# Supporting User-Centered Requirements Elicitation from Lean Personas: A UX Data Visualization-Based Approach

Maylon Macedo[a], Gabriel V. Teixeira[b], Ariel E. S. Campos[c] and Luciana Zaina[d]
*Federal University of São Carlos (UFSCar), São Paulo, Brazil*

Keywords: Lean Personas, User Experience, UX, UX Data, Requirement Elicitation, Information Visualization.

Abstract: The interest in exploring User Experience (UX) data to support the requirement elicitation of interactive systems is not new. Although the literature discusses traditional methods to gather UX data (e.g., interviews and surveys), personas have arisen as a more user-centered technique that presents information about users' needs, preferences, and characteristics about the application domain. Nonetheless, persona data is often represented from qualitative data in textual format, which can insert difficulties in browsing and exploring a set of personas. This paper aims to present visualizations designed using Information Visualization (InfoVis) principles that support the navigation and search-out UX data in a persona dataset. To aid in eliciting UX-related requirements, our visualizations are based on a funnel perspective that guides designers and developers to examine data from an overview first, then zoom and filter, to achieve the qualitative data in detail finally. We evaluated with 20 participants concerning the interpretation of the visualizations. The results revealed that the participants, even those with little experience in requirement elicitation, could interpret and find relevant UX data from the visualizations.

## 1 INTRODUCTION

User experience (UX) is an important aspect of software quality that affects software acceptance by users (Kashfi et al., 2019). Although the literature provides different definitions of UX, most of them state that UX encompasses both the software functionalities and its quality characteristics that are perceived by end-users (Hassenzahl, 2018). Studies have discussed the importance of including the discussion of UX from the software conceptualization stages (i.e., requirement elicitation, software ideation) (Kashfi et al., 2019; Choma et al., 2022). Different requirements elicitation techniques have emerged in the literature (e.g., personas, user stories) (Faily and Lyle, 2013) and the personas technique has been recognized as a more focused user-centered approach to explore data from end-users (Pinheiro et al., 2019). By creating fictional characters that represent different groups of end-users, the personas provide designers and developers with users' data about their needs, experiences, behaviors, and goals, hereinafter called UX data (Billestrup et al., 2014; Pinheiro et al., 2019). UX data contains information that allows mapping users' decisions and interactions with a product, enabling measurements and statements about the causes and results of implementations in interactive systems (Luther et al., 2020).

Personas often provide a rich amount of qualitative UX data (Gothelf, 2012). Nonetheless, the traditional persona demands time and effort in user data collection which becomes an expensive technique (Billestrup et al., 2014). As an alternative, Gothelf proposed the proto-persona also called lean persona, an agile approach that allows designers/developers to create concise personas based on their prior knowledge about the target audience (Gothelf, 2012; Pinheiro et al., 2019).

On the one hand, designers and developers recognize the qualitative UX data from lean personas as useful to elicit users' needs and preferences in their interaction (Isherwood, 2020). On the other hand, they struggle to identify and extract meaningful insights about UX from qualitative data in textual format which turns the elicitation of UX-related requirements into a complex task (Ye Lim Rhie and Yun, 2017). The extraction of requirements involving text interpretation requires defining meanings to provide

[a] https://orcid.org/0000-0002-2686-1103
[b] https://orcid.org/0000-0001-7589-3622
[c] https://orcid.org/0000-0003-0857-4570
[d] https://orcid.org/0000-0002-1736-544X



Macedo, M., Teixeira, G., Campos, A. and Zaina, L.
Supporting User-Centered Requirements Elicitation from Lean Personas: A UX Data Visualization-Based Approach.
DOI: 10.5220/0012567400003690

In *Proceedings of the 26th International Conference on Enterprise Information Systems (ICEIS 2024) - Volume 2*, pages 461-472
ISBN: 978-989-758-692-7; ISSN: 2184-4992

different values to the raw data (Ye Lim Rhie and Yun, 2017). Without defining meanings, the analysis depends on the judgment of each researcher, and the result may vary in relation to knowledge and experience about UX (Ye Lim Rhie and Yun, 2017; Desai, 2019).

Visual data representations can guide designers and developers during the requirement elicitation (Kashfi et al., 2019) on the exploration of textual data which reduces the effort to obtain information based on patterns and emergent data (Desai, 2019). Considering the problem of browsing and exploring the textual UX data provided by lean personas, this paper presents three visualizations that deliver UX data that are obtained from lean personas previously elaborated. These visualizations lead designers and developers to explore the lean persona data gradually ranging from the data overview to data in detail taking into account Shneiderman's mantra (Shneiderman, 1996).

This paper is organized as follows. section 2 presents the fundamental background that underlies the design and development of the visualizations and the related work. We explain all activities made in our systematic process to design the visualizations, including the visualizations' rationale and characteristics, in section 3. In subsection 3.1 we explain the dataset used as a baseline to design the visualizations. We discuss the study validity and present the planning, execution, and analysis of the visualizations evaluation in section 4. The analysis of the evaluation results and our findings about the use of visualizations to get information by UX data are presented in section 5. In section 6 we presented conclusions and suggestions for future work.

# 2 BACKGROUND

## 2.1 Requirements Elicitation and Personas

Software professionals have a common understanding that a good process of requirements elicitation promotes support for defining requirements (Ormeño and Panach, 2013). Software requirements have two main classifications which are named functional and non-functional. Quality requirements like UX requirements fit into the definition of non-functional and involve understanding system tasks, user expectations, ease of use, and user satisfaction (Ormeño and Panach, 2013).

As mentioned before (see Section 1), personas have been used as an artifact to support UX-related requirements elicitation due to the details about users' needs and characteristics these artifacts provide to developers and designers (Faily and Lyle, 2013; Teixeira. and Zaina., 2022). However, the construction of traditional personas requires efforts of time and a great amount of data collection (Billestrup et al., 2014). Lean personas is a technique that impresses more agility to the personas creation process by considering the prior knowledge of the software practitioners about the target audience (Gothelf, 2012).

Pinheiro et al. (2019) extended Gothelf's lean persona and proposed a four-quadrant template that contained guideline questions to guide the lean persona artifact construction. The four quadrants organize the lean persona information as follows: Q1 - Demographic data; Q2 - Objectives and needs; Q3 - Behaviors and preferences; and Q4 - Difficulties. The four quadrants of the template and the guideline questions enhance the description of users' information while keeping the characteristic of being a lean artifact (Teixeira. and Zaina., 2022). To automatize the creation of lean personas based on the four-quadrant template, Teixeira. and Zaina. (2022) developed the Lean Persona+ tool.

The results about the effectiveness and efficiency of adopting personas artifacts during requirements identification were presented by Salminen et al. (2020). The authors compared the use of personas with requirements elicitation conducted using data from an analytics tool (Salminen et al., 2020). The results revealed that the developers spent more time identifying the requirements that were caused by the need to interpret a great amount of data from the analytics tool. On the other hand, the personas artifacts presented end-user data in a straight way which makes the developers work faster (Salminen et al., 2020).

## 2.2 UX Data Visualization

Techniques such as lean persona produce qualitative data about user characteristics, needs, preferences, and experiences (Gothelf, 2012). This qualitative UX data can aid designers and developers in setting priorities for designing a better user experience during the requirement elicitation process (Luther et al., 2020). Besides, it can bring insights about *why* users need some software features, *what* software features are suitable to fulfill users' needs and preferences, and *how* users can interact with the features (Hassenzahl, 2018). However, the alignment on the meaning of UX can insert difficulties in using the UX qualitative data to requirement elicitation (Choma et al., 2022; Ye Lim Rhie and Yun, 2017).

Different UX definitions are found in the literature. Hassenzahl provides a content-model definition

that categorizes UX into three levels based on interaction action (Hassenzahl, 2018). The *why* level encompasses the motivations and needs that lead an individual to use the product. The *what* level refers to product features that fulfill users' needs. The *how* level is about user activity on the product to interact with the functionalities. When the user reaches their goal (i.e., *why* level) through successful use of the concrete actions (i.e., *how* level) of product functions (i.e., *what* level) a feeling of wellbeing is awakened (Hassenzahl, 2018). Hassenzahl's content model provides a perspective of the UX information linked to users' interaction with the product (*what* and *how* levels) and with the motivations and needs for having these interactions (*why* levels). Each level of Hassenzahl's content model focuses on information related to UX which facilitates the levels of association with UX qualitative data (Zaina et al., 2021).

Nonetheless, qualitative data provided from lean personas are based on text data which turns the data exploration for requirement elicitation harder (Slone, 2009). The visualization of data in plain text format does not assist users to infer patterns and find trends or outliers (Ware, 2012). The adoption of visual representations can assist the navigation of qualitative data guiding professionals to explore and interpret UX data instead of relying on statements of individuals that analyzed the results (Slone, 2009; Ware, 2012).

The elaboration of visual representations can be supported by Information Visualization (i.e., InfoVis) techniques (Munzner, 2014; Ware, 2012). InfoVis offers methods and techniques to enhance human perception in the recognition and interpretation of data (Ware, 2012). Concerning Human-Computer Interaction (HCI), InfoVis aims to build visualizations that are more adherent to the needs of a target audience and prevent users from employing excessive efforts to interpret data (Ware, 2012; Munzner, 2014).

## 2.3 Related Work

As far as we know, there is no previous work that proposes visualizations to support the use of data from personas. The work of personas related to requirement elicitation mostly discusses the potential of uncovering user-centered data available from the personas (Pinheiro et al., 2019). Lean Persona+ tool developed by Teixeira. and Zaina. (2022) allows the visualization of personas data; however, the visualization is available from its template format. Considering that our approach is based on visual representations, we explored studies that provide contributions to the visualizing UX data.

Móro et al. (2014) proposed a bar chart view for visualizing gaze-tracking data focused on testing dynamic web applications. An assessment of the usability of the visualization showed that users want to visualize the data in other formats, for instance heat map graphs. To view website navigation data, four visualizations (i.e., Arc Diagram, Word Tree, Sankey Diagram, and Node-Link) were proposed by Buono et al. (2020) to support novice evaluators in usability testing. An evaluation by applying the System Usability Scale questionnaire (SUS) with fifteen participants revealed that the Sankey Diagram was the visualization most appreciated by the evaluators for showing navigation data quickly and objectively. To support the analysis of the results of usability and UX assessments based on user tasks, Bernhaupt et al. (2020) has created three visualizations. These visualizations were built by applying the Shneiderman's mantra (1996) (i.e., overview first, then zoom and filter, details on-demand) with two levels of granularity: overview and detailed.

Considering visualizations of qualitative data, Bakiu and Guzman (2017) proposed an approach to automatically detect software feature issues, usability, and UX dimensions (e.g., satisfaction, comfort, and motivation), and sentiment polarities (i.e., positive, negative, or neutral) according to user ratings in apps reviews. Similar to Bernhaupt et al. (2020) work, Shneiderman's mantra (1996) was applied in building the views, visualizing the results at two levels of granularity: overview and detailed. The authors do not report an assessment of the visualizations.

# 3 UX DATA VISUALIZATION DESIGN

To design the visualizations, we followed two approaches: the Design Activity framework and the Nested Model for Visualization Design proposed by McKenna et al. (2014) and Munzner (2014), respectively. Design Activity Framework (DAF) encompasses a process of four activities to support the design of visualizations: *Understand* - encourage designers to adopt a user-centered design thinking about requirements, goals, and opportunities of visualizations; *Ideate* - motivate the brainstorm of ideas and thus the selection of one that best fulfills the needs discovered in the *understand* activity; *Make* - prototype the selected idea in a visualization (or a set of visualizations), and *Deploy* - deploy an effective visualization system which can be explored and evaluated by end-users (McKenna et al., 2014).

Nested Model for Visualization Design (i.e., in

short, named Nested Model) is a well-known approach to support the evaluation and design of visual representations (Munzner, 2014). It contains four levels that cover (see Figure 1): (i) Domain Situation - which guides designers in understanding the proposal of the visualization; (ii) Data/task abstraction – which helps designers find which data and its formats are used to do a task; (iii) Visual encoding/Interaction idiom – encourage designers to consider the visual representations and approaches to show the data for users (i.e., idiom of visualization); and (iv) Algorithm – develop the visualization (Munzner, 2014). The idiom of visualization can be perceived by chart models, interaction features (e.g., zoom and pinch), and visualization systems with the information presented in different degrees of granularity (Munzner, 2014).

We decided to adopt both approaches because they present a complementary perspective (see Figure 1). Design Activity Framework (McKenna et al., 2014) supporting us in applying the good practices presented in the Nested Model for creating the visualizations. We applied this complementary view for each visualization we have proposed. Taking into account the complementary view of the approaches, we proceeded to design the visualizations based on two steps, i.e., preparation of lean personas dataset, and visualizations elaborations. Each step is presented in the next sections.

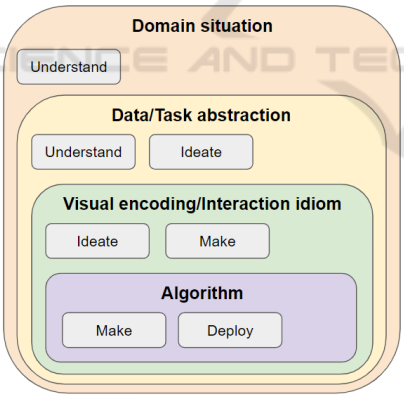


Figure 1: The complementary view of DAF and Nested Model approaches - DAF in grey boxes and the Nested Mode in colors - adapted from (McKenna et al., 2014) and (Munzner, 2014), respectively.

Considering the complementary view of McKenna et al. (2014) and Munzner (2014) model (see Figure 1), we conducted the *understand* step about the *domain situation*, i.e., how the visualizations could minimize the designers and developers efforts to browse the qualitative data of lean personas. Taking into account the great amount of qualitative data, we decided to adopt a funnel perspective to visualize the UX data as used in (Bakiu and Guzman, 2017; Bernhaupt et al., 2020). In both works, the authors applied two levels of the Shneiderman's mantra (1996) (i.e., overview and detailed). In our proposal, we planned to design three visualizations to disclose the UX data gradually throughout the three levels (i.e., *overview*, *zoom and filter*, and *details*). After that, we searched for a lean personas dataset that could be used in the visualization construction. Besides, we conducted the *understand* of the data available to then *ideate* how this data could support the conception of the three visualizations (see *data/task abstraction* level in Figure 1) as we described in the next section.

## 3.1 Lean Personas Dataset Model

Our first activity was to obtain the persona dataset. We contacted the Lean Persona+ tool authors because we considered they would have a dataset of virtual data (Teixeira. and Zaina., 2022). We asked for access to a dataset with the lean persona artifacts and they provided a dataset containing 23 lean personas specifications in the four quadrants template (see the quadrants template explanation in section 2). According to the authors, this dataset was produced from the studies conducted to evaluate the Lean Persona+ tool (Teixeira. and Zaina., 2022). The dataset encompassed lean personas that represented the target users of tourism mobile apps (e.g., TripAdvisor[1]). Each lean persona is composed by *quadrants*, *questions*, and *answers* which are the base elements of the lean persona template (see an example of a persona's data in the Figure 2-III) (Pinheiro et al., 2019).

## 3.2 Labeling Lean Personas Dataset

Besides the feature of creating lean persona artifacts, the Lean Persona+ tool provides a labeling tool. The labeling tool allows the activity of marking chunks of text available in the quadrant which are part of lean personas descriptions. The labeling tool provides *labels* based on the levels proposed by Hassenzahl (i.e., *why*, *what*, and *how*, see details in Section 2.2). With these labels, we can conduct the *labeling* of chunks of qualitative data to identify UX-relevant excerpts presented in the quadrants of lean personas. Different labels could be assigned to the same chunks of text. In a conversation with the authors tool, we have permission to use the labeling tool to prepare the dataset for being used in our visualization proposals. Three experts with (i) knowledge of Hassenzahl's content

[1]https://www.tripadvisor.com.br/

model; and (ii) academic and practical experience in Human-Computer Interaction and in Requirement Engineering participated in the labeling activity. The profile of experts was (i) one professor with 15+ years of experience; (ii) one PhD candidate with 5+ years of experience in the software industry; and (iii) one junior researcher with 1+ years who also works in the industry as a developer. After labeling 23 lean personas available in the dataset, we produced 165 labels in total (i.e., 55 *why*, 77 *what*, 33 *how*).

## 3.3 Design the Visualizations

Taking into account the lean personas data labeled with Hassenzahl's content model levels, we moved to *ideate* and *make* the *visual encoding* level with the participation of the three UX experts that labeled the lean persona dataset (see experts profile in Section 3.2). These activities were performed for each visualization that was associated with the three mantra levels (i.e., *overview*, *zoom and filter*, and *details*).

In sequence, the *make* and *deploy* activities were carried out for each visualization creation to complete the *algorithm level* (see Figure 1). To provide a functional version of the visualizations, we developed a web application. It is worth noticing that although we used a predefined lean persona dataset, our visualizations proposal are extensible to other datasets that follow the data structure presented in subsection 3.1.

Our three visualizations intend to orchestrate a gradual navigation to the UX data of lean personas. In this sense, the following description illustrates how the visualizations are connected one each other. By interacting with the *overview* visualization designers and developers can first filter the dataset by choosing one of the labels (i.e. *why*, *what*, and *how*) to see the personas that have information about that selected label. With the *zoom and filter* visualization they see the quantitative data related to each persona-quadrant relationship and can select one persona to be examined in detail. *Details* visualization shows the text data and the labels assigned to each lean persona that highlight the role of that chunk of text in providing UX-relevant information. Such information can become a UX-related requirement or trigger insights to search for other requirements.

The following sections discuss each visualization design. For each visualization, we will provide information about our *rationale* for ideation that visualization, the *visual representation format* selected and its respective *characteristics*, and the *chart* and its details that implemented that visualization.

### 3.3.1 Visualization to *Overview* the UX Data

Considering the organization of lean persona artifacts data described in subsection 3.1, we noticed that there is no direct way (i.e., without performing calculations) to visualize the quantitative data about the labels (i.e., UX data). Primary navigation through lean persona artifacts is performed without an overview by selecting a particular persona in a tabular view to see all data.

*Rationale:* An *overview* visualization avoids the need to open each persona to observe the existence of labels. This type of visualization (i.e. overview) helps users see the scope of data and choose what information they need to see in detail (Shneiderman, 1996; Munzner, 2014). By looking at the labeling distribution, designers and developers can concentrate their attention on the lean personas that may contain UX data that they want to look for guided by the label that abstracts the meaning of the data. Developers and designers can take advantage of information such as: if there are labels; the number of labels, and what kind of existing labels.

*Visual representation characteristics:* In the Sankey chart, the line can represent a relationship between categories while the thickness of the line represents quantitative data. *The objective of this visualization* is to get an overview of all available data to guide users on the data exploration. Our *overview* visualization (see Figure 2-I) can represent: the number of labels that were found in each quadrant (see Figure 2-I-A)); the number of labels that exist of each label type (see Figure 2-I-B)); and the number of labels of each type is present in each quadrant (see example in Figure 2-I-C)). *The visualization interaction is* Mouse hover in left axle to show the amount of all existing labels in that quadrant; Mouse hover in right axle to show the amount of all occurrences of that label; Mouse click in right axle to open the *zoom and filter* visualization; Mouse hover on lines to show the amount of a given label in a given quadrant.

### 3.3.2 Visualization to *Zoom and Filter* the Data

The *overview* visualization (see subsubsection 3.3.1) provides the view of the representativeness of each type of label assigned to all the lean personas available in the dataset. Taking into account the label selected (i.e., *why*, *what*, and *how*) previously in the *overview* visualization, designers and developers can explore the quantitative data by choosing which lean personas have the selected label.

*Rationale:* Considering our objective of eliciting requirements from UX data present in lean persona, *zoom and filter* visualization aids to reduce and fo-

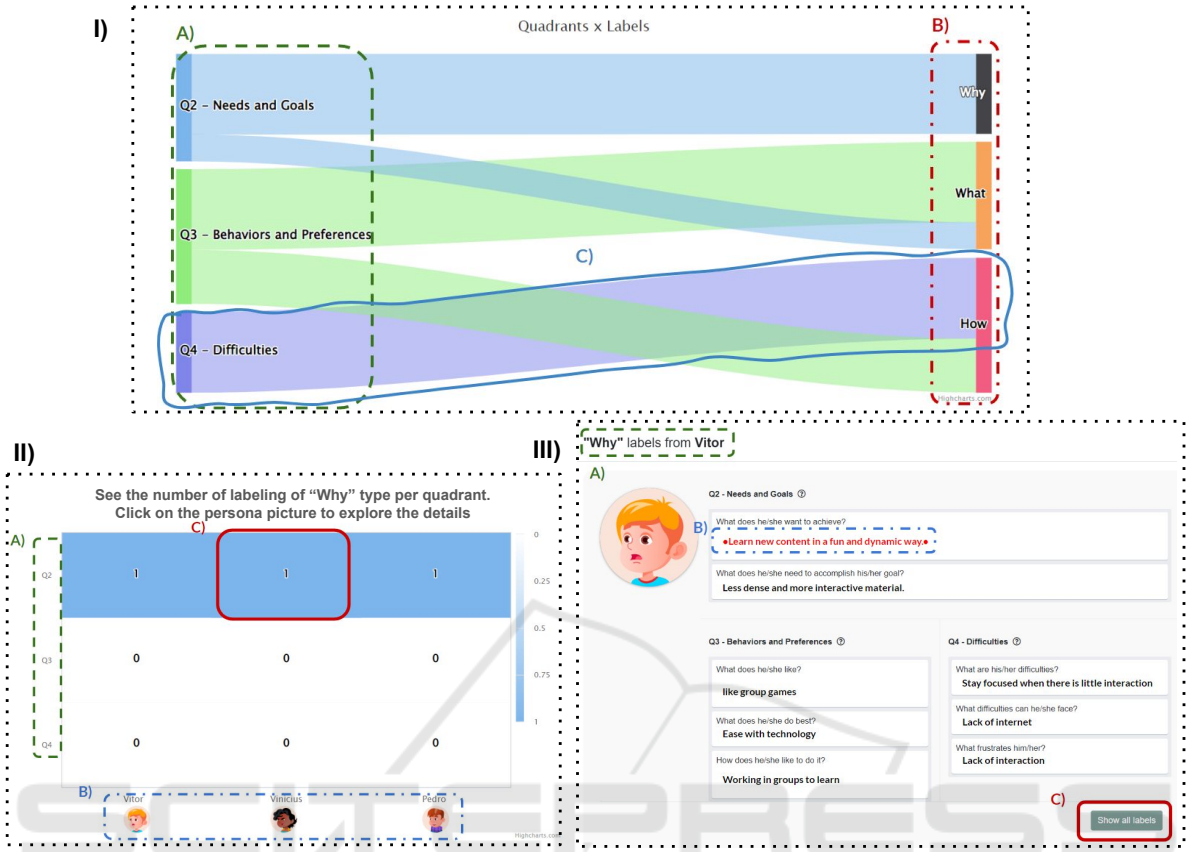


Figure 2: I) Sankey visualization for overview, II) Heat Map showing the labeling distribution for zoom and filter, and III) Card visualization to see the detail of qualitative data of the persona — High resolution PDF on Google Drive.



cus on a more detailed level of information (i.e. only personas with the select label) achieving the goal of presenting the data in a funnel perspective.

*Visual representation characteristics:* We chose Heat Map as *zoom and filter* visualization because it can show the quantitative relationship between two categorical variables by highlighting the variation of this relationship through colors (i.e., the color scale is associated with the value scale). *The objective of this visualization* is to show distribution of a pre-selected label in quadrants-persona relationship. In our proposal (see Figure 2-II) the title of the quadrants (see Figure 2-II-A) that organize the lean personas information was inserted on the Y-axis, and the identification of the personas on the X-axis (see Figure 2-II-B). The quantitative information presented in the Heat Map is the number of labels that exist for each set of quadrants and lean personas (see Figure 2-II-C). *The visualization interaction is* Mouse click in x-axis to show all information about the selected persona; Mouse hover in cells to show a textual explanation following the pattern: "[PERSONA_NAME] has [LABEL_AMOUNT] in [QUANDRANT_NAME]".

### 3.3.3 Visualization to See the *Detail*

After selecting the cell in *zoom and filter*, the visualization of *details* delivers the UX qualitative data in the lean persona essence by showing all the quadrants descriptions and the excerpts highlighted with labels.

*Rationale:* The visualization of the lean personas detailed provides the UX data more contextualized due to being available all the qualitative data. Card visualization presents small clusters of information, i.e., lean personas quadrants, which allows the delivery of content appropriate to the domain, i.e., description of needs and preferences from lean personas.

*Visual representation characteristics:* In the *detail* visualization, by default, only labels that match the selected label type on the *overview* visualization will be loaded with highlights, however exists the possibility of seeing all the labels to give software practitioners an *overview* of the labeling data. *The objective of this visualization* is to access all information for a pre-selected persona. In our proposal (see Figure 2-III) the card header (see Figure 2-III-A)) shows the label chosen in the *zoom and filter* visualization. Labels are

identified by colors plus a symbol. By looking at the personas, software practitioners can clearly recognize where the labels are placed and where they are not (see Figure 2-III-B)). Finally, the visualization provides a function that enables the viewing of all the labels that were assigned to that persona (see Figure 2-III-C)). *The visualization interaction is* Mouse click to enable/disable the display of all persona labels (i.e., by default only shows labels of the pre-selected type in the Sankey chart).

# 4 UX DATA VISUALIZATION EVALUATION

We conducted an experimental study with 20 participants following the guidelines proposed by Lazar et al. (2017) and Wohlin et al. (2012). We aimed to evaluate the facility of interpreting the three visualizations. The objective of the visualizations was to assist in extracting requirements based on the data present in the personas, for this reason the interpretation of the visualizations was analyzed. Subjects are sampled by convenience. Our study was approved by the ethical committee of the Federal University of São Carlos (UFSCar) under the process number 68524023.0.0000.5504. The next sections present the study details.

## 4.1 Apparatus

We prepared four artifacts to support our study that is described below.

An *online questionnaire* was elaborated to gather participants' consent to use the data collected (i.e., Informed Consent Form and their profile data (i.e., demographic data, years of experience, or whether they had no experience, position in the company, and knowledge of information visualization and personas techniques).

As personas descriptions are tightly associated with the domain of the product, we prepared a *scenario description* to explain the nature of the data that participants will see. We got the same scenario description that the Lean Persona+ tool authors used to produce the dataset. The scenario presents users' interaction with a tourism app: *"A tourist usually uses a mobile application (mobile, tablet, etc.) to plan and guide their trips. The app displays places in a city or region according to the interest and searches made by users. These places can be hotels, monuments, museums, parks, and restaurants, among others. For each location, the apps show details such as the location name, photos, addresses, and feedback from other individuals that often are ranked by a score from 0 to 5. Moreover, these apps can present estimates of expenses to spend in the places and also comments to assist the user to decide and plan visits to places that have good ratings"*.

We constructed a questionnaire using Google Forms to evaluate the *interpretations* of the visualizations. The questionnaire was composed of nine questions (see Table 1) and guided the participants in tasks that encouraged the exploration of the three visualizations (i.e., *overview*, *zoom and filter*, and *detail*. At the beginning of the questionnaire, an image of the *overview* visualization was presented with numerical labels to support the participants in identifying each part of the visualization the questions were referring to (see Figure 3).

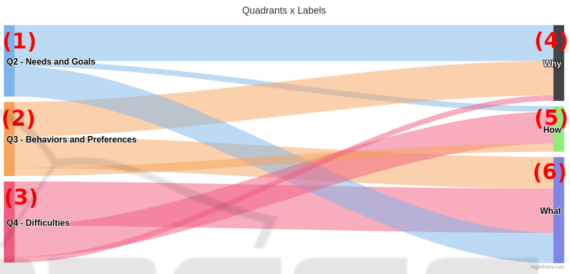


Figure 3: Overview visualization image with numerical labels.

## 4.2 Data Collection

The study was carried out with 20 participants, i.e., 14 undergraduate and 6 graduate students. The subjects were invited in the context of the "Human-Computer Interaction - (HCI)" course that was held in Computer Science at the UFSCar. The participants accepted to take part in the study voluntarily and no type of reward was involved. Although the participants had different levels of experience in relation to UX and data visualization, they mostly were professionals with experience in software development in practice. The study was conducted by two researchers, a senior researcher with 15+ years of experience and a researcher with 5+ years of experience at a laboratory at UFSCar, and lasted 3 hours.

We initially presented the concepts about data visualization (based on (Munzner, 2014)), levels of UX (based on (Hassenzahl, 2018)), and lean persona (based on (Pinheiro et al., 2019)) to level off the participants' knowledge. After that, we asked the participants to navigate into the visualizations to explore their features and understand the purpose of the personas' quadrants. During this step, the participants could clarify doubts about the concepts and the tool.

Table 1: Questionnaire to conduct users during the visualizations evaluation - Question TQ2 is a cluster of three questions.

| ID | Visualization objective | Question | Answer type | Evaluation purpose |
|---|---|---|---|---|
| TQ1 | *Overview* | Is it possible to clearly visualize the distribution of the quantities of each label (i.e., *what*, *why*, and *how*) in relation to the quadrants? | We used a four-point Likert scale as answer options ranging from strongly disagree to totally agree | Verify whether that visualization informs the participants of the labels with the highest and lowest amounts in relation to the quadrants without the need for absolute numerical verification |
| TQ2 | *Overview* | If you want to know more information about UX data consider: [(a) application functionality and their relationship with the persona, (b) motivations and needs of the persona, (c) concrete details of the user's interaction with the application] you should click on: | The answers present the numbers that are available in the overview image in the questionnaire (see Figure 3). The participant should provide three answers, one for each item (i.e., items a), b), and c)) | Aim to verify whether the participants identified the visualization element that provides access to information from each label (i.e., *why*, *what*, and *how*). The labels have semantic meaning that represents the functionalities, user information, and forms of interaction |
| TQ3 | *Overview* | Which quadrant has the fewest number of labels? | Titles that identify the quadrant | Identify particular information about the distribution of labels presented in the visualization |
| TQ4 | *Overview* | Which label appears four times in the "Q4 - Difficulties" quadrant? | Name that identifies the label | Evaluate the use of interactive functions to identify specific information about the number of labels in a specific quadrant |
| TQ5 | *Zoom and filter* | Select the incorrect alternative(s): a) The persona Helena presents information about the needs and motivations for using the tourism application in all quadrants; b) The persona Jorge presents information from the tourists' feedback feature; c) Quadrant "Q2 - Needs and Goals" quadrant is suitable to know the types of concrete actions that can be performed during the use of the tourism application; d) Quadrant "Q3 - Behaviors and Preferences" is suitable to know the types of concrete actions that exist during the use of the tourism application | Multiple-choice alternatives with the statements as options | Verify whether by interacting with the *zoom and filter* and *details* visualizations the participants could evaluate the information in the alternatives; see the participants interpretation on the visual elements. |
| TQ6 | *Zoom and filter* and *details* | Which persona(s) provided more labels that can give insights about features to the tourism app? Justify your answer | Open-question answer from which the participants write up the personas' name and the motivation for choosing a persona | Verify whether by exploring the *zoom and filter* and *details* visualizations the participants were able to identify which personas are suitable for getting insights of the application features |
| TQ7 | *Overview*, *zoom and filter*, and *details* | What is the persona name that displays the information "*When the post text field has limited characters? In which quadrant is this excerpt found? What label was used to highlight this excerpt?*" | Open-question answer to write up the persona name, quadrant where the information is placed, and type of label assigned to the excerpt | Verify whether by navigating in all visualizations (i.e., *overview*, *zoom and filter*, and *details*) the participants could find specific information of a persona |

We then proceeded by presenting the study's objective and after that, we asked the participants to read and answer the Informed Consent Form that state the agreement on the use of the data and images for academic ends. After that, the participants filled out the *profile questionnaire*.

In the next step, all participants received the links to: (i) the description of the *scenario* about the tourism app; (ii) the online questionnaire that guided the participants' interaction with the three visualizations and evaluates the *interpretation* of the visualizations (see details in subsection 4.1); and (iii) the three visualizations.

## 4.3 Data Analysis and Study Validity

We adopted a descriptive approach to examine the data collected. To analyze the *interpretation* of the visualizations, we first split the participants' responses by the perspectives of *overview*, *zoom and filter*, and *details* considering the arrangement of the question presented in Table 1.

We considered the conclusion, construction, internal and external threats to discuss our study validity according to Wohlin et al. (2012) recommendations. To deal with the conclusion threats, three researchers adopted the same UX levels definition to label the data in the personas dataset which avoided the possible bias that could be introduced by different interpretations of UX data meaning.

To mitigate construct problems, we provided a set of artifacts (i.e., a scenario of the tourism apps and the questionnaire) to support the study conduction. All the participants interacted with the same visualizations developed with the same dataset, which prevents different results from being due to the types of data or visualizations. We also delivered a presentation of the relevant concepts to the study (i.e., visualization, levels of UX, and lean persona). A hands-on exercise ensured the participants had some experience with the visualizations. These two activities allowed us to mitigate the impact of little knowledge of the participants about the study concepts. Moreover, these activities benefited participants as they could clarify any doubts about the concepts.

The internal threat related to participants' fatigue during the study. We proposed a lightweight set of tasks guided by questions that stimulated the participants to explore the visualizations. Besides, the execution of tasks on the visualization lasted 1 hour at most. Participation in the study was voluntary without any financial compensation. The participants were invited to freely and optionally participate in the study, and a few chose not to participate. It is worth mentioning that there was no reward to the participants

and the students who did not take part were not affected in any way. The participants' motivation was due to the fact that the topics covered in the study were popular and of interest to them. In the case of an external threat, it commonly refers to the fact that the study includes software developers who are still students. However, Salman et al. provide evidence of few performance differences between students and professionals when performing new activities (Salman et al., 2015). In the case of this study, the activity was new for all participants as none of them had experience exploring UX data using visualizations.

# 5 RESULTS AND DISCUSSION

We present our results in three sections: (i) the participants' profile, (ii) the discussion about the *interpretation* of the three visualizations, and (iii) the comparison of our results with the literature.

**Participants' Profiles.** The profile questionnaire results (see Table 2) reveal that 70% (14) of the participants had a position in technology companies. Considering the knowledge background of the participants, 65% (13) have practical and/or theoretical knowledge about InfoVis. On the other hand, more than half of the participants (i.e., 60% (12)) had their first contact with the concepts of personas and lean personas in the HCI course. We also noticed that the more experienced professionals (i.e., $>$ 1 year) reported having little knowledge of personas technique before attending the HCI course.

**The Interpretation of the Three Visualizations.** Table 3 shows the participants' answers to the questions that guided the participants' tasks (see the questions in Table 1). The last line of the table provides the correct answers of the questions. In next sections, we will present the results for each visualization individually and the use of the three visualizations together, and an overall discussion of the results.

In the *Overview* visualization the participants did not have difficulties in identifying and interpreting quantitative data about labels to select their first step for navigation. We saw that only two participants (one participant for each question) did not answer correctly questions TQ3 and TQ4 (see Table 1) about the distribution of UX labels, i.e., *why*, *what* and *how*. We see that almost all participants agreed with the statement on visualizing the distribution of the quantities, i.e., 45% (9) of the participants "partially agree" and 55% (11) "strongly agree" with the statement (see TQ1 in Table 1). We observed more than 70% success rate in answering correctly questions on finding

Table 2: Participants marked with * were graduate students — Participants profile - Background on InfoVis: (1) I have no knowledge about the area; (2) I have theoretical knowledge about good practices; (3) I have practical knowledge with visualizations, but I don't know good practices; and (4) I have practical knowledge and theoretical knowledge about good practices to develop visualizations. Background on persona and lean persona: (a) My first contact with personas techniques was in the HCI course; (b) I already knew the personas techniques but never used them in practice, and (c) I already knew the personas technique and have also used it in practice.

| Identification | | | Background | | |
|---|---|---|---|---|---|
| **ID** | **Experience** | **Position** | **InfoVis** | **Persona** | **Lean persona** |
| 1* | 1 to 3 years | Developer | 2 | c | b |
| 2* | $>$ 8 years | Developer | 3 | b | a |
| 3 | $<$ 1 year | No job | 1 | a | a |
| 4 | $<$ 1 year | No job | 1 | a | a |
| 5* | $>$ 8 years | Developer | 2 | a | a |
| 6 | 1 to 3 years | Analyst | 3 | a | a |
| 7 | $<$ 1 year | No job | 1 | b | b |
| 8* | $>$ 8 years | Developer | 2 | b | b |
| 9 | $<$ 1 year | Developer | 1 | a | a |
| 10 | 1 to 3 years | Developer | 3 | a | a |
| 11* | $<$ 1 year | Support | 3 | b | a |
| 12* | 6 to 8 years | Developer | 3 | a | b |
| 13 | $<$ 1 year | Analyst | 2 | a | a |
| 14 | $<$ 1 year | No job | 1 | a | a |
| 15 | $<$ 1 year | No job | 1 | a | a |
| 16 | $<$ 1 year | No job | 3 | b | a |
| 17 | 1 to 3 years | Developer | 2 | a | b |
| 18 | $<$ 1 year | Developer | 1 | c | b |
| 19 | 1 to 3 years | Researcher | 4 | b | b |
| 20 | 1 to 3 years | Analyst | 2 | a | a |

UX labels throughout the entire process of navigating into the visualizations, i.e., *overview*, *zoom and filter*, and *details* (see TQ2 in Table 1 and Table 3): (i) 85% (17) of respondents correctly identified where *what* labels were placed in the visualization; (ii) 65% (13) of respondents correctly pinpointed where *why* labels could be found; and (iii) 70% (14) of respondents correctly identified the *how* labels. These results revealed the effectiveness of the Sankey chart in (i) clearly showing the distribution of labels between the quadrants; and (ii) allowing navigation and data considering a specific purpose.

We motivated the participants to interact with the three different visual representations (i.e., *overview*, *zoom and filter*, and *details*) based on statements about the personas' data to use filtering feature to achieve the target information (see question TQ5 in Table 1). We understood that TQ5 suffers the influence of previous knowledge about the UX labels. We observed that 70% (14) of the participants could select at least one right answer (i.e., options *c* and *d* in Table 3). Our findings suggest that participants' performance on question TQ5 was influenced by their prior familiarity with UX labels, with 70% (14) successfully selecting at least one correct answer from the available options.

In question TQ6, the participants should examine the personas to find the ones that provide insights about the features of the tourism app (see Table 1). To

Table 3: Participants' answers to the tasks on the three visualizations - TQ2-A to C: answers were guided by Figure 3; TQ5: see the alternatives in Table 1; TQ7:"N/A" was assigned to participants that did not report an answer.

| ID | TQ1 | TQ2-A | TQ2-B | TQ2-C | TQ3 | TQ4 | TQ5 | TQ6 | TQ7 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Strongly agree | (6) | (4) | (5) | Q2: Needs and Goals | Why | b, d | Claudia, Leandro | (Janaína), (Q4), (How) |
| 2 | Strongly agree | (6) | (4) | (5) | Q2: Needs and Goals | Why | d | Leandro | (Janaína), (N/A), (How) |
| 3 | Strongly agree | (6) | (4) | (5) | Q2: Needs and Goals | Why | b, c | Leandro, Clara, Cláudia | (Janaína), (Q4), (How) |
| 4 | Strongly agree | (6) | (4) | (5) | Q2: Needs and Goals | Why | b, c | Clara, Leandro, Claudia | (Janaína), (Q4), (How) |
| 5 | Strongly agree | (6) | (2) | (1) | Q2: Needs and Goals | Why | a, c | Claudia, Lucas, Luiz, Janaína, Lyn, Elena | (Janaína), (Q4), (N/A) |
| 6 | Strongly agree | (6) | (4) | (5) | Q2: Needs and Goals | Why | b, c | Leandro, Claudia, Clara | (Janaína), (Q4), (How) |
| 7 | Partially agree | (4) | (6) | (5) | Q2: Needs and Goals | Why | b, c, d | Clara, Leandro, Claudia | (Janaína), (N/A), (How) |
| 8 | Partially agree | (5) | (4) | (6) | Q2: Needs and Goals | Why | b, c | Fábio | (Leandro), (Q3), (N/A) |
| 9 | Partially agree | (5) | (4) | (6) | Q2: Needs and Goals | Why | c | Fábio, Francisco | (Janaína), (Q4), (N/A) |
| 10 | Partially agree | (6) | (1) | (2) | Q2: Needs and Goals | Why | a, b, c | Clara, Leandro, Claudia | (Janaína), (Q4), (N/A) |
| 11 | Strongly agree | (6) | (4) | (5) | Q2: Needs and Goals | Why | b, c, d | Clara, Leandro, Claudia | (Janaína), (N/A), (How) |
| 12 | Strongly agree | (6) | (4) | (5) | Q2: Needs and Goals | How | b, c, d | Carlos, Clara, Leandro, Claudia, Luiz, Francisco, Jorge, Adriana, Helena, Rogério, Patrícia | (Janaína), (Q4), (N/A) |
| 13 | Strongly agree | (6) | (4) | (5) | Q2: Needs and Goals | Why | c, d | Clara, Leandro, Claudia | (Janaína), (Q4), (How) |
| 14 | Strongly agree | (6) | (4) | (5) | Q4 - Difficulties | Why | d | Jorge, Adriana | (Janaína), (Q4), (How) |
| 15 | Partially agree | (6) | (2) | (5) | Q2: Needs and Goals | Why | a, c | Leandro | (N/A), (Q4), (Why) |
| 16 | Partially agree | (6) | (4) | (5) | Q2: Needs and Goals | Why | c, d | Carla, Lauren, Francisco, Jorge | (Janaína), (Q4), (How) |
| 17 | Strongly agree | (6) | (4) | (5) | Q2: Needs and Goals | Why | a, d | Ana | (Janaína), (Q4), (How) |
| 18 | Partially agree | (6) | (1) | (2) | Q2: Needs and Goals | Why | a, b | Patrícia | (Janaína), (Q4), (N/A) |
| 19 | Partially agree | (6) | (5) | (4) | Q2: Needs and Goals | Why | a, c | Fábio | (Janaína), (Q4), (N/A) |
| 20 | Partially agree | (6) | (1) | (5) | Q2: Needs and Goals | Why | c, d | Leandro | (N/A), (Q4), (How) |
| Key answers | Agree | (6) | (4) | (5) | Q2: Needs and Goals | Why | c, d | Clara, Leandro, Claudia | (Janaína), (Q4), (How) |

accomplish the *detail* visualization to explore the lean personas information, we motivated the participants to interact with *zoom and filter* and *detail* visualizations more than once and brought an interpretative approach to the task. To correctly answer this question, the participants should pinpoint three personas (key answers: Clara, Leandro, and Claudia). Our results showed that more than half of the participants (i.e., 11 participants - 55%) answered the question by mentioning the three personas or at least one of them (Table 3). Our findings indicate that the funnel-based approach helped participants (i.e., 11 participants - 55%) to successfully address the question by mentioning at least one of the key answers.

To get a perspective of the interpretation with the three visualizations connected one each other, we proposed question TQ7 (see Table 1). In this question, the participants should explore the different paths in the visualizations and browse the *overview* and *zoom and filter* visualizations to achieve the answers available from the *detail* visualization to thus select the lean persona. The results showed (see Table 3) that (i) 85% (17) of the participants selected the right lean persona; (ii) 80% (16) selected the right quadrant; and (iii) 60% (12) selected the right label. From this result, we could conclude that the elements and the interactions provided by the three visualizations supported the search for particular UX data.

The results showed that the participants did not have difficulties in finding specific information about UX data (see questions TQ1, TQ3, TQ4, and TQ7 in Table 1 and their results in Table 3). Our results revealed that all participants got at least 50% of the questions right. We understand that the knowledge in the UX labels could influence the use of the visualizations in particular to determine which label has the desired UX data (e.g., questions TQ2-A, TQ2-B, TQ2-C, TQ5, and TQ6 in Table 1).

We noticed the results of the questions TQ2-A and TQ6 were connected. In the TQ6 question the participants should inform which persona had the information about features. In a lean way, in TQ2-A question they should inform where in the visualization they had to click to access information about features (i.e. which label). Two of the three participants who chose the wrong answer in TQ2-A also selected the wrong option in TQ6. This result suggests that some participants could struggle to understand the relationship between labels and the embedded UX data of each label. To mitigate this issue, we conducted a warm-up to leverage the participants' knowledge about UX labels; however, we concluded that we needed to find alternatives to present the UX label meanings in the visualizations.

**Comparison with the Related Work.** We can see three main differences in relation to the use of visualization to explore personas data, the adoption of complementary approaches for the conceptions of the visualizations, and the use of different chart formats to view the data.

Firstly, we proposed three visualizations that together and connected aid developers and designers in streamlining the search for useful UX data into lean personas textual information. As far as we know there is no other similar proposal that works to make easier the exploration of personal data although personas are recognized as a proper technique for UX-related requirement elicitation as we mentioned in (Pinheiro et al., 2019).

We have the consciousness that there are many

works that adopt the Nested Model of Munzner (2014) to support the elaboration of visualizations. However, we used a different approach by putting harmonically together the good practices proposed by the Nested Model and the systematic process of visualization construction, i.e., Design Activity Framework (DAF) of McKenna et al. (2014) (see section 3). The complementary perspective of the approaches supported us in following a sequence of steps (DAF), observing the details of the visualizations, and clearly specifying the elements of each one (Nested Model).

While the approaches above guided our process of visualization elaboration, Shneiderman's Mantra sustained the conception of the visualizations by introducing ways to gradually conduct developers and designers to the lean personas data. Although Bernhaupt et al. (2020) and Bakiu and Guzman (2017) have applied Shneiderman's Mantra, they do not use all three levels of visualization. The visualizations proposed by Bakiu and Guzman (2017) do not apply zoom and filter levels. Bernhaupt et al. (2020) work presents a close perspective of ours by applying the mantra; however, the authors focus only on the levels of *overview* and *detail*.

Taking into account the chart formats, we see that Buono et al. (2020) also used the Sankey chart and that this chart was highly accepted in the evaluations conducted by the authors. In the work, the authors built the Sankey chart to show the number of visits (i.e., quantitative data) for each page (i.e., categories) that the users navigated on the website. Similar to the authors, we adopted the Sankey chart to show the relationship between quantitative data (i.e., numbers of labels) and categorical data (i.e. *why*, *what*, and *how*). At the design granularity of *zoom and filter*, we adopted the Heat Map to show a three-leg relationship. We associated a particular UX data with the lean personas and the quadrants. In this visualization, developers and designers can identify, through the color pattern, where UX data is concentrated (i.e., *why*, *what*, and *how*). Móro et al. (2014) work mentions the Heat Map as a visualization that is desired by users but they do not implement it.

## 6 FINAL CONSIDERATIONS

In this paper, we presented a new visual approach to UX requirements gathering from lean personas. The three visualizations were developed to assist developers and designers in searching and exploring UX data available in the textual descriptions of lean personas. The visualizations are intended to guide the elicitation of UX-related requirements following Shneiderman's mantra (1996), i.e. provide the *overview* of data first, make available *zoom and filter* of the data, and observe the *details*. In this way, we proposed a funnel-based approach for data exploration. By connecting the three visualizations, we provided ways of exploring the data gradually throughout the visualizations. We labeled the lean personas descriptions by using Hassenzahl's UX levels. It aimed to give meaning to the UX data available since qualitative data can introduce subjectiveness to the requirement elicitation. We evaluated the three visualizations with 20 participants with regard to the interpretation of the visualizations.

Overall, our findings revealed that the three visualizations provide easy ways of identifying and finding UX data available in the lean personas. Nonetheless, the interpretation evaluation revealed the need to add some kind of help that aids the better understanding of the UX level which was used to provide meaning to the data. The participants' feedback showed us that improvements on the *zoom and filter* features are requested to give more flexibility to users' search and find information. We also presented a method contribution by using Nested Model (Munzner, 2014) and Design Activity Framework (McKenna et al., 2014) in a complementary perspective for building the visualizations. This same combination of approaches can be replicated in other designs of the visualizations.

In future work, we intend to improve our visualizations to add the features suggested by the evaluation participants. We also intend to conduct new studies in real scenarios (i.e., software projects with designers, requirement analysts, and developers) with different samples of lean personas. Regarding the evaluation, we intend to analyze the usability and efficiency of the visualizations to facilitate the organization and speed up the understanding of the UX information collected through lean personas.

## ACKNOWLEDGEMENTS

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001 and grant 309497/2022-1 and 147915/2022-8, Consellho Nacional de Desenvolvimento Científico e Tecnológico (CNPq - Brazil).

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