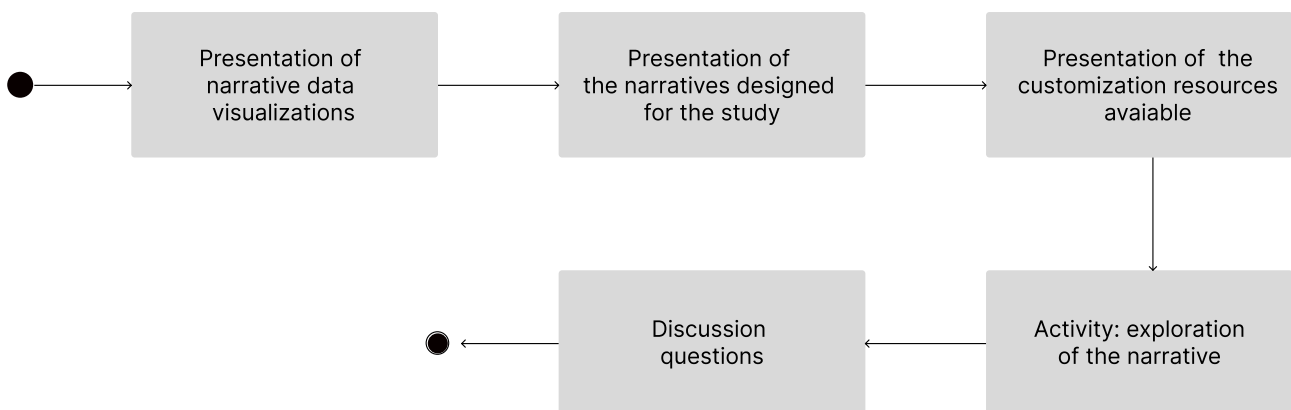


Figure 4.3 – Stages of the workshop sessions

The first stage, the **Presentation of narrative data visualizations**, was dedicated to introducing significant narrative visualization concepts to the participants. We showed the design space for narratives [111] and the perspective of genres as a structure of components [11]. We then approached the design patterns for flexible user interaction [7] and explained how these studies complement one another to make the narratives more flexible.

In the second stage, the **Presentation of the narratives designed for the study**, we show participants the scenes available to be explored during the task. We organized our narrative into two scenes. One scene contained the components available for participants to customize the narrative. We provided components containing different visualization techniques to display the same event and components containing the same

event but shown by different data aggregations. The second scene contained the default narrative instantiated from where the participants started to explore the story.

Figure 4.4 shows the elements available in the scene of options. Regarding this stage, the events are categorized into six columns. Each column contains options to display the narrative's events defined using our process to plan narratives. The boxes with gray and green borders represent the elements. These colors guided the participants on how each element could be used. The gray elements can be placed simultaneously in the stage once they represent variations of events concerning a common topic, e.g., vaccination. The green elements cannot be placed simultaneously in the primary stage because they represent different ways of visualizing the same information. The four head arrow represents components that can be moved. On the other hand, components with a lock represent components that are fixed. The content of each column is described below.

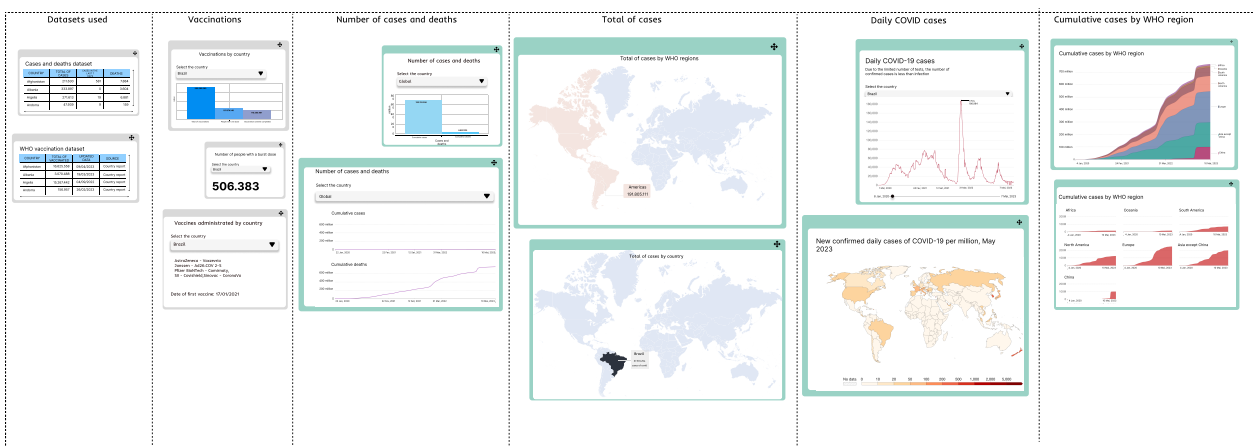


Figure 4.4 – Scene with options to customize the narrative

- **Column 1 - Dataset used:** We have provided two narrative components that contain tables showing the datasets content. Each column of the table indicates quantitative data about the pandemic. We used tables because they are useful in comparing values and conveying various measures [76]. Figure 4.5 shows the options of the first column.

Cases and deaths dataset			
COUNTRY	TOTAL OF CASES	CASES IN THE LAST 7 DAYS	DEATHS
Afghanistan	211.630	581	7.884
Albania	333.897	0	3.604
Argelia	271.613	19	6.881
Andorra	47.939	9	159

WHO vaccination dataset			
COUNTRY	TOTAL OF VACCINATED	UPDATED DATA	SOURCE
Afghanistan	16.625.558	09/04/2023	Country report
Albania	3.070.488	19/03/2023	Country report
Argelia	15.267.442	04/09/2022	Country report
Andorra	156.957	26/02/2023	Country report

Figure 4.5 – Options of column 1

- **Column 2 - Vaccinations:** We have provided three components to present vaccination information in the narrative. In the first component, we used a bar chart to show the quantitative of people vaccinated with one, two, and burst doses. We used bar charts because they are easy to read and permit the viewer to check the highest value in a series [76]. The second component presents the number of people with a burst dose. This component employs a simple text to present this information. This technique is proper when we have just a number to show and want to highlight it [76]. Finally, the third component presents the name of the vaccines used by countries. We also choose the text to present this information because it shows the information at first glance. Figure 4.6 shows the options of the second column.

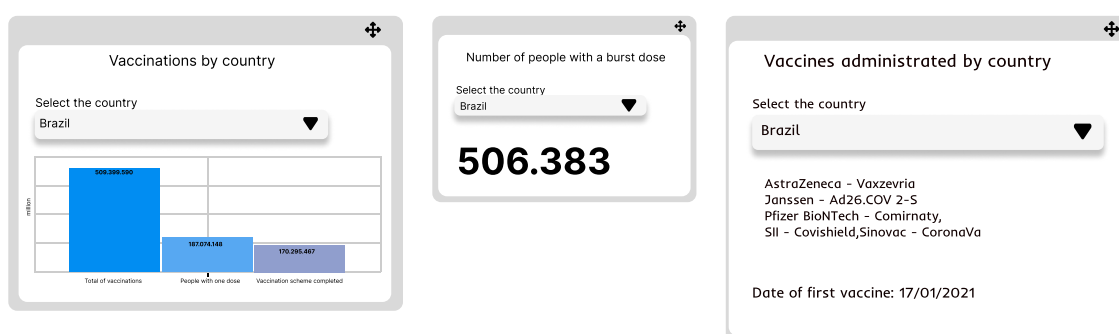


Figure 4.6 – Options of column 2

- **Column 3 - Number of cases and deaths:** We have provided two components to display the number of cases and deaths. In the first element, we provided a bar chart comparing these values. We chose bar chart because it is suitable to compare values. In the second element, we provide a line chart to display the numbers over time. Line charts help show continuous data [76]. Note that in this column, the participants could pick up one of the components at once to place in the main stage. Figure 4.7 shows the options of the third column.
- **Column 4 - Total of cases:** We have provided two components to show the number of cases in this column. For the two components, we choose a map to inform the data. In the first component, we presented the information aggregated by WHO regions. On the other component, we present the information aggregated by country. We use a map because it is a suitable technique to compare data across regions. Note that in this column, the participants could pick up one of the components at once to place in the main stage. Figure 4.8 shows the options of the fourth column.
- **Column 5 - Daily COVID cases:** We have provided two components to display the daily covid cases by country. Firstly, we provided a line chart showing the cases over May. We chose line chart because it is suitable to represent data over time [76]. Secondly, we provide a choropleth map chart showing the information. We picked



Figure 4.7 – Options of column 3

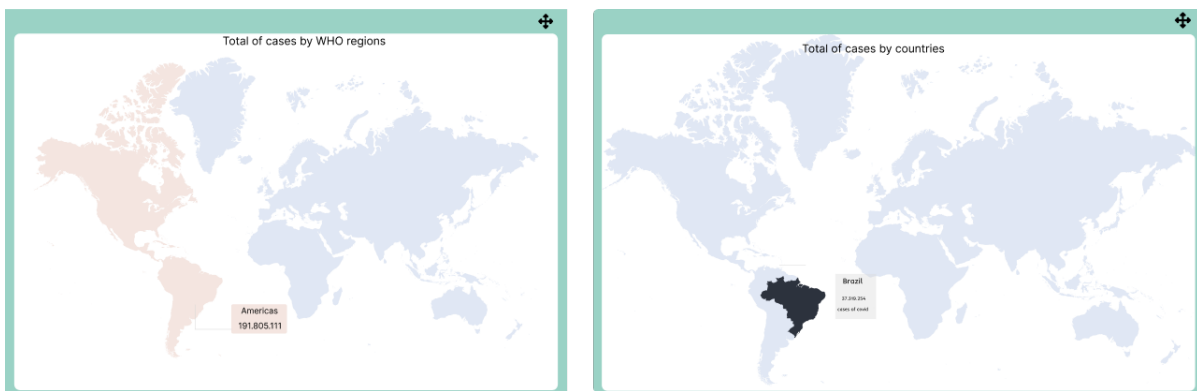


Figure 4.8 – Options of column 4

up the choropleth technique because it enables to visualize a variation or pattern across the regions. Note that in this column, the participants could pick up one of the components at once to place in the main stage. Figure 4.9 shows the options of the fifth column.

Daily COVID cases

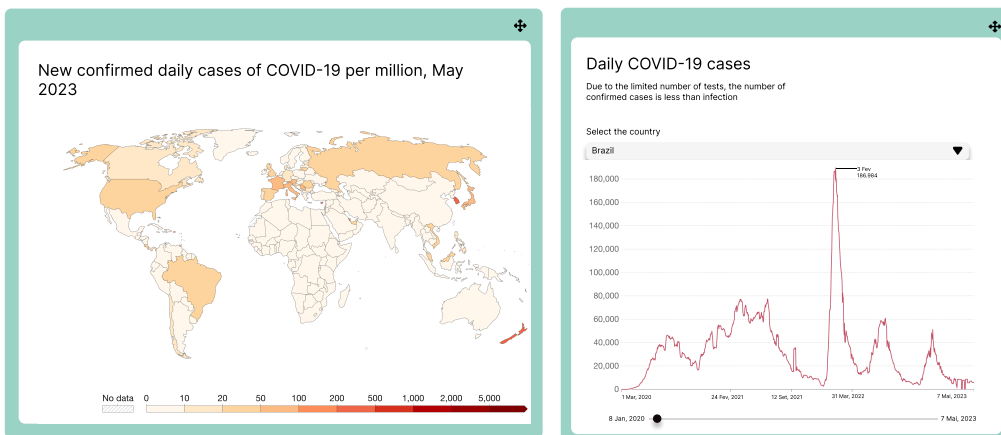


Figure 4.9 – Options of column 5

- **Column 6 - Cumulative cases by WHO region:** We have provided two components to show cumulative cases by region. For both components, we employed an area chart to display the information. In the first component, the information is presented the regions all together. In the second, we split them by region. We use the area chart because it is interesting to represent data with different magnitudes [76]. Note that in this column, the participants could pick up one of the components at once to place in the main stage. Figure 4.10 shows the options of the sixth column.

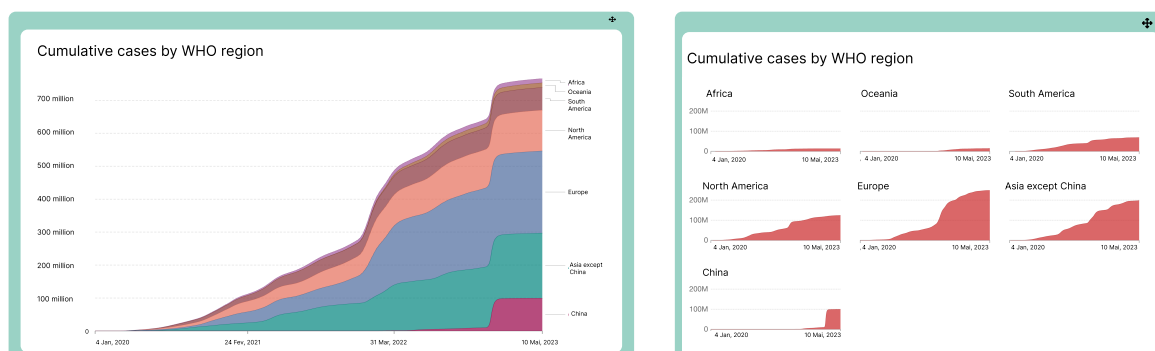


Figure 4.10 – Options of column 6

Figure 4.11 shows the default narrative presented during the workshop session. It contains six components addressing the COVID-19 pandemic. Three of the six components are fixed in the narrative, i.e., the users cannot move them out of the scene because they are responsible for maintaining the context of the narrative. The remaining components can be exchanged by one more component available in the options scene (Figure 4.4).

In the third stage of our workshop, the **Presentation of the customization resources available**, we explained to the participants what customization resources they had available to explore the narrative. We offered three design patterns associated with the partitioned poster: *user preferences*, *user annotations*, and *customized windows*. To simulate the user preferences, we orientated the participants to use the Figma tools to change the component's color, size, or font type. Regarding the user annotations, we orientated the participants to use the comment tool present in Figma. Finally, the customized windows were simulated by dragging and dropping the components from one scene to another.

The fourth stage, the **Activity: the exploration of the narrative**, comprised the task participants should engage in during the session. Following, we present the task proposed to the participants.

T1: Considering the narrative and the design space provided, explore and customize the narrative if you consider it is needed.

Finally, the last stage of our session, **the Discussion questions**, addressed seven questions to be answered by the participants. Four of the seven questions were



Figure 4.11 – Default narrative instantiated for the workshop

dedicated to mapping attendees' profiles. The remaining questions were related to participants' perceptions of the study. To analyze the results, we employed the thematic analysis, which is a suitable approach to identify, analyze, and find data patterns [14].

The questions answered by participants addresses the topics below.

Q1: Prior knowledge of narrative visualization.

Q2: Perceptions about the tailoring techniques provided during the session and how they support the narrative exploration.

Q3: Suggestions regarding the design space and topic.

4.2.2 Results

This section summarizes the results obtained from the workshop sessions. We had one participant per group who acted as their representative and answered questions about their experience in the session. We organized our results into three categories: **access to alternative viewpoints**, **customization of narratives**, and **general contributions to customization** to ease the readers' comprehension.

Generally speaking, the customization features helped explore and access different viewpoints based on the analysis of participant responses. Participants highlighted the benefits of reordering components to clarify the relationship between vaccination and mortality, incorporating relevant information, and resizing components to fit the visualization stage. They also used this feature to reorder the components to present the COVID cases, and then the COVID vaccines. Following, we present findings of each category.

The category of **access to alternative viewpoints** addresses attendees' contribution regarding their perception of how the customizable resources supported them in exploring the narrative. G1 said that *by dragging and dropping the components, they could reorder them to present information on cumulative cases and daily cases of Covid*. Similarly, G2 and G3 added that this facility allowed them to add information to the narrative they judged most relevant to the context. Finally, G5, G6, and G8 wrote that *the customization permitted them to present the components following a line of reasoning that made sense for them and, simultaneously, was comfortable to visualize*. Regarding this, G9 complemented that *the possibility of dragging the components allowed them to organize the information first to see the problem, the COVID cases, and then the solution, the vaccines*.

The category of **customization of narratives** addresses participants' contributions to the customization of the narratives. The participants stated that *customization helped them highlight the most important information and summarize the content*. In addition, customization made it easier to develop a cohesive narrative and align visual elements with their thought process. G5 commented that *they started exploring the narrative by separating the components they desired to use. They then arranged these components to make sense to the group*. They also mentioned that they resized the components to prioritize some data over others. G2 also reported that they changed the size of narrative components.

G9 commented that *they arranged the components in columns to improve the organization of their ideas*. Besides, the group mentioned that the other means to customize the narrative are important. However, they said, *these other means of customization are secondary compared to the components' drag and drop*. According to the group, *annotations and changes in the color of the charts, for example, will be helpful only after the*

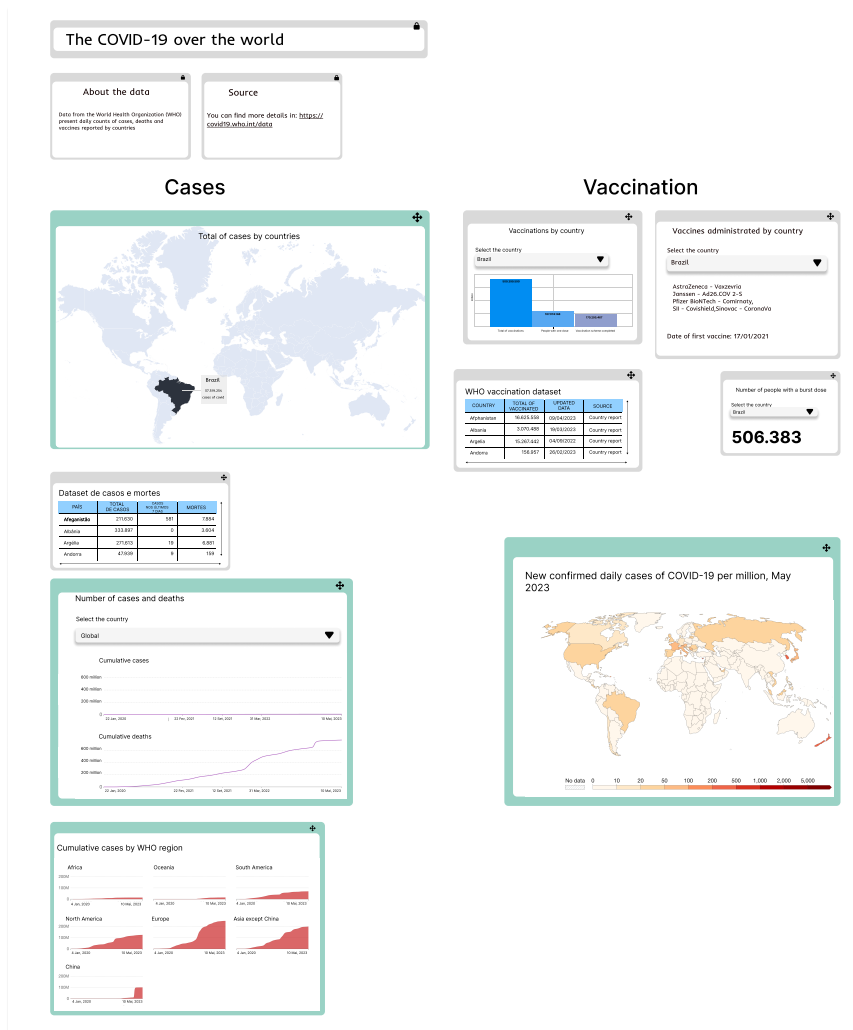


Figure 4.12 – Narrative customized by G9

end-users ensure they understand what is displayed. To this end, the capability to move and reorder the components is more representative.

Figure 4.12 shows the result of the narrative customized by G9. Note that the group organized the scene into two columns. The left column illustrates the cases of COVID. In comparison, the right columns show information about the vaccination. According to the group, this organization helps them to focus on each specific category at a time.

Figure 4.13 shows the narrative customized by G6. Note that the group expanded the narrative by adding more components instead of replacing the existing ones with others. They also resized the components and organized first to present the cumulative cases, then the daily ones.

The third category, **general contributions to customization**, addresses participants' suggestions for further customization possibilities. These suggestions included the ability to customize component colors without compromising image proportions. They also mentioned the need for improved automatic scaling and the option for multiple windows within the customization tool. G2, G3, and G4 reported the same desire to resize the

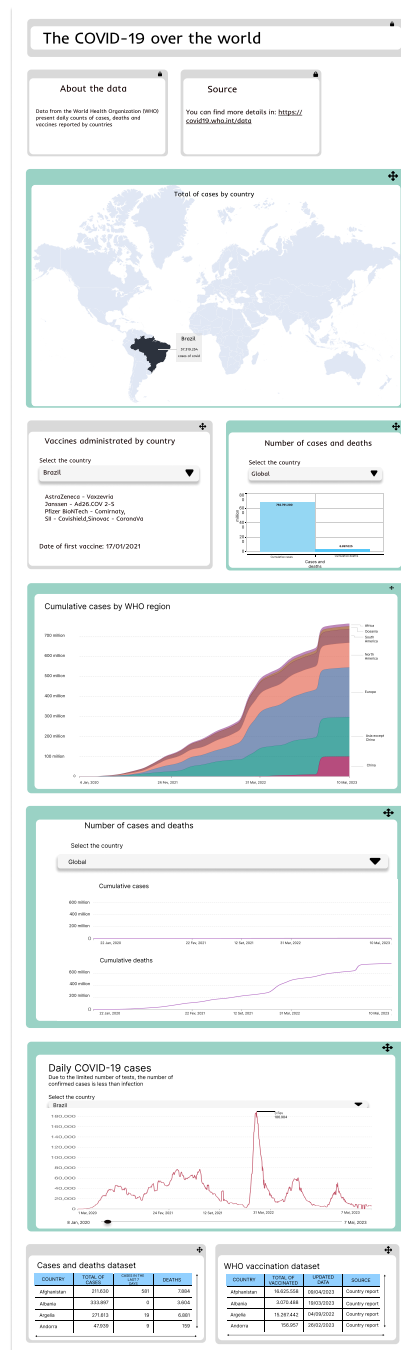


Figure 4.13 – Narrative customized by G6

components without compromising the scale of the images. In other words, they desire the narrative to be responsive to permit this customization without impairing the other elements. G6 and G7 suggested options to let users customize the data transformation presented, i.e., they desired to be able to aggregate or normalize the data. G8 suggested automatically recommending components instead of user customization

Following the topic, reasoning about other means to customize the narrative, during the interaction with the narrative, G9 made two suggestions. The first suggestion comprises a feature to let users change the chart used to visualize specific information.

According to the group, it would be interesting if they could change the chart to one they are more acquainted with. The chart options must be suitable to the information displayed. The second suggestion is that they could create textual components to the narrative. As long they reorganized the components in columns, they desired to identify the columns according to the information presented.

G3 and G4 proposed changing the size of the components as a valuable resource. They want to ensure a proper balance between the importance of information and its presentation size to draw attention. G5 and G7 mentioned *the desire to change the period of the data and the presentation of the values from absolute numbers to numbers in percentage*.

G8 made a final suggestion regarding component resizing. They proposed that *the tool offers both manual and automatic component resizing options. This would allow users to specify the desired size and have it automatically adjusted*. The group emphasized the importance of component size and the convenience of automatic resizing.

4.2.3 Considerations about the study

In this study, we focused on observing how our study participants would use the customization resources to explore and customize the narrative presented. This subsection summarizes our observations during the session and addresses possible solutions to tackle the improvements participants suggested.

We must highlight that we cannot claim that our results mapped a broad range of user profiles once they involved a small number of participants. However, by conducting them, we could identify significant perspectives of how end-users employed customizable features to engage in narrative exploration and shape it to a particular context of use.

We observed that the participants within their groups engaged in the task proposed. Before customizing the narrative, they discussed what each component contained in terms of information. In addition, they also considered the visualization techniques employed in terms of what else could be added to the components to expand the possibilities of exploration of the narrative.

Regarding how the participants used the design space options to experience the narrative, we noted that they used the *customized windows* to place components that support the group's specific data or reasoning line. Two groups also used *annotations* to place comments on the components. The *annotations* addressed additional explanations of the information conveyed in the visualization or explanations that justified the choices made when customizing the narrative. It showed us that participants used *annotations* to remind decisions and interpretations of the narrative. One group changed the color scheme of the charts presented for aesthetic reasons

We observed that the components picked up by participants showed a balanced choice concerning the visualization techniques, i.e., we did not identify a preference for a technique such as a line chart over a bar chart. On the other hand, we noted that participants were prone to add more components to the narrative instead of exchanging one another (see Figure 4.13). In addition, they rearranged the components of the stage to fit their own expectations about how that could be presented.

G9 customized the narrative into two columns and suggested the creation of textual components to identify with what information each column is related. Although there is no restriction regarding the distribution of partitioned poster components, our model does not prevent the creation of components by end-users. We believe this feature would lead to the mischaracterization of the narrative regardless of the genre employed to tell the story.

We also noted differences in how the groups approached the narratives regarding their expertise profiles. The participants from the other IT courses, except Data Science (G1 to G5), attempt to organize the components according to the information presented, following a certain sense of organization. In addition, they also reported the customization in terms of size and colors of the components and charts due to aesthetic purposes.

The Data Science students (G6 to G8) approached the customization concerning the type of data transformations available. In other words, although they employed the customization features to organize the components, they were more prone to handle the data presented than to change color, size, or another aspect of the components. Both profiles used annotations to pin explanations or reminders about why they picked up the components.

The last profile of the participants (G9), the graduated students from other IT courses except Data Science, approached the customizations differently when compared to the first two profiles. They first observed what information was presented in the narrative. Then they decided how to organize the components to contextualize the problem and present the solution. According to this group, the other means of customization are not helpful until they can ensure they have customized the narrative (dragging and dropping the components) regarding their intention

Finally, the suggestions concerning data transformations are tied to the data used to build the narrative rather than potential design space limitations, they are important once they shed light on a characteristic of the presentation helpful to the participants. It also indicates that data transformations are valuable ways to explore and customize the narrative presented.

Throughout this study, we observed how the end-users approached the narratives and the customization features proposed. We picked up the partitioned poster because this genre offers multiview visualizations and can be combined with the major options of design patterns for flexible user interaction. The groups engaged in the activity by

analyzing the information presented in each component and then using the dragging and dropping components. By far, the groups prioritized this design pattern over other means of customization. It reflects their attempt to understand and organize the narrative within their thought process. The suggestions made regarding the customization features and the narrative unveiled means of interaction that can be added to empower the end-users of narrative data visualizations

4.3 Threats to validity

The following points summarize the main threats to the validity of our user studies and the strategies we followed trying to overcome them.

- **Sampling bias:** Selecting participants for a focus group and the workshop sessions may not represent the more expansive population of interest. In our study, we sought to select a diverse profile of participants regarding background and years of experience. By doing this, we aimed to capture a widening range of perspectives and experiences.
- **Group dynamic:** Group interactions within the session may influence an individual's responses. The remote session may influence the individual's responses, as well. In our study, we took advantage of lessons learned in conducting studies in remote settings acquired due to the pandemic [28].
- **Lack of knowledge of narrative visualizations:** The absence of prior knowledge in visualization may influence how participants interacted with the prototype. To mitigate this, we dedicated a moment within the workshop to explain our research's key points and make clarifications. In addition, we employed standard visualization techniques and used data from widely spoken occasions in recent history.
- **Research's desired responses:** Participants may feel pressure to provide positive feedback during the focus group and workshop sessions. Thus, they may hesitate to critique the proposal. To mitigate this, we explained the ethical issues of researching with humans and clarified that the feedback form was not linked to participants' identification. Besides, we informed them that negative feedbacks were valuable to analyze our study and did not interact with them while they were responding to the feedback form.
- **Results:** The results represent our interpretation of the textual analysis information. To mitigate the interpretation bias, we held meetings among the authors to discuss the analysis produced.

5. DISCUSSION

A narrative data visualization differs from ordinary visualization mainly because we usually visualize a variable in the latter, whereas narratives concern the visualization of information units [133]. Transforming data into a human-understandable form requires an analytical process, understanding the context, definition of appropriate methods, and visualization techniques. Also, data visualization is placed at the intersection between science and art. Therefore, there are guidelines and best practices but also an artistic flavor [76]. It is also true when it comes to narrative data visualization. Besides defining the context and visualization techniques, designers must define how the data will be displayed in a narrative structure. From this point of view, it becomes essential to bring up points for reflection on our process.

Naturally, our approach only caught some nuances of designing customizable narrative data visualization, such as the definition of elements and their relation to the components of the genres. However, while planning the story, the designer's choices can be influenced by factors like the medium where the narrative will be presented or its target audience.

The target audience is a crucial point when planning a narrative. The more specific the target audience, the more the communicative intention will likely be successful once it may represent using more explanations on the visualization, for example [76]. Additionally, it can define whether the designer will adopt one of the narrative models defined by Segel and Heer [111].

Regarding the process, the designer may proceed or go back in the process if it is needed. In addition, it is possible to remain in the same phase as long as the designer needs before proceeding to the next one. Although we presented the process with quite a linear path, in the real world, it requires many iterations to move from an initial idea to the final product. In addition, during the creation process, besides the visualization techniques, visual tactics, narrative structure, and the tailoring behavior of the narrative, the designer must define specific aspects of the narrative, such as labels to the components and their position and distribution. These aspects are not detailed in our process; however, they are intrinsic actions that must be followed while implementing the narrative.

To illustrate the application of our process, we put forward two narrative instantiations based on the flow described in it. The first instantiation was made during our collaboration abroad with Dalhousie University researchers. This instantiation explored the four data layers from the Quality in Canada Built Environment project. The second instantiation was outlined during our study to investigate how data visualization researchers employed our process to plan a narrative data visualization with customization features. This instantiation explored COVID-19 data provided by WHO.

Table 5.1 summarizes them. The first and second columns present the phase and step of the process, respectively. The remaining two columns show the first and second instantiation made. Following, we discuss the two instantiations made.

Table 5.1 – Visual narrative instantiations

Phase	Step	1 st instantiation (Canada)	2 nd instantiation (COVID)
Understanding the problem	Collect Data	Perceived space Designed space Observed space Lived space	WHO vaccination data WHO Covid-19 global data
Defining the message	Define the communicative intention Define the narrative elements	Show the different perspectives of quality in a built environment Actors: students, professors, and others University stakeholders Events: design intention of architects, activities performed by the stakeholders, stakeholders personal experiences Time: shift of the day, day, semester Location: Computer Science Building	Show the landscape of cases and deaths worldwide by region and country. In addition, show vaccine information in different regions of the world Actors: people from different countries, covid, vaccine, WHO regions Events: covid cases and deaths, vaccination, beginning of the vaccination, vaccination by dose Time: 2020 to present Location: regions defined by WHO and countries
Structuring the narrative	Define the visualization techniques Define the narrative components Define the tailoring capabilities	textbox, cloudwords, bar charts Genre(s): annotated chart Visual tactics: texts, labels, tooltips, highlights Structure tactics: prompt with options to filter the activities, time, or space analysis User annotations: in the visualizations placed in the areas or other points of the virtual environment	maps, texts, bar charts, line charts, area charts, and tables Genre(s): partitioned poster and annotated chart Visual tactics: heatmap, texts, labels, tooltips, highlights Structure tactics: filter (region and country) User annotations: in the annotated chart and other components of the narrative Customized window: to change the events shown in the narrative User preferences: to change font, font-size, and visualization technique of some event displayed
Implementing the narrative		To be implemented using mixed reality toolkits such as MRTK ¹	To be implemented using programming languages and frameworks for web development such as ReactJS and VueJS

We used datasets concerning different subjects in **Understanding the problem**. The first instantiation comprised the four data layers we considered in the project

we participated in in Canada. It is important to mention that this is an ongoing project in Canada. Hence, not all information from the data layers is available currently. Therefore, we considered the potential information to be retrieved when the research achieves these respective steps. The second instantiation comprised two COVID-19 datasets provided by WHO. These datasets contain information about the number of cases and deaths due to the pandemic and the number of vaccines and types administered by each country and WHO region.

In the second phase of our process, the **Defining the message**, we defined the communicative intention of our narrative and identified the narrative elements from the datasets. We defined the communicative intention of the first instantiation as "show the different perspectives of quality in a built environment." Once our goal is to gather perspective from diverse stakeholders, this intention is broad enough to cover our goals and to be reached considering the data available. Regarding the second instantiation, we defined the communicative intention as "show the landscape of cases and deaths worldwide by region and country. In addition, show vaccine information in different regions of the world." This intention offers readers a variety of means to explore the pandemic panorama over the world.

We defined the narrative elements of each instantiation considering our communicative intention and the data available. Our list of elements is not exhaustive once it is intended to follow the narrative's goal. Regarding the first instantiation, we described the actors as students, professors, and other university staff. We consider them the main actors from which we can take information to convey the quality of physical spaces of learning environments. The events of this instantiation address the activities performed by people attending the physical space in a certain shift of the day or semester. As the information was retrieved, it was aggregated to permit the analysis of activities performed by the day shifts. These data comprised observations made in the Goldberg Computer Science Building. This set of information allowed us to prototype ideas of narratives that allow the readers to explore different perspectives of the story.

We specified the actors from our second instantiation as people from different countries, vaccines, and WHO regions. We considered the people as actors because the data about the cases and vaccinations represent the number of individuals affected by the events. Countries, vaccines, and regions are also actors once the data enables us to analyze the topic from these perspectives. The events comprised quantitative information on the pandemic and the beginning date of the vaccination. Time and location refer to the information retrieved from the datasets.

During this phase, no significant factors affected the decisions made when comparing the two instantiations. The communicative intention and narrative elements were determined based on the characteristics of the available data. However, analyzing the data required slight differences. The second instantiation used structured data, making

elements identification straightforward. The first one used semistructured data, necessitating a content analysis.

The third phase, the **Structuring the narrative**, involved defining the narrative's structure in terms of visualization techniques, narrative components, and tailoring capabilities. The choices made in the first instantiation considered that the narrative being planned would be presented in a virtual setting with the support of a Head Mounted Display (HMD) such as Microsoft HoloLens or Apple Vision Pro. Hence, the visualization techniques included textbox, choropleth, cloud words, and bar charts, i.e., techniques suitable to such environments. The genre picked up was the annotated chart because it is possible to visualize annotations over the ground while wearing an HMD. Following, we defined the visual tactics and narrative structure tactics. In such a setting, we defined that the users can place annotations while consuming the story presented as the tailoring feature of the narrative.

In the second instantiation, we defined the web as a setting to present the narrative. Once this platform offers a wide variety of techniques to display the events of the narrative, we defined the visualization techniques of maps, texts, bar charts, line charts, area charts, and tables to present the events to end-users. Regarding the genre, the participants chose the partitioned poster combined with an annotated chart once this combination permitted them to present multiple views of the narrative and explain a point of view in detail. Next, the visual and narrative structure tactics were defined as a heatmap, texts, labels, tooltips, highlights, and filters by country and region. In the last step of this phase, the participants selected User Annotations, Customized windows, and User preferences to provide users with customization of the narrative.

During the third phase, we encountered variations in how we defined the methods used to organize the story. These differences were due to the platform we planned to present the narrative. In the first instance, we limited the visualization techniques and narrative components (genre, visual tactics, narrative structure tactics) to those best suited for user interaction in virtual environments. For example, we utilized text boxes, bar charts, and prompts, which are more manageable than other techniques like maps. In the second instance, we had access to the full range of narrative design options since we were developing web applications.

In the last phase of our process, **Implementing the narrative**, we describe the platform where each narrative would be deployed. As mentioned, the first instantiation was intended to be presented in virtual settings. Thus, we described technologies in this setting in the process. This information for the second instantiation, in turn, was described using web development technologies such as ReactJS and VueJS.

Figure 5.1 illustrates the two narratives outlined with the assistance of our process that we summarized in Table 5.1. Figure 5.1 (a) shows how a viewer experiencing the narrative would interact with the story. This example focuses on the perspective of

someone wearing a head-mounted display (HMD) and moving through a physical environment. Note that in the first quadrant, the user has a prompt showing option of what can be seen in the virtual setting. These options work as filters that let users choose the information presented. After picking up a category, the aggregated information about activities performed in that local is shown over a table in the physical space.

Figure 5.1 (b) shows how a narrative from the second instantiation would be. This example considers the perspective of a web application being accessed through a browser in a device such as a laptop. Note that the partitioned poster has multiple components showing specific events defined during the process. In the case of the map, a tooltip is shown when the user hovers the mouse pointer over a country, as defined in the visual tactics step.

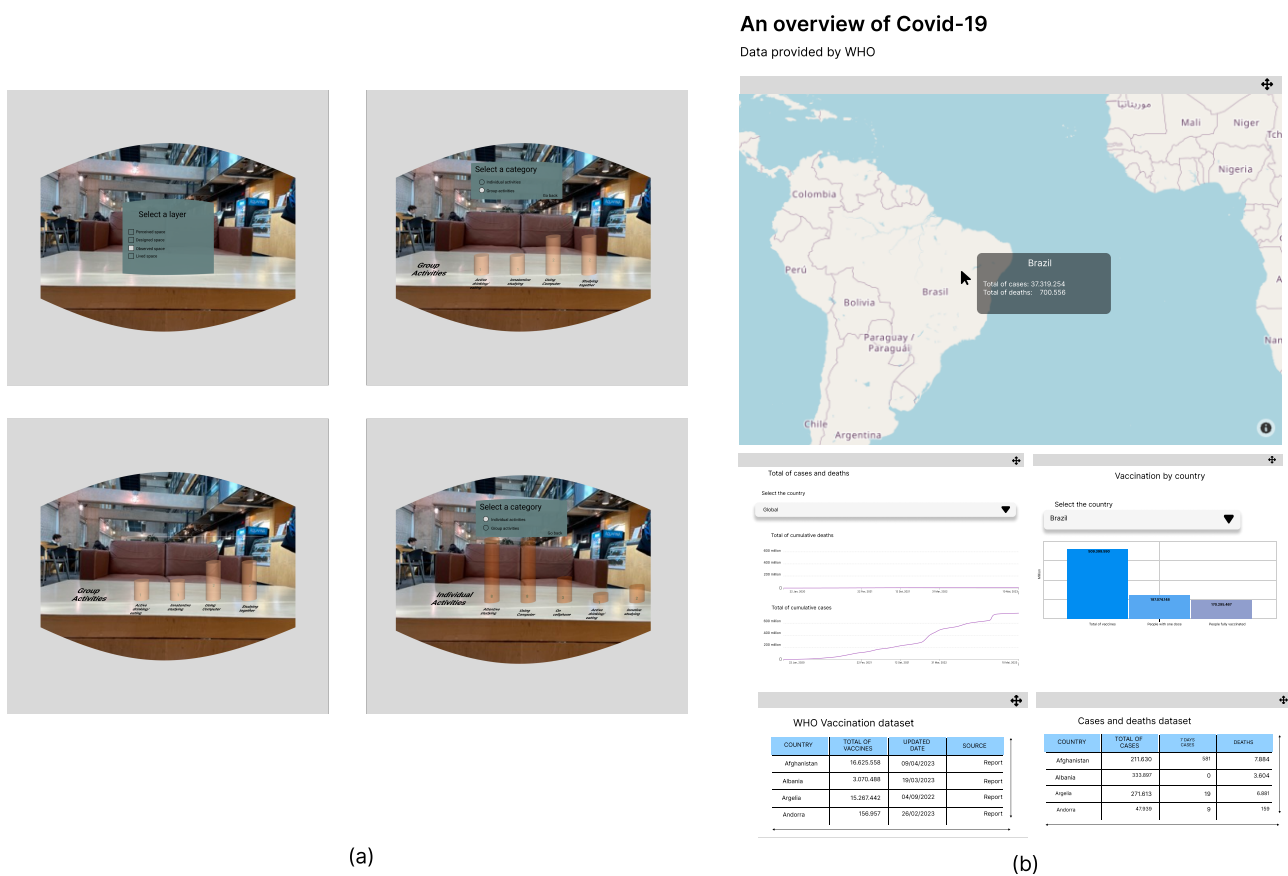


Figure 5.1 – Examples of narratives for virtual and web applications

When comparing the two narratives, Figure 5.1 (b) shows all events in one view, but in the virtual setting, events are revealed gradually as the user moves around. This situation occurs because showing all information at once would be overwhelming, so the narrative should be presented gradually. In addition, when planning a narrative for virtual settings, designers should consider what actions users can perform while interacting with the virtual interface and how the visualization techniques can be placed in the real environment.

Our initial intention was to develop a process specifically aimed to cover data visualization for web settings. However, our collaboration with VR/AR researchers made us realize that our process also helps identify narrative elements that are essential for narratives regardless of the target medium. For example, the visualization techniques described in the process can be used in stories for locative storytelling [114] or situated visualizations [16] in virtual settings.

Finally, although additional user studies must be performed to explore narratives in such environments, we believe that our process is helpful for planning narrative data visualizations once it makes the designers gather significant narrative elements and define the structure of how the story will be conveyed. Besides, it allows designers to freely iterate, proceed, or go back as often as they like to refine the narrative without any constraints on their flow in the various phases and steps.

6. FINAL REMARKS

Narrative data visualizations emerged as an alternative to present data in a story-like shape with a context, making it more accessible to end-users' comprehension. The idea arose because human beings have used stories to convey information across generations since the beginning [12, 41].

The topic has attracted various authors contributing to it from different perspectives. Riche and colleagues [104] covered various of topics, from technical matters like tools to support storytelling to design patterns and ethics in data-driven storytelling. Hullmann and Diakopoulos [71] explored rhetorical techniques to convey particular messages from data.

The seminal work of Segel and Heer [111] reported the design space for narratives, shedding light on the structure of the information, visual and narrative techniques. Drucker and colleagues [44] focused on communicating the data to the target audience. Throughout their contribution, the authors investigated matters like audience knowledge and literacy and how to tailor the story to an unknown audience.

The audience, or end-users, are important in visualizations because they are the ones designers intend to reach. End-users have specific needs and preferences for how data is presented and organized. Therefore, it is helpful to have applications that allow viewers to adjust the content to meet their needs. It makes it worthwhile to consider applications that allow users to customize the content they see.

The topic that addresses end-users perspectives within an application is named End-User Development (EUD). EUD envisions empowering end-users to perform meaningful actions in applications like customization and adaptation to make them fit some context of use [84].

In this scenario, it became interesting to put effort into the investigation of how to blend narrative data visualizations and methods from the EUD community to develop narrative visualizations in which the end-users could play a more substantial role, having agency over what is displayed without mischaracterizing the message conveyed by the designer through the narrative.

In the work presented in this thesis, we proposed a process to assist designers in planning narrative data visualizations with customization features, i.e., customizable narrative data visualizations. In the past, few researchers have considered the process of creating data-driven stories. Lee and colleagues [83], and Zhang and colleagues [133] are examples. However, to the best of our knowledge, our research is the first that blends narratives with EUD toward developing a narrative data visualization approach.

Regarding the scope of customizations end-users can perform, it is essential to mention that the designer of the narratives is in charge of this definition. Our approach

describes a design space and a set of design patterns for flexible interfaces to support this definition. Our design space is not exhaustive, which means that we can consider other design patterns in the future to increase the customization features of narrative visualizations.

Finally, we hope our results instigate other researchers to engage in narrative data visualization research. We believe that our process may be helpful to familiarize data visualization researchers with the process of planning a narrative once it enables them to gather the significant elements of a narrative and tie them into a narrative structure.

6.1 Contributions of this thesis

Our research group^{1 2} has extensive experience in researching data visualization. Therefore, this thesis presents a twofold contribution. First, this thesis contributes to the information visualization field by presenting a process to assist designers in planning customizable narrative data visualizations.

The process proposed is based on narrative data visualization and EUD concepts and consists of phases and steps. It helps the designers to define the significant narrative elements required to design a narrative data visualization with customization features.

Second, this thesis advanced the studies of our research group regarding narrative data visualizations. We have published three research studies regarding the subject.

Ghidini [65] explored narrative data visualizations to present data from Twitter. His work exploited a model based on the partitioned poster, and the significant findings encompass the model's usefulness to enable users to explore data to discover specific information by filtering or discovering information without any prior knowledge on the subject of the narrative. Therefore, Ghidini[65] explored a narrative for presenting social media data and how users experienced it. A gap from his research is the employment of customization features on the narrative to expand the possibilities of user exploration and the absence of guidance for designers in building narratives.

Similarly, Santos [109] also explored narrative data visualizations to present data from social media. However, she explored these visualizations from the designers' and data analysts' perspectives. She developed a model of an interactive user interface where the designer provides data analysts with resources to customize their narrative data visualization. In this context, the data analysts assume the role of co-designers of the narratives. As a result, her research showed that the model accurately enabled designers to express decisions concerning the customization of narrative data visualizations. A re-

¹<http://dgp.cnpq.br/dgp/espelhogrupo/8219151435325502>

²<https://www.inf.pucrs.br/davint/>

search opportunity not addressed in her work is how end-users of the narratives could be approached in the context of customizable narratives.

More recently, Borges [11] investigated the composition of the narrative genres Segel and Heer [111] described. By conducting literature and user studies, she described the seven narrative genres as structures composed of components that can hold images, texts, charts, or other visualization techniques. The significant contributions of her work are this definition of the structure of the genres and a guide to describe how designers and data analysts can build a narrative based on the genres' components. A gap from her research is exploring how this description of the genres' structure can make the genres more flexible by enabling end-users to use them to customize the narratives.

In this work, we took advantage of this experience in information visualization to fill the gaps we identified in the referred works. Our work encompasses both designers and end-users in the context of narrative data visualizations. We also offered a perspective of customization of the genres based on their component structure. In addition, we provided initial findings on how customizable resources affect end-users in exploring narratives. Finally, in the next section, we address research opportunities from our findings.

6.2 Future work

We envision future studies in the short, medium, and long term. Some of the future work is related to the limitations of this work, and others are related to contributions that arose in our user studies and research paths we foresee for the future. Next, we present them following the expected term.

In the short term, we foresee additional user studies to investigate the use of the process in other information visualization contexts and with a range of designer profiles organized according to their experience in visualization research. We also expect to build a toolkit written in simple language, i.e., avoiding technical terms to be accessed online, and that may be helpful to introduce new researchers and the general audience to narrative data visualization.

In the medium term, we envision building samples of customizable data narratives fully functioning by adopting frameworks like ReactJS³ to develop a web application. The development of these samples will allow us to carry out analysis using Visual Analytics [108, 129] methods to unveil additional information regarding user interaction with the customizable narratives.

Finally, our research group has experience in research on narrative data visualizations. Hence, in the long term, we envision advancing this topic by aggregating our results with those reported by Santos [109] toward developing a tool to support design-

³<https://react.dev>

ers in designing narrative visualizations. We also envision advancing our research toward enabling end-users to customize the narrative by adding new data to the story, which requires means to perform data curation to ensure narrative congruence.

6.3 Limitations of the work

Although the number of participants is adequate for qualitative research, variations in their knowledge and experience can affect the accuracy of results, particularly if some are unfamiliar with narrative visualizations. Furthermore, finding professionals with data visualization expertise who can participate in user studies can be challenging. Another limitation is related to user studies. We conducted studies in which users had to plan a narrative or interact with prototypes that simulated the customizable behavior of the visualization instead of a real application. This research may not deeply reach the range of interactions with customizable applications in this scenario.

The research on narrative data visualizations may aggregate a variety of matters that we are aware of and have not been addressed in this work. For example, the target audience of a narrative data visualization plays an important role and should be considered when developing a story. Other aspects not addressed in this work concern the ethical development of narratives regarding data provenance, transformation, and connecting insights through the story to not misinform the user. We are aware of these matters. However, we believe they are intrinsic to visualization development and a designer's duty.

6.4 Academic Journey

The Ph.D. course encompassed a variety of activities to provide broad training as a researcher. In this sense, the Ph.D. candidate accomplished various tasks throughout this research, including publishing papers in journals and conferences, reviewing for different conferences, giving lectures, co-working with researchers abroad, and co-supervising undergraduate students. The following subsections provide a detailed account of each action carried out during this journey.

6.4.1 Publications

We have published eight papers, three of which are published in journals and the rest in conferences.

Journals:

1. CORREA, C.M.; SILVEIRA, M.S. **End-User Development Landscape: A Tour into Tailoring Software Research**. International Journal of Human–Computer Interaction, p. 1-15, 2022. (Qualis A1).
2. CORREA, C.M.; BARBOSA, G.D.J.; BARBOSA, S.D.J; SILVEIRA, M.S. **HCI Research Experiences during the Pandemic: Lessons Learned for the Road Ahead**. Interacting With Computers, p. 1-14, 2022. (Qualis A2).
3. BORGES, M.; CORREA, C. M.; SILVEIRA, M. S. **Fundamental elements and characteristics for telling stories using data**. Journal on Interactive Systems, Porto Alegre, RS, v. 13, n. 1, p. 77–86, 2022. (Qualis B1).

Conferences:

1. NUNES, F.; CORREA, C.M.; JANDREY, A.; BARCELOS, A.; REYES, D., BERNARDES, M.; SALES, A.; SILVEIRA, M.S. **Data visualization on focus: exploring communicability of dashboards generated from BI tools**. In: Proceedings of the 19th Brazilian Symposium on Human Factors in Computing Systems. 2020. p. 1-6. (Qualis A3).
2. CORREA, C. M.; de FREITAS, G.V.M.; dos SANTOS, E.; SILVEIRA, M.S. **From now on: experiences from user-based research in remote settings**. In: Proceedings of the XX Brazilian Symposium on Human Factors in Computing Systems. 2021. p. 1-7. (Qualis A3).
3. CORREA, C.M.; SILVEIRA, M.S. **End-User Highlighted: featuring tailorable systems development**. In: Proceedings of the XX Brazilian Symposium on Human Factors in Computing Systems. 2021. p. 1-9. (Qualis A3).
4. CORREA, C.M.; SILVEIRA, M.S. **Diving in the story: exploring tailoring in narrative data visualizations**. In: Proceedings of the XXI Brazilian Symposium on Human Factors in Computing Systems. 2022. p. 1-7. (Qualis A3).
5. CORREA, C.M.; SILVEIRA, M.S. **Desenvolvimento por Usuário Final: Panorama da Pesquisa em Customização de Software por Usuário Final**. In: Extended Annals of the XXII Brazilian Symposium on Human Factors in Computing Systems. 2023. p. 1-5.

6.4.2 Visiting Graduated Research Student (VGRS)

For six months, from September 2022 to February 2023, we have been granted a scholarship to do an internship as a visiting graduate research student at the Faculty

of Computer Science at Dalhousie University to advance our studies in the subject of our thesis under the supervision of Professor Derek Reilly. This internship was sponsored by CAPES/PrInt program.

6.4.3 Participations in activities/events

We attended a diversity of activities during the Ph.D. These activities encompass two speeches at Universities, two events, five events committees, and four cosupervision of undergraduate research students. Following, we detail each activity performed.

Speeches:

- Lecture given in 2023 at Universidade Regional Integrada do Alto Uruguai e das Missões (URI). Title: "Ciência para Além das Fronteiras do Brasil". The goal of the lecture was to show my experience abroad as a Visiting Researcher at Dalhousie University, Canada.
- Lecture given in 2021 to the Computer Science Graduate Course of Universidade Federal de São Paulo (UNIFESP). Title: End-User Development: empoderando usuários finais no uso do software. The goal of the lecture was to show initial results of my research.

Events:

1. XX Brazilian Symposium on Human Factors in Computing Systems. 2021.
2. 19th Brazilian Symposium on Human Factors in Computing Systems. 2020.

Events Committees:

1. Reviewer of the Computing Education Workshop (WEI). 43^o Brazilian Congress of Computer Science Society, 2023.
2. Member of the Evaluation Committee of PUCRS candidates to CAPES Thesis Awards 2023.
3. Reviewer of Research track. XXI Brazilian Symposium on Human Factors in Computing Systems, 2022.
4. Reviewer of the HCI Education Workshop (WEIHC). XXI Brazilian Symposium on Human Factors in Computing Systems, 2022.

5. Reviewer of the HCI Education Workshop (WEIHC). XX Brazilian Symposium on Human Factors in Computing Systems, 2021.

Cosupervision of undergraduate research students:

1. BERNARDON, E. Desenvolvimento de Modelos de Visualização Narrativa. Programa Institucional de Bolsa de Iniciação Científica e de Iniciação em Desenvolvimento Tecnológico e Inovação da PUCRS (PIBIT). 2022.
2. ILGES, C.; ROMANI, G.; PAGNONCELLI, I.; CORREA, C.M. Análise sobre Visualização Narrativa de Dados. 2022. Disciplina de Introdução à Pesquisa. Curso de Ciência da Computação. PUCRS.
3. FRAÇÃO, C. Desenvolvimento de Modelos de Visualização Narrativa. Programa Institucional de Bolsa de Iniciação Científica e de Iniciação em Desenvolvimento Tecnológico e Inovação da PUCRS (PIBIT). 2021.
4. PAIZ, G. Desenvolvimento de Modelos de Visualização Narrativa. Programa Institucional de Bolsa de Iniciação Científica e de Iniciação em Desenvolvimento Tecnológico e Inovação da PUCRS (PIBIT). 2020.

REFERENCES

- [1] Ardito, C.; Costabile, M. F.; Desolda, G.; Lanzilotti, R.; Matera, M. “Reflections on system properties valued by end users in designing end-user development systems”. In: IFIP TC13 International Conference on Human-Computer Interaction, 2018, pp. 106–113.
- [2] Ardito, C.; Costabile, M. F.; Desolda, G.; Lanzilotti, R.; Matera, M.; Picozzi, M. “Visual composition of data sources by end users”. In: International Working Conference on Advanced Visual Interfaces, 2014, pp. 257–260.
- [3] Ardito, C.; Costabile, M. F.; Desolda, G.; Matera, M. “A three-layer meta-design model for addressing domain-specific customizations”. In: *New Perspectives in End-User Development*, Springer, 2017, pp. 99–120.
- [4] Arya, A.; Gerroir, J.; Mike-Ifeta, E.; Navarro-Newball, A. A.; Prakash, E. “Museum: Personalized experience with narrative visualization for museum visitors”. In: International Conference on Human-Computer Interaction, 2016, pp. 179–190.
- [5] Arévalo, S.; Dewan, A. “Unveiling storytelling and visualization of data”. In: Student Colloquium at University of Groningen, 2017, pp. 38–42.
- [6] Bach, B.; Wang, Z.; Farinella, M.; Murray-Rust, D.; Henry Riche, N. “Design patterns for data comics”. In: International Conference on Human Factors in Computing Systems, 2018, pp. 1–12.
- [7] Baranauskas, M. C. C.; Neris, V. P. d. A. “Using patterns to support the design of flexible user interaction”. In: International Conference on Human-Computer Interaction, 2007, pp. 1033–1042.
- [8] Barricelli, B. R.; Cassano, F.; Fogli, D.; Piccinno, A. “End-user development, end-user programming and end-user software engineering: A systematic mapping study”, *Journal of Systems and Software*, vol. 149, Mar 2019, pp. 101–137.
- [9] Battle, L.; Heer, J. “Characterizing exploratory visual analysis: A literature review and evaluation of analytic provenance in tableau”. In: Eurographics Conference on Visualization, 2019, pp. 145–159.
- [10] Borges, M.; Correa, C. M.; Silveira, M. S. “Fundamental elements and characteristics for telling stories using data”, *Journal on Interactive Systems*, vol. 13, Jun 2022, pp. 77–86.
- [11] Borges, M. G. “Apoio à construção de visualizações narrativas de dados com Ênfase em gêneros narrativos”, Master’s Thesis, Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS), 2022, 98p.

- [12] Boy, J.; Detienne, F.; Fekete, J.-D. "Storytelling in information visualizations: Does it engage users to explore data?" In: International Conference on Human Factors in Computing Systems, 2015, pp. 1449–1458.
- [13] Boyd Davis, S.; Vane, O.; Kräutli, F. "Using data visualisation to tell stories about collections". In: Electronic Visualisation and the Arts, 2016, pp. 221–228.
- [14] Braun, V.; Clarke, V. "Using thematic analysis in psychology", *Qualitative Research in Psychology*, vol. 3, Jul 2006, pp. 77–101.
- [15] Brehmer, M.; Lee, B.; Bach, B.; Riche, N. H.; Munzner, T. "Timelines revisited: A design space and considerations for expressive storytelling", *IEEE Transactions on Visualization and Computer Graphics*, vol. 23, Oct 2016, pp. 2151–2164.
- [16] Bressa, N.; Korsgaard, H.; Tabard, A.; Houben, S.; Vermeulen, J. "What's the situation with situated visualization? A survey and perspectives on situatedness", *IEEE Transactions on Visualization and Computer Graphics*, vol. 28, Jan 2022, pp. 107–117.
- [17] Brolcháin, N. Ó.; Porwol, L.; Ojo, A.; Wagner, T.; Lopez, E. T.; Karstens, E. "Extending open data platforms with storytelling features". In: Annual International Conference on Digital Government Research, 2017, pp. 48–53.
- [18] Bryan, C.; Ma, K.-L.; Woodring, J. "Temporal summary images: An approach to narrative visualization via interactive annotation generation and placement", *IEEE Transactions on Visualization and Computer Graphics*, vol. 23, Aug 2016, pp. 511–520.
- [19] Cabitza, F.; Fogli, D.; Piccinno, A. "Each to His Own: Distinguishing activities, roles and artifacts in eud practices". In: Smart Organizations and Smart Artifacts. Lecture Notes in Information Systems and Organisation, 2014, pp. 193–205.
- [20] Cai, L.; Zhu, Y. "The challenges of data quality and data quality assessment in the big data era", *Data Science Journal*, vol. 14, May 2015, pp. 1–10.
- [21] Cappiello, C.; Daniel, F.; Matera, M.; Picozzi, M.; Weiss, M. "Enabling end user development through mashups: requirements, abstractions and innovation toolkits". In: International Conference on End-User Development, 2011, pp. 9–24.
- [22] Carpendale, S.; Thudt, A.; Perin, C.; Willett, W. "Subjectivity in personal storytelling with visualization", *Information Design Journal*, vol. 23, Oct 2017, pp. 48–64.
- [23] Chan, Y.-Y.; Qu, H. "Finavistory: Using narrative visualization to explain social and economic relationships in financial news". In: International Conference on Big Data and Smart Computing, 2016, pp. 32–39.

- [24] Chen, Q.; Li, Z.; Pong, T.-C.; Qu, H. "Designing narrative slideshows for learning analytics". In: IEEE Pacific Visualization Symposium, 2019, pp. 237–246.
- [25] Chen, S.; Li, J.; Andrienko, G.; Andrienko, N.; Wang, Y.; Nguyen, P. H.; Turkay, C. "Supporting story synthesis: Bridging the gap between visual analytics and storytelling", *IEEE Transactions on Visualization and Computer Graphics*, vol. 26, Dec 2018, pp. 2499–2516.
- [26] Comet, L. T. M. "Visual narrative data-driven storytelling", *ACM Transactions on Multimedia Computing, Communications and Applications*, vol. 1, Jul 2018, pp. 1–20.
- [27] Corbin, J.; Straus, A. "Basics of Qualitative research: techniques and procedures for developing grounded theory". Sage Publications, 2008, 400p.
- [28] Correa, C. M.; Barbosa, G. D. J.; Barbosa, S. D. J.; Silveira, M. S. "HCI research experiences during the pandemic: Lessons learned for the road ahead", *Interacting With Computers*, vol. 1, Nov 2022, pp. 1–15.
- [29] Correa, C. M.; de Freitas, G. V. M.; dos Santos Eberhardt, A. L.; Silveira, M. S. "From now on: Experiences from user-based research in remote settings". In: Brazilian Symposium on Human Factors in Computing Systems, 2021, pp. 1–7.
- [30] Correa, C. M.; Silveira, M. S. "End-user highlighted: featuring tailorable systems development". In: Brazilian Symposium on Human Factors in Computing Systems, 2021, pp. 1–9.
- [31] Correa, C. M.; Silveira, M. S. "Diving in the story: exploring tailoring in narrative data visualizations". In: Brazilian Symposium on Human Factors in Computing Systems, 2022, pp. 1–7.
- [32] Correa, C. M.; Silveira, M. S. "End-user development landscape: A tour into tailoring software research", *International Journal of Human-Computer Interaction*, vol. 39, Jun 2022, pp. 1–15.
- [33] Costabile, M. F.; Fogli, D.; Fresta, G.; Mussio, P.; Piccinno, A. "Building environments for end-user development and tailoring". In: IEEE Symposium on Human Centric Computing Languages and Environments, 2003, pp. 31–38.
- [34] Costabile, M. F.; Fogli, D.; Lanzilotti, R. "Supporting work practice through end-user development environments", *Journal of Organizational and End User Computing*, vol. 18, Oct 2006, pp. 43–65.
- [35] Costabile, M. F.; Fogli, D.; Lanzilotti, R.; Marcante, A.; Mussio, P.; Provenza, L. P.; Piccinno, A. "Meta-design to face co-evolution and communication gaps between

- users and designers”. In: International Conference on Universal Access in Human-Computer Interaction, 2007, pp. 46–55.
- [36] Costabile, M. F.; Fogli, D.; Mussio, P.; Piccinno, A. “Visual interactive systems for end-user development: A model-based design methodology”, *IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans*, vol. 37, Oct 2007, pp. 1029–1046.
- [37] Costabile, M. F.; Mussio, P.; Provenza, L. P.; Piccinno, A. “Advanced visual systems supporting unwitting eud”. In: Working Conference on Advanced Visual Interfaces, 2008, pp. 313–316.
- [38] Cruz, P.; Machado, P. “Generative storytelling for information visualization”, *IEEE Computer Graphics and Applications*, vol. 31, Feb 2011, pp. 80–85.
- [39] de Andrade Cardieri, G.; Zaina, L. A. M. “Playing the role of co-designers on mobile pwas: An investigation of end-users interaction”. In: International Conference on Enterprise Information Systems, 2020, pp. 476–486.
- [40] Desolda, G.; Ardito, C.; Matera, M. “Efesto: a platform for the end-user development of interactive workspaces for data exploration”. In: International Rapid Mashup Challenge, 2015, pp. 63–81.
- [41] Diakopoulos, N. “Game-y information graphics”. In: International Conference on Human Factors in Computing Systems, 2010, pp. 3595–3600.
- [42] Dittrich, Y.; Erikseji, S.; Hanssoni, C. “PD in the wild; evolving practices of design in use”. In: Participatory Design Conference, 2002, pp. 23–25.
- [43] Dittrich, Y.; Lindeberg, O.; Lundberg, L. “End-user development as adaptive maintenance”. In: *End User Development*, Springer, 2006, pp. 295–313.
- [44] Drucker, S.; Huron, S.; Kosara, R.; Schwabish, J.; Diakopoulos, N. “Communicating Data to an Audience”. CRC Press, 2018, chap. 9, pp. 212–230.
- [45] Dörner, C.; Hess, J.; Pipek, V. “Improving information systems by end user development: A case study”. In: European Conference on Information Systems, 2007, pp. 783–794.
- [46] Echeverria, V.; Martinez-Maldonado, R.; Granda, R.; Chiluzia, K.; Conati, C.; Shum, S. B. “Driving data storytelling from learning design”. In: International Conference on Learning Analytics and Knowledge, 2018, pp. 131–140.
- [47] Echeverria, V.; Martinez-Maldonado, R.; Shum, S. B. “Towards data storytelling to support teaching and learning”. In: Australian Conference on Computer-Human Interaction, 2017, pp. 347–351.

- [48] Elias, M.; Aufaure, M.-A.; Bezerianos, A. "Storytelling in visual analytics tools for business intelligence". In: IFIP TC13 International Conference on Human-Computer Interaction, 2013, pp. 280–297.
- [49] Figueiras, A. "How to tell stories using visualization". In: International Conference on Information Visualisation, 2014, pp. 18–18.
- [50] Figueiras, A. "Narrative visualization: A case study of how to incorporate narrative elements in existing visualizations". In: International Conference on Information Visualisation, 2014, pp. 46–52.
- [51] Fischer, G. "Meta-design: expanding boundaries and redistributing control in design". In: IFIP TC13 International Conference on Human-Computer Interaction, 2007, pp. 193–206.
- [52] Fischer, G. "End-user development and meta-design: Foundations for cultures of participation", *Journal of Organizational and End User Computing*, vol. 22, Jan 2010, pp. 52–82.
- [53] Fischer, G.; Fogli, D.; Mørch, A.; Piccinno, A.; Valtolina, S. "Design trade-offs in cultures of participation: empowering end users to improve their quality of life", *Behaviour & Information Technology*, vol. 39, Jan 2020, pp. 1–4.
- [54] Fischer, G.; Fogli, D.; Piccinno, A. "Revisiting and broadening the meta-design framework for end-user development". In: *New Perspectives in End-User Development*, Springer, 2017, pp. 61–97.
- [55] Fischer, G.; Giaccardi, E. "Meta-design: A framework for the future of end-user development". In: *End User Development*, Springer, 2006, pp. 427–457.
- [56] Fischer, G.; Giaccardi, E.; Ye, Y.; Sutcliffe, A. G.; Mehandjiev, N. "Meta-design: a manifesto for end-user development", *Communications of the ACM*, vol. 47, Sep 2004, pp. 33–37.
- [57] Fischer, G.; Nakakoji, K.; Ye, Y. "Metadesign: Guidelines for supporting domain experts in software development", *IEEE Software*, vol. 26, Sep-Oct 2009, pp. 37–44.
- [58] Fischer, G.; Piccinno, A.; Ye, Y. "The ecology of participants in co-evolving socio-technical environments". In: Conference on Human-Centered Software Engineering and International Workshop on Task Models and Diagrams, 2008, pp. 279–286.
- [59] Fogli, D. "Designing visual interactive systems in the e-government domain". In: International Working Conference on Advanced Visual Interfaces, 2012, pp. 46–49.

- [60] Fogli, D.; Piccinno, A. "Enabling domain experts to develop usable software artifacts". In: *Organizational Change and Information Systems. Lecture Notes in Information Systems and Organisation*, Springer, 2013, pp. 419–428.
- [61] Fogli, D.; Provenza, L. P. "A meta-design approach to the development of e-government services", *Journal of Visual Languages & Computing*, vol. 23, Apr 2012, pp. 47–62.
- [62] Fu, Y.; Stasko, J. "Supporting data-driven basketball journalism through interactive visualization". In: *International Conference on Human Factors in Computing Systems*, 2022, pp. 1–17.
- [63] Furlan, P. K.; Laurindo, F. J. B. "Agrupamentos epistemológicos de artigos publicados sobre big data analytics", *Transinformação*, vol. 29, Jan-Mar 2017, pp. 91–100.
- [64] Garcia, F. E.; de Almeida Neris, V. P. "A framework for tailorable games: toward inclusive end-user development of inclusive games", *Universal Access in the Information Society*, vol. 21, Nov 2020, pp. 1–45.
- [65] Ghidini, E. "Representação de narrativas interativas por meio de visualizações com dados extraídos de redes sociais", Master's Thesis, Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS), 2017, 119p.
- [66] Gutiérrez, A.; Pérez, C. B. "Data visualization process through storytelling technique in business intelligence", *Avances en Interacción Humano-Computadora*, vol. 1, Sep 2016, pp. 49–52.
- [67] Heer, J.; Bostock, M.; Ogievetsky, V. "A tour through the visualization zoo", *Communications of the ACM*, vol. 53, May 2010, pp. 59–67.
- [68] Heer, J.; Mackinlay, J.; Stolte, C.; Agrawala, M. "Graphical histories for visualization: Supporting analysis, communication, and evaluation", *IEEE Transactions on Visualization and Computer Graphics*, vol. 14, Oct 2008, pp. 1189–1196.
- [69] Heer, J.; Viégas, F. B.; Wattenberg, M. "Voyagers and voyeurs: supporting asynchronous collaborative information visualization". In: *International Conference on Human Factors in Computing Systems*, 2007, pp. 1029–1038.
- [70] Hertel, H.; Dittmar, A.; Linke, D. "Meta-level support for facilitating participation in website (re-) design activities". In: *Symposium on Engineering Interactive Computing Systems*, 2020, pp. 1–6.
- [71] Hullman, J.; Diakopoulos, N. "Visualization rhetoric: Framing effects in narrative visualization", *IEEE Transactions on Visualization and Computer Graphics*, vol. 17, Sep 2011, pp. 2231–2240.

- [72] Hullman, J.; Drucker, S.; Riche, N. H.; Lee, B.; Fisher, D.; Adar, E. "A deeper understanding of sequence in narrative visualization", *IEEE Transactions on Visualization and Computer Graphics*, vol. 19, Oct 2013, pp. 2406–2415.
- [73] Johnsson, B. A.; Magnusson, B. "Towards end-user development of graphical user interfaces for internet of things", *Future Generation Computer Systems*, vol. 107, Jun 2020, pp. 670–680.
- [74] Joshi, A. "Learning cues to improve the understanding of explanatory storytelling". In: *Workshop on Data Vis Activities to Facilitate Learning, Reflecting, Discussing, and Designing*, 2021, pp. 1–6.
- [75] Kahler, H.; Mørch, A.; Stiemerling, O.; Wulf, V. "Computer supported cooperative work: the journal of collaborative computing", *Computer Supported Cooperative Work*, vol. 9, Mar 2000, pp. 1–4.
- [76] Knaflic, C. N. "Storytelling com dados: um guia sobre visualização de dados para profissionais de negócios". Alta Books, 2019, 256p.
- [77] Ko, A. J.; Abraham, R.; Beckwith, L.; Blackwell, A.; Burnett, M.; Erwig, M.; Scaffidi, C.; Lawrance, J.; Lieberman, H.; Myers, B.; et al.. "The state of the art in end-user software engineering", *ACM Computing Surveys*, vol. 43, Apr 2011, pp. 1–44.
- [78] Kontio, J.; Bragge, J.; Lehtola, L. "The focus group method as an empirical tool in software engineering". In: *Guide to Advanced Empirical Software Engineering*, Springer, 2008, pp. 93–116.
- [79] Kosara, R.; Mackinlay, J. "Storytelling: The next step for visualization", *Computer*, vol. 46, Jan 2013, pp. 44–50.
- [80] Latif, S.; Chen, S.; Beck, F. "A Deeper Understanding of Visualization-text Interplay in Geographic Data-driven Stories", *Computer Graphics Forum*, vol. 40, Jun 2021, pp. 311–322.
- [81] Lee, B.; Dwyer, T.; Baur, D.; Veira, X. G. "Watches to augmented reality: Devices and gadgets for data-driven storytelling". In: *Data-driven storytelling*, AK Peters/CRC Press, 2018, pp. 135–149.
- [82] Lee, B.; Kazi, R. H.; Smith, G. "Sketchstory: Telling more engaging stories with data through freeform sketching", *IEEE Transactions on Visualization and Computer Graphics*, vol. 19, Oct 2013, pp. 2416–2425.
- [83] Lee, B.; Riche, N. H.; Isenberg, P.; Carpendale, S. "More than telling a story: Transforming data into visually shared stories", *IEEE Computer Graphics and Applications*, vol. 35, Sep 2015, pp. 84–90.

- [84] Lieberman, H.; Paternò, F.; Klann, M.; Wulf, V. "End-user development: An emerging paradigm". In: *End User Development*, Springer, 2006, pp. 1–8.
- [85] Liem, J.; Perin, C.; Wood, J. "Structure and empathy in visual data storytelling: Evaluating their influence on attitude", *Computer Graphics Forum*, vol. 39, Jun 2020, pp. 277–289.
- [86] Liu, S.; Wu, Y.; Wei, E.; Liu, M.; Liu, Y. "Storyflow: Tracking the evolution of stories", *IEEE Transactions on Visualization and Computer Graphics*, vol. 19, Oct 2013, pp. 2436–2445.
- [87] Ma, K.-L.; Liao, I.; Frazier, J.; Hauser, H.; Kostis, H.-N. "Scientific storytelling using visualization", *IEEE Computer Graphics and Applications*, vol. 32, Dec 2011, pp. 12–19.
- [88] Maceli, M.; Atwood, M. "'human crafters' once again: Supporting users as designers in continuous co-design". In: *International Symposium on End-User Development*, 2013, pp. 9–24.
- [89] Maceli, M. G. "Tools of the trade: a survey of technologies in end-user development literature". In: *International Symposium on End-User Development*, 2017, pp. 49–65.
- [90] Macías, J. "Development of end-user-centered eud software". In: *International Conference on Interacción Persona-Ordenador*, 2012, pp. 1–2.
- [91] McKenna, S.; Henry Riche, N.; Lee, B.; Boy, J.; Meyer, M. "Visual narrative flow: Exploring factors shaping data visualization story reading experiences". In: *Eurographs Conference on Visualization*, 2017, pp. 377–387.
- [92] Mørch, A. "Three levels of end-user tailoring: Customization, integration, and extension". The MIT Press, 1997, chap. 3, pp. 51–76.
- [93] Moretti, M.; De Chiara, F.; Napolitano, M. "Beyond transparency: Making the italian public administration more accessible through data storytelling." In: *International Conference Information Visualisation*, 2018, pp. 247–250.
- [94] Mørch, A.; Mehandjiev, N. "Tailoring as collaboration: The mediating role of multiple representations and application units", *Computer Supported Cooperative Work*, vol. 9, Mar 2000, pp. 75–100.
- [95] Nardi, B. A. "A small matter of programming: perspectives on end user computing". MIT press, 1993, 162p.

- [96] Neris, V. P. d. A.; Baranauskas, M. C. C. "Designing tailorable software systems with the users' participation", *Journal of the Brazilian Computer Society*, vol. 18, Apr 2012, pp. 213–227.
- [97] Norambuena, B. F. K.; Mitra, T.; North, C. "Design guidelines for narrative maps in sensemaking tasks", *Information Visualization*, vol. 21, Mar 2022, pp. 220–245.
- [98] Nowak, S.; Bartram, L.; Schiphorst, T. "A micro-phenomenological lens for evaluating narrative visualization". In: *IEEE Evaluation and Beyond-Methodological Approaches for Visualization*, 2018, pp. 11–18.
- [99] Ørngreen, R.; Levinsen, K. "Workshops as a research methodology.", *Electronic Journal of E-learning*, vol. 15, Apr 2017, pp. 70–81.
- [100] Oussous, A.; Benjelloun, F.-Z.; Lahcen, A. A.; Belfkih, S. "Big data technologies: A survey", *Journal of King Saud University-Computer and Information Sciences*, vol. 30, Oct 2018, pp. 431–448.
- [101] Pantazos, K.; Lauesen, S.; Vatrapu, R. "End-user development of information visualization". In: *International Symposium on End-User Development*, 2013, pp. 104–119.
- [102] Paternò, F. "End user development: Survey of an emerging field for empowering people", *International Scholarly Research Notices*, vol. 2013, Jun 2013, pp. 1–12.
- [103] Qiang, L.; Bingjie, C.; Haibo, Z. "Storytelling by the storycake visualization", *The Visual Computer*, vol. 33, Jun 2017, pp. 1241–1252.
- [104] Riche, N. H.; Hurter, C.; Diakopoulos, N.; Carpendale, S. "Data-driven storytelling". AK Peters/CRC Press, 2018, 286p.
- [105] Robinson, S. J.; Williams, G.; Parnami, A.; Kim, J.; McGregor, E.; Chandler, D.; Mazalek, A. "Storied numbers: Supporting media-rich data storytelling for television". In: *ACM International Conference on Interactive Experiences for TV and Online Video*, 2014, pp. 123–130.
- [106] Rodrigues, S.; Figueiras, A.; Alexandre, I. "Once upon a time in a land far away: Guidelines for spatio-temporal narrative visualization". In: *International Conference Information Visualisation*, 2019, pp. 44–49.
- [107] Roth, R. E. "Cartographic design as visual storytelling: synthesis and review of map-based narratives, genres, and tropes", *The Cartographic Journal*, vol. 58, Aug 2021, pp. 83–114.

- [108] Sacha, D.; Stoffel, A.; Stoffel, F.; Kwon, B. C.; Ellis, G.; Keim, D. A. "Knowledge generation model for visual analytics", *IEEE transactions on visualization and computer graphics*, vol. 20, Dec 2014, pp. 1604–1613.
- [109] Santos, C. Q. "Civis: modelo de design de interface customizável para apoiar a construção de visualizações narrativas interativas de dados extraídos de mídias sociais", Ph.D. Thesis, Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS), 2018, 147p.
- [110] Schwartz, V.; Blumendorf, M.; Albayrak, S. "Adjustable context adaptations for user interfaces at runtime". In: International Conference on Advanced Visual Interfaces, 2010, pp. 321–324.
- [111] Segel, E.; Heer, J. "Narrative visualization: Telling stories with data", *IEEE Transactions on Visualization and Computer Graphics*, vol. 16, Oct 2010, pp. 1139–1148.
- [112] Seyser, D.; Zeiller, M. "Scrollytelling—an analysis of visual storytelling in online journalism". In: International Conference Information Visualisation, 2018, pp. 401–406.
- [113] Sharp, H.; Rogers, Y.; Jennifer, P. "Interaction Design: Beyond Human-Computer Interaction". John Wiley & Sons, 2019, 619p.
- [114] Singh, A.; Kaur, R.; Haltner, P.; Peachey, M.; Gonzalez-Franco, M.; Malloch, J.; Reilly, D. "Story creator: a toolkit for spatially-adaptive augmented reality storytelling". In: Virtual Reality and 3D User Interfaces, 2021, pp. 713–722.
- [115] Spierling, U. "Authoring interactive narrative meets narrative interaction design". In: *The Authoring Problem: Challenges in Supporting Authoring for Interactive Digital Narratives*, Springer, 2023, pp. 113–130.
- [116] Stolper, C. D.; Lee, B.; Riche, N. H.; Stasko, J. "Emerging and recurring data-driven storytelling techniques: Analysis of a curated collection of recent stories". AK Peters/CRC Press, 2016, chap. 4, pp. 85–105.
- [117] Sutcliffe, A.; Papamargaritis, G. "End-user development by application-domain configuration", *Journal of Systems and Software*, vol. 91, May 2014, pp. 85–99.
- [118] Thöny, M.; Schnürer, R.; Sieber, R.; Hurni, L.; Pajarola, R. "Storytelling in interactive 3d geographic visualization systems", *ISPRS International Journal of Geo-Information*, vol. 7, Mar 2018, pp. 1–14.
- [119] Thudt, A.; Walny, J.; Gschwandtner, T.; Dykes, J.; Stasko, J. "Exploration and explanation in data-driven storytelling". AK Peters/CRC Press, 2018, chap. 3, pp. 59–83.

- [120] Tong, C.; Roberts, R. C.; Laramée, R. S.; Wegba, K.; Lu, A.; Wang, Y.; Qu, H.; Luo, Q.; Ma, X. "Storytelling and visualization: An extended survey", *Information*, vol. 9, Mar 2018, pp. 1–42.
- [121] Trichopoulos, G.; Alexandridis, G.; Caridakis, G. "A survey on computational and emergent digital storytelling", *Heritage*, vol. 6, Jan 2023, pp. 1227–1263.
- [122] Wang, Y.; Liu, D.; Qu, H.; Luo, Q.; Ma, X. "A guided tour of literature review: Facilitating academic paper reading with narrative visualization". In: International Symposium on Visual Information Communication and Interaction, 2016, pp. 17–24.
- [123] Wang, Z.; Romat, H.; Chevalier, F.; Riche, N. H.; Murray-Rust, D.; Bach, B. "Interactive data comics", *IEEE Transactions on Visualization and Computer Graphics*, vol. 28, Sep 2021, pp. 944–954.
- [124] Ward, M. O.; Grinstein, G.; Keim, D. "Interactive data visualization: foundations, techniques, and applications". CRC Press, 2010, 578p.
- [125] Ware, C. "Information visualization: perception for design". Morgan Kaufmann, 2019, 531p.
- [126] Weber, W. "Exploring narrativity in data visualization in journalism". In: *Data Visualization in Society*, Amsterdam University Press, 2020, pp. 295–311.
- [127] Wohlin, C. "Guidelines for snowballing in systematic literature studies and a replication in software engineering". In: International Conference on Evaluation and Assessment in Software Engineering, 2014, pp. 1–10.
- [128] Wulf, V.; Golombek, B. "Direct activation: A concept to encourage tailoring activities", *Behaviour & Information Technology*, vol. 20, Nov 2001, pp. 249–263.
- [129] Xu, K.; Ottley, A.; Walchshofer, C.; Streit, M.; Chang, R.; Wenskovitch, J. "Survey on the analysis of user interactions and visualization provenance", *Computer Graphics Forum*, vol. 39, Jul 2020, pp. 757–783.
- [130] Xu, X.; Yang, L.; Yip, D.; Fan, M.; Wei, Z.; Qu, H. "Fromwow'towhy': Guidelines for creating the opening of a data video with cinematic styles". In: International Conference on Human Factors in Computing Systems, 2022, pp. 1–20.
- [131] Yang, L.; Xu, X.; Lan, X.; Liu, Z.; Guo, S.; Shi, Y.; Qu, H.; Cao, N. "A design space for applying the freytag's pyramid structure to data stories", *IEEE Transactions on Visualization and Computer Graphics*, vol. 28, Sep 2021, pp. 922–932.
- [132] Yousuf, B.; Conlan, O. "Constructing narrative visualizations as a means of increasing learner engagement". In: Data Visualization Workshop of Hypertext, 2014, pp. 1–4.

- [133] Zhang, Y.; Reynolds, M.; Lugmayr, A.; Damjanov, K.; Hassan, G. M. "A visual data storytelling framework", *Informatics*, vol. 9, Sep 2022, pp. 1–22.
- [134] Zhao, J.; Xu, S.; Chandrasegaran, S.; Bryan, C.; Du, F.; Mishra, A.; Qian, X.; Li, Y.; Ma, K.-L. "Chartstory: Automated partitioning, layout, and captioning of charts into comic-style narratives", *IEEE Transactions on Visualization and Computer Graphics*, vol. 29, Feb 2023, pp. 1384–1399.
- [135] Zhao, Z.; Elmqvist, N. "The stories we tell about data: Media types for data-driven storytelling", *arXiv preprint arXiv:2202.00047*, vol. 1, Jan 2022, pp. 1–15.
- [136] Zhao, Z.; Marr, R.; Shaffer, J.; Elmqvist, N. "Understanding partitioning and sequence in data-driven storytelling". In: *International Conference on Information in Contemporary Society*, 2019, pp. 327–338.
- [137] Zhi, Q.; Ottley, A.; Metoyer, R. "Linking and layout: Exploring the integration of text and visualization in storytelling", *Computer Graphics Forum*, vol. 38, Jul 2019, pp. 675–685.
- [138] Zupic, I.; Čater, T. "Bibliometric methods in management and organization", *Organizational Research Methods*, vol. 18, Jul 2015, pp. 429–472.

APPENDIX A – PROTOCOLS OF THE SYSTEMATIC REVIEWS CONDUCTED

A.1 End-User Development (EUD)

We conducted a literature review on EUD following the Snowballing procedure proposed by Wohlin [127]. Snowballing involves defining a set of initial studies and rounds or interactions of backward and forward steps. In the backward step, the paper's reference list is considered. The forward step encompasses the analysis of articles citing the paper under evaluation. Both steps are unrolled to seek additional papers. We pushed each new paper found into a pile for the next round of the forward and backward steps. The process ends when no papers are added to the pile.

The choice for the snowballing procedure relied on the fact that when we started the review, we found a literature review encompassing EU topics. Barricelli and colleagues [8] employed a literature review, and their study considered EUD, EUP, and EUSE topics. Therefore, we decided not to replicate their methodology because we were interested in EUD studies. Hence, we choose to employ snowballing to seek additional papers on the topic starting from remarkable papers within it.

We conducted two analyses using the studies selected from our snowballing performance. In the first analysis, we assessed each paper to identify the work's overall purpose and main contributions. Thus, we employed a textual analysis used in the open codification phase from the Grounded Theory [27] for each paper full-reading. This approach helped us to define and merge concepts and patterns we found during the process. We then organized the studies into four periods. The complete results of this study we published in the XX Brazilian Symposium on Human Factors in Computing Systems (for more details the reader is referred to Correa and Silveira [30]).

In the second analysis, we performed a bibliometric analysis of the selected papers' metadata in the second study. We leverage the possibilities provided by bibliometric methods to identify additional information in our literature review. We adopted the five-step approach for bibliometric analysis proposed by Zupic and Čater [138]. Then, we ran co-authorship, co-citation, and bibliometric coupling analyses. The complete results of this study we published in the International Journal of Human-Computer Interaction (IJHCI) (for more details the reader is referred to Correa and Silveira [32]).

Following, we present the protocol used to select papers for our analyses.

A.1.1 Methodology

The snowballing procedure's first step is to define the initial set of studies to start the procedure. Following the rules stated by Wohlin [127], to avoid bias in favor of any specific publisher, we used Google Scholar to define the initial set of studies. We searched for EUD studies on Google Scholar, and we found a secondary study on the End-User Development topic conducted by Barricelli et al. [8]. We analyzed this study's reference list to determine the initial set of papers to start our literature review, employing snowballing. According to Wohlin [127], although there is no recipe to define the initial set of studies, a helpful approach is to select highly cited papers in the area. Hence, based on this characteristic, we selected the following studies to compound our initial set:

P1: Fischer, G., & Giaccardi, E. (2006). Meta-design: A framework for the future of end-user development. In *End user development* (pp. 427-457). Springer, Dordrecht.

P2: Lieberman, H., Paternò, F., Klann, M., & Wulf. (2006). End-user development: An emerging paradigm. In *End user development* (pp. 1-8). Springer, Dordrecht.

P3: Fisher, G., Fogli, D., & Piccinno, A. (2017). Revisiting and broadening the meta-design framework for end-user development. In *New perspectives in end-user development* (pp. 61-97). Springer, Cham.

The third study has not a high citation score. However, we decided to include it in the starting set due to its scope. This study broads the discussion addressed by the first high cited study.

Selection Strategy

To conduct our literature review, we defined the exclusion and inclusion criteria as follows.

Publications that met any of the following criteria were excluded from the review:

- Duplicated papers.
- Studies that were not written in English.
- Ph.D. or Master dissertations.

The inclusion criteria are:

- Studies must be published in the Computer Science area.

- Studies must address EUD and/or terms related to tailoring software by end-user.
- The time frame considered was 1997 - 2020.

We defined the beginning of the time frame range taking into account the fundamental work in tailoring activities published by Mørch [92] and ending the time frame range by the year in which the review was carried out.

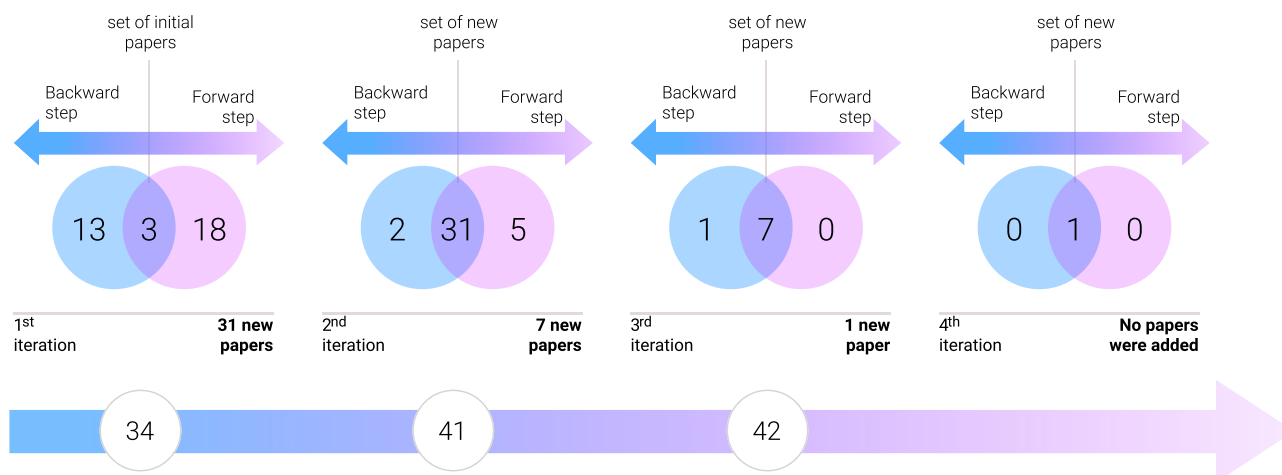


Figure A.1 – Amount of selected studies per performed iteration

Conducting

After defining the starting set, we conducted the backward and forward steps seeking additional papers related to the research question. Hence, considering the set of papers being analyzed, we checked their reference list in the backward step. We excluded papers that do not fulfill our inclusion criteria. Following this, we removed papers from the list that have already been examined in previous iterations. We then analyzed the title, publication venue, authors, and the most relevant parts of each paper to decide whether they should be included or not in a pile for the next iteration.

In the forward step, we identified new papers based on the papers citing the paper being examined. We considered the information provided by Google Scholar, and we checked the papers similarly as approached in the backward step. Each selected paper was included in a pile for the next iteration of backward and forward steps. The process ended when no new papers are included.

To address our research question and select studies adhering to it, we only selected studies that met at least one of the following criteria: (i) present systems architectures that allow customization or modification by end-users; (ii) address significant concepts for tailoring software development; and (iii) present methodologies or frameworks for tailoring software development.

We started to carry out our review at the end of 2019. During the time required to conduct all the analyses, we also decided to include papers published in 2020. From the starting set, a total of four iterations were performed until no new papers were found. In the first, second, and third iterations, we added 31, 7, and one study, respectively. In the fourth iteration, no papers were added, and the snowballing procedure was concluded. Thus, 42 publications were selected. Fig. A.1 illustrates the performed iterations from the snowballing process. Note that considering the three papers in the starting set in the first iteration, we found 13 new studies in the backward step and 18 new ones in the forward step. Thus, 31 publications compounded the set for the subsequent iteration. The process lasted until no papers were found.

These studies address End-User Development towards tailoring software or related terms to this subject. The studies selected can be seen in the Table B.1 of Appendix B. Studies from Barricelli et al. [8] and Maceli [89] are also systematic reviews. We found and decided to maintain them during the snowballing iterations due to their contribution and because they differ from this study in scope.

A.2 Narrative Data Visualization

In this review, we also employed snowballing to retrieve papers. To identify the papers, we searched on Google Scholar using the keywords "*narrative visualization*" or "*storytelling*". We found 911 papers in the first query. Analyzing the results provided, we choose three studies to compound the initial set for starting the snowballing iterations.

The three initial studies were chosen due to their relevance to the topic. The first, published by Segel and Heer [111], was chosen as it is the seminal article in the area, with great importance for continuing the research on narrative visualization. The other two articles were also chosen for their relevance to the topic, their ability to answer the questions of this research, and also due to their high number of citations in Google Scholar. The three studies are presented below.

P1. Segel, Edward, and Jeffrey Heer. "Narrative visualization: Telling stories with data." *IEEE transactions on visualization and computer graphics* 16.6 (2010): 1139-1148.

P2. Hullman, Jessica, and Nick Diakopoulos. "Visualization rhetoric: Framing effects in narrative visualization." *IEEE transactions on visualization and computer graphics* 17.12 (2011): 2231-2240.

P3. Kosara, Robert, and Jock Mackinlay. "Storytelling: The next step for visualization." *Computer* 46.5 (2013): 44-50.

After defining the initial set, we proceeded to the **iterations** of backward and forward snowballing.

In the **first iteration**, after backward and forward snowballing, from the initial set, two papers were selected in the backward step and 46 papers were selected in forward step. In the **second iteration**, after removing articles examined in previous iterations, and applying the inclusion and exclusion criteria, no new papers were selected and the process was finished. Thus, considering the three papers from initial set and the 48 selected during the process, a total of 51 papers were selected. Figure A.2 outlines the snowballing procedure performed in this study and Table C.1 (see Appendix C) shows the selected papers that are in accordance with the research topic, bringing relevant results to our questions. The analysis of the papers to be selected was done by pairs.

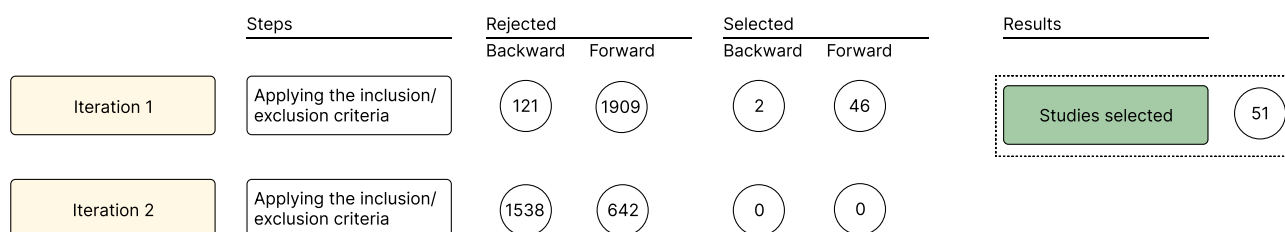


Figure A.2 – Snowballing procedure performed during the review. Adapted from Borges et al. [10]

The complete results of this study were published in the Journal on Interactive Systems (JIS) (for more details the reader is referred to Borges et al. [10]).

APPENDIX B – PAPERS SELECTED DURING THE LITERATURE REVIEW ON END-USER DEVELOPMENT - EUD

Table B.1 shows the selected papers ordered by year and title. The last column shows the number of the paper according to the reference list.

Table B.1 – Selected EUD papers ordered by year

N.	Title	Author(s)	Year	N. Ref.
1	Tailoring as collaboration: The mediating role of multiple representations and application units	Anders Mørch, Nicolay Mehandjiev	2000	[94]
2	Direct activation: A concept to encourage tailoring activities	Volker Wulf, Bjorn Golombek	2001	[128]
3	PD in the Wild: Evolving Practices of Design in Use	Yvonne Dittrich, Sara Erik-sén, Christina Hansson	2002	[42]
4	Building environments for end-user development and tailoring	Maria Francesca Costabile, Daniela Fogli, Giuseppe Fresta, Piero Mussio, Antonio Piccinno	2003	[33]
5	Meta-design: A manifesto for end-user development	Gerhard Fischer, Elisa Giaccardi, Yunwen Ye, Alistair Sutcliffe, Nikolay Mehandjiev	2004	[56]
6	End-User Development as Adaptive Maintenance	Yvonne Dittrich, Olle Lindeberg; Lars Lundberg	2006	[43]
7	End-User Development: An Emerging Paradigm	Henry Lieberman, Fabio Paternò, Markus Klann, Volker Wulf	2006	[84]

N.	Title	Author(s)	Year	N. Ref.
8	Meta-design: A Framework for the Future of End-User Development	Gerhard Fischer, Elisa Giaccardi	2006	[55]
9	Supporting work practice through end-user development environments	Maria Francesca Costabile, Daniela Fogli, Rosa Lanzilotti, Piero Mussio, Antonio Piccinno	2006	[34]
10	Improving information systems by end user development: A case study	Maria Francesca Costabile, Daniela Fogli, Rosa Lanzilotti, Andrea Marcante, Piero Mussio, Loredana Parasiliti Provenza, Antonio Piccinno	2007	[45]
11	Meta-design to face co-evolution and communication gaps between users and designers	Maria Francesca Costabile, Daniela Fogli, Rosa Lanzilotti, Andrea Marcante, Piero Mussio, Loredana Parasiliti Provenza, Antonio Piccinno	2007	[35]
12	Meta-design: Expanding boundaries and redistributing control in design	Gerhard Fischer	2007	[51]
13	Using patterns to support the design of flexible user interaction	Maria Cecília Calani Baranauskas., Vânia Paula de Almeida Neris	2007	[7]
14	Visual interactive systems for end-user development: A model-based design methodology	Maria Francesca Costabile, Daniela Fogli, Piero Mussio, Antonio Piccinno	2007	[36]

N.	Title	Author(s)	Year	N. Ref.
15	Advanced visual systems supporting unwitting EUD	Maria Francesca Costabile, Piero Mussio, Loredana Parasiliti Provenza, Antonio Piccinno	2008	[37]
16	The ecology of participants in co-evolving socio-technical environments	Gerhard Fischer., Antonio Piccinno, Yunwen Ye	2008	[58]
17	Metadesign: Guidelines for supporting domain experts in software development	Gerhard Fischer, Kumiyo Nakakoji, Yunwen Ye	2009	[57]
18	Adjustable context adaptations for user interfaces at runtime	Veit Schwartze, Marco Blumendorf, Sahin Albayrak	2010	[110]
19	End user development and meta-design: Foundations for cultures of participation	Gerhard Fischer	2010	[52]
20	Enabling end user development through mashups: Requirements, abstractions and innovation toolkits	Cinzia Cappiello, Florian Daniel, Maristella Matera, Matteo Picozzi., Michael Weiss	2011	[21]
21	A meta-design approach to the development of e-government services	Daniela Fogli, Loredana Parasiliti Provenza	2012	[61]
22	Designing tailorable software systems with the users' participation	Vânia Paula de Almeida Neris., Maria Cecília Calani Baranauskas	2012	[96]
23	Designing visual interactive systems in the e-government domain	Daniela Fogli	2012	[59]
24	Development of end-user-centered EUD software	José Macías	2012	[90]

N.	Title	Author(s)	Year	N. Ref.
25	"Human crafters" once again: Supporting users as designers in continuous co-design	Monica Maceli, Michael Atwood	2013	[88]
26	Enabling domain experts to develop usable software artifacts	Daniela Fogli, Antonio Piccinno	2013	[60]
27	End User Development: Survey of an Emerging Field for Empowering People	Fabio Paternò	2013	[102]
28	End-user development of information visualization	Kostas Pantazos, Soren Lauesen., Ravi Vatrapu	2013	[101]
29	"Each to his own": Distinguishing activities, roles and Artifacts in EUD practices	Federico Cabitza, Daniela Fogli, Antonio Piccin	2014	[19]
30	End-user development by application-domain configuration	Alistair Sutcliffe, George Papamargaritis	2014	[117]
31	Visual composition of data sources by end users	Carmelo Ardito, Maria Francesca Costabile, Giuseppe Desolda, Rosa Lanzilotti, Maristella Matera, Matteo Picozzi	2014	[2]
32	EFESTO: A platform for the end-user development of interactive workspaces for data exploration	Giuseppe Desolda, Carmelo Ardito, Maristella Matera	2015	[40]
33	A three-layer meta-design model for addressing domain-specific customizations	Carmelo Ardito, Maria Francesca Costabile, Giuseppe Desolda, Maristella	2017	[3]

N.	Title	Author(s)	Year	N. Ref.
34	Revisiting and broadening the meta-design framework for end-user development	Gerhard Fischer., Daniela Fogli, Antonio Piccinno	2017	[54]
35	Tools of the trade: A survey of technologies in end-user development literature	Monica Maceli	2017	[89]
36	Reflections on system properties valued by end users in designing	Carmelo Ardito, Maria Francesca Costabile, Giuseppe Desolda, Rosa Lanzilotti, Maristella Matura	2018	[1]
37	End-user development, end-user programming and end-user software engineering: A systematic mapping study	Barbara Rita Barricelli, Fabio Cassano, Daniela Fogli, Antonio Piccinno	2019	[8]
38	A framework for tailorable games: toward inclusive end-user development of inclusive games	Franco Eusébio Garcia, Vânia Paula de Almeida Neris	2020	[64]
39	Design trade-offs in cultures of participation: empowering end users to improve their quality of life	Gerhard Fischer, Daniela Fogli, Anders Mørch, Antonio Piccinno, Stefano Valtolina	2020	[53]
40	Playing the role of Co-designers on Mobile PWAs: An investigation of end-users interaction	Giulia de Andrade Cardieri, Luciana Aparecida Martinez Zaina	2020	[39]
41	Meta-level support for facilitating participation in website (re-)design activities	Henrik Hertel, Anke Dittmar, Doritt Linke	2020	[70]

N.	Title	Author(s)	Year	N. Ref.
42	Towards end-user development of graphical user interfaces for internet of things	Johnsson Björn, Magnus-son Boris	2020	[73]

APPENDIX C – PAPERS SELECTED DURING THE LITERATURE REVIEW ON NARRATIVE VISUALIZATIONS

Table C.1 shows the selected papers ordered by year and title. The last column shows the number of the paper according to the reference list.

Table C.1 – Narrative visualization papers

N.	Title	Author(s)	Year	N. Ref.
1	Narrative Visualization: telling stories with data	Edward Segel, Jeffrey Heer	2010	[111]
2	Visualization rhetoric: Framing effects in narrative visualization	Jessica Hullman, Nicholas Diakopoulos	2011	[71]
3	Scientific storytelling using visualization	Kwan-Liu Ma, Isaac Liao, Jennifer Frazier, Helwig Hauser, Helen-Nicole Kostis	2012	[87]
4	A deeper understanding of sequence in narrative visualization	Jessica Hullman, Steven Drucker, Nathalie Henry Riche, Bongshin Lee, Danyel Fisher, Eytan Adar	2013	[72]
5	Storytelling: The next step for visualization	Robert Kosara, Jock Mackinlay	2013	[79]
6	SketchStory: Telling more engaging stories with data through freeform sketching	Bongshin Lee, Rubaiat Habib Kazi, Greg Kazi	2013	[82]
7	Storyflow: Tracking the evolution of stories	Shixia Liu, Yingcai Wu, Enxun Wei, Mengchen Liu, Yang Liu	2013	[86]
8	How to tell stories using visualization	Ana Figueiras	2014	[49]

N.	Title	Author(s)	Year	N. Ref.
9	Narrative visualization: A case study of how to incorporate narrative elements in existing visualizations	Ana Figueiras	2014	[50]
10	Storyed numbers: Supporting media-rich data storytelling for television	Susan Robinson, Graceline Williams, Aman Parnami, Jinhyun Kim, Emmett McGregor, Dana Chandler, Ali Mazalek	2014	[105]
11	Constructing Narrative Visualizations as a Means of Increasing Learner Engagement	Bilal Yousuf, Owen Conlan	2014	[132]
12	More than telling a story: Transforming data into visually shared stories	Bongshin Lee, Nathalie Henry Riche, Petra Isenberg, Sheelagh Carpendale	2015	[83]
13	MEseum: Personalized experience with narrative visualization for museum visitors	Ali Arya, Jesse Gerroir, Efe-tobore Mike-Ifeta, Andres Adolfo Navarro-Newball, Edmund Prakash	2016	[4]
14	Using data visualisation to tell stories about collections	Stephen Boyd Davis, Olivia Vane, Florian Kräutli	2016	[13]
15	Timelines revisited: A design space and considerations for expressive storytelling	Matthew Brehmer, Bongshin Lee, Benjamin Bach, Nathalie Henry Riche, Tamara Munzner	2016	[15]
16	Temporal summary images: An approach to narrative visualization via interactive annotation generation and placement	Chris Bryan, Kwan-Liu Ma, Jonathan Woodring	2016	[18]

N.	Title	Author(s)	Year	N. Ref.
17	FinaVistory: Using Narrative Visualization to explain social and Economic relationships in financial news	Yeuk-Yin Chan, Huamin Qu	2016	[23]
18	Data visualization process through storytelling technique in Business Intelligence	Andrés Gutiérrez, Cynthia Pérez	2016	[66]
19	Emerging and recurring data-driven storytelling techniques: Analysis of a curated collection of recent stories	Charles Stolper, Bongshin Lee, Nathalie Henry Riche, John Stasko	2016	[116]
20	A guided tour of literature review: Facilitating academic paper reading with narrative visualization	Yun Wang, Dongyu Liu, Huamin Qu, Qiong Luo, Xiaojuan Ma	2016	[122]
21	Unveiling storytelling and visualization of data	Stephanie Arévalo, Ankita Dewan	2017	[5]
22	Extending open data platforms with storytelling features	Niall Ó Brolcháin, Lukasz Porwol, Adegboyega Ojo, Tilman Wagner, Eva Tamara Lopez, Eric Karstens	2017	[17]
23	Subjectivity in personal storytelling with visualization	Sheelagh Carpendale, Alice Thudt, Charles Perin, Wesley Willett	2017	[22]
24	Towards data storytelling to support teaching and learning	Vanessa Echeverria, Roberto Martinez-Maldonado, Simon Shum Buckingham	2017	[47]

N.	Title	Author(s)	Year	N. Ref.
25	Visual narrative flow: Exploring factors shaping data visualization story reading experiences	Sean McKenna, Nathalie Henry Riche, Bongshin Lee, Jeremy Boy, Miriah Meyer	2017	[91]
26	Storytelling by the storycake visualization	Lu Qiang, Chai Bingjie, Zhang Haibo	2017	[103]
27	Design patterns for data comics	Benjamin Bach, Zezhong Wang, Matteo Farinella, Dave Murray-Rust, Nathalie Henry Riche	2018	[6]
28	Supporting story synthesis: Bridging the gap between visual analytics and storytelling	Siming Chen, Jie Li, Genady Andrienko, Natalia Andrienko, Yun Wang, Phong Nguyen, Cagatay Turkey	2018	[25]
29	Visual narrative data-driven storytelling	Lina Teresa Molinas Comet	2018	[26]
30	Driving data storytelling from learning design	Vanessa Echeverria, Roberto Martinez-Maldonado, Roger Granda, Katherine Chiluiza, Cristina Conati, Simon Buckingham Shum	2018	[46]
31	Beyond Transparency: Making the Italian Public Administration more Accessible through Data Storytelling	Matteo Moretti, Francesca De Chiara, Maurizio Napolitano	2018	[93]
32	A micro-phenomenological lens for evaluating narrative visualization	Stanislaw Nowak, Lyn Bartram, Thecla Schiphorst	2018	[98]

N.	Title	Author(s)	Year	N. Ref.
33	Scrollytelling -an analysis of visual storytelling in online journalism	Doris Seyser, Michael Zeiller	2018	[112]
34	Storytelling in interactive 3D geographic visualization systems	Matthias Thöny, Raimund Schnürer, René Sieber, Lorenz Hurni, Renato Pajarola	2018	[118]
35	Storytelling and Visualization: A Survey	Chao Tong, Richard Roberts, Robert Laramée, Kodzo Wegba, Aidong Lu, Yun Wang, Huamin Qu, Qiong Luo, Xiaojuan Ma	2018	[120]
36	Designing Narrative Slideshows for Learning Analytics	Qing Chen, Zhen Li, Ting-Chuen Pong, Huamin Qu	2019	[24]
37	Once Upon a Time in a Land Far Away: Guidelines for Spatio-Temporal Narrative Visualization	Sara Rodrigues, Ana Figueiras, Ilo Alexandre	2019	[106]
38	Understanding Partitioning and Sequence in Data-Driven Storytelling	Zhao Zhenpeng, Rachael Shaffer, Elmquist Niklas, Marr Jason,	2019	[136]
39	Linking and layout: Exploring the integration of text and visualization in storytelling	Qiyu Zhi, Alvitta Ottley, Ronald Metoyer	2019	[137]
40	Structure and empathy in visual data storytelling: Evaluating their influence on attitude	Johannes Liem, Charles Perin, Jo Wood,	2020	[85]
41	Exploring narrativity in data visualization in journalism	Wibke Weber	2020	[126]

N.	Title	Author(s)	Year	N. Ref.
42	Learning Cues to Improve the Understanding of Explanatory Storytelling	Alark Joshi	2021	[74]
43	A Design Space for Applying the Freytag's Pyramid Structure to Data Stories	Leni Yang, Xian Xu, XingYu Lan, Ziyang Liu, Shunan Guo, Yang Shi, Huamin Qu, Nan Cao	2021	[131]
44	A Deeper Understanding of Visualization-Text Interplay in Geographic Data-driven Stories	Shahid Latif, Siming Chen, Fabian Beck	2021	[80]
45	Design guidelines for narrative maps in sensemaking tasks	Brian Felipe Keith Norambuena, Tanushree Mitra, Chris North	2021	[97]
46	Cartographic design as visual storytelling: synthesis and review of map-based narratives, genres, and tropes	Robert Roth	2021	[107]
47	Interactive Data Comics	Ze Zhong Wang, Hugo Romat, Fanny Chevalier, Nathalie Henry Riche, Dave Murray-Rust, Benjamin Bach	2021	[123]
48	A Design Space for Applying the Freytag's Pyramid Structure to Data Stories	Leni Yang, Xian Xu, XingYu Lan, Ziyang Liu, Shunan Guo, Yang Shi, Huamin Qu, Nan Cao	2021	[131]
49	Chartstory: Automated partitioning, layout, and captioning of charts into comic-style narratives	Jian Zhao, Shenyu Xu, Senthil Chandrasegaran, Chris Bryan, Fan Du, Aditi Mishra, Xin Qian, Yiran Li, Kwan-Liu Ma,	2021	[134]

N.	Title	Author(s)	Year	N. Ref.
50	The Stories We Tell About Data: Media Types for Data-Driven Storytelling	Zhenpeng Zhao, Niklas Elmqvist	2022	[135]
51	FromWow'toWhy': Guidelines for Creating the Opening of a Data Video with Cinematic Styles	Xian Xu, Leni Yang, David Yip, Mingming Fan, Zheng Wei, Huamin Qu	2022	[130]

ATTACHMENT A – Information and Consent Form- Focus Group 1



Pontifícia Universidade Católica do Rio Grande do Sul
PRÓ-REITORIA DE PESQUISA E PÓS-GRADUAÇÃO

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE)

Nós, Mariana Gomes Borges (aluna de mestrado), Claiton Marques Correa (aluno de doutorado) e Milene Selbach Silveira (professora orientadora), responsáveis pela pesquisa Apoio à Construção de Visualizações Narrativas, estamos fazendo um convite para você participar como voluntário neste estudo.

Esta pesquisa pretende investigar a relação entre os elementos narrativos - entenda-se dados, gêneros e recursos de interação - durante o processo de desenvolvimento de uma visualização narrativa. Além desta investigação, outro ponto a ser explorado é a possibilidade de agregar elementos exploratórios para permitir que o leitor das histórias possa consumir as visualizações narrativas a partir de outras perspectivas, sem que, para isso, fuja da intenção original definida pelo autor da visualização.

Acreditamos que ela seja importante porque técnicas de visualização de dados podem levar os leitores a descobrir novos insights a partir do momento em que estes podem observar padrões e fazer distinções entre eles. O tópico de visualização narrativa de dados é emergente dentro da área de visualização de dados e possibilita que os usuários consumam os dados dentro do contexto de uma narrativa. Ao explorá-lo, estamos contribuindo com a comunidade científica para o amadurecimento da compreensão do processo de construção de uma visualização narrativa.

Para sua realização será feito o seguinte: grupo de foco, com a participação de 6 a 10 pessoas. O método está organizado em quatro rodadas com apresentações, tarefas e questões para discussão em grupo.

Sua participação constará de participar da reunião do grupo de foco, trazendo suas contribuições e debatendo, com os demais participantes, os tópicos tratados.

É possível que aconteçam os seguintes desconfortos ou riscos como cansaço, desconforto durante as gravações ou quebra de sigilo de dados. É importante ressaltar que o objetivo do estudo é avaliar o processo de desenvolvimento de uma visualização narrativa, e não o usuário participante. Atuamos para minimizar a possibilidade dos riscos descritos, mantendo o sigilo e anonimato da participação. O uso do material gravado é estritamente para fins acadêmicos. Você tem o direito de pedir uma indenização por qualquer dano que, comprovadamente, resulte da sua participação no estudo.



Não há benefícios a curto prazo para os participantes desta pesquisa, contudo, acreditamos que o contato e prática de técnicas de visualização narrativa pode agregar ao conhecimento dos participantes conceitos que lhes serão úteis na atividade profissional e acadêmica.

Durante todo o período da pesquisa você tem o direito de esclarecer qualquer dúvida ou pedir qualquer informação sobre o estudo, bastando para isso entrar em contato, com:

Mariana Gomes Borges - email: mariana.borges@edu.pucrs.br

Claiton Marques Correa - email: claiton.correa@edu.pucrs.br

Milene Selbach Silveira - email: milene.silveira@pucrs.br

Secretaria do Programa de Pós-Graduação em Computação da PUCRS: (51) 3320-3558

Você tem garantido o seu direito de não aceitar participar ou de retirar sua permissão, a qualquer momento, sem nenhum tipo de prejuízo ou retaliação, pela sua decisão.

Se por algum motivo você tiver despesas decorrentes da sua participação neste estudo com transporte e/ou alimentação, você será reembolsado adequadamente pelos pesquisadores.

As informações desta pesquisa serão confidenciais, e serão divulgadas apenas em eventos ou publicações científicas, não havendo identificação dos participantes, a não ser entre os responsáveis pelo estudo, sendo assegurado o sigilo sobre sua participação.

Caso você tenha qualquer dúvida quanto aos seus direitos como participante de pesquisa, entre em contato com o Comitê de Ética em Pesquisa da Pontifícia Universidade Católica do Rio Grande do Sul (CEP-PUCRS) em (51) 33203345, Av. Ipiranga, 6681/prédio 50 sala 703, CEP: 90619-900, Bairro Partenon, Porto Alegre – RS, e-mail: cep@pucrs.br, de segunda a sexta-feira das 8h às 12h e das 13h30 às 17h. O Comitê de Ética é um órgão independente constituído de profissionais das diferentes áreas do conhecimento e membros da comunidade. Sua responsabilidade é garantir a proteção dos direitos, a segurança e o bem-estar dos participantes por meio da revisão e da aprovação do estudo, entre outras ações.

Ao assinar este termo de consentimento, você não abre mão de nenhum direito legal que teria de outra forma.

Não assine este termo de consentimento a menos que tenha tido a oportunidade de fazer perguntas e tenha recebido respostas satisfatórias para todas as suas dúvidas.

Se você concordar em participar deste estudo, você rubricará todas as páginas e assinará e datará duas vias originais deste termo de consentimento. **Ao assinar e rubricar todas as páginas**



deste documento, você de forma voluntária e esclarecida, nos autoriza a utilizar todas as informações de natureza pessoal que constam em seu prontuário de atendimento, imagens, resultados de exames e diagnóstico, material biológico se for o caso, para finalidade de pesquisa e realização deste estudo. Você receberá uma das vias para seus registros e a outra será arquivada pelo responsável pelo estudo.

Eu, _____, após a leitura deste documento e de ter tido a oportunidade de conversar com o pesquisador responsável, para esclarecer todas as minhas dúvidas, acredito estar suficientemente informado, ficando claro para mim que minha participação é voluntária e que posso retirar este consentimento a qualquer momento sem penalidades ou perda de qualquer benefício. Estou ciente também dos objetivos da pesquisa, dos procedimentos aos quais serei submetido, dos possíveis danos ou riscos deles provenientes e da garantia de confidencialidade e esclarecimentos sempre que desejar.

Diante do exposto expresso minha concordância de espontânea vontade em participar deste estudo, autorizando o uso, compartilhamento e publicação dos meus dados e informações de natureza pessoal para essa finalidade específica.

Assinatura do participante da pesquisa ou de seu representante legal

Assinatura de uma testemunha

ATTACHMENT B – Information and Consent Form - Focus Group 2



Pontifícia Universidade Católica do Rio Grande do Sul
PRÓ-REITORIA DE PESQUISA E PÓS-GRADUAÇÃO

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE)

Nós, Claiton Marques Correa e Milene Selbach Silveira responsáveis pela pesquisa Apoio à Construção de Visualizações Narrativas, estamos fazendo um convite para você participar como voluntário neste estudo.

Esta pesquisa pretende dar continuidade à investigação sobre o desenvolvimento de visualizações narrativas customizáveis pelo usuário final. A partir de estudos realizados anteriormente, elaborou-se um processo que visa auxiliar o planejamento de narrativas que possam ser customizáveis pelo usuário final, ou seja, usuário que está consumindo a narrativa. O objetivo deste estudo é avaliar o processo criado.

Acreditamos que ela seja importante porque técnicas de visualização de dados podem levar os leitores a descobrir novos insights a partir do momento que estes podem observar padrões e fazer distinções entre eles. O tópico de visualização narrativa de dados é emergente dentro da área de visualização de dados e possibilita que os usuários consumam dados dentro do contexto de uma narrativa. Ao explorá-lo, estamos contribuindo com a comunidade científica para o amadurecimento da compreensão do processo de uma visualização narrativa.

Para sua realização será feito o seguinte: grupo de foco, com participação de 6 a 10 pessoas. O método está organizado em cinco etapas com apresentações e questões para discussão em grupo. Sua participação consistirá em participar da reunião do grupo de foco, trazendo suas contribuições e debatendo, com os demais participantes, os tópicos tratados.

É possível que aconteçam os seguintes desconfortos ou riscos como cansaço, desconforto durante as gravações ou quebra de sigilo de dados. É importante ressaltar que o objetivo do estudo é avaliar o processo, e não o usuário. Atuamos para minimizar a possibilidade dos riscos descritos, mantendo o sigilo e anonimato da participação. Você tem o direito de pedir uma indenização por qualquer dano que, comprovadamente, resulte da sua participação no estudo.

Os benefícios que esperamos do estudo são a curto prazo, a agregação do conhecimento acerca de visualização de dados. Estes conceitos são úteis na atividade profissional e acadêmica.

Rubrica do participante

Rubrica do pesquisador



Durante todo o período da pesquisa você tem o direito de esclarecer qualquer dúvida ou pedir qualquer informação sobre o estudo, bastando para isso entrar em contato, com Milene Selbach Silveira no telefone (XXXXXX) a qualquer hora para esclarecimentos.

Em caso de algum problema relacionado com a pesquisa você terá direito à assistência gratuita que será prestada pelos pesquisadores Claiton Marques Correa (aluno de Doutorado) e Milene Selbach Silveira (pesquisadora responsável).

Você tem garantido o seu direito de não aceitar participar ou de retirar sua permissão, a qualquer momento, sem nenhum tipo de prejuízo ou retaliação, pela sua decisão.

Se, por algum motivo, você tiver despesas decorrentes da sua participação neste estudo com transporte e/ou alimentação, você será reembolsado adequadamente pelos pesquisadores (ressarcimento de despesas com transporte e alimentação do participante e de seu acompanhante se for o caso mediante nota fiscal).

As informações desta pesquisa serão confidenciais, e serão divulgadas apenas em eventos ou publicações científicas, não havendo identificação dos participantes, a não ser entre os responsáveis pelo estudo, sendo assegurado o sigilo sobre sua participação.

Caso você tenha qualquer dúvida quanto aos seus direitos como participante de pesquisa, entre em contato com o Comitê de Ética em Pesquisa da Pontifícia Universidade Católica do Rio Grande do Sul (CEP-PUCRS) em (51) 33203345, Av. Ipiranga, 6681/prédio 50 sala 703, CEP: 90619-900, Bairro Partenon, Porto Alegre – RS, e-mail: cep@pucrs.br, de segunda a sexta-feira das 8h às 12h e das 13h30 às 17h. O Comitê de Ética é um órgão independente constituído de profissionais das diferentes áreas do conhecimento e membros da comunidade. Sua responsabilidade é garantir a proteção dos direitos, a segurança e o bem-estar dos participantes por meio da revisão e da aprovação do estudo, entre outras ações.

Ao assinar este termo de consentimento, você não abre mão de nenhum direito legal que teria de outra forma.

Rubrica do participante

Rubrica do pesquisador



Não assine este termo de consentimento a menos que tenha tido a oportunidade de fazer perguntas e tenha recebido respostas satisfatórias para todas as suas dúvidas.

Se você concordar em participar deste estudo, você rubricará todas as páginas e assinará e datará duas vias originais deste termo de consentimento. **Ao assinar e rubricar todas as páginas deste documento, você, de forma voluntária e esclarecida, nos autoriza a utilizar todas as informações de natureza pessoal que constam em seu formulário, imagens e voz, para finalidade de pesquisa e realização deste estudo.** Você receberá uma das vias para seus registros e a outra será arquivada pelo responsável pelo estudo.

Eu, _____, após a leitura deste documento e de ter tido a oportunidade de conversar com o pesquisador responsável, para esclarecer todas as minhas dúvidas, acredito estar suficientemente informado, ficando claro para mim que minha participação é voluntária e que posso retirar este consentimento, a qualquer momento, sem penalidades ou perda de qualquer benefício. Estou ciente também dos objetivos da pesquisa, dos procedimentos aos quais serei submetido, dos possíveis danos ou riscos deles provenientes e da garantia de confidencialidade e esclarecimentos sempre que desejar.

Diante do exposto explico minha concordância de espontânea vontade em participar deste estudo, autorizando o uso, compartilhamento e publicação dos meus dados e informações de natureza pessoal para essa finalidade específica.

Assinatura do participante da pesquisa ou de seu representante legal

Rubrica do participante

Rubrica do pesquisador



Assinatura de uma testemunha

DECLARAÇÃO DO PROFISSIONAL QUE OBTVE O CONSENTIMENTO

Expliquei integralmente este estudo ao participante (e/ou ao seu tutor). Na minha opinião e na opinião do participante (e/ou do tutor), houve acesso suficiente às informações, incluindo riscos e benefícios, para que uma decisão consciente seja tomada.

Data: _____

Assinatura do Investigador

Nome do Investigador (letras de forma)

Rubrica do participante

Rubrica do pesquisador

ATTACHMENT C – Information and Consent Form - Workshop



Pontifícia Universidade Católica do Rio Grande do Sul
PRÓ-REITORIA DE PESQUISA E PÓS-GRADUAÇÃO

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE)

Nós, Claiton Marques Correa e Milene Selbach Silveira responsáveis pela pesquisa Apoio à Construção de Visualizações Narrativas, estamos fazendo um convite para você participar como voluntário neste estudo.

Esta pesquisa pretende dar continuidade à investigação sobre o desenvolvimento de visualizações narrativas customizáveis pelo usuário final. A partir de estudos realizados anteriormente, elaborou-se um processo que visa auxiliar o planejamento de narrativas que possam ser customizáveis pelo usuário final, ou seja, usuário que está consumindo a narrativa. O objetivo deste estudo é identificar como as visualizações narrativas customizáveis são utilizadas para exploração das narrativas .

Acreditamos que ela seja importante porque técnicas de visualização de dados podem levar os leitores a descobrir novos insights a partir do momento que estes podem observar padrões e fazer distinções entre eles. O tópico de visualização narrativa de dados é emergente dentro da área de visualização de dados e possibilita que os usuários consumam dados dentro do contexto de uma narrativa. Ao explorá-lo, estamos contribuindo com a comunidade científica para o amadurecimento da compreensão do processo de uma visualização narrativa.

Para sua realização será feito o seguinte: workshop, com participação de 6 a 10 pessoas. O método está organizado em cinco etapas com apresentações e questões para discussão em grupo.

Sua participação consistirá em participar da reunião do grupo de foco, trazendo suas contribuições e debatendo, com os demais participantes, os tópicos tratados.

É possível que aconteçam os seguintes desconfortos ou riscos como cansaço, desconforto durante as gravações ou quebra de sigilo de dados. É importante ressaltar que o objetivo do estudo é avaliar o processo, e não o usuário. Atuamos para minimizar a possibilidade dos riscos descritos, mantendo o sigilo e anonimato da participação. Você tem o direito de pedir uma indenização por qualquer dano que, comprovadamente, resulte da sua participação no estudo.

Os benefícios que esperamos do estudo são a curto prazo, a agregação do conhecimento acerca de visualização de dados. Estes conceitos são úteis na atividade profissional e acadêmica.

Rubrica do participante

Rubrica do pesquisador



Durante todo o período da pesquisa você tem o direito de esclarecer qualquer dúvida ou pedir qualquer informação sobre o estudo, bastando para isso entrar em contato, com Milene Selbach Silveira no telefone [REDACTED] a qualquer hora para esclarecimentos.

Em caso de algum problema relacionado com a pesquisa você terá direito à assistência gratuita que será prestada pelos pesquisadores Claiton Marques Correa (aluno de Doutorado) e Milene Selbach Silveira (pesquisadora responsável).

Você tem garantido o seu direito de não aceitar participar ou de retirar sua permissão, a qualquer momento, sem nenhum tipo de prejuízo ou retaliação, pela sua decisão.

Se, por algum motivo, você tiver despesas decorrentes da sua participação neste estudo com transporte e/ou alimentação, você será reembolsado adequadamente pelos pesquisadores (ressarcimento de despesas com transporte e alimentação do participante e de seu acompanhante se for o caso mediante nota fiscal).

As informações desta pesquisa serão confidenciais, e serão divulgadas apenas em eventos ou publicações científicas, não havendo identificação dos participantes, a não ser entre os responsáveis pelo estudo, sendo assegurado o sigilo sobre sua participação.

Caso você tenha qualquer dúvida quanto aos seus direitos como participante de pesquisa, entre em contato com o Comitê de Ética em Pesquisa da Pontifícia Universidade Católica do Rio Grande do Sul (CEP-PUCRS) em (51) 33203345, Av. Ipiranga, 6681/prédio 50 sala 703, CEP: 90619-900, Bairro Partenon, Porto Alegre – RS, e-mail: cep@pucls.br, de segunda a sexta-feira das 8h às 12h e das 13h30 às 17h. O Comitê de Ética é um órgão independente constituído de profissionais das diferentes áreas do conhecimento e membros da comunidade. Sua responsabilidade é garantir a proteção dos direitos, a segurança e o bem-estar dos participantes por meio da revisão e da aprovação do estudo, entre outras ações.

Ao assinar este termo de consentimento, você não abre mão de nenhum direito legal que teria de outra forma.

Rubrica do participante

Rubrica do pesquisador



Não assine este termo de consentimento a menos que tenha tido a oportunidade de fazer perguntas e tenha recebido respostas satisfatórias para todas as suas dúvidas.

Se você concordar em participar deste estudo, você rubricará todas as páginas e assinará e datará duas vias originais deste termo de consentimento. **Ao assinar e rubricar todas as páginas deste documento, você, de forma voluntária e esclarecida, nos autoriza a utilizar todas as informações de natureza pessoal que constam em seu formulário, imagens e voz, para finalidade de pesquisa e realização deste estudo.** Você receberá uma das vias para seus registros e a outra será arquivada pelo responsável pelo estudo.

Eu, _____, após a leitura deste documento e de ter tido a oportunidade de conversar com o pesquisador responsável, para esclarecer todas as minhas dúvidas, acredito estar suficientemente informado, ficando claro para mim que minha participação é voluntária e que posso retirar este consentimento, a qualquer momento, sem penalidades ou perda de qualquer benefício. Estou ciente também dos objetivos da pesquisa, dos procedimentos aos quais serei submetido, dos possíveis danos ou riscos deles provenientes e da garantia de confidencialidade e esclarecimentos sempre que desejar.

Diante do exposto expresse minha concordância de espontânea vontade em participar deste estudo, autorizando o uso, compartilhamento e publicação dos meus dados e informações de natureza pessoal para essa finalidade específica.

Assinatura do participante da pesquisa ou de seu representante legal

Rubrica do participante

Rubrica do pesquisador



Assinatura de uma testemunha

DECLARAÇÃO DO PROFISSIONAL QUE OBTVE O CONSENTIMENTO

Expliquei integralmente este estudo ao participante (e/ou ao seu tutor). Na minha opinião e na opinião do participante (e/ou do tutor), houve acesso suficiente às informações, incluindo riscos e benefícios, para que uma decisão consciente seja tomada.

Data: _____

Assinatura do Investigador

Nome do Investigador (letras de forma)

Rubrica do participante

Rubrica do pesquisador

ATTACHMENT D – Ethics Committee Approval

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Apoio à construção de visualizações narrativas

Pesquisador: Milene Selbach Silveira

Área Temática:

Versão: 3

CAAE: 54348321.1.0000.5336

Instituição Proponente: UNIAO BRASILEIRA DE EDUCACAO E ASSISTENCIA

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 5.239.873

Apresentação do Projeto:

As informações elencadas nos campos "Apresentação do Projeto", "Objetivo da Pesquisa" e "Avaliação dos Riscos e Benefícios" foram retiradas do arquivo Informações Básicas da Pesquisa (PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1873487.pdf, de 08/02/2022).

O projeto "apoio à construção de visualizações narrativas" está focado na área de visualização de dados, mas em diálogo com um componente de interpretação baseado em algum tipo de narrativa, normalmente designado pela palavra inglesa storytelling, embutido em sua construção. A ideia por trás disto é lidar com o desafio contemporâneo de ajudar os leitores/espectadores/usuários a darem conta de um excesso de mensagens e dados disponíveis, ajudando a criar sentido e compreensão.

Estas visualizações podem ser estáticas ou interativas, aumentando em complexidade de elaboração e organizado em quatro rodadas; cada rodada contém tarefas, questões para serem respondidas e a discussão das questões sobre o objeto já apresentado.

interpretação. Como esta combinação é considerada um campo emergente, este projeto de

Endereço: Av.Ipiranga, 6681, prédio 50, sala 703

Bairro: Partenon

CEP: 90.619-900

UF: RS

Município: PORTO ALEGRE

Telefone: (51)3320-3345

Fax: (51)3320-3345

E-mail: cep@puhrs.br

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



Continuação do Parecer: 5.239.873

pesquisa visa

investigar estas relações, buscando dessa forma, aprofundar o conhecimento acerca do desenvolvimento de visualizações narrativas com dados.

O projeto propõe a realização de coleta de dados com a técnica de grupo focal. O estudo está

Objetivo da Pesquisa:

O projeto tem dois objetivos identificados como principais. O primeiro é aproximar-se e formar um repertório e compreensão aprofundada de relações dos designers entre os dados e os gêneros narrativos. O segundo busca entender como os designers usam os gêneros narrativos e conceitos de visualização narrativa exploratória e seus recursos para agregar alternativas de interpretação durante o processo de criação de uma narrativa.

Como objetivos secundários, elementos e ações presentes nos primeiros objetivos são desdobradas, tais como: revisão de literatura sobre aspectos pertinentes, desenvolvimento de protótipos de visualizações narrativas, verificação de comportamento de usuários de visualizações narrativas.

Avaliação dos Riscos e Benefícios:

Os riscos e benefícios estão bem delimitados. O desenho da pesquisa não expõe os participantes a riscos significativos, inclusive por ser realizada por mediação de videochamadas. Assim, riscos pontuais de aborrecimento ou sensibilidade a algum ponto podem ser facilmente administrados e são reconhecidos na proposta.

Comentários e Considerações sobre a Pesquisa:

A pesquisa tem um caráter inovador e se apropria de uma base da ciência da computação para dialogar com um objeto potencialmente interdisciplinar e de grande impacto: quando visualizações de

Endereço: Av. Ipiranga, 6681, prédio 50, sala 703
Bairro: Partenon **CEP:** 90.619-900
UF: RS **Município:** PORTO ALEGRE
Telefone: (51)3320-3345 **Fax:** (51)3320-3345 **E-mail:** cep@pucrs.br

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



Continuação do Parecer: 5.239.873

dados podem

ajudar a compreensão de alguma atividade narrativa. Esta narrativa, como desenhado na pesquisa, não é apenas uma obra narrativa de grande porte, como um filme de longa metragem ou um romance, mas qualquer peça em que o sentido é guiado pela explicação e demonstração dos organizadores do discurso e não apenas a partir de inferências realizadas pelos leitores/usuários.

Considerações sobre os Termos de apresentação obrigatória:

Todos os termos foram apresentados.

Conclusões ou Pendências e Lista de Inadequações:

Não há pendências.

Considerações Finais a critério do CEP:

Diante do exposto, o CEP-PUCRS, de acordo com suas atribuições definidas na Resolução CNS n° 466 de 2012, Resolução n° 510 de 2016 e da Norma Operacional n° 001 de 2013 do CNS, manifesta-se pela aprovação do projeto de pesquisa Apoio à construção de visualizações narrativas proposto pelo pesquisador Milene Selbach Silveira com numero de CAAE 54348321.1.0000.5336.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Outros	Carta_Alteracoes_Apoio_a_construcao_de_visualizacoes_narrativa_v2.pdf	08/02/2022 14:21:58	CATIA REGIANE DA SILVA ASSINK	Aceito
Outros	Carta_Alteracoes_Apoio_a_construcao_de_visualizacoes_narrativa_v2.docx	08/02/2022 14:21:44	CATIA REGIANE DA SILVA ASSINK	Aceito
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1873487.pdf	08/02/2022 09:24:34		Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_Apoio_construcao_de_visualizacoes_narrativas_v2.pdf	08/02/2022 09:24:09	CLAITON MARQUES CORREA	Aceito
Solicitação registrada pelo CEP	Carta_Alteracoes_Apoio_a_construcao_de_visualizacoes_narrativa.pdf	14/01/2022 15:03:02	CLAITON MARQUES CORREA	Aceito
Projeto Detalhado / Brochura	projeto_pesquisa.pdf	14/01/2022 14:31:59	CLAITON MARQUES CORREA	Aceito

Endereço: Av.Ipiranga, 6681, prédio 50, sala 703

Bairro: Partenon

CEP: 90.619-900

UF: RS

Município: PORTO ALEGRE

Telefone: (51)3320-3345

Fax: (51)3320-3345

E-mail: cep@puhrs.br

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



Continuação do Parecer: 5.239.873

Investigador	projeto_pesquisa.pdf	14/01/2022 14:31:59	CLAITON MARQUES CORREA	Aceito
Declaração de Pesquisadores	Carta_Encaminhamento_Apoio_a_construcao_de_visualizacoes_narrativas.pdf	14/12/2021 10:33:16	CLAITON MARQUES CORREA	Aceito
Brochura Pesquisa	Documento_Unificado_Apoio_a_construcao_de_visualizacoes_narrativas.pdf	14/12/2021 10:27:58	CLAITON MARQUES CORREA	Aceito
Outros	Lattes_pesquisadores_Apoio_a_construcao_de_visualizacoes_narrativas.pdf	14/12/2021 10:26:49	CLAITON MARQUES CORREA	Aceito
Orçamento	Orcamento_Apoio_a_construcao_de_visualizacoes_narrativas.pdf	14/12/2021 10:26:06	CLAITON MARQUES CORREA	Aceito
Declaração de concordância	Carta_de_conhecimento_Apoio_a_construcao_de_visualizacoes_narrativas.pdf	14/12/2021 10:25:46	CLAITON MARQUES CORREA	Aceito
Folha de Rosto	folha_de_rosto_Apoio_a_construcao_e_visualizacoes.pdf	11/12/2021 15:32:24	CLAITON MARQUES CORREA	Aceito

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

PORTO ALEGRE, 11 de Fevereiro de 2022

Assinado por:
Denise Cantarelli Machado
(Coordenador(a))

Endereço: Av. Ipiranga, 6681, prédio 50, sala 703
Bairro: Partenon **CEP:** 90.619-900
UF: RS **Município:** PORTO ALEGRE
Telefone: (51)3320-3345 **Fax:** (51)3320-3345 **E-mail:** cep@pucrs.br

ATTACHMENT E – Ethics Committee Approval for the Amendment

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



PARECER CONSUBSTANCIADO DO CEP

DADOS DA EMENDA

Título da Pesquisa: Apoio à construção de visualizações narrativas

Pesquisador: Milene Selbach Silveira

Área Temática:

Versão: 5

CAAE: 54348321.1.0000.5336

Instituição Proponente: UNIAO BRASILEIRA DE EDUCACAO E ASSISTENCIA

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 5.980.275

Apresentação do Projeto:

O pesquisador principal Milene Selbach Silveira, responsável pelo projeto com número de CAAE 54348321.1.0000.5336 e Título: Apoio à construção de visualizações narrativas encaminhou emenda ao CEP-PUCRS com os seguintes documentos:

Arquivo: Apoio à construção de visualizações narrativas. Este arquivo apresenta o texto atualizado para contemplar os novos estudos. Assim, este contém, na seção 2.2, subseções 2.2.3 e 2.2.4 a organização do grupo de foco e workshop, respectivamente. De forma complementar, os Anexos 4 e 5 apresentam, respectivamente, os instrumentos de coleta de dados dos estudos.

Arquivo: TCLE_grupo_de_foco_customizacao. Este arquivo apresenta o TCLE que será assinado pelos participantes ao aceitarem participar da atividade.

Arquivo: TCLE_workshop_customizacao. Este arquivo apresenta o TCLE que será assinado pelos participantes ao aceitarem participar da atividade.

Há uma crescente necessidade de apresentar os dados de uma forma que seja clara e de fácil compreensão pelos usuários em diferentes áreas de conhecimento. Nos últimos anos, pesquisadores da área de visualização de dados propuseram unir elementos narrativos às visualizações de dados, para assim contar histórias (storytelling) com os dados; esta técnica é conhecida como visualização narrativa (Segel e Heer, 2010). A possibilidade de contar histórias

Endereço: Av. Ipiranga, nº 6681, Prédio 50, sala 703

Bairro: Partenon

CEP: 90.619-900

UF: RS

Município: PORTO ALEGRE

Telefone: (51)3320-3345

Fax: (51)3320-3345

E-mail: cep@puhrs.br

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



Continuação do Parecer: 5.980.275

com os dados é discutida em muitas áreas do conhecimento. Visualizações estáticas são utilizadas para apoiar a narrativa, frequentemente na forma de gráficos ou diagramas junto com o texto. Neste formato, o texto comunica a história e a imagem usualmente provê uma evidência ou relata algum detalhe. Uma questão emergente nesta área é a tentativa de combinar narrativas com gráficos interativos, para que, assim, o usuário possa entender e interagir com o que está sendo apresentado para ele (Segel e Heer, 2010). As visualizações narrativas podem oferecer explicações, de uma forma que não é possível com a visualização tradicional (Kosara e Mackinlay, 2013). Há um conjunto de ferramentas e técnicas diferentes que são utilizadas para criar uma história usando dados de forma que o usuário, isto é, o leitor da história, possa entendê-la da melhor forma possível. Mas, embora a visualização narrativa seja um tópico emergente dentro das pesquisas sobre visualização de dados e que, em razão disso, muitos trabalhos tenham sido publicados sobre o tema, ainda há oportunidades de pesquisa e questões abertas acerca destas visualizações. Por exemplo, no trabalho seminal da área, Segel e Heer (2010) afirmam que a escolha de uma ou mais estruturas narrativas por eles definidas no trabalho depende do tipo de dados e das intenções de quem cria a narrativa. Contudo, os autores não fornecem maiores explicações sobre como esta relação entre dados, estruturas narrativas e intenções se estabelece. Considerando o exposto, este projeto visa explorar a relação entre os tipos de dados e os recursos de visualização narrativa apresentados por Segel e Heer (2010). Além desta busca, outro ponto a ser explorado é a possibilidade de utilizar recursos narrativos para permitir que o leitor das histórias possa interpretar as visualizações narrativas a partir de outras perspectivas, sem que, para isso, fuja da intenção original definida pelo autor da visualização. Antecedentes científicos e dados que justifiquem a pesquisa

Técnicas de visualização de dados podem levar os leitores a descobrir novos insights a partir do momento em que estes podem observar padrões e fazer distinções entre eles (Heer et al., 2007). Além de prover uma compreensão apropriada dos dados, uma visualização pode aumentar o engajamento dos leitores, uma vez que os dados são visualizados dentro de um contexto (Heer et al., 2010; Ward et al., 2010). Avançando nas pesquisas em visualização de dados, autores, como Segel e Heer (2010), Hullmann e Diakopoulos (2011) e Kosara e Mackinlay (2013), consideraram o uso de storytelling, isto é, de visualizações narrativas, com um meio para melhorar o engajamento e compreensão dos usuários em visualização de dados. Elementos narrativos podem oferecer explicações de uma forma que dificilmente é possível a partir de técnicas tradicionais de visualização. Visualizações narrativas diferem do conceito de contar histórias (Segel e Heer, 2010). Histórias em textos ou vídeos mostram a sequência de eventos e progressão. A visualização de dados é similar, pois ela pode ser organizada em uma sequência linear, mas pode

Endereço: Av. Ipiranga, n° 6681, Prédio 50, sala 703
Bairro: Partenon **CEP:** 90.619-900
UF: RS **Município:** PORTO ALEGRE
Telefone: (51)3320-3345 **Fax:** (51)3320-3345 **E-mail:** cep@pucrs.br

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



Continuação do Parecer: 5.980.275

também oferecer recursos de interação que permitem ao usuário buscar interpretações alternativas. No trabalho seminal intitulado Narrative visualization: Telling stories with data, Segel e Heer (2010) organizam o desenvolvimento de visualizações narrativas em três dimensões: gêneros, estratégias de visualização narrativa, e estratégias de estruturas narrativas. Os gêneros relacionam-se à forma como a história é apresentada, o número de cenas, os elementos, a ordenação e o número de quadros. As estratégias de visualização narrativa compreendem dispositivos para auxiliar e facilitar a narrativa, como o recurso de realçar algum elemento. A terceira dimensão, estratégias de estrutura narrativas, por sua vez, envolve mecanismos para comunicar a estrutura da narrativa, como barras de progresso e/ou sliders. Os autores identificaram sete gêneros de visualização narrativa que podem ser mais ou menos adequados conforme os dados que estão sendo explorados. De acordo com eles, as estratégias e gêneros devem ser empregados de forma a balancear narrativas dirigidas pelo leitor ou pelo autor. As perspectivas de narrativas dirigidas pelo autor ou pelo leitor dizem respeito a quanto o leitor da narrativa pode interagir com ela. As narrativas que oferecem recursos interativos que permitam ao leitor explorar os dados de formas alternativas são conhecidas como dirigidas pelo leitor (do inglês reader-driven); já as narrativas que não oferecem ao leitor recursos interativos, ou seja, somente lhes oferecem a possibilidade de consumir o que foi previamente desenvolvido pelo autor, são conhecidas como dirigidas pelo autor (do inglês author-driven). Seguindo os estudos em visualizações narrativas, Hullmann e Diakopoulos (2011) exploraram estratégias retóricas empregadas em visualizações narrativas e como elas podem ser utilizadas para comunicar mensagens particulares. Os autores identificaram um conjunto de técnicas e formas que podem ser utilizadas para levar o leitor para, direta ou indiretamente, priorizar determinadas interpretações. O trabalho também explorou como estas estratégias se relacionam com o conhecimento e a realidade social dos usuários. Em Storytelling: the next step for visualization, Kosara e Mackinlay (2013) observaram que as pesquisas em visualização narrativa envolvem outras áreas do conhecimento além da ciência da computação, como psicologia e ciências sociais. Eles apresentaram rumos de pesquisa em relação a abordagens para storytelling, acessibilidade, avaliação, como tornar as visualizações memorizáveis, incluir anotações e realces, interações e o que aprender a partir de outras disciplinas. Ghidini et al. (2017) identificaram que a visualização narrativa pode ser considerada uma área de pesquisa recente, ainda que esteja em crescimento e esteja cada vez mais ganhando atenção. Santos e Silveira (2019) também notaram que este é um tópico emergente e identificaram a necessidade de explorar aspectos fundamentais na teoria e na prática para o desenvolvimento de narrativas. Um dos grandes desafios contemporâneos é como

Endereço: Av. Ipiranga, n° 6681, Prédio 50, sala 703
Bairro: Partenon **CEP:** 90.619-900
UF: RS **Município:** PORTO ALEGRE
Telefone: (51)3320-3345 **Fax:** (51)3320-3345 **E-mail:** cep@pucrs.br

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



Continuação do Parecer: 5.980.275

apresentar dados aos usuários de forma clara e de fácil compreensão. Neste sentido, as pesquisas na área de visualização de dados apontam para a visualização narrativa como um dos caminhos para apresentar os dados dentro de um contexto. Com o crescente número de pesquisas na área, alguns pontos de interesse surgiram, como a relação emergente entre os elementos narrativos durante o processo de criação de uma visualização narrativa. Considerando este cenário, este projeto de pesquisa visa investigar estas relações, buscando dessa forma, aprofundar o conhecimento acerca do desenvolvimento de visualizações narrativas com dados. Esta pesquisa será realizada utilizando para coleta de dados a técnica de grupo focal. Este método privilegia o compartilhamento de impressões coletivas e individuais (Sharp et al., 2019). O estudo está organizado em quatro rodadas; cada rodada contém tarefas, questões para serem respondidas e a discussão das questões, conforme listado abaixo.

Rodada 1: Apresentação do projeto e questões de mapeamento do perfil do participante.

Rodada 2: Tarefas (T1), Questões (Q2 e Q3) e discussão.

Rodada 3: Tarefas (T2), Questões (Q4) e discussão.

Rodada 4: Questões (Q5), discussão e finalização.

As tarefas definidas dentro dos grupos são:

T1: Tarefas relacionadas à primeira questão de pesquisa

- 1 - A partir da intenção de narrativa inicial, dada pelos pesquisadores, visualize e escolha os dados para serem apresentados
- 2 - Escolha um ou mais gêneros da visualização narrativa
- 3 - Escolha as técnicas de visualização para exibir os dados do item anterior. Caso nenhuma delas satisfaça, indique uma outra técnica não listada no conjunto
- 4 - Defina a distribuição do que foi criado anteriormente nos gêneros escolhidos
- 5 - Justifique suas escolhas

T2- Tarefas relacionadas à segunda questão de pesquisa

- 1 - A partir da narrativa criada no tópico anterior e das dimensões de exploração e suas técnicas, determine quais recursos serão empregados para permitir que o usuário leitor da narrativa possa explorar a história criada por outros pontos de vista (pode variar em gênero, dimensão e técnicas utilizadas)
- 2 - Justifique suas escolhas

As questões definidas para o estudo são:

Q1: Questões para mapear o perfil do participante

- 1 - Nome
- 2 - Idade
- 3 - Formação Acadêmica
- 4 - Área de atuação
- 5 - Tempo e tipo de experiência com visualização de dados

Q2: Questões relacionadas à percepção dos participantes sobre os gêneros de visualização narrativa apresentados

- 1 - Você já conhecia a visualização narrativa?
- 2 - De forma geral, a partir do que foi apresentado sobre visualização narrativa, quais dos gêneros você mais gostou e por quê?
- 3 - Em relação aos gêneros narrativos, qual a sua percepção em relação às suas aplicações no que se refere a forma que eles podem ser utilizados para apresentar uma história?
- 4 - Em relação aos gêneros de visualização narrativa e recursos apresentados, o que você achou mais difícil de entender ao relacionar os assuntos, e por quê?
- 5 - Qual a sua opinião sobre o uso de gêneros para aprimorar a compreensão de uma narrativa sob o

Endereço: Av. Ipiranga, n° 6681, Prédio 50, sala 703
Bairro: Partenon **CEP:** 90.619-900
UF: RS **Município:** PORTO ALEGRE
Telefone: (51)3320-3345 **Fax:** (51)3320-3345 **E-mail:** cep@pucrs.br

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



Continuação do Parecer: 5.980.275

ponto de vista do usuário? Q3: Questões relacionadas sobre a preferência dos participantes ao relacionar os dados e/ou intenções aos gêneros apresentados 1 - Considerando as características dos gêneros apresentados no estudo e os dados utilizados, qual sua percepção sobre a forma como estes foram escolhidos e utilizados em conjunto pelos participantes para construir a narrativa? Q4: Questões relacionadas aos recursos de exploração que podem ser fornecidos aos usuários 1 - Qual sua percepção sobre as visualizações narrativas exploratórias? 2 - Como você percebe o uso dos gêneros narrativos para explorar pontos de vista diferentes em uma narrativa? Quais outras formas de interação, além do que foi apresentado, você julga interessante prover em uma narrativa, para permitir que o usuário explore diferentes pontos de vista? Q5: Questões de fechamento 1 - Em relação aos elementos narrativos, como os gêneros, qual a sua percepção em relação ao nível de instrução em visualização que um usuário deva ter para consumi-las? 2 - Mais alguma observação sobre o tema? Algo que gostaria de relatar? O participante inicia sua participação no estudo somente após ser informado e concordar com as condições da atividade conforme declarado no TCLE. Para análise dos resultados utilizaremos técnicas de análise de conteúdo, como a análise temática, que é uma técnica que busca identificar, analisar e reportar padrões nos dados. O tempo de participação na sessão é planejado para o mínimo de 45 minutos e máximo de 120 minutos.

Objetivo da Pesquisa:

O objetivo primário proposto pelos pesquisadores é o seguinte: "O projeto possui dois objetivos primários. O primeiro tem foco na relação estabelecida pelos autores de narrativas, doravante tratados como designers, entre os tipos de dados e os gêneros narrativos. Neste ponto, o objetivo é investigar as relações emergentes entre os elementos de uma narrativa durante o processo de desenvolvimento de uma visualização, em especial, relações estabelecidas pelos designers entre os dados e os gêneros narrativos. Espera-se, a partir deste estudo, compreender com maior refinamento, o desenvolvimento de uma visualização narrativa. O segundo tem foco em entender como os designers usam os gêneros narrativos e conceitos de visualização narrativa exploratória e seus recursos para agregar alternativas de interpretação durante o processo de criação de uma narrativa. Neste ponto, o objetivo é investigar como os designers empregam os elementos narrativos e de visualização narrativa exploratória para criar narrativas que ofereçam ao leitor formas para explorá-las sob outros pontos de vista ou perspectivas. Outro ponto de interesse relacionado à questão de pesquisa é investigar como os designers percebem os elementos narrativos no que se refere a possibilidades que eles oferecem para a compreensão da história, isto é, o quanto estes podem ser mais ou menos adequados para determinadas intenções e/ou

Endereço: Av. Ipiranga, n° 6681, Prédio 50, sala 703
Bairro: Partenon **CEP:** 90.619-900
UF: RS **Município:** PORTO ALEGRE
Telefone: (51)3320-3345 **Fax:** (51)3320-3345 **E-mail:** cep@pucrs.br

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



Continuação do Parecer: 5.980.275

público-alvo. A intenção é verificar com os designers quais outras interpretações ou pontos de vista podem ser exploradas dentro de uma mesma narrativa.”.

Avaliação dos Riscos e Benefícios:

Os pesquisadores citam os seguintes riscos: “De acordo com o Conselho Nacional da Saúde (2002), qualquer pesquisa que envolve seres humanos pode ter um risco associado, na possibilidade de danos à dimensão física, psíquica, moral, intelectual, social, cultural ou espiritual do ser humano. Desta forma, listamos alguns destes riscos de acordo com a dinâmica em grupo:- Cansaço ou aborrecimento durante a realização das tarefas ou durante as discussões em grupo.- Desconforto, constrangimento ou alterações de comportamento durante gravações de áudio e vídeo.- Divulgação de dados confidenciais ou quebra de sigilo. Para mitigar estes riscos adotamos estratégias conforme segue. Para o item 1, elaboramos um roteiro semi-estruturado com atividades e questões para orientar a dinâmica do grupo de foco. Para evitar desorientação, optamos por somente os pesquisadores terem permissão de manipular os objetos na interface. Assim, os participantes farão a discussão e orientarão os pesquisadores na montagem de narrativas. Para o item 2, optamos pelo compartilhamento da tela de um dos pesquisadores, evitando, desta forma, que os participantes sintam-se desconfortáveis caso tivessem que compartilhar a tela de seus computadores. Os participantes terão apenas que deixar a câmera e áudio aberto durante a realização das sessões. Para o item 3, desassociaremos a identificação dos participantes do material produzido, ou seja, aquilo que for resultado do processo de criação não conterá quaisquer etiquetas que identifiquem os participantes das sessões. Além disso, o material produzido e gravado será armazenado em diretórios os quais somente os pesquisadores têm acesso, via identificação. Por fim, conforme destacado no Termo de Consentimento Livre e Esclarecido, o qual será discutido com os participantes antes da atividade de coleta de dados, o participante é livre para se retirar da atividade a qualquer momento, sem haver necessidade de explicar as razões para isso.”. Os pesquisadores citam os seguintes benefícios: “Não há benefícios a curto prazo para os participantes desta pesquisa, contudo, acreditamos que o contato e prática de técnicas de visualização narrativa pode agregar ao conhecimento dos participantes conceitos que lhes serão úteis na atividade profissional e acadêmica.”

Comentários e Considerações sobre a Pesquisa:

Este é um estudo acadêmico para tese de doutorado, que seguirá uma metodologia qualitativa de coleta de dados usando as técnicas de grupo focal e workshop. Para processamento dos resultados serão utilizadas técnicas de análise de conteúdo, como a análise temática, que é uma técnica que busca identificar, analisar e reportar padrões nos dados. O cronograma de execução

Endereço: Av. Ipiranga, n° 6681, Prédio 50, sala 703
Bairro: Partenon **CEP:** 90.619-900
UF: RS **Município:** PORTO ALEGRE
Telefone: (51)3320-3345 **Fax:** (51)3320-3345 **E-mail:** cep@pucrs.br

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



Continuação do Parecer: 5.980.275

prevê que a finalização do projeto em julho de 2023.

Considerações sobre os Termos de apresentação obrigatória:

Todos os termos foram apresentados.

Conclusões ou Pendências e Lista de Inadequações:

Não há pendências.

Considerações Finais a critério do CEP:

Diante do exposto, o CEP-PUCRS, de acordo com suas atribuições definidas na Resolução CNS n° 466 de 2012, Resolução n° 510 de 2016 e da Norma Operacional n° 001 de 2013 do CNS, manifesta-se pela aprovação da emenda ao projeto de pesquisa "Apoio à construção de visualizações narrativas" proposto pela pesquisadora Milene Selbach Silveira com número de CAAE 54348321.1.0000.5336.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_2112191_E2.pdf	28/03/2023 09:30:00		Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_workshop.pdf	28/03/2023 09:28:29	CLAITON MARQUES CORREA	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_grupoFoco.pdf	28/03/2023 09:28:21	CLAITON MARQUES CORREA	Aceito
Outros	carta_apresentacao_emenda_claiton.pdf	28/03/2023 09:28:07	CLAITON MARQUES CORREA	Aceito
Brochura Pesquisa	apoio_a_construcao_de_narrativas.pdf	28/03/2023 09:26:05	CLAITON MARQUES CORREA	Aceito
Outros	cartaEmenda.pdf	17/05/2022 18:06:33	CLAITON MARQUES CORREA	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	WorkshopTCLE.pdf	17/05/2022 18:05:50	CLAITON MARQUES CORREA	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	grupoDeFocoTCLE.pdf	17/05/2022 18:05:35	CLAITON MARQUES CORREA	Aceito

Endereço: Av. Ipiranga, n° 6681, Prédio 50, sala 703

Bairro: Partenon

CEP: 90.619-900

UF: RS

Município: PORTO ALEGRE

Telefone: (51)3320-3345

Fax: (51)3320-3345

E-mail: cep@puhrs.br

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



Continuação do Parecer: 5.980.275

Brochura Pesquisa	apoio_construcao_narrativas_projeto.pdf	17/05/2022 18:04:15	CLAITON MARQUES CORREA	Aceito
Outros	Carta_Alteracoes_Apoio_a_construcao_de_visualizacoes_narrativa_v2.pdf	08/02/2022 14:21:58	CATIA REGIANE DA SILVA ASSINK	Aceito
Outros	Carta_Alteracoes_Apoio_a_construcao_de_visualizacoes_narrativa_v2.docx	08/02/2022 14:21:44	CATIA REGIANE DA SILVA ASSINK	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_Apoio_construcao_de_visualizacoes_narrativas_v2.pdf	08/02/2022 09:24:09	CLAITON MARQUES CORREA	Aceito
Solicitação registrada pelo CEP	Carta_Alteracoes_Apoio_a_construcao_de_visualizacoes_narrativa.pdf	14/01/2022 15:03:02	CLAITON MARQUES CORREA	Aceito
Projeto Detalhado / Brochura Investigador	projeto_pesquisa.pdf	14/01/2022 14:31:59	CLAITON MARQUES CORREA	Aceito
Declaração de Pesquisadores	Carta_Encaminhamento_Apoio_a_construcao_de_visualizacoes_narrativas.pdf	14/12/2021 10:33:16	CLAITON MARQUES CORREA	Aceito
Brochura Pesquisa	Documento_Unificado_Apoio_a_construcao_de_visualizacoes_narrativas.pdf	14/12/2021 10:27:58	CLAITON MARQUES CORREA	Aceito
Outros	Lattes_pesquisadores_Apoio_a_construcao_de_visualizacoes_narrativas.pdf	14/12/2021 10:26:49	CLAITON MARQUES CORREA	Aceito
Orçamento	Orcamento_Apoio_a_construcao_de_visualizacoes_narrativas.pdf	14/12/2021 10:26:06	CLAITON MARQUES CORREA	Aceito
Declaração de concordância	Carta_de_conhecimento_Apoio_a_construcao_de_visualizacoes_narrativas.pdf	14/12/2021 10:25:46	CLAITON MARQUES CORREA	Aceito
Folha de Rosto	folha_de_rosto_Apoio_a_construcao_e_visualizacoes.pdf	11/12/2021 15:32:24	CLAITON MARQUES CORREA	Aceito

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

PORTO ALEGRE, 03 de Abril de 2023

Assinado por:
Karen Cherubini
(Coordenador(a))

Endereço: Av. Ipiranga, nº 6681, Prédio 50, sala 703
Bairro: Partenon **CEP:** 90.619-900
UF: RS **Município:** PORTO ALEGRE
Telefone: (51)3320-3345 **Fax:** (51)3320-3345 **E-mail:** cep@pucrs.br

PONTIFÍCIA UNIVERSIDADE
CATÓLICA DO RIO GRANDE
DO SUL - PUC/RS



Continuação do Parecer: 5.980.275

Endereço: Av. Ipiranga, nº 6681, Prédio 50, sala 703
Bairro: Partenon **CEP:** 90.619-900
UF: RS **Município:** PORTO ALEGRE
Telefone: (51)3320-3345 **Fax:** (51)3320-3345 **E-mail:** cep@pucrs.br



Pontifícia Universidade Católica do Rio Grande do Sul
Pró-Reitoria de Pesquisa e Pós-Graduação
Av. Ipiranga, 6681 – Prédio 1 – Térreo
Porto Alegre – RS – Brasil
Fone: (51) 3320-3513
E-mail: propesq@pucrs.br
Site: www.pucrs.br